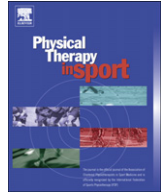


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Literature review

A review of systematic reviews on anterior cruciate ligament reconstruction rehabilitation

Ryan Lobb, Steve Tumilty, Leica S. Claydon*

Centre for Physiotherapy Research, University of Otago, 325 Great King Street, PO Box 56, Dunedin, New Zealand

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ABSTRACT

The aim of this systematic review of systematic reviews was to critically appraise systematic reviews on Anterior Cruciate Ligament (ACL) reconstruction rehabilitation to determine which interventions are supported by the highest quality evidence. Electronic searches were undertaken, of MEDLINE, AMED, EMBASE, EBM reviews, PEDro, Scopus, and Web of Science to identify systematic reviews of ACL rehabilitation. Two reviewers independently selected the studies, extracted data, and applied quality criteria. Study quality was assessed using PRISMA and a best evidence synthesis was performed. Five systematic reviews were included assessing eight rehabilitation components. There was strong evidence (consistent evidence from multiple high quality randomised controlled trials (RCTs)) of no added benefit of bracing (0–6 weeks post-surgery) compared to standard treatment in the short term. Moderate evidence (consistent evidence from multiple low quality RCTs and/or one high quality RCT) supported no added benefit of continuous passive motion to standard treatment for increasing range of motion. There was moderate evidence of equal effectiveness of closed versus open kinetic chain exercise and home versus clinic based rehabilitation, on a range of short term outcomes. There was inconsistent or limited evidence for some interventions. Recommendations for clinical practice are made at specific time points for specific outcomes.

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1. Introduction

Anterior cruciate ligament (ACL) injuries are common, with a reported incidence of 30 cases per 100,000 (Bacchs & Boonos, 2001). Arthroscopically assisted ACL reconstruction using a hamstring or patella-bone-tendon-bone auto-graft is the standard surgical treatment particularly for those who are unable to perform jumping and cutting manoeuvres in sports because of resulting knee instability (Gianotti, Marshall, Humeb, & Bunt, 2009). Systematic review evidence of randomised trials (RCTs) comparing hamstring and patella tendon auto-grafts reports that there is no significant difference between the grafts on a variety of post-operative outcomes, such as return to sport (RTS), pain, muscle strength, knee stability, and range of motion (ROM) (Herrington, Wrapson, Matthews, & Matthews, 2005; Magnussen, Carey, & Spindler, 2011).

There is a general consensus for the effectiveness of a post-operative ACL reconstruction rehabilitation program, however there is little consensus regarding the optimal components of a program (Risberg, Lewek, & Snyder-Mackler, 2004). The speed

with which an individual returns to their pre-injury level of sport and activity is mostly dependent on the type of rehabilitation protocol they receive (van Grinsven, van Cingel, Holla, & van Loon, 2010). Conservative approaches of six week cast immobilisation, followed by open kinetic chain (OKC) knee extensor resistive exercises, and a slow return to activity have been superseded by more aggressive approaches which emphasise earlier strength and range of motion (ROM) retraining and time to return to activity (Grodski & Marks, 2004). From a biomechanical perspective, the conservative approach conflicts with evidence of detrimental effects of suboptimal muscle “use” on joints (such as the knee) as well as immobilisation complications (Grodski & Marks, 2004). While the more aggressive approaches focussing on optimal muscle function may stress the graft and compromise joint stability the very objective of the reconstructive surgery (Heijne & Werner, 2007). Findings from a large international survey of orthopaedic surgeons’ opinions on ACL reconstruction rehabilitation protocols reflect this variation of thought with large differences in the length or immobilisation, the use of bracing, amount of physical therapy prescribed, and time to return to physical activity being reported (Cook et al., 2008). It is therefore essential to know the effective components of ACL reconstruction rehabilitation programs to inform both clinicians and policy makers.

* Corresponding author. Tel.: +64 3 479 7473; fax: +64 3 479 8414.

E-mail address: leica.claydon@otago.ac.nz (L.S. Claydon).

Clinical practice guidelines usually incorporate the results from systematic reviews as this is considered to be 'best evidence'. Systematic reviews on the topic of effective treatments for ACL reconstruction rehabilitation programmes have been published however the methodological rigour of these systematic reviews has not been evaluated using internationally recommended validated guidance. The purpose of this systematic review of systematic reviews is to critically appraise systematic reviews on ACL reconstruction rehabilitation programmes using internationally recommended assessment procedures. The aim is to determine which rehabilitation components are supported by high quality systematic reviews to be included in a post-operative ACL reconstruction rehabilitation program for a variety of outcomes including strength, ROM, pain, laxity, activity levels, and RTS.

