Continuous passive motion following total knee arthroplasty in people with arthritis (Review)

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[Intervention Review]

Continuous passive motion following total knee arthroplasty in people with arthritis

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ABSTRACT

Background

Total knee arthroplasty is a common intervention for patients with arthritis. Post-surgical rehabilitation often includes continuous passive motion. However, it is not clear whether continuous passive motion is effective.

Objectives

To evaluate the effectiveness of continuous passive motion following total knee arthroplasty in people with arthritis.

Search strategy

We searched the Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library* 2009, Issue 3), MEDLINE (January 1966 to January 2009), EMBASE (January 1980 to January 2009), CINAHL (January 1982 to January 2009), AMED (January 1985 to January 2009) and PEDro (to January 2009).

Selection criteria

Randomised controlled trials in which the experimental group received continuous passive motion, and both the experimental and control groups received similar postoperative care and therapy following total knee arthoplasty in people with arthritis.

Data collection and analysis

Two reviewers independently selected trials for inclusion. Data were then extracted and the quality of trials assessed. The primary outcomes were active knee flexion range of motion, passive knee flexion range of motion, active knee extension range of motion, passive knee extension range of motion, length of hospital stay, function and incidence of manipulation under anaesthesia. The secondary outcomes were pain, swelling and quadriceps strength. Effects were estimated as weighted mean differences or standardised mean differences with 95% confidence intervals (CI). Meta-analyses were performed using random-effects models for continuous variables.

Main results

Twenty randomised controlled trials of 1335 participants met the inclusion criteria. There is high-quality evidence that continuous passive motion increases passive knee flexion range of motion (mean difference 2 degrees, 95% CI 0 to 5) and active knee flexion range of motion (mean difference 3 degrees, 95% CI 0 to 6). These effects are too small to be clinically worthwhile. There is low-quality evidence that continuous passive motion has no effect on length of hospital stay (mean difference -0.3 days; 95% CI -0.9 to 0.2) but reduces the need for manipulation under anaesthesia (relative risk 0.15; 95% CI 0.03 to 0.70).

Authors' conclusions

The effects of continuous passive motion on knee range of motion are too small to justify its use. There is weak evidence that continuous passive motion reduces the subsequent need for manipulation under anaesthesia.

PLAIN LANGUAGE SUMMARY

Continuous passive motion after knee replacement surgery

This summary of a Cochrane review presents what we know about the effect of continuous passive motion (CPM) as a treatment to improve range of motion and function after knee replacement surgery.

In people who had knee replacement surgery:

- Continuous passive motion improved their range of motion slightly;

- Continuous passive motion may not make any difference to how long they stayed in hospital;

We often do not have precise information about side effects and complications. This is particularly true for rare but serious complications.

What is osteoarthritis and what is continuous passive motion (CPM)?

Osteoarthritis of the knee can make the knee joint painful and unstable. Knee replacement surgery is a treatment that can sometimes help this condition. One side effect of having knee surgery is stiffness in the knee. When your knees are stiff, it can be difficult to stand from a sitting position. Up to a year later, some people walk and climb stairs more slowly than they did before surgery.

This has led to the development of a therapy called continuous passive motion (CPM). Continuous passive motion is a way of providing regular movement to your knee using a machine. The movement is passive which means that machine moves your knee for you through a preset range of motion. The movement that tests the range of motion for your knee is called flexion. Flexion is a movement which moves the two ends of a jointed body part closer to each other. In this case, knee flexion is how close you are able to move the heel of your foot close to your buttocks. This distance is measured in degrees.

Best estimate of what happens to people who have CPM after knee replacement surgery:

Range of motion - Active knee flexion

- People who did not have CPM were able to move their knee an average of 75 degrees

- People who did have CPM were able to move their knee 3 degrees more, an average of 78 degrees.

Range of motion - Passive knee Flexion

- People who did not have CPM were able to move their knee an average of 82 degrees

- People who did have CPM were able to move their knee 2 degrees more, an average of 84 degrees.

Length of Hospital Stay

SUMMARY OF FINDINGS FOR THE MAIN COMPARISON *[Explanation]*

Primary comparison - short-term effect (less than 6wks) - all studies

Patient or population: patients with patients with arthritis
Settings: post-operative (in-hospital or rehabilitation facility)
Intervention: CPM
Comparison: standard care with or without additional exercises

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of Participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	standard care with or without additional exercises	CPM				
Active knee flexion ROM degrees	The mean active knee flexion rom in the control groups was **75 degrees**	The mean Active knee flexion ROM in the intervention groups was **3 higher** (0 to 6 higher)		379 (9 studies)	⊕⊕⊕⊕ **high**[1]	
Passive knee flexion ROM degrees	The mean passive knee flexion rom in the control groups was **82 degrees**	The mean Passive knee flexion ROM in the intervention groups was **2 higher** (0 to 4 higher)		634 (13 studies)	⊕⊕⊕⊕ **high**[1]	
Active knee extension ROM degrees	The mean active knee extension rom in the control groups was **-12 degrees**	The mean Active knee extension ROM in the intervention groups was **1 higher** (0 to 2 higher)		743 (12 studies)	⊕⊕⊕⊕ **high**[1]	

Passive knee extension ROM degrees	The mean passive knee extension rom in the control groups was **-7 degrees**	The mean Passive knee extension ROM in the intervention groups was **0 higher** (0 to 1 higher)		749 (13 studies)	⊕⊕⊕⊕ **high**[1]
Length of hospital stay days	The mean length of hospital stay in the control groups was **13 days**	The mean Length of hospital stay in the intervention groups was **0.3 lower** (0.9 lower to 0.2 higher)		748 (12 studies)	⊕⊕◯◯ **low**[1,2]
Function [standardised mean]	See comment	See comment	Not estimable	0 (4 studies)	⊕⊕◯◯ **low**[1,3,4]
Manipulation under anaesthesia	**Study population**		**RR 0.15** (0.03 to 0.7)	234 (3 studies)	⊕⊕◯◯ **low**[1,5,6]
	119 per 1000	**18 per 1000** (4 to 83)			
	Medium risk population				
	81 per 1000	**12 per 1000** (2 to 57)			

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).
CI: Confidence interval; **RR:** Risk ratio;

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

[1] Too few trials to enable estimation of risk of publication bias.

[2] Decisions about length of hospital stay would have been made by treating clinicians. In trials of CPM it is difficult or impossible to blind treating clinicians.
[3] Inconsistency may reflect use of different measures of function.
[4] Imprecision may reflect use of different measures to function.
[5] Decisions about manipulation under anaesthesia would have been determined by treating clinicians. It trials of CPM it is difficult or impossible to blind treating clinicians.
[6] The effect size is large but associated with imprecision.

BACKGROUND

Total knee arthroplasties (TKA) are surgical procedures which involve replacing the knee joint with artificial components. They are commonly performed to reduce pain and increase function in patients with severe arthritis such as osteoarthritis (OA) and rheumatoid arthritis (RA). The surgery often involves periods of postoperative immobilisation which can lead to joint stiffness (McCarthy 1992). Animal studies have demonstrated that early movement minimises joint stiffness and improves range of motion (ROM) (Videman 1987). This has led to the development of a therapy called continuous passive motion (CPM). Continuous passive motion is a way of providing regular movement to the knee using an external motorised device which passively moves the joint through a preset arc of motion (Sheppard 1995). Continuous passive motion was first introduced by Salter et al in the 1960s (Salter 1989). Since then, CPM has been used as part of postoperative care following TKA in some hospitals.

Continuous passive motion is primarily advocated in the belief that it increases knee ROM (McCarthy 1992; Salter 1989). However, some also claim that it reduces pain (Harms 1991), length of hospital stay (Fisher 1985; Schebel 1989) and the need for manipulation under anaesthesia (a procedure which involves forcefully flexing the knee while the patient is anaesthetised to increase knee ROM (Fox 1981)). The purpose of this systematic review was to objectively synthesise evidence of the effectiveness of CPM following TKA for people with arthritis.

OBJECTIVES

To determine the effectiveness of CPM and standard postoperative care compared to similar postoperative care with or without additional knee exercises on knee ROM, length of hospital stay, function, incidence of manipulation under anaesthesia, pain, swelling and quadriceps strength in patients following TKA for management of arthritis.

METHODS

Criteria for considering studies for this review

Types of studies

Only randomised controlled trials (RCT) were included. Trials were included regardless of language. Abstracts were accepted. Trials were not excluded based on quality assessment.

Types of participants

Participants could be of any age provided they were hospitalised following TKA. All participants needed to have a pre-surgery diagnosis of arthritis.

Types of interventions

Trials were included if CPM and standard postoperative care were compared with similar postoperative care with or without additional knee exercises. Standard postoperative care could include muscle strengthening exercises (isometric or dynamic), functional exercises, gait training, immobilisation or ice, provided both groups received the same intervention. Additional knee exercises could include instructions or supervised active or passive knee ROM exercises. They could not include knee exercises provided with any type of CPM device.

Types of outcome measures

Primary outcomes

The primary outcomes of interest were active knee flexion ROM, passive knee flexion ROM, active knee extension ROM, passive knee extension ROM, length of hospital stay, function, and incidence of manipulation under anaesthesia. If authors did not distinguish between active and passive knee ROM then it was assumed that the measurement was passive. "Knee extension lag" was interpreted as active knee extension ROM and "fixed deformity" was interpreted as passive knee extension ROM.

Secondary outcomes

Secondary outcomes were pain, swelling and quadriceps strength. Only direct measures of pain intensity were of interest. These included pain scales but not pain medication.

Results were categorised into short-term effects of CPM (reflected in outcomes taken less than 6 weeks after randomisation), medium-term effects of CPM (reflected in outcomes taken 6 weeks to 6 months after randomisation) and long-term effects of CPM (reflected in outcomes taken more than 6 months after randomisation). Where trials collected data at multiple time periods within one of these categories, we used the data collected at the longest time since randomisation.

Search methods for identification of studies

We searched the Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library* 2009, Issue 3), MEDLINE (January 1966 to January 2009), EMBASE (January 1980 to January 2009), CINAHL (January 1982 to January 2009), AMED (January 1985 to January 2009) and PEDro (to January 2009). We also searched reference lists of relevant trials and reviews. We

contacted content experts for additional trials and unpublished data.

Details of the search strategies used are outlined in Appendices 1 to 6.

Data collection and analysis

Identification of eligible trials

Two independent review authors examined the titles and abstracts of trials identified by the search strategy to identify trials that potentially met the inclusion criteria. All trials classified as potentially eligible by at least one of the review authors were retrieved. The retrieved articles were re-examined to ensure that they met the inclusion criteria.

Risk-of-bias assessment

The risk-of-bias in each trial was assessed by two independent reviewers using the method recommended by the Cochrane Collaboration. The following methodological domains were assessed:

1. sequence generation;
2. allocation sequence concealment;
3. blinding of participants;
4. blinding of personnel;
5. blinding of outcome assessors;
6. incomplete outcome data;
7. selective outcome reporting; and
8. other potential threats to validity.

We rated each trial using the following criteria: Yes = low risk of bias; No = high risk of bias; Unclear = either lack of information or uncertainty over the potential for bias. We attempted to contact all authors to clarify ambiguities.

Disagreements in rating were resolved by discussion or where necessary by a third person. Trials published in languages other than English were rated by colleagues fluent in that language.

Overall quality of evidence

The GRADE approach was used to summarise the quality of evidence where levels of quality were defined as follows:

1. high quality: randomised trials;
2. medium quality: downgraded randomised trials;
3. low quality: double-downgraded randomised trials; and
4. very low quality: triple-downgraded randomised trials.

The quality of evidence was downgraded if:

1. there were limitations in the design and implementation of available trials suggesting high likelihood of bias;
2. there was only indirect evidence (indirect population, intervention, control, outcomes);
3. there was unexplained heterogeneity or inconsistency of results (including problems with subgroup analyses);
4. the results were imprecise (wide confidence intervals); and
5. there was a high probability of publication bias.

In the same way, the quality of evidence was upgraded if:

1. the effect sizes were large;
2. all confounding factors reduced a demonstrated effect or suggested a spurious effect in trials which showed no effect; and
3. there was a dose-response gradient.

The Summary of Findings Table was compiled using GRADEpro software.

Extraction of results

Results were extracted from each of the included trials by two independent review authors and cross-checked by a third author. Discrepancies were resolved by consensus. If outcomes were only reported graphically, the mean scores and standard deviations were estimated from the graphs. In trials with more than two groups, only data from the two groups with the most contrasting interventions were extracted and used for analyses. For example, in trials with a control and two CPM groups, only the results of the control group and CPM group with the highest dosage were included in analyses. We adopted this approach to reduce complexity and increase the readability of the systematic review. Questions regarding the relative effectiveness of different dosages of CPM were addressed in a meta-regression (see next section for details). For outcomes where it is desirable to have a lower score (e.g. pain), a negative value indicates a beneficial treatment effect of CPM. Conversely, for outcomes where it is desirable to have a larger score (e.g. knee flexion ROM), a positive value indicates a beneficial treatment effect of CPM. Standardised mean differences were used when different scales were used to measure the same construct (e.g. function). Standardised mean differences were calculated by dividing the difference between treated and control means by the pooled estimate of the standard deviation. Where possible, the analyses were based on intention-to-treat data from the individual trials. Missing standard deviations were imputed from the mean of available standard deviations provided at least 75% of trials reported standard deviations and there was reasonable homogeneity of standard deviations. Missing standard deviations were not imputed if outcomes were expressed as standardised mean differences or if imputation resulted in considerable between-study heterogeneity.

Analysis of results

The effect of CPM was estimated by taking the difference in the mean outcome of the groups that did and did not receive CPM. For the primary analysis, the standard postoperative care may or may not have included additional knee exercises to one or both groups. A secondary analysis was also conducted on just those trials in which the standard postoperative care for the control group included additional knee exercises. These trials provide a head-to-head comparison of the effectiveness of CPM and additional knee exercises. The mean differences in outcomes from each trial were pooled to obtain a summary estimate of the effectiveness of CPM provided the I^2 statistic was not greater than 50%. For continuous data, summary estimates are presented as weighted mean differences (weighted by the inverse of the variances of the estimates). For dichotomous outcomes, results are presented as relative risks. Random-effects models were used throughout. Random-effects

meta-regression was used to explore the effect of mean total CPM time (hours) on passive knee flexion ROM in the short term. The user-written metareg routine in the Stata software package (version 10) was used for this purpose.

RESULTS

Description of studies

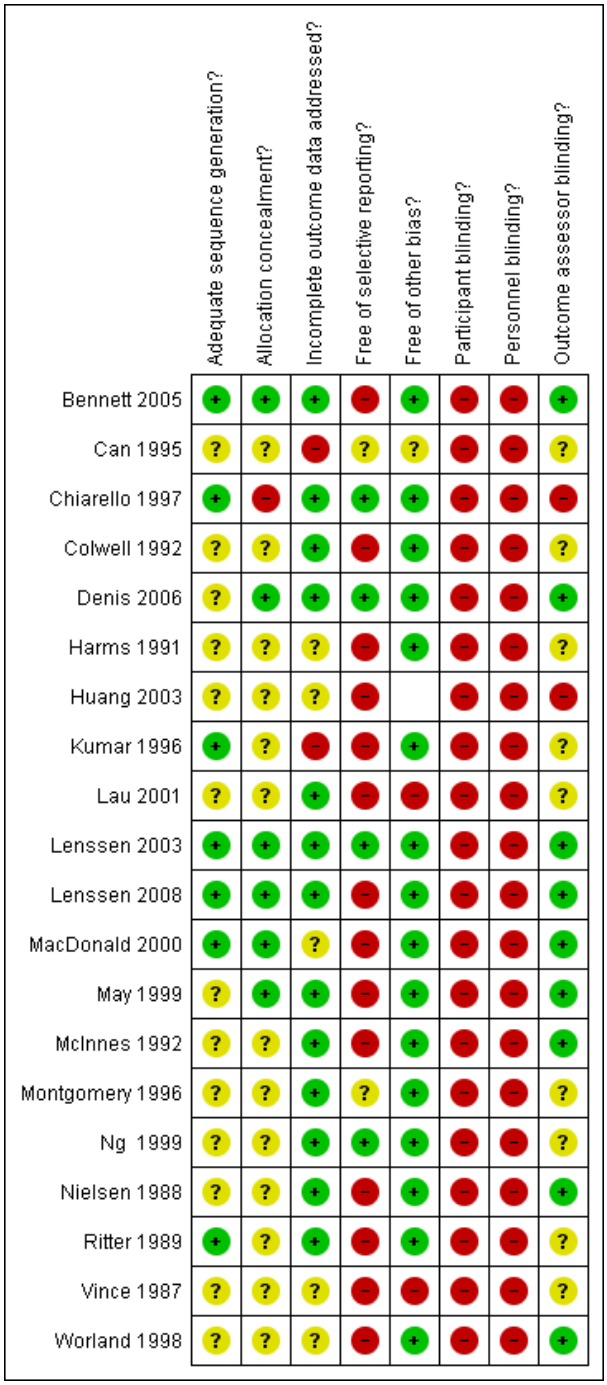
See: Characteristics of included studies; Characteristics of excluded studies; Characteristics of studies awaiting classification.

Three hundred and twenty seven trials were identified from the electronic searches. Of these, 51 trials were potentially eligible. On inspection of the full reports, 20 met the inclusion criteria (Bennett 2005; Can 1995; Chiarello 1997; Colwell 1992; Denis 2006; Harms 1991; Huang 2003; Kumar 1996; Lau 2001; Lenssen 2003; Lenssen 2008; MacDonald 2000; May 1999; McInnes 1992; Montgomery 1996; Ng 1999; Nielsen 1988; Ritter 1989; Vince 1987; Worland 1998). All but one (Can 1995) were full papers. Potentially eligible trials were most commonly excluded because the control group received something other than usual care with or without additional exercises. In the 20 included trials, CPM was administered from two to 24 hours a day (median 7.5, interquartile range 4 to 17.8) and for between one and 17 days (median 10, interquartile range 7 to 14). A total of 1335 patients were randomised. Most patients had OA rather than RA. Treatments were initiated between the first and fourth postoperative day (POD) in all trials except one (May 1999) in which CPM treatment was initiated on transfer to a rehabilitation facility (between POD 2 and 13).

