Physical Therapy Reviews

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/yptr20

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To cite this article: Wayne A. Fausett, Duncan A. Reid & Peter J. Larmer (2023): The relationship between the quantity and duration of post-operative physiotherapy treatment and patient outcomes following primary anterior cruciate ligament reconstruction: a systematic review, Physical Therapy Reviews, DOI: 10.1080/10833196.2023.2195213

To link to this article: https://doi.org/10.1080/10833196.2023.2195213

Published online: 30 Mar 2023.

PHYSICAL THERAPY REVIEWS
https://doi.org/10.1080/10833196.2023.2195213

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The relationship between the quantity and duration of post-operative physiotherapy treatment and patient outcomes following primary anterior cruciate ligament reconstruction: a systematic review

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ABSTRACT

Background: Functional rehabilitation following anterior cruciate ligament reconstruction (ACLR) is often physiotherapist-led, and generally required to achieve patient goals. The quantity and duration of physiotherapist-led following could therefore potentially influence outcomes following ACLR, although the nature of this relationship is not clear.

Objective: To clarify the relationship between the quantity and duration of post-operative physiotherapy treatment and patient outcomes following ACLR.

Methods: A search of the PubMed/MEDLINE, Google Scholar, Cochrane Library, and EBSCO databases was made from inception to March 2021 to identify relevant studies. Key characteristics of the selected studies were extracted, with methodological quality evaluated using a modified version of the Downs and Black appraisal tool.

Results: The search strategy identified 1137 studies, 15 of which met inclusion criteria. Two studies were rated strong methodological quality, eight were rated moderate, and five were rated limited. Results across all 15 studies provided conflicting evidence regarding the effects of the quantity and duration of physiotherapy treatment on patient outcomes following ACLR.

Conclusions: Based on evidence of variable methodological quality, a clear relationship between the quantity and duration of physiotherapy treatment and patient outcomes following ACLR could not be established. Several themes were identified to guide future research in this area, including ensuring participant homogeneity, monitoring participant adherence to unsupervised rehabilitation, and utilising rehabilitation interventions that replicate everyday physiotherapy practice.

ARTICLE HISTORY
Received 26 October 2021
Accepted 11 March 2023

KEYWORDS
ACL; Physiotherapy; outcomes; rehabilitation

Introduction

An anterior cruciate ligament (ACL) rupture is a devastating injury leading to a loss of structural knee stability and reduced functional ability in the short term, and decreased activity levels and an increased risk of knee osteoarthritis in the long-term [1–3]. The optimal management of an ACL rupture remains elusive, with multiple factors influencing whether the injury is managed conservatively or surgically [4]. ACL reconstruction (ACLR) is often considered necessary to reduce subsequent episodes of knee instability, permit a return to pre-injury activities, and preserve long-term knee joint health [5–7]. Despite increased knowledge of how to prevent ACL injuries [8], acceptable outcomes with conservative management [9], and a high incidence of subsequent ACL injury after ACLR [10], rates of ACLR have increased significantly in recent years [11–13].

Multiple factors can influence patient outcomes following ACLR, including, but not limited to, age, gender, concomitant injury, time from injury to surgery, and post-injury/ACLR rehabilitation [14–17]. Post-ACLR rehabilitation typically involves a significant functional component [18], although may also include psychological and vocational elements [19, 20]. The functional component typically includes exercises and activities to re-establish knee joint mobility, rebuild muscle strength, and optimise neuromuscular control [21, 22], followed by a graduated return to pre-injury activities [23].

With evidence-based clinical knowledge in rehabilitation and exercise therapy [24], physiotherapists possess the requisite skills to lead the functional component of an ACLR rehabilitation programme [25, 26]. Following ACLR, the quantity and duration of physiotherapy treatment is associated with an increased rate of return to sport [27–29], a decreased re-injury risk [30], greater self-reported knee function [31], and better performance

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on functional and clinical tests [17, 32]. Results are equivocal however, with studies also reporting the quantity and duration of post-ACLR physiotherapy treatment has no effect on knee strength [33], patient-reported outcomes [34], and re-injury rates [35].

Numerous patient reported outcome measures (PROMs) have been developed to evaluate outcomes following knee injury [36], with over 50 related to the ACL deficient knee alone [37]. PROMs provide an objective measure of an individual's subjective perception in relation to their functional status [38, 39]. The increasing use of PROMs to assess patient outcomes has realised the following benefits: increased patient-centred care, greater ability to establish treatment value, and improved patient outcomes [40]. Factors associated with superior patient reported outcomes following ACLR include younger age, male sex, not smoking, receiving a hamstring tendon autograft, and the absence of concomitant injuries [15].

Although physiotherapist-led rehabilitation following ACLR can have a positive effect on patient outcomes [41], the optimal dosage of post-ACLR physiotherapy treatment is currently unknown [42]. It is also not clear how the quantity and duration of post-ACLR physiotherapy treatment influences patient outcomes [43]. Therefore, the aim of this review is to determine the relationship between the quantity and duration of post-operative physiotherapy treatment and patient reported outcomes following primary ACLR.

Methods

Registration

This review was registered on 1/4/21 with the PROSPERO International Register for Systematic Reviews. The ID for this review is: CRD42021240112.

Information sources

Following advice from an experienced university librarian, a literature search was undertaken by the primary investigator (identifier removed for review process) using electronic databases accessible *via* the Auckland University of Technology library. Pubmed/MEDLINE, Google Scholar, Cochrane Library, Sportdiscus, AMED, and CINAHL were searched from inception to March 2021. Search terms used included: patient reported outcome measures, outcome, physiotherapy, "physical therapy", rehabilitation, ACL, "anterior cruciate ligament", "anterior cruciate ligament reconstruction", duration, quantity, supervis*, unsupervis*, "home based". Boolean operators were used to combine search terms. An example of the search strategy for PubMed is shown in Figure 1. Only full text studies published in English were selected. Reference lists of included studies were searched to identify any eligible studies that may have been missed during database searches.