2. Methods

2.1. Eligibility criteria

To be included the review had to meet all of the following criteria:

- Population: male or female adult participants (i.e. 16 years and older) who had a post-traumatic ACL reconstruction either by a hamstring or patella tendon auto-graft.
- Intervention: any physiotherapy intervention from the day of surgery.
- Comparison: the interventions were compared to standard treatment.
- Outcomes: pain, ROM, strength, function, Return to work (RTW), and RTS.
- Level of Evidence: systematic reviews needed to state the level of evidence for their recommendations, or provide sufficient information to allow a level of evidence grading (van Tulder, Furlan, Bombardier, & Bouter, 2003)
- Design: systematic reviews.
- Language: the article was written in English.

Exclusion Criteria was as follows:

- Population: multiple anatomical reconstructive surgeries that included ACL's (e.g.: ACL and meniscectomy-) and reviews investigating conservative physiotherapy intervention for ACL rupture.
- Interventions: pre-operative interventions.
- Comparisons: placebo and control (i.e. efficacy trials).
- Design: narrative reviews.

2.2. Information sources

Electronic literature searches were undertaken to identify all systematic reviews of ACL reconstruction rehabilitation. The MEDLINE (1966-1st Apr 2011), CINHAHL (1982-1st Apr 2011), AMED (1985-1st Apr 2011), EMBASE (1988-1st Apr 2011), EBM reviews, Cochrane Libraries, PEDro, and SCOPUS (1960-1st Apr 2011) databases were searched. Web of Knowledge (1960-Apr 2011) was also searched for any unpublished reviews. Reference lists of retrieved articles were also searched.

2.3. Search

Table 1 is an example of the search strategy performed on OVID Medline. This strategy was modified for use on the other electronic databases.

Table 1
Review of reconstruction rehabilitation.

Database search	Results
1. Anterior cruciate ligament	24,203
2. Surgery	2,102,823
3. Reconstructive surgical procedures/	76,092
4. 2 OR 3	2,118,580
5. Physiotherapy	72,601
6. Physical therapy/	45,528
7. Rehabilitation	295,863
8. Exercise therapy	32,119
9. Electrothers	7278
10. 5 OR 6 OR 7 OR 8 OR 9	383,487
11. Systematic review	89,845
12. 1 AND 4 AND 10 AND 11	45
13. Remove duplicates	38
14. Limit 13 to English language	36
15. Limit 14 to full systematic reviews	32
16. Limit 15 to humans	32

2.4. Study selection

The abstracts were screened independently by two reviewers (LC and RL); full text reports were retrieved when abstracts appeared to meet the inclusion criteria or if insufficient information was provided. The full text articles were then screened independently by the same reviewers against the eligibility criteria. If a consensus between the two reviewers could not be made regarding reviews eligibility a third reviewer (ST) was consulted.

2.5. Data collection process and data items

Two reviewers (LC and RL) independently performed data extraction with the use of a standardized form. Data concerning the number of RCTs in the review, the scope of the review, the outcomes, author's recommendations and level of evidence were collected.

2.6. Risk of bias in individual studies

Each included review was scored independently by two reviewers (LC and RL) using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher, Liberati, Tetzlaff, Altman, & The PRISMA Group, 2009). The reviewers compared their scores and discussed them until a consensus was obtained. Each review could achieve a maximum of 27 points using the PRISMA scale. No reviews were excluded based on the PRISMA score.

2.7. Synthesis of results

Review authors conclusions based on systematic reviews and/or meta-analysis were extracted for each treatment intervention. Outcomes for interventions investigated in the reviews were given a level of evidence consistent with the following criteria (van Tulder et al., 2003):

- Strong: Consistent findings among multiple high quality (HQ) RCTs.
- Moderate: consistent findings among multiple low quality RCTs and/or Clinical Control Trials (CCTs) and/or one high quality RCT.
- Limited:—one low quality RCT and/or CCT
- Conflicting:—inconsistent findings among multiple trials (RCTs and/or CCTs).

- No evidence from trials:—no RCTs or CCTs.

The level of evidence for each intervention outcome was therefore dependent on the number of RCTs and the quality of the RCTs for each intervention. This best evidence synthesis was performed to determine if the conclusions made by review authors were based on the quality of the evidence i.e. the conclusions made were consistent with the evidence reviewed.