Risk of bias in included studies

The 20 trials had varying levels of susceptibility to bias (see Figure 1). The nature of the intervention prevented blinding of patients and treating therapists. Only six trials concealed allocation and used an adequate method to generate the random sequence. Nine trials blinded assessors and 13 trials had adequate follow-up. Selective reporting was potentially a problem in 16 of the 20 trials.

Figure 1. Methodological quality summary: review authors' judgements about each methodological quality item for each included study.



Effects of interventions

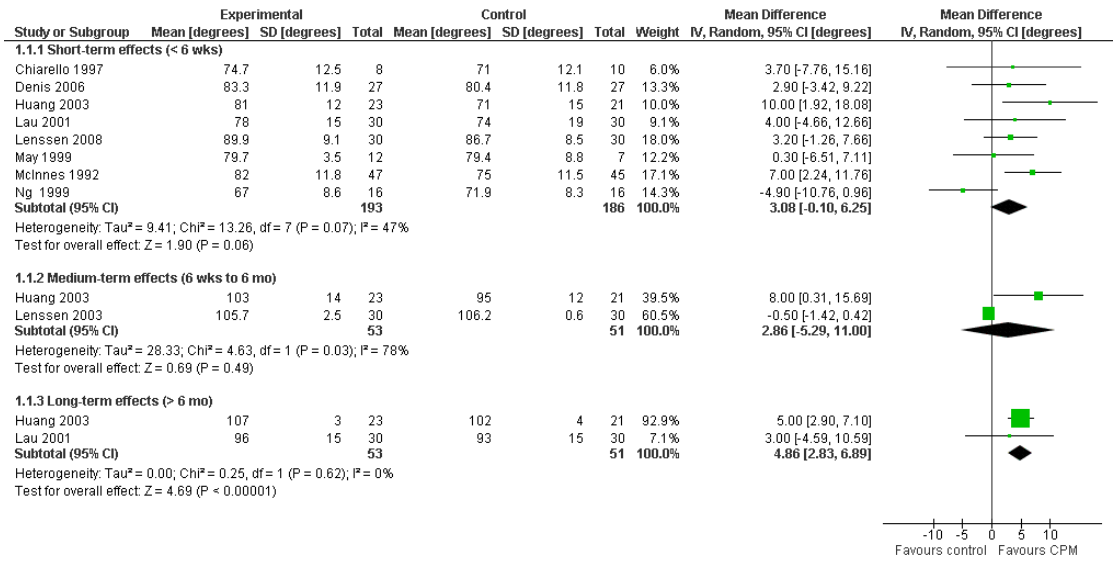
See: **Summary of findings for the main comparison** Primary comparison - short-term effect (less than 6 wks) - all studies

The primary comparisons compared CPM combined with standard postoperative care versus standard postoperative care with or without additional knee exercises to one or both groups. These analyses included all trials for which data were available. The results are summarised below.

1. Active knee flexion ROM

Short-term effects: Nine trials with a total of 479 patients measured active knee flexion ROM (Bennett 2005; Chiarello 1997; Denis 2006; Huang 2003; Lau 2001; Lenssen 2008; May 1999; McInnes 1992; Ng 1999). Eight trials with a total of 379 patients provided useful data (Chiarello 1997; Denis 2006; Huang 2003; Lau 2001; Lenssen 2008; May 1999; McInnes 1992; Ng 1999). The mean difference was 3 degrees (95% CI 0 to 6; P = 0.06; I^2 = 47%; see Figure 2).

Figure 2. Forest plot of primary comparison. Outcome: 7.1 Active knee flexion ROM [degrees].



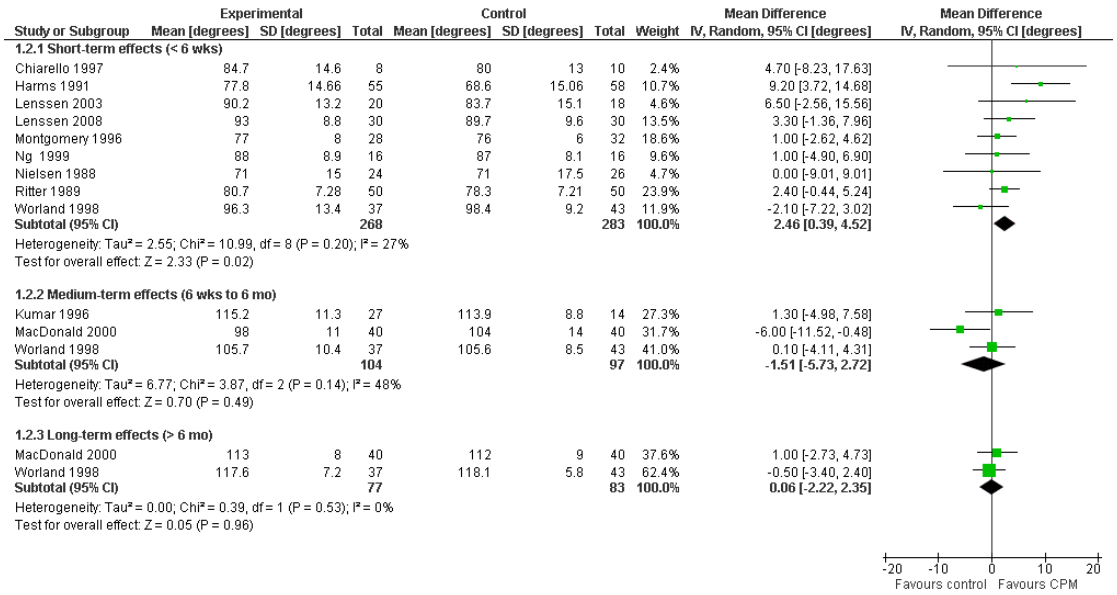
Medium-term effects: Four trials with a total of 264 patients measured active knee flexion ROM (Bennett 2005; Huang 2003; Lau 2001; Lenssen 2008). Two trials with a total of 104 patients provided useful data (Huang 2003; Lenssen 2008). There was considerable between-study heterogeneity in estimates of effect (I^2 = 78%) and although the pooled estimates are displayed (due to software limitations), they were not planned and should be interpreted with caution. Point estimates of effect ranged from -1 to 8 degrees; see Figure 2).

Long-term effects: Three trials with a total of 204 patients measured active knee flexion ROM (Bennett 2005; Huang 2003; Lau 2001). Two trials with a total of 104 patients provided useful data (Huang 2003; Lau 2001). The mean difference was 5 degrees (95% CI 3 to 7; P < 0.00001; I^2 = 0%; see Figure 2).

2. Passive knee flexion ROM

Short-term effects: Thirteen trials with a total of 817 patients measured passive knee flexion ROM (Bennett 2005; Chiarello 1997; Colwell 1992; Harms 1991; Kumar 1996; Lenssen 2003; Lenssen 2008; Montgomery 1996; Ng 1999; Nielsen 1988; Ritter 1989; Vince 1987; Worland 1998). Nine trials with a total of 479 patients provided useful data (Chiarello 1997; Harms 1991; Lenssen 2003; Lenssen 2008; Montgomery 1996; Ng 1999; Nielsen 1988; Ritter 1989; Worland 1998). The mean difference was 2 degrees (95% CI 0 to 5; P = 0.02; I^2 = 27%; see Figure 3).

Figure 3. Forest plot of primary comparison. Outcome: 7.2 Passive knee flexion ROM [degrees].



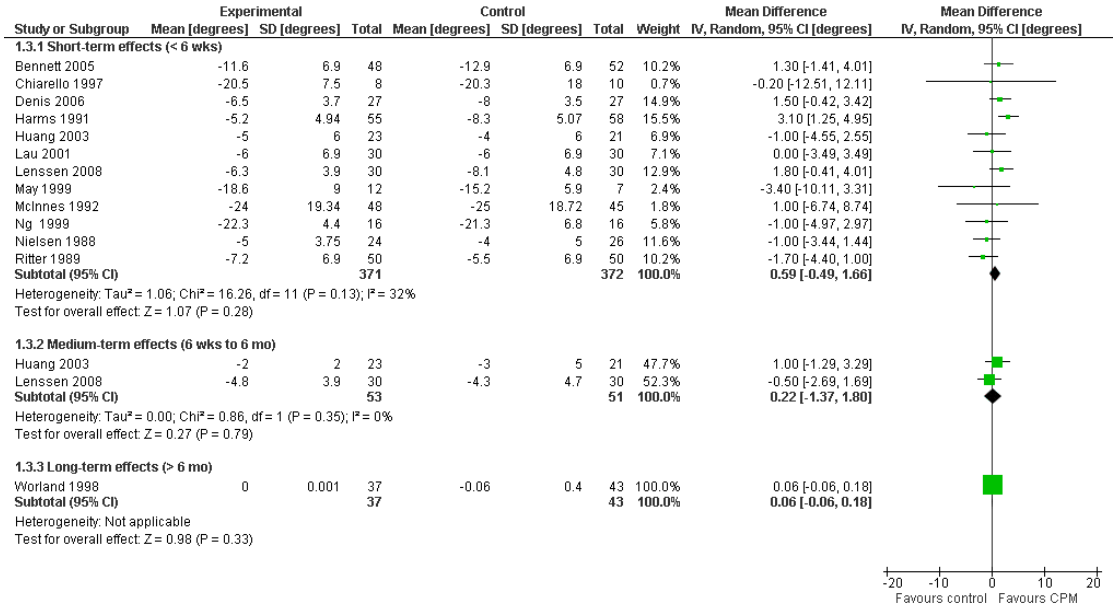
Medium-term effects: Five trials with a total of 320 patients measured passive knee flexion ROM (Colwell 1992; Kumar 1996; MacDonald 2000; Ritter 1989; Worland 1998). Three trials with a total of 201 patients provided useful data (Kumar 1996; MacDonald 2000; Worland 1998). The mean difference was -2 degrees (95% CI -6 to 3; P = 0.49; I^2 = 48%; see Figure 3).

Long-term effects: Three trials with a total of 177 patients measured passive knee flexion ROM (Colwell 1992; MacDonald 2000; Worland 1998). Two trials with a total of 160 patients provided useful data (MacDonald 2000; Worland 1998). The mean difference was 0 degrees (95% CI -2 to 2; P = 0.96; I^2 = 0%; see Figure 3).

3. Active knee extension ROM

Short-term effects: Twelve trials with a total of 743 patients measured active knee extension ROM (Bennett 2005; Chiarello 1997; Denis 2006; Harms 1991; Huang 2003; Lau 2001; Lenssen 2008; May 1999; McInnes 1992; Ng 1999; Nielsen 1988; Ritter 1989). Standard deviations were imputed for three trials (Bennett 2005; Lau 2001; Ritter 1989). The mean difference was 1 degree (95% CI 0 to 2; P = 0.28; I^2 = 32%; see Figure 4).

Figure 4. Forest plot of primary comparison. Outcome: 7.3 Active knee extension ROM [degrees]. The SD of the CPM group for Worland 1998 was zero but entered as 0.001 to enable calculation of a point estimate.



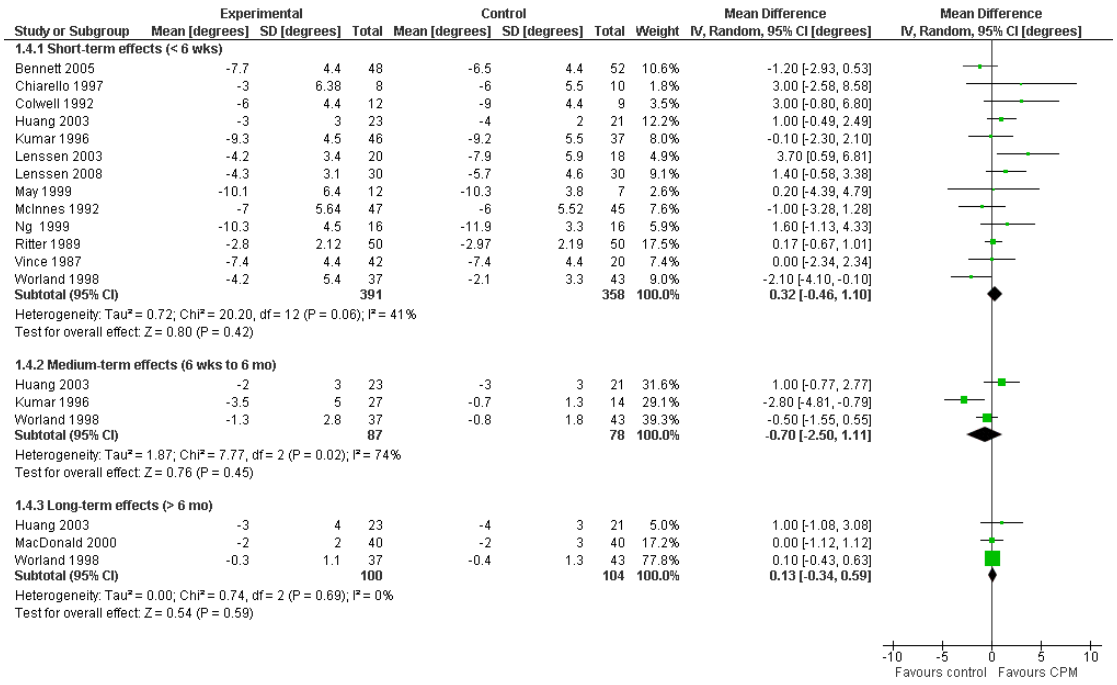
Medium-term effects: Four trials with a total of 264 patients measured active knee extension ROM (Bennett 2005; Huang 2003; Lau 2001; Lenssen 2008). Two trials with a total of 104 patients provided useful data (Huang 2003; Lenssen 2008). The mean difference was 0 degrees (95% CI -1 to 2; P = 0.79; I^2 = 0%; see Figure 4).

Long-term effects: Four trials with a total of 284 patients measured active knee extension ROM (Bennett 2005; Huang 2003; Lau 2001; Worland 1998). One trial with a total of 80 patients provided useful data (Worland 1998). The mean difference was 0 degrees (95% CI 0 to 0; see Figure 4).

4. Passive knee extension ROM

Short-term effects: Thirteen trials with a total of 749 patients measured passive knee extension ROM (Bennett 2005; Chiarello 1997; Colwell 1992; Huang 2003; Kumar 1996; Lenssen 2003; Lenssen 2008; May 1999; McInnes 1992; Ng 1999; Ritter 1989; Vince 1987; Worland 1998). Standard deviations were imputed for two trials (Bennett 2005; Colwell 1992). The mean difference was 0 degrees (95% CI 0 to 1; P = 0.42; I^2 = 41%; see Figure 5).

Figure 5. Forest plot of primary comparison. Outcome: 7.4 Passive knee extension ROM [degrees].



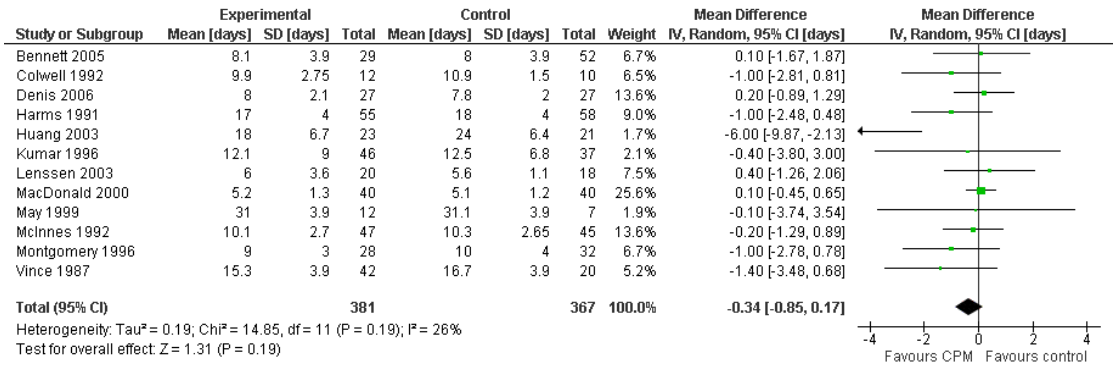
Medium-term effects: Five trials with a total of 284 patients measured passive knee extension ROM (Bennett 2005; Colwell 1992; Huang 2003; Kumar 1996; Worland 1998). Three trials with a total of 165 patients provided useful data (Huang 2003; Kumar 1996; Worland 1998). There was considerable between-study heterogeneity in estimates of effect (I^2 = 74%) and although the pooled estimates are displayed (due to software limitations), they were not planned and should be interpreted with caution. Point estimates of effect ranged from -3 to 1 degree (see Figure 5).

Long-term effects: Five trials with a total of 321 patients measured passive knee extension ROM (Bennett 2005; Colwell 1992; Huang 2003; MacDonald 2000; Worland 1998). Three trials with a total of 204 patients provided useful data (Huang 2003; MacDonald 2000; Worland 1998). The mean difference was 0 degrees (95% CI 0 to 1; P = 0.59; I^2 = 0%; see Figure 5).

5. Length of hospital stay

Short-term effects: Twelve trials with a total of 748 patients measured length of hospital stay (Bennett 2005; Colwell 1992; Denis 2006; Harms 1991; Huang 2003; Kumar 1996; Lenssen 2003; MacDonald 2000; May 1999; McInnes 1992; Montgomery 1996; Vince 1987). Standard deviations were imputed for three trials (Bennett 2005; May 1999; Vince 1987). The mean difference was -0.3 days (95% CI -0.9 to 0.2; P = 0.19; I^2 = 26%; see Figure 6).