3. Results

3.1. Study selection

Fig. 1 summarizes the study selection process. Thirty-two reviews were excluded because they did not meet the inclusion criteria. Five reviews were eligible for inclusion (Andersson, Samuelsson, & Karlsson, 2009; Kim, Croy, Hertel, & Saliba, 2010; Smith & Davies, 2007, 2008; Trees, Howe, Dixon, & White, 2005). The outcomes and methodological quality of the five reviews are reported in Table 2. A total of eight specific interventions were reported on within these five reviews: bracing, Continuous passive motion (CPM), neuromuscular electrical stimulation (NMES), open kinetic chain (OKC) versus closed kinetic chain (CKC) exercise, progressive eccentric exercise, home versus supervised rehabilitation, accelerated rehabilitation and water based rehabilitation.

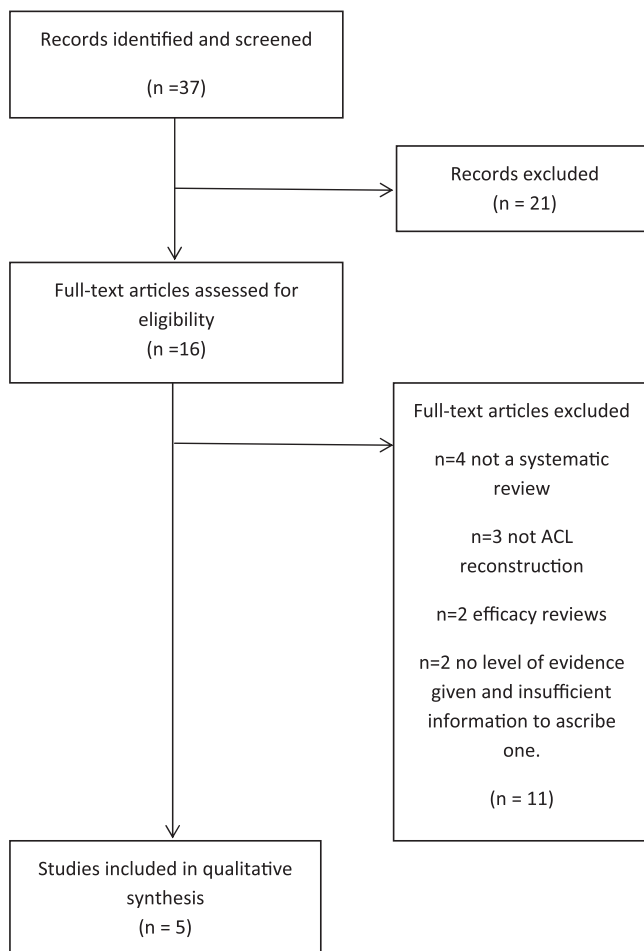


Fig. 1. Study selection process.

3.2. Levels of evidence

The strength of evidence ranged from strong evidence of no difference between interventions to limited evidence of effectiveness of an intervention. No evidence was found to strongly or moderately support a particular treatment. From reviewing the evidence the following levels of evidence can be supported:

There was strong evidence of no significant difference for:

- Bracing as an adjunct to standard treatment for ROM, strength, knee joint laxity, pain, and function (at six weeks to five years follow-up) (Andersson et al., 2009; Smith & Davies, 2008). RCTs employed accelerated rehabilitation approaches for both brace and standard treatment groups, however many RCTs lacked detail on the use of different treatments at different time points (Smith & Davies, 2008)

There was moderate evidence of no significant difference between:

- CPM and standard treatment and non-CPM and standard treatment on ROM and knee joint laxity (at one week to six months and six months to a year, respectively) (Smith & Davies, 2007). None of the RCTs detailed the standard treatment programs, these programs appeared to differ according to the weight bearing status, use of knee bracing, and progression (Smith & Davies, 2007).
- OKC and CKC strengthening exercises (for leg extensor muscles) on knee laxity, pain, and function (at 6–14 weeks) (Andersson et al., 2009). Typically OKC exercises involved leg extensor resistance training using ankle weights or machines where the foot was not planted, whereas CKC involved leg extensor training using a leg press (Andersson et al., 2009). Participants were typically permitted to do other forms of exercise such as step ups, bicycle ergometry, stretches, and proprioception exercises.
- Home based and clinic based exercise on knee laxity, ROM, strength, and function (Andersson et al., 2009) (at 6 months to 1 year). Two RCTs specified that home based exercisers had 6 physiotherapy consults and clinic based exercisers had between 24 and 40 consults; two RCTs did not specify the amount of physiotherapy input.
- Bracing and standard treatment and non-bracing and standard treatment on pain and post-operative complications at any time point (Smith & Davies, 2008)

There was limited evidence of no significant difference between:

- Bracing and standard treatment and non-bracing and standard treatment for risk of intra-articular injury (Andersson et al., 2009) and patient satisfaction (Smith & Davies, 2008)
- Bracing and standard treatment and a neoprene sleeve and standard treatment on function, and ROM (at 6 months, 1 year and 2 year follow-up) (Andersson et al., 2009)
- Accelerated (19 weeks) and non-accelerated (32 weeks) rehabilitation on function and knee laxity (at 2 years) (Andersson et al., 2009). The rehabilitation programs contained the same exercises but in the accelerated group the exercises that produced more ACL strain were started earlier (Andersson et al., 2009)
- CPM and standard treatment and non-CPM and standard treatment on radiological changes (at 6 months), function (at 6 months), muscle atrophy (at 6 weeks), and ecchymoses (at 2 weeks) (Smith & Davies, 2007)
- Water based and land based rehabilitation on strength (except knee flexion at 90°) (at 2 months) (Trees et al., 2005). At 2–8

Table 2
Summary of reviews.

Review	Quality/27 (PRISMA)	No of studies	Scope of the review/Interventions	Outcomes	Authors conclusions	Level of Evidence
Andersson et al., 2009	14	34	Rehabilitation techniques : 1) Bracing versus no brace (7 articles) 2) Early versus Delayed Rehabilitation (6 Articles) 3) Accelerated versus Non-accelerated (1 article) 4) Home based versus supervised (7 articles) 5) OKC versus CKC exercises (8 articles) 6) Early progressive eccentric exercise versus standard rehabilitation 7) Protonics device and knee brace versus knee brace (1 article), Brace at –5 compared to brace at 0 (1 article), Knee brace versus Neoprene sleeve (1 article)	'clinical tests' including: ROM, strength, laxity, Lysholm knee score, Tegner activity level, 1-leg hop test, IKDC score, pain and RTS.	1) A post-operative knee brace does not affect clinical outcome and does not reduce the risk of subsequent intra-articular injury after ACL reconstruction. Only one study used the HT graft. 2) Early versus Delayed Rehabilitation: a well-designed RCT with a follow-up of at least 1 year is needed. 3) Inconclusive whether there is a difference between an accelerated and a non-accelerated rehabilitation program. 4) Home-based and supervised clinic-based rehabilitation programs produce equal clinical outcomes in short term, however multiple methodological flaws noted in reviewed RCT's. 5) CKC exercises produce less pain and laxity and better subjective outcomes than OKC exercises after PT reconstruction. No trials that have used the HT graft. 6) Eccentric resistance training might yield better muscle function in key muscles, but further studies are required.	Level I (High quality RCT) and Level II (Low Quality RCT) for the review, no individual technique gradings given. Authors graded overall review as Level II. 1) Strong evidence no differences between brace and no brace on ROM, strength, laxity, function, and pain at 4 month to 5 years follow up. 2) Limited evidence knee brace does not reduce the risk of intra-articular injuries. Limited evidence brace at –5 compared to normal brace prevents loss of extension at 3 months.. Limited evidence no difference between a brace and a neoprene sleeve on function and ROM. 3) Inconsistent evidence regarding early versus delayed rehab at 1–2 years follow up. 4) limited evidence no significant difference between accelerated (19 weeks) and non-accelerated (32 weeks) rehabilitation on function (IKDC, hop test, Tegner), KOOS, and arthrometer at 2 year follow up. 5) Moderate evidence no significant difference between home and supervised exercise in short term on ROM, laxity, function and strength (6 months–1 year). Limited evidence of no significant difference for, Hospital for SpecialSurgery score, and thigh atrophy 6) moderate to strong evidence OKC and CKC show no significant difference ROM, Laxity, Pain, and function in short term (6–14 weeks) Limited evidence CKC significantly better outcomes of pain, laxity, subjective outcomes and RTS at 1 year. Limited evidence combination of CKC and OKC compared to CKC alone results in better strength and RTS no time points given. 7) Limited evidence 12 weeks of eccentric resistance training might yield better outcomes regarding muscle volume, quadriceps strength and function (1 leg hop test) after 1 year. 8) Limited evidence of no difference between neoprene sleeve and standard treatment on function, and ROM (at 6 months, 1 year and 2 year follow-up). Limited evidence of a significant difference between bracing at –5° and a brace at 0° preventing extension loss at 3 months.
Kim et al., 2010	18	8 RCTS	NMES versus control treatments	1) Strength, 2) Function, 3) Self-reported function	1) NMES compared to exercise alone or EMG, may result in equal to moderately positive effects on quadriceps strength during the first 4 weeks post-operatively (grade 2b evidence) 2) There is no evidence to suggest that NMES has an effect on functional performance tests. 3) NMES has a moderate effect on self-reported function compared to standard treatment at 12–16 weeks post-surgery.	1) Inconsistent evidence for strength outcomes. 2) Limited evidence for significant effects of NMES on function (lateral step, anterior reach, and squat) at 6 weeks 3) Limited evidence for significant effects of NMES on self-reported function at 12 weeks and 16 weeks.