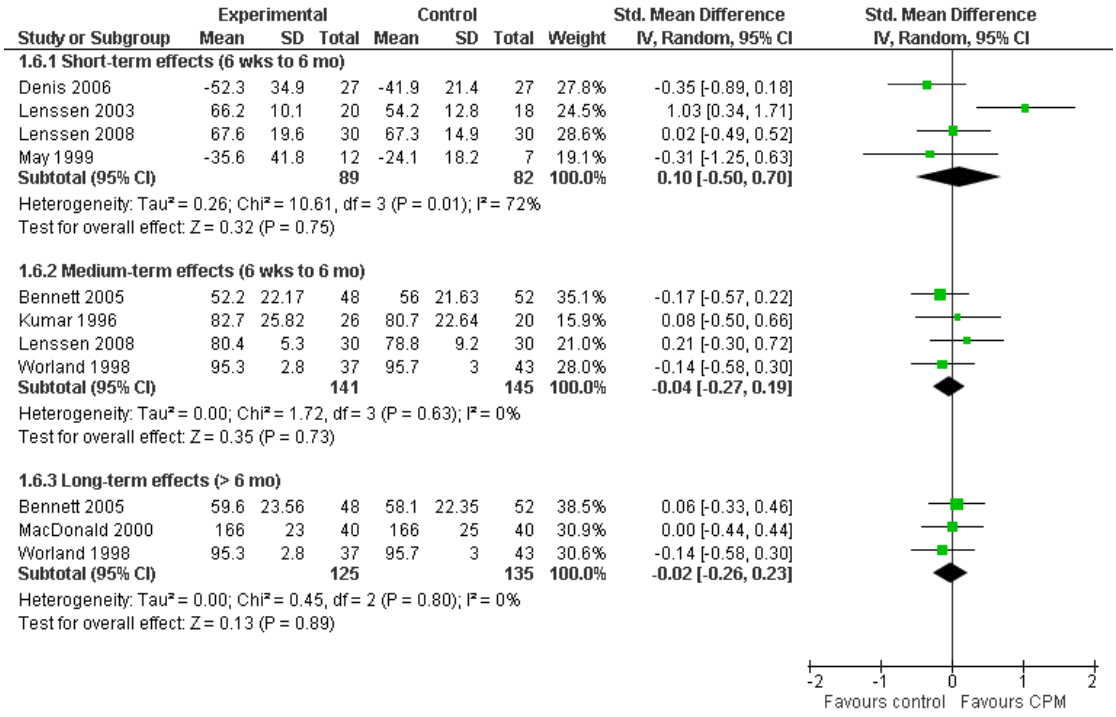
Figure 6. Forest plot of primary comparison. Outcome: 7.6 Length of hospital stay [days].



6. Function

Short-term effects: Four trials with a total of 171 patients measured function (Denis 2006; Lenssen 2003; Lenssen 2008; May 1999). All four trials provided useful data. There was considerable between-study heterogeneity in estimates of effect (I^2 = 72%) and although the pooled estimates are displayed (due to software limitations), they were not planned and should be interpreted with caution. Point estimates of effect ranged from -0.3 SD to 1 SD (see Figure 7).

Figure 7. Forest plot of primary comparison. Outcome: 7.11 Function [standardised mean].



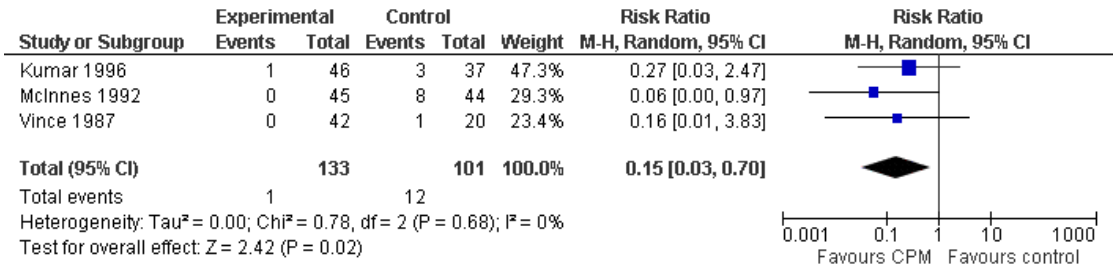
Medium-term effects: Five trials with a total of 372 patients measured function (Bennett 2005; Kumar 1996; Lenssen 2008; McInnes 1992; Worland 1998). Four trials with a total of 286 patients provided useful data (Bennett 2005; Lenssen 2003; Lenssen 2008; May 1999). The mean difference was 0.0 SD (95% CI -0.3 to 0.2; P = 0.73; I^2 = 0%; see Figure 7).

Long-term effects: Three trials with a total of 260 patients measured function (Bennett 2005; MacDonald 2000; Worland 1998). All three trials provided useful data. The mean difference was 0.0 SD (95% CI -0.3 to 0.2; P = 0.89; I^2 = 0%; see Figure 7).

7. Manipulation under anaesthesia

Short-term effects: Three trials with a total of 234 patients measured incidence proportion of manipulation under anaesthesia (Kumar 1996; McInnes 1992; Vince 1987). All three trials provided useful data. It was not stated in one trial whether the manipulations occurred within 6 weeks or 6 months of randomisation (Kumar 1996), but for the purpose of the analysis, it was assumed that all manipulations occurred within 6 weeks. In total there were 13 manipulations under anaesthesia. The relative risk was 0.15 (95% CI 0.03 to 0.70; P = 0.02; I^2 = 0%; see Figure 8).

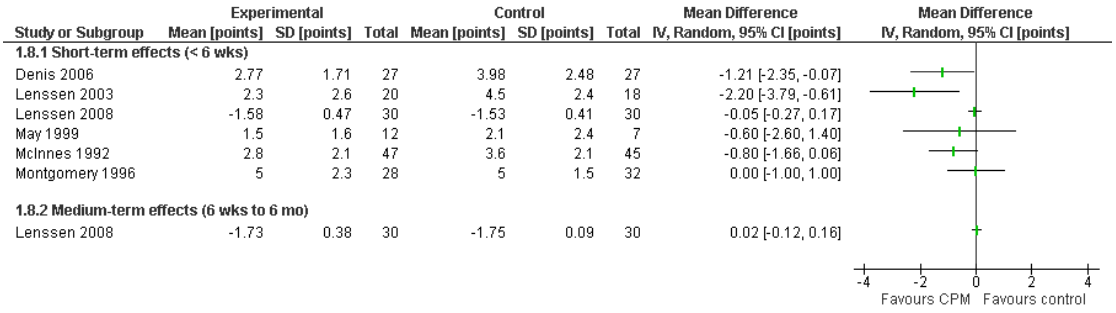
Figure 8. Forest plot of primary comparison. Outcome: 7.7 Manipulation under anaesthesia [number].



8. Pain

Short-term effects: Eight trials with a total of 536 patients measured pain (Bennett 2005; Denis 2006; Harms 1991; Lenssen 2003; Lenssen 2008; May 1999; McInnes 1992; Montgomery 1996). Six trials with a total of 323 patients provided useful data (Denis 2006; Lenssen 2003; Lenssen 2008; May 1999; McInnes 1992; Montgomery 1996). There was considerable between-study heterogeneity in estimates of effect (I^2 = 61%) so pooled estimates were not calculated. Point estimates of effect ranged from -2 to 1 points (see Figure 9).

Figure 9. Forest plot of primary comparison. Outcome: 7.8 Pain [points].



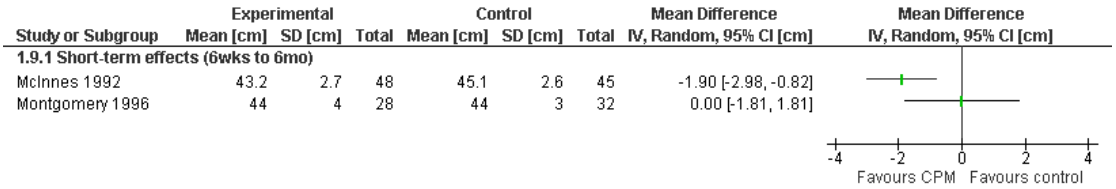
Medium-term effects: One trial with a total of 60 patients measured pain (Lenssen 2008). The mean difference was 0 points (95% CI -0.1 to 0.2; see Figure 9).

Long-term effects: No trial measured this outcome during this time period.

9. Swelling

Short-term effects: Three trials with a total of 253 patients measured swelling (McInnes 1992; Montgomery 1996; Ritter 1989). Two trials with a total of 153 patients provided useful data (McInnes 1992; Montgomery 1996). There was considerable between-study heterogeneity in estimates of effects (I^2 = 68%) so pooled estimates were not calculated. Point estimates of effect ranged from -2 to 0 cm (see Figure 10).

Figure 10. Forest plot of primary comparison. Outcome: 7.9 Swelling [cm].

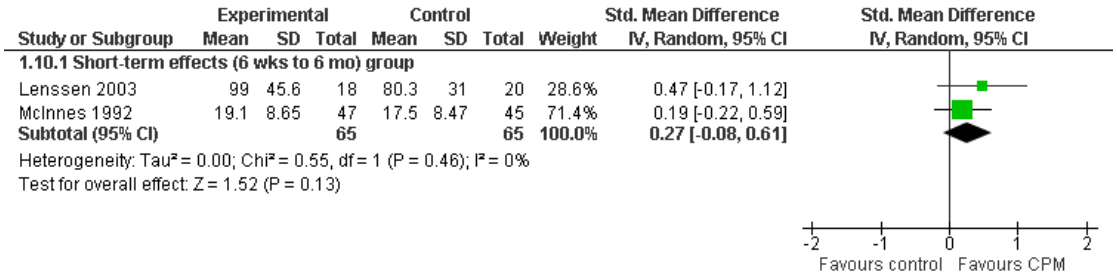


Medium- and long-term effects: No trial measured this outcome during these time periods.

10. Quadriceps strength

Short-term effects: Two trials with a total of 130 patients measured quadriceps strength (Lenssen 2003; McInnes 1992). Both trials provided useful data. The mean difference was 0.3 SD (95% CI -0.1 to 0.6; P = 0.13; I^2 = 0%; see Figure 11).

Figure 11. Forest plot of primary comparison. Outcome: 7.10 Quadricep strength [standardised mean].



Medium- and long-term effects: No trial measured this outcome during these time periods.

The **secondary comparison** compared CPM combined with standard postoperative care versus standard postoperative care and additional knee exercises. These analyses provide a head-to-head comparison of the effectiveness of CPM and exercise. Analyses were performed on data from four trials for which data were available (May 1999; Montgomery 1996; Ritter 1989; Worland 1998). Where it was possible to calculate pooled estimates there was no indication of the superiority of either intervention (CPM or exercise).

The short-term effects of mean total CPM time on passive knee flexion ROM

Ten trials with a total of 634 patients measured passive knee flexion ROM and provided sufficient data to estimate mean total CPM time. The duration of CPM had no effect on passive knee flexion ROM (mean increase of 0.01 degrees for every additional hour of CPM; 95% CI -0.04 to 0.07). This effect was not statistically significant (P = 0.66).

DISCUSSION

Summary of main findings

This systematic review provides high-quality evidence to indicate that CPM has small short-term effects on active knee flexion ROM (mean difference 3 degrees, 95% CI 0 to 6) and passive knee flexion ROM (mean difference 2 degrees, 95% CI 0 to 5). However, there is no similar evidence to support any effects on active knee extension ROM or passive knee extension ROM (see Summary of Findings Table). The effects on active and passive knee flexion ROM are too small to be clinically meaningful. The medium- and long-term effects of CPM on all ROM measures are unclear although the data suggest there is a small long-term effect of CPM on active knee flexion ROM (mean difference 5 degrees, 95% CI 3 to 7). There is low-quality evidence to indicate that CPM does not produce meaningful reductions in length of hospital stay (mean difference -0.3 days; 95% CI -0.9 to 0.2; see Summary of Findings Table) but does reduce the need for manipulation under anaesthesia (relative risk 0.15; 95% CI 0.03 to 0.66; see Summary of Findings Table). This later result implies that, for the observed baseline risk of 12%, one manipulation will be prevented for every 56 people treated with CPM. This reduction in the need for manipulation may be sufficient to justify the use of CPM although the quality of the evidence supporting this finding is low. There is inconclusive evidence of short-, medium- or long-term effects of CPM on pain, function, swelling or quadriceps strength.

Continuous passive motion following TKA is primarily advocated

for its proposed benefits on knee ROM. For example, knee flexion ROM is important for mobility tasks such as walking, transferring and performing activities of daily living (Rowe 2000). Even greater ranges are required for squatting and kneeling; activities of daily living for many cultures (Hemmerich 2006). However, the important question is how much additional knee ROM is required to justify CPM. Few would claim that an added benefit of less than five degrees is functionally important, and most would probably claim that considerably more than five degrees is required to justify the added time, cost and inconvenience of CPM. In this systematic review no pooled estimates of effects of CPM on any measure of knee ROM were greater than five degrees. Importantly, the corresponding upper 95% confidence limits of most estimates were also well short of five degrees. The only exceptions were active knee flexion in the short- and long-term. Taken together, the data in this review suggest that CPM does not produce sufficient effects on knee ROM to justify its widespread usage for this purpose.

Some patients develop very stiff knees following TKA. One way to manage this problem is to manipulate the knee under anaesthesia. Continuous passive motion appears to reduce the incidence of manipulation under anaesthesia. The effect is large in relative terms (relative risk 0.15; 95% CI 0.03 to 0.70). The three trials which included incidence of manipulation under anaesthesia as an outcome reported a total of 13 manipulations on 234 patients, yielding an incidence proportion of 5.3%. With this incidence proportion, a relative risk of 0.15 corresponds to an absolute reduction in risk of manipulation of 4.5%. This means that one manipulation will be prevented in every 56 patients receiving CPM. Some may consider this reduction in the need for manipulation sufficient to warrant the widespread use of CPM. However, these findings need to be interpreted with caution. The evidence supporting these findings is weak and based on just three trials (see Summary of Findings Table). In all three trials the clinicians making decisions about the need for manipulation were not blinded to allocation. Interestingly, while knee stiffness is the most common indication for manipulation under anaesthesia, the results from this systematic review indicate there was little difference in knee ROM of patients who did and did not receive CPM. It is, therefore, surprising that there was such a marked difference in the need for manipulation in the two groups. Of course manipulations may have been done very soon after surgery when differences in knee ROM may have been more pronounced. These very early differences may have been missed in this review because all outcomes measures in the first six weeks were analysed together.

There was no clear effect of CPM on function. Estimates of effects of CPM on function were imprecise (i.e. the 95% CI were wide). The available data suggest that CPM had short-term effects on knee function. For example, one high-quality trial reported a convincing short-term effect on the Hospital for Special Surgery Score (standardised mean difference 1 SD, 95% CI 0.3 to 1.7) (Lenssen 2003). These findings seem surprising in the absence of accompanying increases in knee ROM but may be due to the multidimensional nature of the Hospital for Special Surgery Score (Ranawat 1976). This score not only measures the ability of patients to walk, transfer and climb stairs but also measures knee ROM, pain, strength and instability. Other trials measured function using a diverse range of scales including the Health Assessments Questionnaire, Knee Society Score and timed walking tests. Future trials would benefit from some agreement on the most appropriate way to measure function in this group of patients.

Many different protocols were used to administer CPM. For example, in some trials CPM was started immediately after the TKA operation whereas in other trials it was started days later. The CPM settings were also different between trials. In some trials, the settings were dictated by a protocol whereas in other trials they were determined by patient comfort or clinician discretion. All these variables may have influenced the observed effects of CPM. A meta-regression was used to explore the possibility that total CPM time influences passive knee flexion ROM. Passive knee flexion ROM was selected because this was the most commonly measured outcome. The meta-regression indicated that there was little or no effect of CPM duration on short-term passive knee flexion ROM. That is, trials that applied CPM for 24 hours a day over an extended time period did not report systematically more passive knee flexion ROM than those that only applied CPM for a few hours over one or two days.

Protocols for co-interventions were also highly variable. In a subset of four trials, control participants also received additional knee exercises. A secondary analysis explored the effect of CPM in this subset of trials. The purpose was to compare the effectiveness of CPM and knee exercises. This analysis was inconclusive because of the small number of trials. Nonetheless, it is unlikely that CPM would be more effective than knee exercises because the primary analysis indicated CPM is no more effective than usual care, with or without additional knee exercises.

There was usually a high degree of consistency (low between-study heterogeneity) in estimates of effects of pooled findings. Heterogeneity was only apparent in a small number of comparisons, typically where standardised mean differences were used and when total sample sizes were small. The heterogeneity could have been due to any number of factors but was most likely due to the use of different tools to measure the same construct. This was particularly problematic for function which was measured with outcomes as diverse as self reporting questionnaires and timed walking tests.

Quality of the evidence

The methodological quality of trials was variable (see Figure 1). Only nine trials clearly blinded assessors. Not surprisingly, given the nature of the intervention, no trial blinded participants or therapists. Failure to blind assessors, participants and therapists exposes the trials to bias. Only six of the 20 trials concealed allocation and nearly all trials were selective in their reporting of data.

These limitations notwithstanding, the main findings are probably robust because bias tends to inflate estimates of effects (Gluud 2006) which did not appear to be the case in this systematic review; rather, most estimates of effects were very small.

Potential biases in the review process

The main potential source of bias in the review process arises from failure to identify all relevant trials. This may have occurred, particularly if trials were unpublished or published in languages other than English. However, retrieval bias generally tends to inflate estimates of effects (Dickersin 1993; Egger 1998) but this review reports small effects of CPM on most outcomes.

Agreement and disagreements with other studies or reviews

The original version of this systematic review was done in 2003.

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SE Milne was responsible for writing the manuscript, extracting and analysing data and screening potentially-eligible trials.

V Welch contributed to updating the analyses and interpretation of the results.

GA Wells and P Tugwell contributed to designing the methodology and commenting on early drafts.

MJ Noel contributed to extracting the data, analysing and selecting trials.

H Drouin contributed to extracting data, analysing and selecting trials.

J Davis contributed to extracting data, analysing and selecting trials.

Update of review (2009):

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* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Bennett 2005

Methods	Randomised trial
Participants	Sample size: Gr1: 48 Gr2: 52 Gr3: 47 Inclusion: 90 dgrs knee flexion ROM with CPM in recovery, OA. Exclusion: bilateral TKA, revision of TKA, RA, haemophilia. Mean age (variance not reported): Gr1: 71 Gr2: 72 Gr3: 71 Gender: Gr1: 65% F Gr2: 67% F Gr3: 72% F Type of arthritis: Combined: 100% OA
Interventions	**Groups included in this review:** **Gr1: Early flexion CPM + standard care** CPM commenced POD 0. Initially 50 - 90 dgrs. Provided for 6 hrs/day. Increased 20 dgrs flexion/day. Continued until POD 5. **Gr2: Standard care** **Other groups:** **Gr3: Standard CPM + standard care** CPM commenced POD 0. Initially 0 - 40 dgrs. Provided 6 hrs/day. Increased 10 dgrs/day. Continued until POD 5. *Standard care for Gr1, Gr2, Gr3:* Commenced POD 1. Provided 1 hr/day. Included active assisted ROM, stretches, gait training, static quads, inner ROM quads, splint, transfer training, education.
Outcomes	**Outcomes included in this review:** 1. Active knee flexion ROM (dgrs)[a] 2. Passive knee flexion ROM (dgrs)[a,^] 3. Active knee extension ROM (dgrs)[a] 4. Passive knee extension ROM (dgrs)[a] 5. Length of hospital stay - acute (days)[a] 6. Function: Knee Society Score (points)[^] 7. Pain: VAS - mean score over 5 days[a,^] **Other outcomes:** wound healing, SF-12 - Physical Component Summary, SF-12 - Mental Component Summary, length of hospital stay - rehab, pain: VAS daily. **Outcomes testing period:** tested at POD 5*, 3 mo†, 1 yr‡ post randomisation.
Notes	

Bennett 2005 (*Continued*)

Risk of bias		
Item	**Authors' judgement**	**Description**
Adequate sequence generation?	Yes	States: "allocation by a block randomization". Clarified through personal communication that a random number generator was used.
Allocation concealment?	Yes	States: "surgeon and the independent assessor were blinded to group allocation". Although these people were not necessarily the people making the decisions about inclusion, it was clarified through personal communication that allocation schedule was kept in a locked cabinet and personnel responsible for recruiting did not have access to it.
Incomplete outcome data addressed? All outcomes	Yes	States: "one patient was subsequently excluded...results were analysed for remaining 147".
Free of selective reporting?	No	Key outcomes reported incompletely preventing their contribution to the meta-analysis.
Free of other bias?	Yes	
Participant blinding?	No	States: "subjects were blinded to the study hypotheses". However, with CPM, it is not possible to blind subjects to whether they did or did not receive CPM.
Personnel blinding?	No	States: "surgeon and the independent assessor were blinded to group allocation". However, with CPM, it is not possible to blind therapists to whether they did or did not administer CPM.
Outcome assessor blinding?	Yes	States: "surgeon and the independent assessor were blinded to group allocation".

Can 1995

Methods	Randomised trial
Participants	Sample size: Gr1: 26 knees Gr2: 22 knees (combined: 44 pts) Inclusion: primary TKA Exclusion: revision of TKA Age / Gender: Not reported Type of arthritis: Not reported

Can 1995 (*Continued*)

Interventions	**Groups included in this review:** **Gr1: CPM + standard care** CPM commenced POD 0. Initially 0 - 30 dgrs. Provided for 4 - 6 hrs/day. Increased 5 - 10 dgrs/day. Continued for unreported period. **Gr2: Standard care** *Standard care for Gr1, Gr2:* Commenced POD 0. Provided 2 x per day. Provided for unreported period. Included isometric exercises, assisted SLR, passive ROM, active ROM, stretches, inner ROM quad strengthening, gait training.
Outcomes	**Outcomes included in this review:** 1. Active knee flexion ROM (dgrs)^ 2. Length of hospital stay (days)^ 3. Function: Knee Society Score (points)^ 4. Quadricep strength (points)^ 5. Swelling: knee circumference (cm)^ **Other outcomes:** none **Outcomes testing period:** tested at POD 3, POD 4, D/C*, 3 mo†, 1 yr‡ post randomisation.
Notes	

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Unclear	Not stated.
Allocation concealment?	Unclear	Not stated.
Incomplete outcome data addressed? All outcomes	No	Key outcomes reported incompletely preventing their contribution to the meta-analysis.
Free of selective reporting?	Unclear	Not stated.
Free of other bias?	Unclear	Not stated.
Participant blinding?	No	Not stated but not possible.
Personnel blinding?	No	Not stated but not possible.
Outcome assessor blinding?	Unclear	Not stated.

Chiarello 1997

Methods	Randomised trial
Participants	Sample size: Gr1: 8 Gr2: 10 Gr3: 8 Gr4: 9 Gr5: 11 Inclusion: degenerative joint disease, primary and unilateral TKA. Exclusion: not reported Mean age (SD): Gr1: 74 (6) Gr2: 63 (10) Gr3: 71 (10) Gr4: 74 (9) Gr5: 71 (10) Gender: Gr1: 100% F Gr2: 70% F Gr3: 88% F Gr4: 56% F Gr5: 64% F Type of arthritis: Not reported
Interventions	**Groups included in this review:** **Gr1: CPM + standard care** CPM commenced POD 1 to 3. Initial settings not reported. Provided for 10 - 12 hrs/day. Increased 10 dgrs/day. Continued until D/C or 2 wks post-surgery. **Gr2: Standard care** **Other groups:** **Gr3: Short duration CPM + standard care** CPM commenced POD 1 to 3. Initial settings not reported. Provided 3 - 5 hrs/day. Increased 10 dgrs/day. Continued until D/C or 2 wks post-surgery. **Gr4: Short duration CPM + standard care** CPM commenced POD 1 to 3. Initial settings not reported. Provided 3 - 5 hrs/day. Increased as tolerated. Continued until D/C or 2 wks post-surgery. **Gr5: Long duration CPM + standard care** CPM commenced POD 1 to 3. Initial settings not reported. Provided 10 - 12 hrs/day. Increased as tolerated. Continued until D/C or 2 wks post-surgery. *Standard care for Gr1, G2, Gr3, Gr4, Gr5:* Commenced POD 1 to 3. Provided daily. Included unspecified ROM exercises, gait training, transfer training, education, moist heat, strength and ROM exercises.
Outcomes	**Outcomes included in this review:** 1. Active knee flexion ROM (dgrs) 2. Passive knee flexion ROM (dgrs)

Chiarello 1997 (*Continued*)

	3. Active knee extension ROM (dgrs) 4. Passive knee extension ROM (dgrs) **Other outcomes:** none **Outcomes testing period:** tested at D/C or 14 days* post randomisation.
Notes	

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Yes	States: "randomly assigned...pre-determined randomized list".
Allocation concealment?	No	Not stated where "pre-determined randomized list" was accessible to those recruiting participants. Clarified through personnel communication that allocation was not concealed.
Incomplete outcome data addressed? All outcomes	Yes	46/49 were present at follow-up.
Free of selective reporting?	Yes	All data reported on all outcomes at all endpoints.
Free of other bias?	Yes	
Participant blinding?	No	Not stated but not possible.
Personnel blinding?	No	Not stated but not possible.
Outcome assessor blinding?	No	States: "treating physical therapists collected data".

Colwell 1992

Methods	Randomised trial
Participants	Sample size: Gr1: 12 Gr2: 10 Inclusion: OA or RA, primary TKA. Exclusion: TKA revisions, bilateral TKA, TKA requiring post-surgical manipulation under anaesthesia. Mean age (variance not reported): Gr1: 73 Gr2: 74 Gender: Gr1: 67% F Gr2: 70% F

Colwell 1992 (*Continued*)

	Type of arthritis: Combined: 95% OA, 5% RA
Interventions	**Groups included in this**

Denis 2006

Methods	Randomised trial
Participants	Sample size: Gr1: 27 Gr2: 27 Gr3: 26 Inclusion: OA, primary TKA, ambulatory, literate. Exclusion: previous major lower-limb surgery, contralateral TKA, total hip arthroplasty < 12 mo. Medical condition preclude testing, comprehension problems, concurrent surgical intervention, neuromuscular or degenerative disease, infection, major health complication. Mean age (SD): Gr1: 68 (7) Gr2: 67 (8) Gr3: 70 (7) Gender: Gr1: 46% F Gr2: 52% F Gr3: 62% F Type of arthritis: Not reported
Interventions	**Groups included in this review:** **Gr1: CPM + standard care** CPM commenced POD 2. Initially 35 - 45 dgrs flexion. Provided for 2 hrs/day. Increments determined by therapist. Continued until D/C or POD 8 to 9. **Gr2: Standard care** **Other groups:** **Gr3: CPM + standard care** CPM commenced POD 2. Initially 35 - 45 dgrs flexion. Provided 35 min/day. Increments determined by therapist. Continued until D/C or POD 8 to 9. *Standard care for Gr1, Gr2, Gr3:* Commenced POD 1. Provided daily. Include passive ROM, active ROM, gait training, inner ROM quads, static quads, transfer training, splint (POD 0 to POD 1), stairs.
Outcomes	**Outcomes included in this review:** 1. Active knee flexion ROM (dgrs) 2. Active knee extension ROM (dgrs) 3. Length of hospital stay (days) 4. Function: Timed Up and Go Test (sec) 5. WOMAC - pain **Other outcomes:** WOMAC - stiffness and functional difficulty, theoretical length of hospital stay, questionnaire - frequency and intensity of physical activity. **Outcomes testing period:** tested at D/C* (approx. POD 8 to 9 post randomisation).
Notes	

Denis 2006 (*Continued*)

Risk of bias		
Item	**Authors' judgement**	**Description**
Adequate sequence generation?	Unclear	States: "two strata were created for an equivalent distribution...one set of prenumbered, sealed envelopes was prepared". However, does not state how randomisation schedule was generated.
Allocation concealment?	Yes	States: "prenumbered sealed envelopes".
Incomplete outcome data addressed? All outcomes	Yes	81/81 were present at follow-up.
Free of selective reporting?	Yes	All data reported on all outcomes at all endpoints.
Free of other bias?	Yes	
Participant blinding?	No	Not stated but not possible.
Personnel blinding?	No	Not stated but not possible.
Outcome assessor blinding?	Yes	States: "Assessment was performed…unaware of group allocation".

Harms 1991

Methods	Randomised trial
Participants	Sample size: Gr1: 55 Gr2: 58 Inclusion: OA or RA, primary TKA, knee flexion contracture < 40 dgrs, presurgical. condition - able to walk 10 metres within 2 min with walking aid, able to rise from chair with arm rests and seat height of 18 inches. Exclusion: TKA revisions, concurrent knee surgery, condition comprising treatment. Mean age (SD): Gr1: 69 (9) Gr2: 71 (10) Gender: Gr1: 78% F Gr2: 93% F Type of arthritis: Combined: 64% OA, 36% RA

Harms 1991 (*Continued*)

Interventions	**Groups included in this review:** **Gr1: CPM + standard care** CPM commenced POD 0. Initially 0 - 40 dgrs at 2 dgrs/sec. Provided for 6 hrs/day. Increased 10 dgrs/day as tolerated (after first 48 hrs). Continued until 80 dgrs of flexion achieved. Immobilised in splint or back slab while off CPM. **Gr2: Standard care** *Standard care for Gr1, Gr2:* Commenced POD 1. Provided 20 min/day. Included: POD1: splint, static quads contractions progressing towards SLR, ankle and gluteal exercises POD2: mobilise with splint POD3: active knee flexion, inner ROM quads exercises, splint removed POD5: mobilise without splint if dynamic control of knee extension or proper SLR
Outcomes	**Outcomes included in this review:** 1. Passive knee flexion ROM (dgrs) 2. Active knee extension ROM (dgrs) 3. Length of hospital stay (days) 4. Pain: VAS[a] **Other outcomes:** Ease Score (VAS), wound drainage, number of patients with complications, type of complications, number of patients requiring outpatient physiotherapy, pain medication. **Outcomes testing period:** tested at POD 7, POD 14*, D/C post randomisation.
Notes	

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Unclear	States: "random allocation table was generated". However, does not state how randomisation schedule was generated.
Allocation concealment?	Unclear	Not stated.
Incomplete outcome data addressed? All outcomes	Unclear	Not stated.
Free of selective reporting?	No	Key outcomes reported incompletely preventing their contribution to the meta-analysis.
Free of other bias?	Yes	
Participant blinding?	No	Not stated but not possible.
Personnel blinding?	No	Not stated but not possible.

Harms 1991 (*Continued*)

Outcome assessor blinding?	Unclear	Not stated.

Huang 2003

Methods	Randomised trial
Participants	Sample size: Gr1: 23 Gr2: 21 Inclusion: primary TKA Exclusion: not reported Mean age (range): Combined: 69 (20 - 92) Gender: Combined: 82% F Type of arthritis: Combined: 77% OA, 23% RA
Interventions	**Groups included in this review:** **Gr1: CPM + standard care** CPM commenced POD 0. Initially 0 - 40 dgrs. Provided for 20 hrs/day. Decreased on POD 3 to 16 hrs/day. Continued until POD 14. **Gr2: Standard care** *Standard care for Gr1, Gr2:* Commenced on POD 0. Provided for unreported period. Included isometric exercises, assisted SLR, passive ROM, active ROM, stretches, inner ROM quad strengthening.
Outcomes	**Outcomes included in this review:** 1. Active knee flexion ROM (dgrs) 2. Active knee extension ROM (dgrs)[a] 3. Passive knee extension ROM (days) 4. Length of hospital stay (days) **Other outcomes:** pain medication, infection. **Outcomes testing period:** tested at POD 7, POD 14*, 6 wks, 3 mo†, 6 mo, 1 yr‡ post randomisation.
Notes	

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Unclear	Not stated.
Allocation concealment?	Unclear	Not stated.

Huang 2003 (*Continued*)

Incomplete outcome data addressed? All outcomes	Unclear	Not stated.
Free of selective reporting?	No	Key outcomes reported incompletely preventing their contribution to the meta-analysis.
Participant blinding?	No	Not stated but not possible.
Personnel blinding?	No	Not stated but not possible.
Outcome assessor blinding?	No	Not stated but not possible.

Kumar 1996

Methods	Randomised trial
Participants	Sample size: Gr1: 40 pts (46 knees) Gr2: 33 pts (37 knees) Inclusion: OA Exclusion: not reported Mean age (range): Gr1: 69 (52 - 86) Gr2: 68 (42 - 88) Gender: Gr1: 58% F Gr2: 67% F Type of arthritis: Not reported
Interventions	**Groups included in this review:** **Gr1: CPM + standard care** CPM commenced POD 0. Initially 0 - 90 dgrs. Provided for 10 hrs/day. Increments not reported. Continued until D/C (criteria = dry wound, 80 dgrs flexion, ambulation 300 feet 2 x per day with single crutch or cane, independent transfers). Immobilization at night. **Gr2: Standard care** Immobilization removed POD 1, passive ROM x 20 min (progressed to 30 - 45 min), 2 x per day 90 dgrs flexion achieved at each session. *Standard care for Gr1, Gr2:* Commencement not reported. Provided 2 hrs/day. Included isometric exercises, passive ROM, active ROM, stretches, gait training (including stairs). FES if extensor lag > 30 dgrs or if no independent SLR performed on POD 3.

Kumar 1996 (*Continued*)

Outcomes	**Outcomes included in this review:** 1. Passive knee flexion ROM (dgrs) 2. Passive knee extension ROM (dgrs) 3. Length of hospital stay (days) 4. Function: Knee Society Score (points)^ 5. Manipulation under anaesthesia: closed manipulation **Other outcomes:** SF-36, Knee Society Function Score, delay in physiotherapy due to wound drainage, length of acute stay (days), length of rehab stay (days). **Outcomes testing period:** tested at POD 5*, 6 wks, 3 mo, 6 mo† post randomisation.
Notes	

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Yes	States: "a random number generator".
Allocation concealment?	Unclear	Not stated.
Incomplete outcome data addressed? All outcomes	No	46/77 were present at follow-up.
Free of selective reporting?	No	Not all data reported for all outcomes at all endpoints (e.g. SF-36).
Free of other bias?	Yes	
Participant blinding?	No	Not stated but not possible.
Personnel blinding?	No	Not stated but not possible.
Outcome assessor blinding?	Unclear	Not stated.

Lau 2001

Methods	Randomised trial
Participants	Sample size: Combined: 43 pts (60 knees) Inclusion: TKA for OA or RA Exclusion: not reported Mean age (range): Combined: 70 (43 - 86) Gender: Combined: 84% F Type of arthritis (combined): OA: 72% pts / 75% knees

Lau 2001 (*Continued*)

	RA: 28% pts / 25% knees
Interventions	**Groups included in this review:** **Gr1: CPM + standard care** CPM commenced POD 1. Initially 0 - 60 dgrs. Provided for 23 hrs/day. Increased as tolerated. Continued until POD 7. **Gr2: Standard care** Immobilised until POD 7. *Standard care for Gr1, Gr2:* Commenced on POD 7. Provided for unreported period. Included assisted ROM, gait training.
Outcomes	**Outcomes included in this review:** 1. Active knee flexion ROM (dgrs)[a] 2. Active knee extension ROM (dgrs)[a] 3. Length of hospital stay (days)^ 4. Pain: VAS^ **Other outcomes:** DVT **Outcomes testing period:** tested at POD 3, POD 5, POD 7, POD 14*, POD 28, POD 42, 3 mo, 6 mo†, 1 yr‡ post randomisation.
Notes	

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Unclear	Not stated.
Allocation concealment?	Unclear	Not stated.
Incomplete outcome data addressed? All outcomes	Yes	38/43 patients (60/66 knees) were present at follow-up.
Free of selective reporting?	No	Does not clearly state what outcomes were measured. Does not report all outcomes for all endpoints. Key outcomes reported incompletely preventing their contribution to the meta-analysis.
Free of other bias?	No	Abandoned VAS.
Participant blinding?	No	Not stated but not possible.
Personnel blinding?	No	Not stated but not possible.
Outcome assessor blinding?	Unclear	Not stated.

Lenssen 2003

Methods	Randomised trial
Participants	Sample size: Gr1: 20 Gr2: 20 Inclusion: OA, undergoing TKA Exclusion: not reported Mean age (SD): Gr1: 65 (9) Gr2: 66 (10) Gender: Gr1: 71% F Gr2: 63% F Type of arthritis: Combined: 100% OA
Interventions	**Groups included in this review:** **Gr1: CPM + standard care** CPM commenced POD 1. Initial settings individually determined. Provided for 4 hrs/day. Increased as tolerated. Continued until POD 4. **Gr2: Standard care** *Standard care for Gr1, Gr2:* Commenced on POD 1. Provided for 40 min/day. Included active ROM, passive ROM exercises, inner ROM and static quads strengthening, gait training, joint mobilisation.
Outcomes	**Outcomes included in this review:** 1. Passive knee flexion ROM (dgrs) 2. Passive knee extension ROM (dgrs) 3. Length of hospital stay (days) 4. Function: The Hospital for Special Surgery Scoring System 5. Pain: 11-point Likert scale 6. Quadricep strength (Nm) **Other outcomes:** pain medication, satisfaction with physical therapist's attention (11-pt scale), satisfaction with physical therapist's treatment (11-pt scale), lowest pain in last 24 hrs (points), worst pain in last 24 hrs (points). **Outcomes testing period:** tested at POD 4, POD 17* post randomisation.
Notes	

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Yes	States: "computer-generated table".
Allocation concealment?	Yes	States: "independent...secretary without knowledge of the randomisation schedule called up the patients for operation". Clar-

Lenssen 2003 (*Continued*)

		ified through personal communication that allocation was concealed.
Incomplete outcome data addressed? All outcomes	Yes	38/40 were present at follow-up.
Free of selective reporting?	Yes	All data reported on all outcomes at all endpoints.
Free of other bias?	Yes	
Participant blinding?	No	Not stated but not possible.
Personnel blinding?	No	Not stated but not possible.
Outcome assessor blinding?	Yes	States: "independent, blinded observer".