Smith & Davies, 2007	16	8 RCT's	Standard Rx versus Standard Rx + CPM	1) joint laxity, 2) ROM, 3) function 4) radiological changes, 5) muscle atrophy, 6) ecchymoses, 7) joint position sense, 8) pain, 9) swelling, 10) blood drainage, 11) post-operative complications 12) length of hospital stay outcomes	Unclear whether the application of CPM post-operatively amongst ACL reconstruction patients is of any benefit, especially relating to 1) joint laxity, 2) ROM, 3) function, IKDC, 4) radiological changes, 5) muscle atrophy and ecchymoses 6) outcomes, 7) Significantly better joint position sense in non-CPM users at day 7. Studies assessing CPM protocols, efficacy of CPM after HT graft, functional outcomes and QOL of CPM and non-CPM groups recommended.	Moderate evidence of no significant difference for 1) joint laxity and 2) ROM. Limited evidence of no significant difference for 3) function using the IKDC, 4) radiological changes, 5) muscle atrophy after 6 weeks or 6) ecchymoses at 15 days. Limited evidence of a significantly better 7) joint position sense in the non-CPM group on day 7. Conflicting evidence regarding effects on 8) pain from 24 h to 3 days, 9) swelling at 6 weeks, 10) blood drainage within 24 h, 11) post-operative complications, and 12) length of hospital stay.
Smith & Davies, 2008	17	7 RCT's	Post operative bracing vs no post-operative bracing	1) Knee laxity, 2) dynamometry, 3) ROM, 4) function, 5) pain, 6) post-operative complications, 7) muscle bulk, 8) patient satisfaction,	No significant difference in bracing compared to no bracing in terms of 1) joint laxity, 2) isokinetic torque, 3) ROM and 4) function measured using Tegner and Lysholm scales at any point in time. Not bracing in early stages post operatively appears to provide significantly better 3) ROM and 4) functional outcomes also significantly less swelling and 7) loss of muscle bulk.	Strong evidence of no significant difference at any time point for 1) joint laxity, 2) isokinetic torque, 3) ROM, and 4) function including the Tegner scale and Lysholm scale at any time point. Moderate evidence of no significant difference at any time point for 5) pain or 6) post-operative complications. There is limited evidence for: 4) greater leg hop at 25 weeks but not at one year in the no-brace group; less swelling in the non-brace group (8 mm less) but this was not significant at 6 weeks; 7) greater decrease in muscle bulk at 3 months in the brace (7%) group at 3 months, this was not significant at follow up; 8) for no difference in patient satisfaction.
Trees et al., 2005	23	7 (after ACL reconstruction)	1) Home versus supervised Rehabilitation (3 RCTS) 2) CKC versus OKC (2 RCTS) 3) CKC versus combined CKC and OKC (1 RCT) 4) Land versus water programme (1 RCT)	RTW and pre-injury level of function were the primary outcome measures (at six months and one year) These could have included, outcome scales such as the Tegner Activity scale and Cincinnati Knee Rating System	1) No evidence of a significant difference between home and supervised exercise (at 6 months on the Lysholm score; 2 RCTS) No difference for any other outcome measures except knee ROM at weeks 18 and 24, 1 RCT) 2) CKC versus OKC trials reported no difference in knee function 6 weeks post-surgery (1 RCT), pain severe enough to restrict activity at one year (1 RCT) and knee laxity at one year (1 RCT) 3) CKC versus combined CKC and OKC return to pre-injury level of sport at 31 months more common in combined group. No difference for secondary measures of strength and knee laxity at 6 months. 4) Higher Lysholm score was observed in the water group versus the land group at 8 weeks. No difference reported in strength, except isokinetic strength which was greater in the land group.	1) Moderate evidence of no significant difference between home and supervised exercise (Lysholm score) at 6 months. Limited evidence of no significant difference for muscle strength (3 and 6 months), joint laxity (6 months) and ROM (6 and 12 weeks) 2) Limited evidence of no significant difference between CKC and OKC on function (6 weeks), patellafemoral pain and joint laxity (1 year) 3) Limited evidence of a significantly better effect of combined CKC and OKC versus CKC on return to sport at 31 months. 4) Limited evidence of a significantly better effect on function with water based exercise (8 weeks) and no difference on muscle strength (8 weeks) except 90/flexion better with land exercise.