Lenssen 2008

Methods	Randomised trial
Participants	Sample size: Gr1: 30 Gr2: 30 Inclusion: primary unilateral TKA, < 80 dgrs at POD 4, able to understand and speak Dutch, not suffering from mental disabilities, resident within the Masstricht Heuvelland region. Exclusion: patients who need to stay in hospital > POD 5, showed relevant comorbidity influencing mobility (e.g. claudication, other prosthesis) or were operated upon by minimally invasive surgery, > 80 years of age, RA. Mean age (SD): Gr1: 64 (8) Gr2: 65 (9) Gender: Gr1: 60% F Gr2: 70% F Type of arthritis: Combined: 100% OA
Interventions	**Groups included in this review:** **Gr1: CPM + standard care** CPM commenced when D/C from acute hospital care (approx. POD 4). Initial settings individually determined. Provided for 4 hrs/day. Increased as tolerated. Continued until POD 17. **Gr2: Standard care** *Standard care for Gr1, Gr2:* Commenced on POD 4. Provided for 20 min/day. Included active ROM, passive ROM exercises, inner ROM and static quads strengthening, gait training (including stairs), sit

	to stand training.
Outcomes	**Outcomes included in this review:** 1. Active knee flexion ROM (dgrs) 2. Passive knee flexion ROM (dgrs)^ 3. Active knee extension ROM (dgrs) 4. Passive knee extension ROM (dgrs)^ 5. Function: Knee Society Score (points) 6. Pain: WOMAC (pain sub scale) **Other outcomes:** WOMAC (measure of function), perceived effects (7-pt Likert scale) , pain medication, satisfaction with treatment (11-pt Likert scale), satisfaction with treatment results (11-pt Likert scale), adherence to treatment protocol and use of CPM (hrs), Knee Society Score - function, WOMAC (stiffness and difficulty sub scale). **Outcomes testing period:** tested at POD 17 (12 days after randomisation)*, 6 wks, 3 mo† post randomisation.
Notes	

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Yes	States: "blocked and concealed randomisation with a block size of four ensured equal distribution of patients over the 2 treatment group....groups were prestratified on pre-operative flexion mobility of the knee...randomly assigned". Clarified through personal communication that sequence was computer generated.
Allocation concealment?	Yes	States: "concealed randomisation".
Incomplete outcome data addressed? All outcomes	Yes	60/60 were present at follow-up.
Free of selective reporting?	No	Not all data reported for all outcomes at all endpoints (e.g. secondary outcomes at 3 mo).
Free of other bias?	Yes	
Participant blinding?	No	Not stated but not possible.
Personnel blinding?	No	Not stated but not possible.
Outcome assessor blinding?	Yes	States: "blinded...assessment and analysis".

MacDonald 2000

Methods	Randomised trial
Participants	Sample size: Gr1: 40 Gr2: 40 Gr3: 40 Inclusion: less than 80 yrs of age with primary OA, no previous surgery on the knee, normal functioning ipsilateral hips, ability to tolerate NSAIDs and Marcaine, ability to ambulate 30 m preoperatively, ability to climb 10 steps. Exclusion: RA, greater than 15 dgrs valgus or fixed flexion deformity. Age / Gender: Not reported Type of arthritis: Not reported
Interventions	**Groups included in this review:** **Gr1: CPM + standard care** CPM commenced POD 0. Initially 0 - 50 dgrs. Provided for 18 - 24 hrs/day. Increased by 10 dgrs/hr as tolerated. Continued until POD 1. **Gr2: Standard care** **Other groups:** **Gr3: CPM + standard care** CPM commenced POD 0. Initially 70 - 110 dgrs. Provided for 18 - 24 hrs/day. Not increased. Continued until POD 1. *Standard care for Gr1, Gr2, G3:* Commenced POD 1. Provided 2 x per day for 6 wks. Included active ROM, passive ROM exercises, mobilised as tolerated using walker or crutches
Outcomes	**Outcomes included in this review:** 1. Passive knee flexion ROM (dgrs)^ 2. Passive knee extension ROM (dgrs)^ 3. Length of hospital stay (days) 4. Function: Knee Society Score (points)^ **Other outcomes:** pain medication. **Outcomes testing period:** tested at D/C*, 6 wks†, 12 wks, 26 wks, 1 yr‡ post randomisation.
Notes	

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Yes	States: "computer generated randomised schedule".
Allocation concealment?	Yes	Not stated. Clarified through personal communication that allocation was concealed.

MacDonald 2000 (*Continued*)

Incomplete outcome data addressed? All outcomes	Unclear	Not stated.
Free of selective reporting?	No	Not all data reported for all outcomes at all endpoints (e.g. 26 wks).
Free of other bias?	Yes	
Participant blinding?	No	Not stated but not possible.
Personnel blinding?	No	Not stated but not possible.
Outcome assessor blinding?	Yes	States: "a blinded independent observer".

May 1999

Methods	Randomised trial
Participants	Sample size: Gr1: 12 Gr2: 7 Inclusion: unilateral primary TKA, OA. Exclusion: Surgical revision or manipulation under anaesthesia of the involved knee, knee flexion ROM > 80 dgrs upon admission to rehabilitation, > POD 14 TKA, inability to participate in hydrotherapy due to factors such as incontinence or wound infection, RA, inability or unwillingness to provide informed consent. Mean age (SD): Gr1: 73 (4) Gr2: 66 (9) Gender: Gr1: 67% F Gr2: 71% F Type of arthritis: Combined: 100% OA
Interventions	**Groups included in this review:** **Gr1: CPM + standard care** CPM commenced when admitted to rehabilitation facility (POD 2 - 13). Initial settings individually determined. Provided for 3 - 5 hrs/day. Increased as tolerated. Continued until 80 dgrs active knee flexion was achieved or until D/C, whichever came first. **Gr2: Lower Limb Mobility Board (LLiMB) + standard care** Commenced when admitted to rehabilitation facility (POD 2 - 13). Provided 5 - 10 min for 6 x per day, 7 days/wk. *Standard care for Gr1, Gr2:* Comenced not reported. Provided 1 - 1.5 hrs/day, 5 days/wk. Included active assisted ROM, gait training, inner ROM and static quads strengthening, hydrotherapy.

May 1999 (*Continued*)

Outcomes	**Outcomes included in this review:** 1. Active knee flexion ROM (dgrs) 2. Active knee extension ROM (dgrs) 3. Passive knee extension ROM (dgrs) 4. Length of hospital stay (days)[a] 5. Function: Average walk time for 10m with walking aide permitted (sec) 6. Pain: VAS **Other outcomes:** none **Outcomes testing period:** tested on admission to rehabilitation facility (POD 2 - 13), D/C* (POD 12 - 31) post randomisation.
Notes	

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Unclear	States: "stratified random technique". However, does not state how randomisation schedule was generated.
Allocation concealment?	Yes	States: "one of two pieces of paper indicating group assignment was drawn from an envelope labelled by gender and surgeon".
Incomplete outcome data addressed? All outcomes	Yes	19/21 were present at follow-up.
Free of selective reporting?	No	Key outcomes reported incompletely preventing their contribution to the meta-analysis.
Free of other bias?	Yes	
Participant blinding?	No	Not stated but not possible.
Personnel blinding?	No	Not stated but not possible.
Outcome assessor blinding?	Yes	States: "one of two assessors....blinded to the subjects' group allocation".

McInnes 1992

Methods	Randomised trial
Participants	Sample size: Gr1: 48 Gr2: 45 Inclusion: RA or OA, primary TKA, passive knee flexion ROM of at least 90 dgrs and no more than 20 dgrs knee flexion contracture. Exclusion: cognitive or sensory deficit, unable to understand or speak English, under-

	going another surgical procedure prior or during TKA, weight > 136 kg. Mean age (SD): Gr1: 66 (2) Gr2: 70 (1) Gender: Gr1: 65% F Gr2: 64% F Type of arthritis: Gr1: 73% OA Gr2: 89% OA Combined: 81% OA, 19% RA
Interventions	**Groups included in this review:** **Gr1: CPM + standard care** CPM commenced POD 0. Initial settings individually determined. Provided on average, 9 hrs/day for POD 0 - 7. Increased as tolerated. Continued until D/C. **Gr2: Standard care** *Standard care for Gr1, Gr2:* Commenced POD 1. Provided 1 - 2 x per day, 7 days/wk. Included inner ROM and static quads strengthening (from POD 1), active assisted ROM and passive ROM exercises (from POD 2), SLR, gait training, transfer training, bicycling, proning.
Outcomes	**Outcomes included in this review:** 1. Active knee flexion ROM (dgrs) 2. Passive knee flexion ROM (dgrs)^ 3. Active knee extension ROM (dgrs) 4. Passive knee extension ROM (dgrs) 5. Length of hospital stay (days) 6. Function: Health Assessment Questionnaire[a],^ 7. Manipulation under anaesthesia 8. Pain: VAS 9. Swelling: knee circumference (cm) 10. Quadricep strength (Nm) **Other outcomes:** Quadricep strength (Nm) **Outcomes testing period:** tested at POD 7*, 6 wks† post randomisation.
Notes	

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Unclear	Not stated.
Allocation concealment?	Unclear	Not stated.

McInnes 1992 (*Continued*)

Incomplete outcome data addressed? All outcomes	Yes	93/102 were present at follow-up.
Free of selective reporting?	No	Does not clearly state what outcomes were measured (e.g. at 6 wks). Key outcomes reported incompletely preventing their contribution to the meta-analysis.
Free of other bias?	Yes	
Participant blinding?	No	Not stated but not possible.
Personnel blinding?	No	Not stated but not possible.
Outcome assessor blinding?	Yes	States: "blinded to whether the patient was using CPM".

Montgomery 1996

Methods	Randomised trial
Participants	Sample size: Gr1: 28 Gr2: 32 Inclusion: gonarthrosis, primary TKA. Exclusion: not reported Mean age (SD): Gr1: 74 (5) Gr2: 76 (6) Gender: Gr1: 86% F Gr2: 75% F Type of arthritis: Not reported
Interventions	**Groups included in this review:** **Gr1: CPM + standard care** CPM commenced POD 1. Initial settings individually determined. Speed set at 2 - 6 min/cycle. Provided for 9 hrs/day, 7 days/wk. Increased as tolerated. Continued until D/C (criteria = active ROM minimum 70 dgrs, no wound problem, ability to walk and climb stairs, independent with activities of daily living) or up to 2 wks. **Gr2: Knee ex's + standard care** Commenced POD 1. Provided for 1 hr/day, 5 days/wk. Included active ROM and passive ROM (assisted by physiotherapist). *Standard care for Gr1, Gr2:* Encouraged to exercise and provided with instructions on gait.

Montgomery 1996 (*Continued*)

Outcomes	**Outcomes included in this review:** 1. Passive knee flexion ROM (dgrs) 2. Length of hospital stay (days) 3. Pain: VAS 4. Swelling: knee circumference (cm) **Other outcomes:** none **Outcomes testing period:** tested at POD 1, POD 3, POD 5, D/C* post randomisation.
Notes	

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Unclear	Not stated.
Allocation concealment?	Unclear	Not stated.
Incomplete outcome data addressed? All outcomes	Yes	60/68 were present at follow-up.
Free of selective reporting?	Unclear	Does not clearly state what outcomes were measured.
Free of other bias?	Yes	
Participant blinding?	No	Not stated but not possible.
Personnel blinding?	No	Not stated but not possible.
Outcome assessor blinding?	Unclear	Not stated.

Ng 1999

Methods	Randomised trial
Participants	Sample size: Gr1: 16 Gr2: 16 Gr3: 17 Inclusion: unilateral TKA, passive knee flexion ROM of 100 dgrs or more, ambulant. Exclusion: cardiopulmonary complications, previous trauma and / or pathology of the hip on affected side, neurological deficits, not assessed by physiotherapist pre-operatively. Age / Gender: Not reported Type of arthritis: Not reported

Ng 1999 (*Continued*)

Interventions	**Groups included in this review:** **Gr1: Early Knee flexion CPM + standard care** Commenced POD 0. Initially 70 - 100 dgrs. Provided for 4 hrs/day. Increased to 50 - 100 dgrs on POD 1 and 0 - 100 dgrs on POD 2. Continued for unreported period. **Gr2: Standard care** **Other groups:** **Gr3: Conventional CPM + standard care** Commenced POD 0. Initially 0 - 40 dgrs. Provided for 4 hrs/day. Increased 10 dgrs/day. Continued for unreported period. *Standard care for Gr1, Gr2, Gr3:* Commencement not reported. Provided for unreported period. Included active ROM, gait training, inner ROM and static quads strengthening exercises, transfer training, gluteal exercises.
Outcomes	**Outcomes included in this review:** 1. Active knee flexion ROM (dgrs) 2. Passive knee flexion ROM (dgrs) 3. Active knee extension ROM (dgrs) 4. Passive knee extension ROM (dgrs) **Other outcomes:** number of days to achieve 90 dgrs flexion ROM. **Outcomes testing period:** tested at POD 3, POD 5, POD 7* post randomisation.
Notes	

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Unclear	Not stated.
Allocation concealment?	Unclear	Not stated.
Incomplete outcome data addressed? All outcomes	Yes	49/55 were present at follow-up.
Free of selective reporting?	Yes	All data reported on all outcomes at all endpoints.
Free of other bias?	Yes	
Participant blinding?	No	Not stated but not possible.
Personnel blinding?	No	Not stated but not possible.
Outcome assessor blinding?	Unclear	Not stated.

Nielsen 1988

Methods	Randomised trial
Participants	Sample size: Gr1: 24 Gr2: 26 Inclusion: arthrosis, primary TKA. Exclusion: previous TKA in contralateral knee. Mean age (range): Gr1: 71 (40 - 83) Gr2: 72 (37 - 83) Gender: Gr1: 70% F Gr2: 70% F Type of arthritis: Not reported
Interventions	**Groups included in this review:** **Gr1: CPM + standard care** CPM commenced POD 2. Initially 0 - 25 dgrs. Provided for 4 hrs/day. Increased 5 - 10 dgrs/day. Continued until POD 12. **Gr2: Standard care** *Standard care for Gr1, G2:* Commenced POD 2. Provided for unreported period. Included inner ROM quads and static quads strengthening, active ROM with full weight bearing.
Outcomes	**Outcomes included in this review:** 1. Passive knee flexion ROM (dgrs) 2. Active knee extension ROM (dgrs) 3. Pain: VAS^ **Other outcomes:** flexion deterioration, number of people with improvement, no change or deterioration. **Outcomes testing period:** tested at POD 14* post randomisation.
Notes	

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Unclear	Not stated.
Allocation concealment?	Unclear	Not stated.
Incomplete outcome data addressed? All outcomes	Yes	50/54 were present at follow-up.

Nielsen 1988 (*Continued*)

Free of selective reporting?	No	Does not clearly state what outcomes were measured. Key outcomes reported incompletely preventing their contribution to the meta-analysis.
Free of other bias?	Yes	
Participant blinding?	No	Not stated but not possible.
Personnel blinding?	No	Not stated but not possible.
Outcome assessor blinding?	Yes	States: "the evaluation was carried out...who was uninformed".

Ritter 1989

Methods	Randomised trial
Participants	Sample size: Gr1: 50 pts (100 knees) Gr2: 50 pts (100 knees) Inclusion: pre-operative range > 90 dgrs. Exclusion: not reported Mean age (range): Combined: 73 (43 - 85) Gender: Combined: 34% F Type of arthritis: Combined: 94% OA, 6% RA
Interventions	**Groups included in this review:** **Gr1: CPM + standard care** CPM commenced POD 2. Initially settings individually determined. Provided for 20 - 24 hrs/day. Increased as tolerated. Continued until POD 7. **Gr2: Standard care** Knee extension splint at night until independent SLR achieved. *Standard care for Gr1, Gr2:* Commenced POD 0. Provided 2 x per day. Included active ROM, stretches, static quads exercises, SLR.
Outcomes	**Outcomes included in this review:** 1. Passive knee flexion ROM (dgrs)[a] 2. Active knee extension ROM (dgrs)[a] 3. Passive knee extension ROM (dgrs) 4. Swelling: knee circumference (cm)É« **Other outcomes:** swelling: suprapatella and distal to patella circumference. **Outcomes testing period:** tested at 1 wk*, 8 wks, 6 mo†, 1 yr‡ post randomisation.

Ritter 1989 (*Continued*)

Notes	

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Yes	Not stated. Clarified through personal communication that sequence was computer generated.
Allocation concealment?	Unclear	Not stated.Clarified through personal communication that sequence was stored on computer but not clear if concealed.
Incomplete outcome data addressed? All outcomes	Yes	47/50 were present at follow-up.
Free of selective reporting?	No	Not all data reported for all outcomes at all endpoints (e.g. knee extension ROM at POD 61). Key outcomes reported incompletely preventing their contribution to the meta-analysis.
Free of other bias?	Yes	
Participant blinding?	No	Not stated but not possible.
Personnel blinding?	No	Not stated but not possible.
Outcome assessor blinding?	Unclear	Not stated. Clarified through personal communication that unblinded assessors were used for short-term assessments and blinded assessors were used for medium- and long-term assessments.