Abbreviations: Closed kinetic chain (CKC), Electromyography (EMG), Hamstring tendon (HT), International Knee, Documentation Committee (IKDC), Knee injury and Osteoarthritis Outcome Score (KOOS), Open kinetic chain (OKC), Patella tendon (PT), Randomised Control Trial (RCT) Range of Motion (ROM), Return to Sport (RTS).

weeks post reconstruction participants completed water or land based rehabilitation, the exercises were the same (e.g., closed chain cycling, gait retraining, side steps, step ups) the only difference was the water or land (Trees et al., 2005)

There was inconsistent evidence of significant differences between:

- Early and delayed rehabilitation (time points 1–2 years) (Andersson et al., 2009). Early rehabilitation consisted of protocols such as immediate weight bearing and ROM exercises (Andersson et al., 2009).
- NMES and exercise, and exercise or EMG for strength (at 6–12 weeks) (Kim et al., 2010). NMES parameters were high frequency (30–75 Hz), long pulse duration (200–400 μ s) at an intensity to the participants maximum tolerance, details about the exercise and EMG were not provided (Kim et al., 2010).
- CPM and standard treatment and non-CPM and standard treatment for pain (at 24 h to 3 days), swelling (at 6 weeks) blood drainage (at 24 h), post-operative complications, and length of hospital stay (Smith & Davies, 2007)

There was limited evidence of a significant difference between:

- Bracing at -5° and a brace at 0° preventing extension loss at 3 months (Andersson et al., 2009)
- CKC exercises resulting in better pain, laxity, subjective outcomes and RTS than OKC at 1 year (Andersson et al., 2009)
- A combination of CKC and OKC resulting in better strength and RTS than CKC (Andersson et al., 2009; Trees et al., 2005).
- Eccentric resistance training resulting in better muscle volume, strength and function at 1 year compared to standard training (Andersson et al., 2009). The eccentric program involved a 12-week eccentric induced negative work exercise whereas the control group received standard training (Andersson et al., 2009).

- NMES and exercise, and exercise on function and self-reported function (at 6 weeks) and self-reported function (at 12 weeks) (Kim et al., 2010)
- CPM and standard treatment versus non-CPM and standard treatment for proprioception (at 1 week) (Smith & Davies 07)
- Non-bracing and standard treatment and bracing and standard treatment for leg hop (at 6 months but not a year), and swelling (at 1 week but not at 6 weeks) (Smith & Davies, 2008)
- Bracing and standard treatment and non-bracing and standard treatment on muscle bulk (at 3 months but not 6 months) (Smith & Davies, 2008)
- Water based and land based exercise on function (at 2 months) (Trees et al., 2005).

3.3. PRISMA scores

The quality rating for each item on the PRISMA is detailed in Table 3. Four out of five of the reviews scored 18 or less (out of a possible 27 marks) on the PRISMA quality checklist (Andersson et al., 2009; Kim et al., 2010; Smith & Davies, 2007, 2008); one scored 23 (Trees et al., 2005). The lower scores indicate a higher risk of bias.

1. Identify the report as a systematic review, meta-analysis, or both.
2. Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.
3. Describe the rationale for the review in the context of what is already known.
4. Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).

Table 3
PRISMA items and criteria (Moher et al., 2009). Y = YES N = NO.

PRISMA item	Andersson et al., 2009	Kim et al., 2010	Smith & Davies, 2007	Smith & Davies, 2008	Trees et al., 2005
1. Title	Y	Y	Y	Y	N
2. Abstract: structured summary	Y	Y	Y	Y	Y
3. Introduction: Rationale	Y	Y	Y	Y	Y
4. Introduction: Objectives	Y	Y	Y	Y	Y
5. Methods: protocol and registration	N	N	N	N	Y
6. Methods: eligibility criteria	N	Y	Y	Y	Y
7. Information sources	Y	Y	Y	Y	Y
8. Methods: search	Y	N	Y	N	Y
9. Methods: study selection	N	N	Y	Y	Y
10. Methods: data collection process	N	Y	N	Y	Y
11. Methods: data items	Y	Y	Y	Y	Y
12. Methods: risk of bias in individual studies	Y	Y	Y	Y	N
13. Methods: summary measures	N	Y	N	N	Y
14. Methods: synthesis of results	N	Y	N	N	Y
15. Methods: risk of bias across studies	N	N	N	N	N
16. Methods: additional analyses	N	N	N	N	Y
17. Results: study selection	N	Y	Y	Y	Y
18. Results: study characteristics	Y	Y	Y	Y	Y
19. Results: risk of bias within studies	Y	Y	Y	Y	Y
20. Results: results of individual studies	N	Y	N	N	Y
21. Results: Synthesis of results	N	Y	N	N	Y
22. Results: risk of bias across studies	N	N	N	N	N
23. Results: additional analyses	N	N	N	N	Y
24. Discussion: summary of evidence	Y	Y	Y	Y	Y
25. Discussion: limitations	Y	N	Y	Y	Y
26. Discussion: conclusions	Y	Y	Y	Y	Y
27. Funding	Y	N	N	Y	Y

5. Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provideregistration information including registration number.
6. Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.
7. Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.
8. Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.
9. State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).
10. Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.
11. List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.
12. Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.
13. State the principal summary measures (e.g., risk ratio, difference in means).
14. Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I²) for each meta-analysis.
15. Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).
16. Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.
17. Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.
18. For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.
19. Present data on risk of bias of each study and, if available, any outcome level assessment.
20. For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.
21. Present results of each meta-analysis done, including confidence intervals and measures of consistency.
22. Present results of any assessment of risk of bias across studies (see Item 15).
23. Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression).
24. Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).
25. Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).
26. Provide a general interpretation of the results in the context of other evidence, and implications for future research.
27. Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.

4. Discussion

The aim of this review was critically appraise systematic reviews on ACL reconstruction rehabilitation programmes using internationally recommended assessment procedures. A best evidence synthesis of the literature was also performed to see if review authors conclusions were consistent with the evidence reviewed. The highest levels of evidence are discussed as follows.

A strong level of evidence was reported in this review for no additional benefit of bracing compared to standard treatment for the outcomes of ROM, strength, laxity, pain, function, and RTS in the short (6 months) and longer term (2–5 years) (Andersson et al., 2009; Smith & Davies, 2008). The RCTs reported no overall significant difference between the bracing and non-bracing groups for these outcomes, when any with isolated differences in one RCT were reported they were not maintained at longer term follow-up. For both standard treatment and bracing groups RCTs employed accelerated rehabilitation; the participants had undergone patella tendon auto-graft reconstructions and in bracing groups the duration of wearing the brace ranged from 3 to 12 weeks, the most common duration was 6 weeks. The rationale for using a brace is often to promote full extension of the knee and to protect the graft from shear forces whilst the quadriceps muscles are weak (Smith & Davies, 2008). Whereas other authors rationalise that a brace may actually increase joint stiffness and muscle weakness (Smith & Davies, 2008). From the evidence reported in this review neither of these theories can be supported, as there was no difference between bracing or not on the outcomes of ROM, strength, and laxity. Given these findings the use of bracing as an adjunct to accelerated rehabilitation in a post-operative ACL rehabilitation program is not supported.

A moderate level of evidence was reported in this review for no additional benefit of CPM compared to standard treatment for knee ROM and laxity in the shorter term (6 months) (Smith & Davies, 2007). Five out of six low quality RCTs comparing the effects of CPM and standard treatment to non-CPM and standard treatment on knee ROM reported no significant difference between groups (Engström, Sperber, & Wredmark, 1995; Friemert, Bach, Schwarz, Gerngross, & Schmidt, 2006; Rigon, Viola, & Lonardo, 1993; Rosen, Jackson, & Atwell, 1992; Witherow, Bollen, & Pinczewski, 1993). Two low quality RCTs also found no difference in knee laxity between CPM and non-CPM groups (McCarthy, Buxton, & Yates, 1993; Rosen et al., 1992) CPM is often promoted as a tool for increasing outcomes such as knee ROM, however, it may be argued that it is often reserved for patients with a longer time from injury to surgery due to risk of arthrofibrosis and as these RCTs did not report time to surgery this clearly a shortcoming (Smith & Davies, 2007). This notwithstanding from the evidence reported in this review the routine use of CPM as an adjunct to standard treatment for the improvement of ROM after ACL reconstruction surgery is not supported.

Moderate evidence was reported in this review to show equal effectiveness of two types of strengthening exercise (OKC versus CKC) and the location of exercise (home versus supervised based) in the short term. CKC exercises (where the distal segment is planted on the ground where movement in one joint produces movement in other joints (Bynum, Barrack, & Alexander, 1995) are advocated during rehabilitation because they mimic functional movements used in activities of daily living and sports (Andersson et al., 2009). OKC exercises (where the distal segment is free from the ground resulting in minimal compression of joints) are believed to increase shear forces across the knee joint in the form of anterior tibial translation (Bynum et al., 1995; Markolf, Gorek, Kabo, & Shapiro, 1990). However, four RCTs comparing OKC versus CKC found no significant difference between groups for knee laxity, pain and