Vince 1987

Methods	Randomised trial
Participants	Sample size: Gr1: 42 Gr2: 20 Inclusion: primary unilateral TKA Exclusion: obese (> 109 kg), bilateral TKA. Mean age (range): Gr1: 68 (44 - 80) Gr2: 66 (47 - 83) Gender: Gr1: 69% F Gr2: 85% F Type of arthritis:

Vince 1987 (*Continued*)

	Combined: 87% OA, 13% RA
Interventions	**Groups included in this review:** **Gr1: CPM + standard care** CPM commenced POD 0. Initially 0 - 30 dgrs. Provided for 20 hrs/day. Increased as tolerated. Continued until D/C. **Gr2: Standard care** *Standard care for Gr1, Gr2:* Commenced POD 3. Provided for unreported period. Included active assisted ROM exercises, gait training.
Outcomes	**Outcomes included in this review:** 1. Passive knee flexion ROM (dgrs)[a] 2. Passive knee extension ROM (dgrs)[a] 3. Length of hospital stay (days)[a] 4. Manipulation under anaesthesia **Other outcomes:** delayed healing, hemarthrosis, time (days) to achieve 90 dgrs flexion ROM, lung emboli, thrombophlebitis **Outcomes testing period:** tested at POD 4, POD 5, D/C* (POD 15 - 16) post randomisation
Notes	

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Unclear	Not stated.
Allocation concealment?	Unclear	Not stated.
Incomplete outcome data addressed? All outcomes	Unclear	Not stated.
Free of selective reporting?	No	Not clear what was measured. Key outcomes reported incompletely preventing their contribution to the meta-analysis.
Free of other bias?	No	Unclear whether random allocated really was used. States: "The patients were assigned to the control or CPM group randomly". However, the imbalance in the size of the two groups was unlikely to occur by chance and nothing to suggest that blocked randomisation was used.
Participant blinding?	No	Not stated but not possible.
Personnel blinding?	No	Not stated but not possible.
Outcome assessor blinding?	Unclear	Not stated.

Worland 1998

Methods	Randomised trial
Participants	Sample size: Gr1: 37 pts (49 knees) Gr2: 43 pts (54 knees) Inclusion: unilateral and bilateral TKA, OA. Exclusion: concomitant medical problems, serious drainage from wounds postoperatively. Mean age (range): Gr1: 69 (54 - 81) Gr2: 71 (44 - 86) Gender: Gr1: 61% F Gr2: 71% F Type of arthritis: Combined: 100% OA
Interventions	**Groups included in this review:** **Gr1: CPM** CPM commenced when D/C from acute hospital care (approx. POD 3 - 4). Initially 90 dgrs. Provided for 3 hrs/day. Increments not reported. Continued for 10 days. **Gr2: Standard care** Commenced when D/C from acute hospital care (approx. POD 3 - 4). Provided for 1 hr, 3 x per wk. Continued for 2 wks. Included home exercises consisting of strengthening, stretching, gait training, SLR.
Outcomes	**Outcomes included in this review:** 1. Passive knee flexion ROM (dgrs) 2. Active knee extension ROM (dgrs)^ 3. Passive knee extension ROM (dgrs) 4. Function: The Hospital for Special Surgery scoring system^ **Other outcomes:** none **Outcomes testing period:** tested at baseline upon randomisation (2 wks post op)*, 6 wks†, 6 mo‡ post randomisation.
Notes	

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Unclear	Not stated.
Allocation concealment?	Unclear	Not stated.
Incomplete outcome data addressed? All outcomes	Unclear	Not stated.

Worland 1998 (*Continued*)

Free of selective reporting?	No	Not all data reported for all outcomes at all endpoints (e.g. 2 wks).
Free of other bias?	Yes	
Participant blinding?	No	Not stated but not possible.
Personnel blinding?	No	Not stated but not possible.
Outcome assessor blinding?	Yes	States: "All patients were evaluated by our senior author, who did not know which therapy the patient received".

* - endpoint included in analysis of short-term effect; † - endpoint included in analysis of medium-term effect; ‡ - endpoint included in analysis of long-term effect; ª - no measure of variability provided for at least one endpoints; ^ - no data provided for at least one endpoint; É« - calculated SD implausible so not reported; Gr - group; dgrs - degrees; ROM - range of motion; CPM - continuous passive motion; OA - osteoarthritis; TKA - total knee arthroplasty; RA - rheumatoid arthritis; F - female; SD - standard deviation; POD - postoperative day; hr - hour; yrs - years; mo - months; wks - weeks; min - minutes; m - metre; VAS - visual analogue scale; pts - patients; SLR - straight leg raise; D/C - discharge; FES - functional electrical stimulation; approx. - approximately; Nm - newton metres; WOMAC - Western Ontario and McMaster Osteoarthritis Index; SF-12 - Short-Form 12-Item Health Survey.

Characteristics of excluded studies *[ordered by study ID]*

Beaupré 2001	Participants. Mixed population
Chen 2000	Participants. Unclear if all OA
Coutts 1983	Design. Not RCT
Davis 1984	Participants. Unclear if all OA
Haug 1988	Comparison. CPM + electrical stimulation versus CPM
Johnson 1990	Comparison. CPM+exercises involving full extension versus splinting + SLR
Johnson 1992	Comparison. CPM + full extension versus splinting + SLR
Kim 1995	Comparison. CPM versus alternative flexion + extension splinting regime
Leach 2006	Design. Not RCT
Leonard 2007	Comparison. One protocol of CPM versus another protocol of CPM
Lynch 1988	Participants. Mixed population

(*Continued*)

Maloney 1990	Design. Not RCT
Odenbring 1989	Participants. Osteotomy, not TKA
Pope 1997	Randomisation. Allocated according to admission
Simkin 1999	Intervention. CPM for the hip
Ververeli 1995	Design. Not RCT
Walker 1991	Participants. Unclear if all OA
Woog 2008	Comparison. One protocol of CPM versus another protocol of CPM
Yashar 1997	Comparison. One protocol of CPM versus another protocol of CPM
Young 1984	Design. Not RCT (retrospective study)

Characteristics of studies awaiting assessment *[ordered by study ID]*

Aubriot 1993

Methods	Published in French - awaiting translation. Unable to determine if eligible.
Participants	
Interventions	
Outcomes	
Notes	

Sahin 2006

Methods	Unable to attain full text. Unable to determine if eligible.
Participants	
Interventions	
Outcomes	
Notes	

Sosin 2000

Methods	Published in Polish - awaiting translation. Unable to determine if eligible.
Participants	
Interventions	
Outcomes	
Notes	

DATA AND ANALYSES

Comparison 1. Primary comparison - all studies

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Active knee flexion ROM	9		Mean Difference (IV, Random, 95% CI)	Subtotals only
1.1 Short-term effects (< 6 wks)	8	379	Mean Difference (IV, Random, 95% CI)	3.08 [-0.10, 6.25]
1.2 Medium-term effects (6 wks to 6 mo)	2	104	Mean Difference (IV, Random, 95% CI)	2.86 [-5.29, 11.00]
1.3 Long-term effects (> 6 mo)	2	104	Mean Difference (IV, Random, 95% CI)	4.86 [2.83, 6.89]
2 Passive knee flexion ROM	11		Mean Difference (IV, Random, 95% CI)	Subtotals only
2.1 Short-term effects (< 6 wks)	9	551	Mean Difference (IV, Random, 95% CI)	2.46 [0.39, 4.52]
2.2 Medium-term effects (6 wks to 6 mo)	3	201	Mean Difference (IV, Random, 95% CI)	-1.51 [-5.73, 2.72]
2.3 Long-term effects (> 6 mo)	2	160	Mean Difference (IV, Random, 95% CI)	0.06 [-2.22, 2.35]
3 Active knee extension ROM	13		Mean Difference (IV, Random, 95% CI)	Subtotals only
3.1 Short-term effects (< 6 wks)	12	743	Mean Difference (IV, Random, 95% CI)	0.59 [-0.49, 1.66]
3.2 Medium-term effects (6 wks to 6 mo)	2	104	Mean Difference (IV, Random, 95% CI)	0.22 [-1.37, 1.80]
3.3 Long-term effects (> 6 mo)	1	80	Mean Difference (IV, Random, 95% CI)	0.06 [-0.06, 0.18]
4 Passive knee extension ROM	14		Mean Difference (IV, Random, 95% CI)	Subtotals only
4.1 Short-term effects (< 6 wks)	13	749	Mean Difference (IV, Random, 95% CI)	0.32 [-0.46, 1.10]
4.2 Medium-term effects (6 wks to 6 mo)	3	165	Mean Difference (IV, Random, 95% CI)	-0.70 [-2.50, 1.11]
4.3 Long-term effects (> 6 mo)	3	204	Mean Difference (IV, Random, 95% CI)	0.13 [-0.34, 0.59]
5 Length of hospital stay	12	748	Mean Difference (IV, Random, 95% CI)	-0.34 [-0.85, 0.17]
6 Function [standardised mean]	8		Std. Mean Difference (IV, Random, 95% CI)	Subtotals only
6.1 Short-term effects (6 wks to 6 mo)	4	171	Std. Mean Difference (IV, Random, 95% CI)	0.10 [-0.50, 0.70]
6.2 Medium-term effects (6 wks to 6 mo)	4	286	Std. Mean Difference (IV, Random, 95% CI)	-0.04 [-0.27, 0.19]
6.3 Long-term effects (> 6 mo)	3	260	Std. Mean Difference (IV, Random, 95% CI)	-0.02 [-0.26, 0.23]
7 Manipulation under anaesthesia [number]	3	234	Risk Ratio (M-H, Random, 95% CI)	0.15 [0.03, 0.70]
8 Pain	6		Mean Difference (IV, Random, 95% CI)	Totals not selected
8.1 Short-term effects (< 6 wks)	6		Mean Difference (IV, Random, 95% CI)	Not estimable

8.2 Medium-term effects (6 wks to 6 mo)	1		Mean Difference (IV, Random, 95% CI)	Not estimable
9 Swelling	2		Mean Difference (IV, Random, 95% CI)	Totals not selected
9.1 Short-term effects (6wks to 6mo)	2		Mean Difference (IV, Random, 95% CI)	Not estimable
10 Quadriceps strength [standardised mean]	2		Std. Mean Difference (IV, Random, 95% CI)	Subtotals only
10.1 Short-term effects (6 wks to 6 mo) group	2	130	Std. Mean Difference (IV, Random, 95% CI)	0.27 [-0.08, 0.61]

Comparison 2. Secondary comparison - subgroup of studies in which control participants received additional knee exercises

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Active knee flexion ROM	1		Mean Difference (IV, Random, 95% CI)	Totals not selected
1.1 Short-term effects (< 6 wks)	1		Mean Difference (IV, Random, 95% CI)	Not estimable
2 Passive knee flexion ROM	3		Mean Difference (IV, Random, 95% CI)	Subtotals only
2.1 Short-term effects (< 6 wks) subgroup	3	240	Mean Difference (IV, Random, 95% CI)	1.14 [-1.09, 3.38]
2.2 Medium-term effects (6 wks to 6 mo)	1	80	Mean Difference (IV, Random, 95% CI)	0.10 [-4.11, 4.31]
2.3 Long-term effects (> 6 mo)	1	80	Mean Difference (IV, Random, 95% CI)	-0.5 [-3.40, 2.40]
3 Active knee extension ROM	2		Mean Difference (IV, Random, 95% CI)	Totals not selected
3.1 Short-term effects (< 6 wks)	1		Mean Difference (IV, Random, 95% CI)	Not estimable
3.2 Long-term effects (> 6 mo)	1		Mean Difference (IV, Random, 95% CI)	Not estimable
4 Passive knee extension ROM	3		Mean Difference (IV, Random, 95% CI)	Totals not selected
4.1 Short-term effects (< 6 wks)	3		Mean Difference (IV, Random, 95% CI)	Not estimable
4.2 Medium-term effects (6 wks to 6 mo)	1		Mean Difference (IV, Random, 95% CI)	Not estimable
4.3 Long-term effects (> 6 mo)	1		Mean Difference (IV, Random, 95% CI)	Not estimable
5 Length of hospital stay	1		Mean Difference (IV, Random, 95% CI)	Subtotals only
6 Function	2		Std. Mean Difference (IV, Random, 95% CI)	Totals not selected
6.1 Short-term effect (< 6 wks)	1		Std. Mean Difference (IV, Random, 95% CI)	Not estimable
6.2 Medium-term effects (6 wks to 6 mo)	1		Std. Mean Difference (IV, Random, 95% CI)	Not estimable
6.3 Long-term effects (> 6 mo)	1		Std. Mean Difference (IV, Random, 95% CI)	Not estimable
7 Pain	2		Std. Mean Difference (IV, Random, 95% CI)	Totals not selected
7.1 Short-term effects (6 wks to 6 mo)	2		Std. Mean Difference (IV, Random, 95% CI)	Not estimable

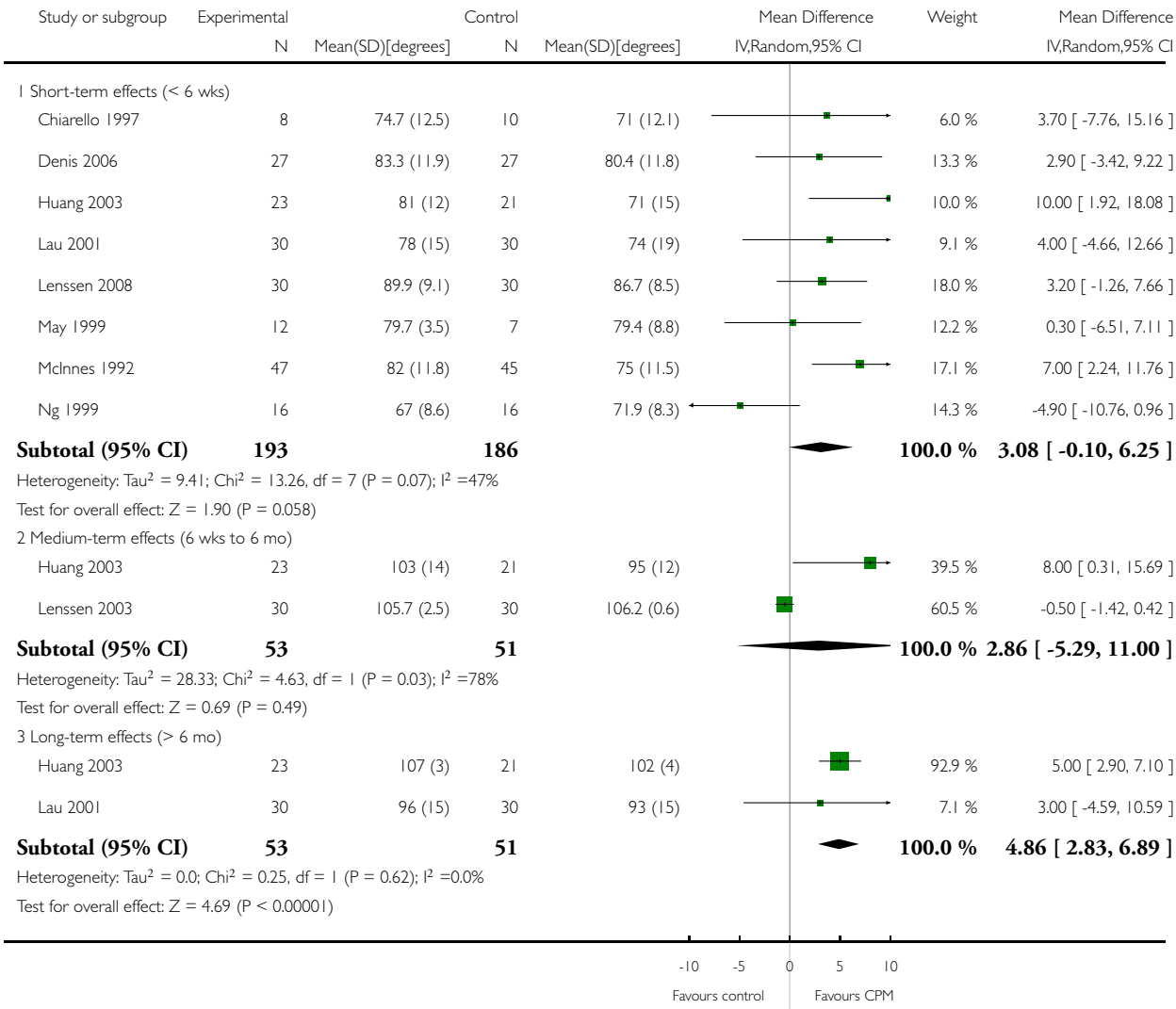
8 Swelling	2	Mean Difference (IV, Random, 95% CI)	Totals not selected
8.1 Short-term effects (6 wks to 6 mo)	2	Mean Difference (IV, Random, 95% CI)	Not estimable

Analysis 1.1. Comparison 1 Primary comparison - all studies, Outcome 1 Active knee flexion ROM.

Review: Continuous passive motion following total knee arthroplasty in people with arthritis

Comparison: 1 Primary comparison - all studies

Outcome: 1 Active knee flexion ROM

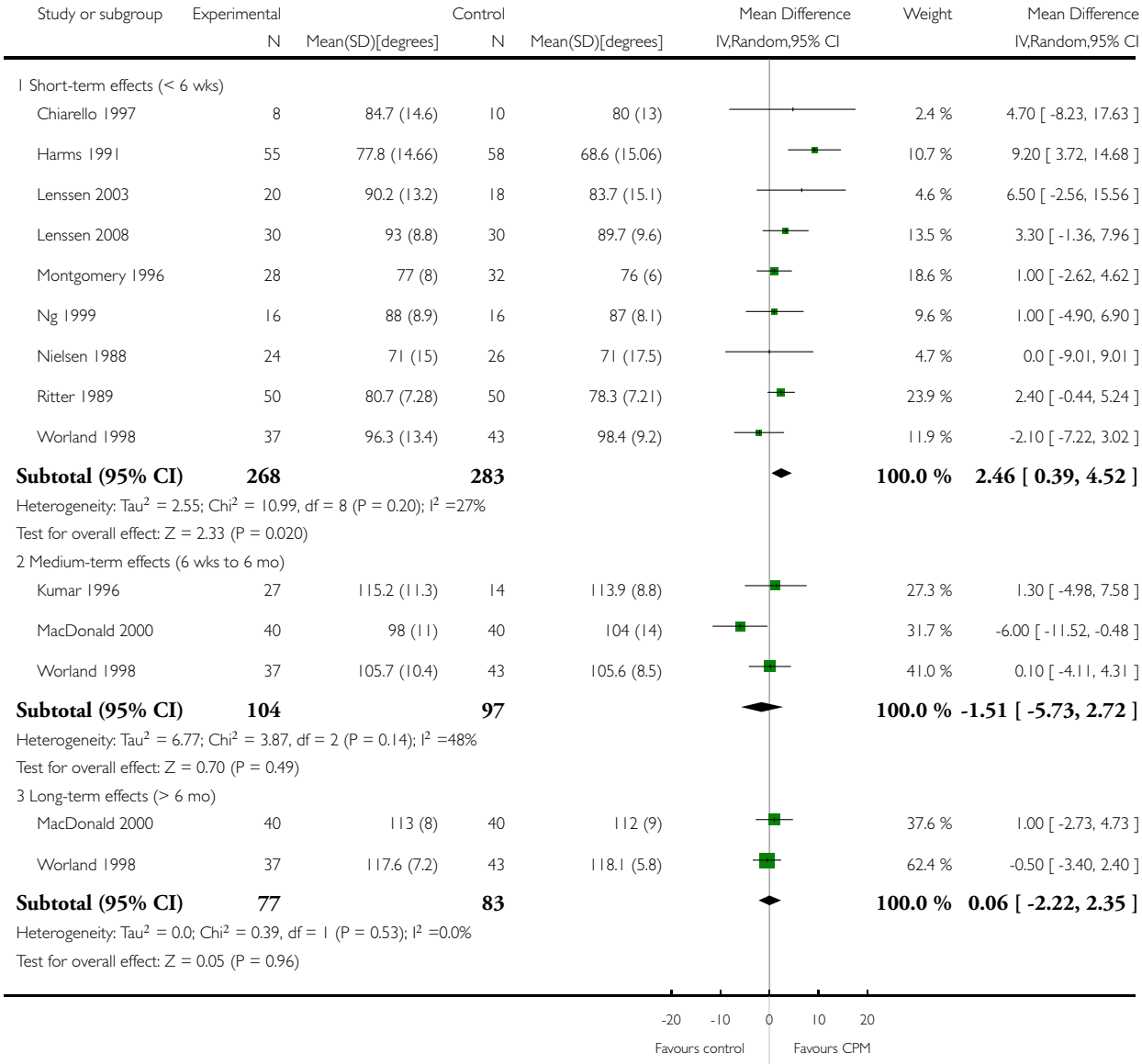


Analysis 1.2. Comparison 1 Primary comparison - all studies, Outcome 2 Passive knee flexion ROM.

Review: Continuous passive motion following total knee arthroplasty in people with arthritis

Comparison: 1 Primary comparison - all studies

Outcome: 2 Passive knee flexion ROM

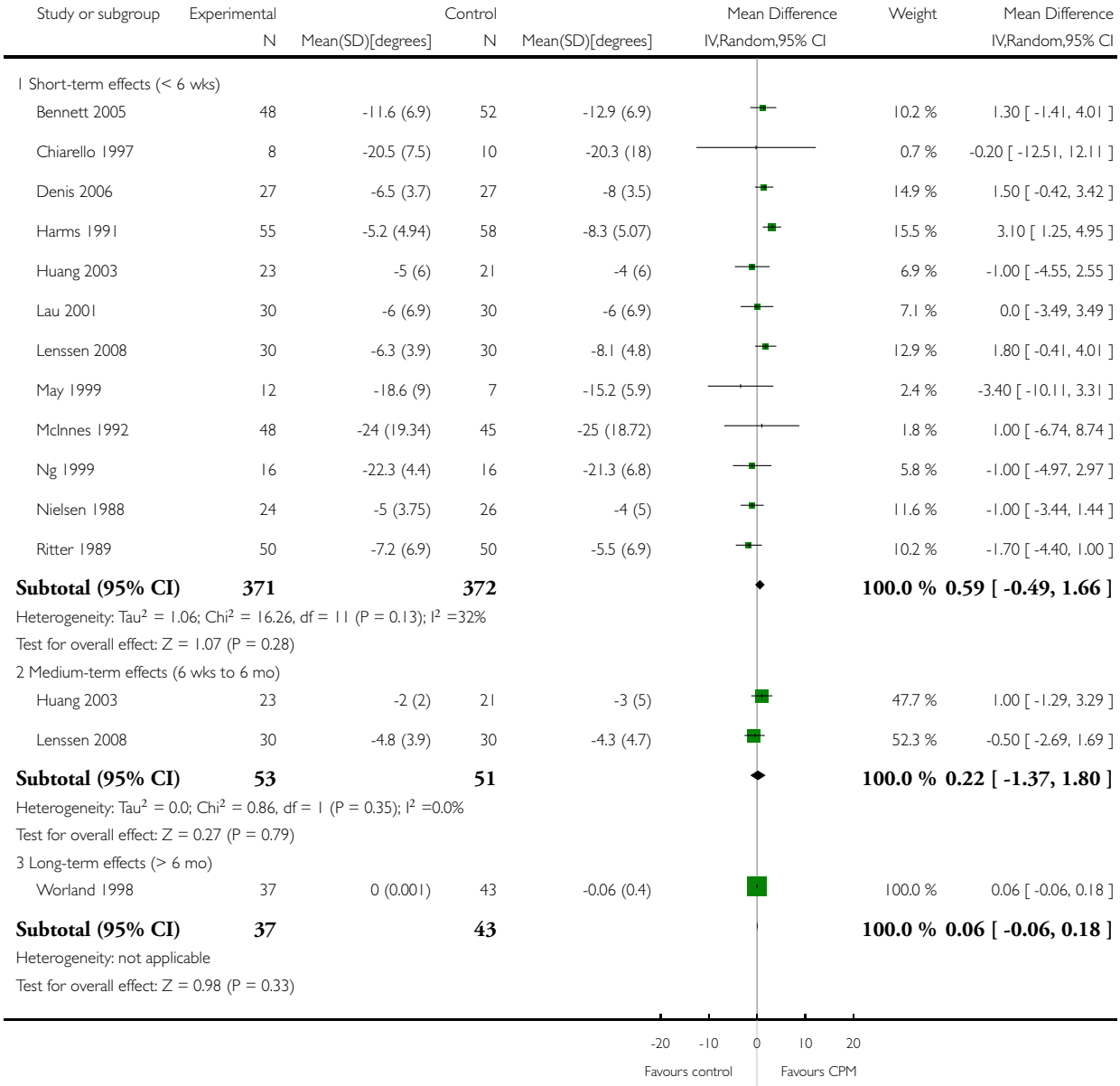


Analysis 1.3. Comparison 1 Primary comparison - all studies, Outcome 3 Active knee extension ROM.

Review: Continuous passive motion following total knee arthroplasty in people with arthritis

Comparison: 1 Primary comparison - all studies

Outcome: 3 Active knee extension ROM

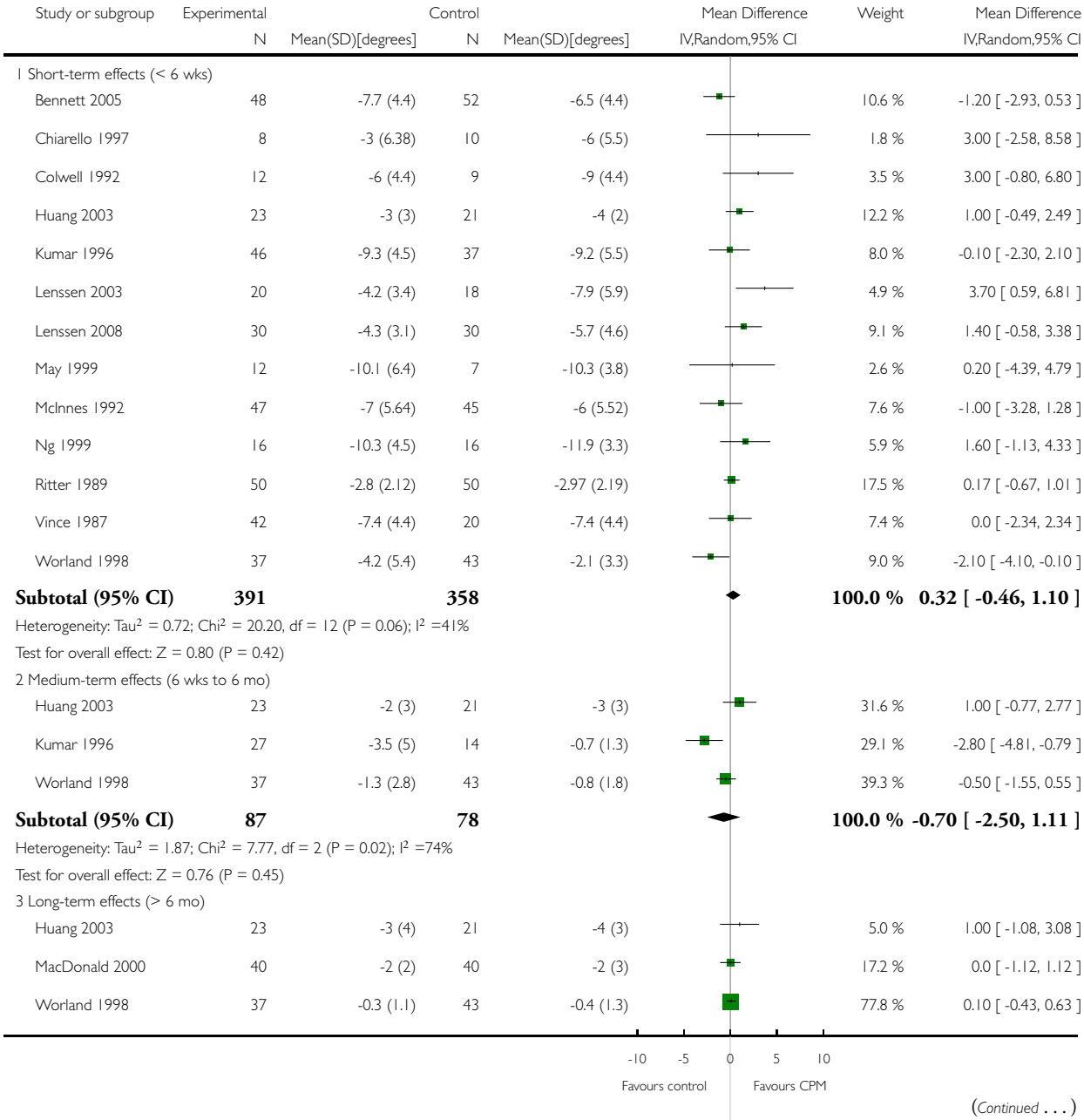


Analysis 1.4. Comparison 1 Primary comparison - all studies, Outcome 4 Passive knee extension ROM.

Review: Continuous passive motion following total knee arthroplasty in people with arthritis

Comparison: 1 Primary comparison - all studies

Outcome: 4 Passive knee extension ROM



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Study or subgroup	Experimental N	Mean(SD)[degrees]	Control N	Mean(SD)[degrees]	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Subtotal (95% CI)	**100**		**104**			**100.0 %**	**0.13 [-0.34, 0.59]**

Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.74$, df = 2 (P = 0.69); $I^2 = 0.0\%$

Test for overall effect: Z = 0.54 (P = 0.59)

Analysis 1.5. Comparison 1 Primary comparison - all studies, Outcome 5 Length of hospital stay.

Review: Continuous passive motion following total knee arthroplasty in people with arthritis

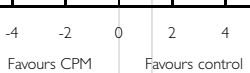
Comparison: 1 Primary comparison - all studies

Outcome: 5 Length of hospital stay

Study or subgroup	Experimental N	Mean(SD)[days]	Control N	Mean(SD)[days]	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Bennett 2005	29	8.1 (3.9)	52	8 (3.9)		6.7 %	0.10 [-1.67, 1.87]
Colwell 1992	12	9.9 (2.75)	10	10.9 (1.5)		6.5 %	-1.00 [-2.81, 0.81]
Denis 2006	27	8 (2.1)	27	7.8 (2)		13.6 %	0.20 [-0.89, 1.29]
Harms 1991	55	17 (4)	58	18 (4)		9.0 %	-1.00 [-2.48, 0.48]
Huang 2003	23	18 (6.7)	21	24 (6.4)		1.7 %	-6.00 [-9.87, -2.13]
Kumar 1996	46	12.1 (9)	37	12.5 (6.8)		2.1 %	-0.40 [-3.80, 3.00]
Lenssen 2003	20	6 (3.6)	18	5.6 (1.1)		7.5 %	0.40 [-1.26, 2.06]
MacDonald 2000	40	5.2 (1.3)	40	5.1 (1.2)		25.6 %	0.10 [-0.45, 0.65]
May 1999	12	31 (3.9)	7	31.1 (3.9)		1.9 %	-0.10 [-3.74, 3.54]
McInnes 1992	47	10.1 (2.7)	45	10.3 (2.65)		13.6 %	-0.20 [-1.29, 0.89]
Montgomery 1996	28	9 (3)	32	10 (4)		6.7 %	-1.00 [-2.78, 0.78]
Vince 1987	42	15.3 (3.9)	20	16.7 (3.9)		5.2 %	-1.40 [-3.48, 0.68]
Total (95% CI)	**381**		**367**			**100.0 %**	**-0.34 [-0.85, 0.17]**

Heterogeneity: $Tau^2 = 0.19$; $Chi^2 = 14.85$, df = 11 (P = 0.19); $I^2 = 26\%$

Test for overall effect: Z = 1.31 (P = 0.19)



Analysis 1.6. Comparison 1 Primary comparison - all studies, Outcome 6 Function [standardised mean].

Review: Continuous passive motion following total knee arthroplasty in people with arthritis

Comparison: 1 Primary comparison - all studies

Outcome: 6 Function [standardised mean]

Study or subgroup	Experimental N	Mean(SD)	Control N	Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
1 Short-term effects (6 wks to 6 mo)							
Denis 2006	27	-52.3 (34.9)	27	-41.9 (21.4)		27.8 %	-0.35 [-0.89, 0.18]
Lenssen 2003	20	66.2 (10.1)	18	54.2 (12.8)		24.5 %	1.03 [0.34, 1.71]
Lenssen 2008	30	67.6 (19.6)	30	67.3 (14.9)		28.6 %	0.02 [-0.49, 0.52]
May 1999	12	-35.6 (41.8)	7	-24.1 (18.2)		19.1 %	-0.31 [-1.25, 0.63]
Subtotal (95% CI)	**89**		**82**			**100.0 %**	**0.10 [-0.50, 0.70]**
Heterogeneity: $Tau^2 = 0.26$; $Chi^2 = 10.61$, df = 3 (P = 0.01); $I^2 = 72\%$							
Test for overall effect: Z = 0.32 (P = 0.75)							
2 Medium-term effects (6 wks to 6 mo)							
Bennett 2005	48	52.2 (22.17)	52	56 (21.63)		35.1 %	-0.17 [-0.57, 0.22]
Kumar 1996	26	82.7 (25.82)	20	80.7 (22.64)		15.9 %	0.08 [-0.50, 0.66]
Lenssen 2008	30	80.4 (5.3)	30	78.8 (9.2)		21.0 %	0.21 [-0.30, 0.72]
Worland 1998	37	95.3 (2.8)	43	95.7 (3)		28.0 %	-0.14 [-0.58, 0.30]
Subtotal (95% CI)	**141**		**145**			**100.0 %**	**-0.04 [-0.27, 0.19]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 1.72$, df = 3 (P = 0.63); $I^2 = 0.0\%$							
Test for overall effect: Z = 0.35 (P = 0.73)							
3 Long-term effects (> 6 mo)							
Bennett 2005	48	59.6 (23.56)	52	58.1 (22.35)		38.5 %	0.06 [-0.33, 0.46]
MacDonald 2000	40	166 (23)	40	166 (25)		30.9 %	0.0 [-0.44, 0.44]
Worland 1998	37	95.3 (2.8)	43	95.7 (3)		30.6 %	-0.14 [-0.58, 0.30]
Subtotal (95% CI)	**125**		**135**			**100.0 %**	**-0.02 [-0.26, 0.23]**
Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.45$, df = 2 (P = 0.80); $I^2 = 0.0\%$							
Test for overall effect: Z = 0.13 (P = 0.89)							

Analysis 1.7. Comparison 1 Primary comparison - all studies, Outcome 7 Manipulation under anaesthesia [number].

Review: Continuous passive motion following total knee arthroplasty in people with arthritis

Comparison: 1 Primary comparison - all studies

Outcome: 7 Manipulation under anaesthesia [number]

Study or subgroup	Experimental n/N	Control n/N	Risk Ratio M-H,Random,95% CI	Weight	Risk Ratio M-H,Random,95% CI
Kumar 1996	1/46	3/37		47.3 %	0.27 [0.03, 2.47]
McInnes 1992	0/45	8/44		29.3 %	0.06 [0.00, 0.97]
Vince 1987	0/42	1/20		23.4 %	0.16 [0.01, 3.83]
Total (95% CI)	**133**	**101**		**100.0 %**	**0.15 [0.03, 0.70]**

Total events: 1 (Experimental), 12 (Control)

Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.78$, df = 2 (P = 0.68); $I^2 = 0.0\%$

Test for overall effect: Z = 2.42 (P = 0.016)

Analysis 1.8. Comparison 1 Primary comparison - all studies, Outcome 8 Pain.

Review: Continuous passive motion following total knee arthroplasty in people with arthritis

Comparison: 1 Primary comparison - all studies

Outcome: 8 Pain

Study or subgroup	Experimental N	Mean(SD)[points]	Control N	Mean(SD)[points]	Mean Difference IV,Random,95% CI	Mean Difference IV,Random,95% CI
1 Short-term effects (< 6 wks)						
Denis 2006	27	2.77 (1.71)	27	3.98 (2.48)		-1.21 [-2.35, -0.07]
Lenssen 2003	20	2.3 (2.6)	18	4.5 (2.4)		-2.20 [-3.79, -0.61]
Lenssen 2008	30	-1.58 (0.47)	30	-1.53 (0.41)		-0.05 [-0.27, 0.17]
May 1999	12	1.5 (1.6)	7	2.1 (2.4)		-0.60 [-2.60, 1.40]
McInnes 1992	47	2.8 (2.1)	45	3.6 (2.1)		-0.80 [-1.66, 0.06]
Montgomery 1996	28	5 (2.3)	32	5 (1.5)		0.0 [-1.00, 1.00]
2 Medium-term effects (6 wks to 6 mo)						
Lenssen 2008	30	-1.73 (0.38)	30	-1.75 (0.09)		0.02 [-0.12, 0.16]

Analysis 1.9. Comparison 1 Primary comparison - all studies, Outcome 9 Swelling.