function in the short term (6–14 weeks) (Hooper, Morrissey, Drechsler, Morrissey, & King, 2001; Morrissey et al., 2000, 2002; Perry, Morrissey, King, Morrissey, & Earnshaw, 2005). Another review on this topic (Trees et al., 2005) provides limited evidence (one RCT) of no significant difference on function. The reason for these conflicting evidence levels between reviews (moderate versus limited) is the primary outcomes of Trees et al., 2005 were function and RTS, limiting the RCTs included in the review. The one RCT (Bynum et al., 1995) which provided limited evidence at one year of the effect of these exercises on knee laxity reports decreased KT-1000 side to side difference in favour of CKC whereas Lachman's showed no difference between groups. The evidence reported in this review therefore supports the use of either CKC (e.g. leg press) or OKC (e.g. use of ankle weights) leg extensor exercises in the short term, with further longer term RCTs (one year) being required.

Home based versus supervised based rehabilitation explores whether the quality of physiotherapy based supervised exercise is attainable in cost saving home based exercise protocols, given to patients on discharge after surgery. Moderate evidence reported in this review supports the finding that both modes of physiotherapy are equally effective as there is no difference between groups for knee laxity, ROM, strength, and function, (time points six months to one year) (Andersson et al., 2009). Again, conflict appears between two reviews on the levels of evidence for some outcomes due to the primary outcomes of one review (Trees et al., 2005) being function and RTS, limiting the number of RCTs in that review. It is unclear; however, what home based rehabilitation consists of. Several of the RCTs (Fischer, Tewes, Boyd, & Smith, 1998; Schenck, Blaschak, Lance, Turturro, & Holmes, 1997) indicated that home based rehabilitation groups received six physiotherapy consultations whereas clinic based rehabilitation received 24–40 consultations; other RCTs omitted this information (Beard & Dodd, 1998; Ugutmen et al., 2008). The lack of clarity surrounding the amount of physiotherapy input with home based rehabilitation is important when considering the evidence that a home based exercise programme is equally effective as a clinic based programme.

This review uses methodology which adheres to procedures outlined in accordance with international guidance on the conduct and reporting of systematic reviews (Moher et al., 2009). Recent research has shown that non-Cochrane systematic reviews are more than twice as likely to have positive conclusion statements compared to Cochrane reviews (Tricco, Tetzlaff, Pham, Brehaut, & Moher, 2009) indicating bias against negative or inconclusive results. The use of a level of evidence synthesis (van Tulder et al., 2003) in this current review permitted the strength of the evidence for a particular intervention to be determined. This clarified instances where author's conclusions contrasted the evidence contain within the systematic review or with other systematic reviews. However, while the level of evidence synthesis is based on the quality and number of RCTs conducted on a particular topic it is recognised that no criteria is included regarding statistical power. This is a limitation of the tool as a statistically powered study may achieve the same level of grading as a study that is not powered. The methodological rigour of a review is limited by the evidence within it. It is acknowledged that systematic reviews contained within this review did not score very highly on the PRISMA, with one exception (Trees et al., 2005). It is therefore plausible that not all RCTs relating to the interventions under investigation were included in the systematic reviews. Also one systematic review only reported RCT's as level II evidence and did not indicate the quality of the RCT's (Andersson et al., 2009). Therefore some of the RCTs may well have been high quality but we were unable to distinguish which. Therefore the best level of evidence we could extract from that paper was a moderate level of evidence. Finally, it is

acknowledged that a language restriction was imposed on this review to RCTs in English, which may have introduced a language bias (Egger et al., 1997).

5. Conclusion

This review reports strong evidence of no added benefit of bracing after ACL reconstruction (0–6 weeks post-surgery) as an adjunct to standard treatment in the short term, its use is therefore not recommended. Moderate evidence was found of no added benefit of CPM to standard treatment for routine use after ACL reconstruction with the aim of increasing knee range of motion. Moderate evidence indicates that CKC and OKC are as effective as each other for knee laxity, pain and function, at least in the short term (6–14 weeks) after ACL reconstruction. Moderate evidence shows home based and clinic based rehabilitation are equally effective; however the degree of physiotherapy input remains unclear. There is consistency and limiting evidence for a lot of other interventions including: the use of NMES and exercise, accelerated and non-accelerated rehabilitation, early and delayed rehabilitation, and eccentric resistance programmes after ACL reconstruction. These specific interventions require further investigation.

Conflict of interest

I affirm that I have no financial affiliation (including research funding) or involvement with any commercial organization that has a direct financial interest in any matter included in this manuscript.

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