Review: Continuous passive motion following total knee arthroplasty in people with arthritis

Comparison: 1 Primary comparison - all studies

Outcome: 9 Swelling

Study or subgroup	Experimental N	Mean(SD)[cm]	Control N	Mean(SD)[cm]	Mean Difference IV,Random,95% CI	Mean Difference IV,Random,95% CI
1 Short-term effects (6wks to 6mo)						
McInnes 1992	48	43.2 (2.7)	45	45.1 (2.6)		-1.90 [-2.98, -0.82]
Montgomery 1996	28	44 (4)	32	44 (3)		0.0 [-1.81, 1.81]

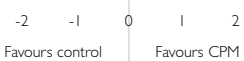
Analysis 1.10. Comparison 1 Primary comparison - all studies, Outcome 10 Quadriceps strength [standardised mean].

Review: Continuous passive motion following total knee arthroplasty in people with arthritis

Comparison: 1 Primary comparison - all studies

Outcome: 10 Quadriceps strength [standardised mean]

Study or subgroup	Experimental N	Mean(SD)	Control N	Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
1 Short-term effects (6 wks to 6 mo) group							
Lenssen 2003	18	99 (45.6)	20	80.3 (31)		28.6 %	0.47 [-0.17, 1.12]
McInnes 1992	47	19.1 (8.65)	45	17.5 (8.47)		71.4 %	0.19 [-0.22, 0.59]



Analysis 2.1. Comparison 2 Secondary comparison - subgroup of studies in which control participants received additional knee exercises, Outcome 1 Active knee flexion ROM.

Review: Continuous passive motion following total knee arthroplasty in people with arthritis

Comparison: 2 Secondary comparison - subgroup of studies in which control participants received additional knee exercises

Outcome: 1 Active knee flexion ROM

Study or subgroup	Experimental N	Mean(SD)[degrees]	Control N	Mean(SD)[degrees]	Mean Difference IV,Random,95% CI	Mean Difference IV,Random,95% CI
1 Short-term effects (< 6 wks)						
May 1999	12	79.7 (3.5)	7	79.4 (8.8)		0.30 [-6.51, 7.11]

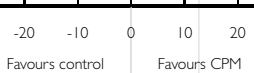
Analysis 2.2. Comparison 2 Secondary comparison - subgroup of studies in which control participants received additional knee exercises, Outcome 2 Passive knee flexion ROM.

Review: Continuous passive motion following total knee arthroplasty in people with arthritis

Comparison: 2 Secondary comparison - subgroup of studies in which control participants received additional knee exercises

Outcome: 2 Passive knee flexion ROM

Study or subgroup	Experimental N	Mean(SD)[degrees]	Control N	Mean(SD)[degrees]	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
1 Short-term effects (< 6 wks) subgroup							
Montgomery 1996	28	77 (8)	32	76 (6)		33.0 %	1.00 [-2.62, 4.62]
Ritter 1989	50	80.7 (7.28)	50	78.3 (7.21)		49.4 %	2.40 [-0.44, 5.24]
Worland 1998	37	96.3 (13.4)	43	98.4 (9.2)		17.7 %	-2.10 [-7.22, 3.02]
Subtotal (95% CI)	**115**		**125**			**100.0 %**	**1.14 [-1.09, 3.38]**
Heterogeneity: $Tau^2 = 0.53$; $Chi^2 = 2.29$, df = 2 (P = 0.32); $I^2 = 13\%$							
Test for overall effect: Z = 1.00 (P = 0.32)							
2 Medium-term effects (6 wks to 6 mo)							
Worland 1998	37	105.7 (10.4)	43	105.6 (8.5)		100.0 %	0.10 [-4.11, 4.31]
Subtotal (95% CI)	**37**		**43**			**100.0 %**	**0.10 [-4.11, 4.31]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.05 (P = 0.96)							
3 Long-term effects (> 6 mo)							



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(. . . *Continued*)

Study or subgroup	Experimental N	Mean(SD)[degrees]	Control N	Mean(SD)[degrees]	Mean Difference IV,Random,95% CI	Weight	Mean Difference IV,Random,95% CI
Worland 1998	37	117.6 (7.2)	43	118.1 (5.8)		100.0 %	-0.50 [-3.40, 2.40]
Subtotal (95% CI)	**37**		**43**			**100.0 %**	**-0.50 [-3.40, 2.40]**
Heterogeneity: not applicable							
Test for overall effect: Z = 0.34 (P = 0.74)							

Analysis 2.3. Comparison 2 Secondary comparison - subgroup of studies in which control participants received additional knee exercises, Outcome 3 Active knee extension ROM.

Review: Continuous passive motion following total knee arthroplasty in people with arthritis

Comparison: 2 Secondary comparison - subgroup of studies in which control participants received additional knee exercises

Outcome: 3 Active knee extension ROM

Study or subgroup	Experimental N	Mean(SD)[degrees]	Control N	Mean(SD)[degrees]	Mean Difference IV,Random,95% CI	Mean Difference IV,Random,95% CI
1 Short-term effects (< 6 wks)						
May 1999	12	-18.6 (9)	7	-15.2 (5.9)		-3.40 [-10.11, 3.31]
2 Long-term effects (> 6 mo)						
Worland 1998	37	0 (0)	43	-0.06 (0.4)		0.0 [0.0, 0.0]

Analysis 2.4. Comparison 2 Secondary comparison - subgroup of studies in which control participants received additional knee exercises, Outcome 4 Passive knee extension ROM.

Review: Continuous passive motion following total knee arthroplasty in people with arthritis

Comparison: 2 Secondary comparison - subgroup of studies in which control participants received additional knee exercises

Outcome: 4 Passive knee extension ROM

Study or subgroup	Experimental N	Mean(SD)[degrees]	Control N	Mean(SD)[degrees]	Mean Difference IV,Random,95% CI	Mean Difference IV,Random,95% CI
1 Short-term effects (< 6 wks)						
May 1999	12	-10.1 (6.4)	7	-10.3 (3.8)		0.20 [-4.39, 4.79]
Ritter 1989	50	-2.8 (2.1)	50	-3 (2.2)		0.20 [-0.64, 1.04]
Worland 1998	37	-4.2 (5.4)	43	-2.1 (3.3)		-2.10 [-4.10, -0.10]
2 Medium-term effects (6 wks to 6 mo)						
Worland 1998	37	-1.3 (2.8)	43	-0.8 (1.8)		-0.50 [-1.55, 0.55]
3 Long-term effects (> 6 mo)						
Worland 1998	37	-0.3 (1.1)	43	-0.4 (1.3)		0.10 [-0.43, 0.63]

Analysis 2.5. Comparison 2 Secondary comparison - subgroup of studies in which control participants received additional knee exercises, Outcome 5 Length of hospital stay.

Review: Continuous passive motion following total knee arthroplasty in people with arthritis

Comparison: 2 Secondary comparison - subgroup of studies in which control participants received additional knee exercises

Outcome: 5 Length of hospital stay

Study or subgroup	Experimental N	Mean(SD)[days]	Control N	Mean(SD)[days]	Mean Difference IV,Random,95% CI	Mean Difference IV,Random,95% CI
Montgomery 1996	28	9 (3)	32	10 (4)		-1.00 [-2.78, 0.78]

Analysis 2.6. Comparison 2 Secondary comparison - subgroup of studies in which control participants received additional knee exercises, Outcome 6 Function.

Review: Continuous passive motion following total knee arthroplasty in people with arthritis

Comparison: 2 Secondary comparison - subgroup of studies in which control participants received additional knee exercises

Outcome: 6 Function

Study or subgroup	Experimental N	Mean(SD)[seconds]	Control N	Mean(SD)[seconds]	Std. Mean Difference IV,Random,95% CI	Std. Mean Difference IV,Random,95% CI
1 Short-term effect (< 6 wks)						
May 1999	12	-35.6 (41.8)	7	-24.1 (18.2)		-0.31 [-1.25, 0.63]
2 Medium-term effects (6 wks to 6 mo)						
Worland 1998	37	95.3 (2.8)	43	95.7 (3)		-0.14 [-0.58, 0.30]
3 Long-term effects (> 6 mo)						
Worland 1998	37	95.3 (2.8)	43	95.7 (3)		-0.14 [-0.58, 0.30]

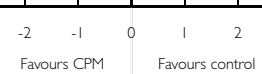
Analysis 2.7. Comparison 2 Secondary comparison - subgroup of studies in which control participants received additional knee exercises, Outcome 7 Pain.

Review: Continuous passive motion following total knee arthroplasty in people with arthritis

Comparison: 2 Secondary comparison - subgroup of studies in which control participants received additional knee exercises

Outcome: 7 Pain

Study or subgroup	Experimental N	Mean(SD)[points]	Control N	Mean(SD)[points]	Std. Mean Difference IV,Random,95% CI	Std. Mean Difference IV,Random,95% CI
1 Short-term effects (6 wks to 6 mo)						
May 1999	12	1.5 (1.6)	7	2.1 (2.4)		-0.30 [-1.24, 0.64]
Montgomery 1996	28	5 (2.3)	32	5 (1.5)		0.0 [-0.51, 0.51]



Analysis 2.8. Comparison 2 Secondary comparison - subgroup of studies in which control participants received additional knee exercises, Outcome 8 Swelling.

Review: Continuous passive motion following total knee arthroplasty in people with arthritis

Comparison: 2 Secondary comparison - subgroup of studies in which control participants received additional knee exercises

Outcome: 8 Swelling

Study or subgroup	Experimental N	Mean(SD)[cm]	Control N	Mean(SD)[cm]	Mean Difference IV,Random,95% CI	Mean Difference IV,Random,95% CI
1 Short-term effects (6 wks to 6 mo)						
Montgomery 1996	28	44 (4)	32	44 (3)		0.0 [-1.81, 1.81]
Ritter 1989	50	40.7 (0)	50	41.1 (0)		0.0 [0.0, 0.0]

APPENDICES

Appendix 1. MEDLINE search strategy (1966 to January 2009)

1. Arthroplasty, Replacement, Knee/
2. Knee Prosthesis/
3. tkr.tw.
4. exp Knee/
5. knee$.tw.
6. 4 or 5
7. exp arthroplasty/
8. Joint Prosthesis/
9. (arthroplast$ or prosthe$ or replac$).tw.
10. or / 7-9
11. 6 and 10
12. or / 1-3,11
13. exp Exercise Therapy/
14. physical therapy modalities/
15. (physical adj therap$).tw.
16. physiotherap$.tw.
17. continuous passive motion.tw.
18. cpm.tw.
19. (gait adj therap$).tw.
20. (exercis$ adj therap$).tw.
21. (therapeutic adj3 exercis$).tw.
22. or / 13-21
23. 12 and 22
24. randomized controlled trial.pt.
25. controlled clinical trial.pt.

26. randomized.ab.
27. placebo.ab.
28. drug therapy.fs.
29. randomly.ab.
30. trial.ab.
31. groups.ab.
32. or / 24-31
33. (animals not (humans and animals)).sh.
34. 32 not 33
35. 23 and 34

Appendix 2. EMBASE (1980 to January 2009)

1. exp ARTHROPLASTY/
2. exp Joint Prosthesis/
3. exp "Prostheses and Orthoses"/
4. exp KNEE/
5. or / 1-3
6. 4 and 5
7. exp Knee Arthroplasty/
8. exp Knee Prosthesis/
9. tka.tw.
10. (knee$ and (replace$ or arthroplast$ or prosthe$ or endoprosthe$ or implant$)).tw.
11. or / 6-10
12. exp kinesiotherapy/
13. exp physiotherapy/
14. (physical adj therap$).tw.
15. physiotherap$.tw.
16. continuous passive motion.tw.
17. cpm.tw.
18. (gait adj therap$).tw.
19. (exercis$ adj therap$).tw.
20. (therapeutic adj3 exercis$).tw.
21. or / 12-20
22. 11 and 21
23. random$.ti,ab.
24. factorial$.ti,ab.
25. (crossover$ or cross over$ or cross-over$).ti,ab.
26. placebo$.ti,ab.
27. (doubl$ adj blind$).ti,ab.
28. (singl$ adj blind$).ti,ab.
29. assign$.ti,ab.
30. allocat$.ti,ab.
31. volunteer$.ti,ab.
32. crossover procedure.sh.
33. double blind procedure.sh.
34. randomized controlled trial.sh.
35. single blind procedure.sh.
36. or / 23-35
37. exp animal/ or nonhuman/ or exp animal experiment/
38. exp human/
39. 37 and 38
40. 37 not 39

41. 36 not 40
42. 22 and 41

Appendix 3. Cochrane Central (to January 2009)

1. MeSH descriptor Arthroplasty, Replacement, Knee explode all trees
2. MeSH descriptor Knee Prosthesis explode all trees
3. tkr:ti,ab
4. MeSH descriptor Knee explode all trees
5. knee*:ti,ab
6. (#4 OR #5)
7. MeSH descriptor Arthroplasty explode all trees
8. MeSH descriptor Joint Prosthesis explode all trees
9. (arthroplast* or prosthe* or replac*):ti,ab
10. (#7 OR #8 OR #9)
11. (#6 AND #10)
12. (#1 OR #2 OR #3 OR #11)
13. MeSH descriptor Exercise Therapy explode all trees
14. MeSH descriptor Physical Therapy Modalities explode all trees
15. physical NEXT therap*:ti,ab
16. physiotherap*:ti,ab
17. "continuous passive motion":ti,ab
18. cpm:ti,ab
19. gait NEXT therap*:ti,ab
20. exercis* NEXT therap*:ti,ab
21. therapeutic NEAR/3 exercis*:ti,ab
22. (#13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21)
23. (#12 AND #21)

Appendix 4. CINAHL (1982 to January 2009)

S23 S11 and S21
S22 S11 and S21
S21 S12 or S13 or S14 or S15 or S16 or S17 or S18 or S19 or S20
S20 ti therapeutic N3 exercis* or ab therapeutic N3 exercis*
S19 ti exercis* therap* or ab exercis* therap*
S18 ti gait therap* or ab gait therap*
S17 ti cpm or ab cpm
S16 ti continuous passive motion or ab continuous passive motion
S15 ti physiotherap* or ab physiotherap*
S14 ti physical therap* or ab physical therap*
S13 (MH "Physical Therapy+")
S12 (MH "Therapeutic Exercise+")
S11 S1 or S2 or S10
S10 S5 and S9
S9 S6 or S7 or S8
S8 ab arthroplast* or ab prosthe* or ab replac*
S7 ti arthroplast* or ti prosthe* or ti replac*
S6 (MH "Joint Prosthesis")
S5 S3 or S4
S4 ti knee* or ab knee*
S3 (MH "Knee")

S2 ti tkr or ab tkr
S1 (MH "Arthroplasty, Replacement, Knee")

Appendix 5. AMED (1985 to January 2009)

1. arthroplasty replacement knee/
2. Knee prosthesis/
3. tkr.tw.
4. knee/
5. knee$.tw.
6. 4 or 5
7. exp Arthroplasty/
8. exp Joint prosthesis/
9. (arthroplast$ or prosthe$ or replac$).tw.
10. or / 7-9
11. 6 and 10
12. or / 1-3,11
13. exp exercise therapy/
14. exp physical therapy modalities/
15. (physical adj therap$).tw.
16. physiotherap$.tw.
17. continuous passive motion.tw.
18. cpm.tw.
19. (gait adj therap$).tw.
20. (exercis$ adj therap$).tw.
21. (therapeutic adj3 exercis$).tw.
22. or / 13-21
23. 12 and 22

Appendix 6. PEDro (up to January 2009)

Search 1 Continuous Passive Motion in Abstract & Title AND Lower leg or knee in Body Part
Search 2 cpm Motion in Abstract & Title AND Lower leg or knee in Body Part

WHAT'S NEW

Last assessed as up-to-date: 16 February 2010.

17 February 2010	New citation required and conclusions have changed	Change in authors and conclusions
10 June 2009	New search has been performed	A new search was conducted and the review updated. Eight new trials were included in the update: four published since the original search was conducted in the 2003 review (Bennett 2005; Denis 2006; Lenssen 2003; Lenssen 2008); two trials published but not identified in the original search (Ng 1999; Ritter 1989); and two additional trials previously excluded met new inclusion criteria and added to the update (Lau 2003; Worland

(*Continued*)

		1998). The update also includes changes to the selection criteria: participants restricted to those with pre-surgery diagnosis of arthritis and comparisons were CPM and standard postoperative care versus CPM and standard postoperative care with active or passive knee exercises; and methods were updated in accordance with current Cochrane Collaboration recommendations: risk of bias assessment and Summary of Findings Tables added, and used updated Cochrane search filter for identifying RCTs
25 July 2008	Amended	Converted to new review format. CMSG ID: C019-R

HISTORY

Review first published: Issue 2, 2003

CONTRIBUTIONS OF AUTHORS

LA Harvey was responsible for rewriting the manuscript, conducting the updated search, screening potentially eligible trials, extracting all data reported in the original review and additional data required for the update, analysing data, interpreting results, updating reference list and creating Summary of Findings Table.

L Brosseau was responsible for the following tasks associated with the 2003 version of this review: extracting data, updating the reference list, updating the analyses and updating the interpretation of results.

RD Herbert contributed to rewriting the manuscript, screening potentially eligible trials, extracting additional data required for the update, analysing data, interpreting results and creating the Summary of Findings Table.

DECLARATIONS OF INTEREST

None known.

SOURCES OF SUPPORT

Internal sources

- The University of Ottawa, Canada.
- The Rehabilitation Studies Unit, Northern Clinical School, School of Medicine, University of Sydney, Not specified.

External sources

- NHMRC, Australia.

fellowship for RDH

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

The protocol was modified when the review was updated in 2009. The modifications were:

1. participants restricted to those with pre-surgery diagnosis of arthritis;

2. comparisons were changed from CPM and physiotherapy versus physiotherapy alone to CPM and standard postoperative care versus CPM and standard postoperative care with active or passive knee exercises;

3. updated methods based on current Cochrane Collaboration recommendations for risk of bias assessment, Summary of Findings Table, and the updated Cochrane search filter for identifying RCTs;

4. endpoints were classified as short-, medium- and long-term;

5. only one observation was extracted for each outcome within a particular endpoint (short, medium or long term);

6. in trials with more than two groups, only data from the two groups with the most contrasting interventions were extracted and used for analyses;

7. the comparisons were divided into primary and secondary comparisons; and

8. pain outcomes were restricted to direct measures of pain intensity (e.g. visual analogue scale); data on pain medication were not extracted.

INDEX TERMS

Medical Subject Headings (MeSH)

*Motion Therapy, Continuous Passive; Arthroplasty, Replacement, Knee [*rehabilitation]; Osteoarthritis, Knee [*surgery]; Randomized Controlled Trials as Topic; Range of Motion, Articular

MeSH check words

Humans