Eligibility criteria

The following inclusion criteria were applied to select primary research studies relevant to the aim of this review:

1. Randomised controlled trials and non-randomised prospective cohort studies.
2. Participants had undergone primary ACLR.
3. Participants had received post-operative physiotherapy treatment.
4. Validated outcome data recorded prior to, and at the conclusion of, post-ACLR rehabilitation.

Studies were excluded if they met one of the following criteria:

1. Retrospective designs, single case studies, abstracts, and expert reviews.
2. Participants underwent revision ACLR.
3. The dosage of post-ACLR physiotherapy treatment could not be quantified.
4. Participants were less than 18 years of age.
5. Participants had significant concomitant knee injury e.g. multi-ligament rupture, fracture, joint dislocation.

Study selection and data collection

Once databases searches were complete, all results were either included or excluded for review in accordance with the PRISMA study selection process for systematic reviews [44]. After duplicates were removed, titles and abstracts of remaining studies were screened for relevance by one reviewer (WF). The full texts of articles that appeared relevant to the aim of the review were retrieved and independently screened by two reviewers (WF and DR). with inclusion and exclusion criteria subsequently applied. Any discrepancies regarding study selection were resolved by consensus discussion, with involvement of a third researcher (PL) if required.

Data was extracted from the selected studies by the lead author (identifier removed for review process) and tabulated under the following headings: (1) study type, (2) participant demographics, (3)

Search	Actions	Details	Query	Results
#21	•••	›	Search: **#11 AND #12 AND #13 AND #19 AND #20** Sort by: **Publication Date**	10
#20	•••	›	Search: **#16 OR #17 OR #18** Sort by: **Publication Date**	94,629
#19	•••	›	Search: **#1 OR #15** Sort by: **Publication Date**	1,973,391
#18	•••	›	Search: **"home based"[Title/Abstract]** Sort by: **Publication Date**	12,223
#17	•••	›	Search: **unsupervis*[Title/Abstract]** Sort by: **Publication Date**	14,364
#16	•••	›	Search: **supervis*[Title/Abstract]** Sort by: **Publication Date**	73,274
#15	•••	›	Search: **outcome*[Title/Abstract]** Sort by: **Publication Date**	1,973,391
#14	•••	›	Search: **#1 AND #11 AND #12 AND #13** Sort by: **Publication Date**	0
#13	•••	›	Search: **#9 OR #10** Sort by: **Publication Date**	725,572
#12	•••	›	Search: **#6 OR #7 OR #8** Sort by: **Publication Date**	26,002
#11	•••	›	Search: **#3 OR #4 OR #5** Sort by: **Publication Date**	217,454
#10	•••	›	Search: **quantity[Title/Abstract]** Sort by: **Publication Date**	91,189
#9	•••	›	Search: **duration[Title/Abstract]** Sort by: **Publication Date**	637,769
#8	•••	›	Search: **"anterior cruciate ligament reconstruction"[Title/Abstract]** Sort by: **Publication Date**	7,687
#7	•••	›	Search: **"anterior cruciate ligament"[Title/Abstract]** Sort by: **Publication Date**	20,602
#6	•••	›	Search: **ACL[Title/Abstract]** Sort by: **Publication Date**	18,283
#5	•••	›	Search: **rehabilitation[Title/Abstract]** Sort by: **Publication Date**	183,432
#4	•••	›	Search: **"physical therapy"[Title/Abstract]** Sort by: **Publication Date**	23,256
#3	•••	›	Search: **physiotherapy[Title/Abstract]** Sort by: **Publication Date**	22,070
#1	•••	›	Search: **"patient reported outcome measures"[Title/Abstract]** Sort by: **Publication Date**	6,433

Figure 1. Example of the search strategy for PubMed.

intervention, (4) control, (5) outcome measures, (6) results.

Risk of bias assessment

Included studies were independently analysed by two reviewers (identifiers removed for review process) using a modified Downs and Black checklist. Any discrepancies were resolved *via* collective scientific debate, which included a third reviewer if necessary (identifier removed for review process). The modified Downs and Black checklist consists of 27 questions, with a maximum possible score of 28 points. The lower the overall score, the lower the methodological quality of the study. There are 4 sections, which look at reporting (x/11), external validity (x/3), internal validity (bias) (x/7) and internal validity–confounding (selection bias) (x/6) of a study. The final question relates to the overall power of the study (x/1). As utilised in previous systematic reviews [45, 46], the last question was modified from the original version, which had a score out of five, to a score out of one, with one point being awarded if a calculation of the study's power was included. As per previous systematic reviews [45, 46], a quality index was calculated, with studies rated as having strong, moderate, limited, or poor methodological quality (Table 1).

Results

Study selection

The literature search identified 1137 records, with 15 studies meeting the inclusion criteria (Figure 2). Physiotherapy treatment data was then extracted from the 15 studies, which were divided into two groups – studies reporting the effects of the *Quantity* of post-ACLR physiotherapy treatment on patient outcomes ($n = 11$), and studies reporting the

Table 1. Quality index scores.

Total score modified Downs and Black checklist (/28)	Percentage of total score	Quality Index
21+	75%+	Strong
14–20	50–74%	Moderate
7–13	25–49%	Limited
<7	<25%	Poor

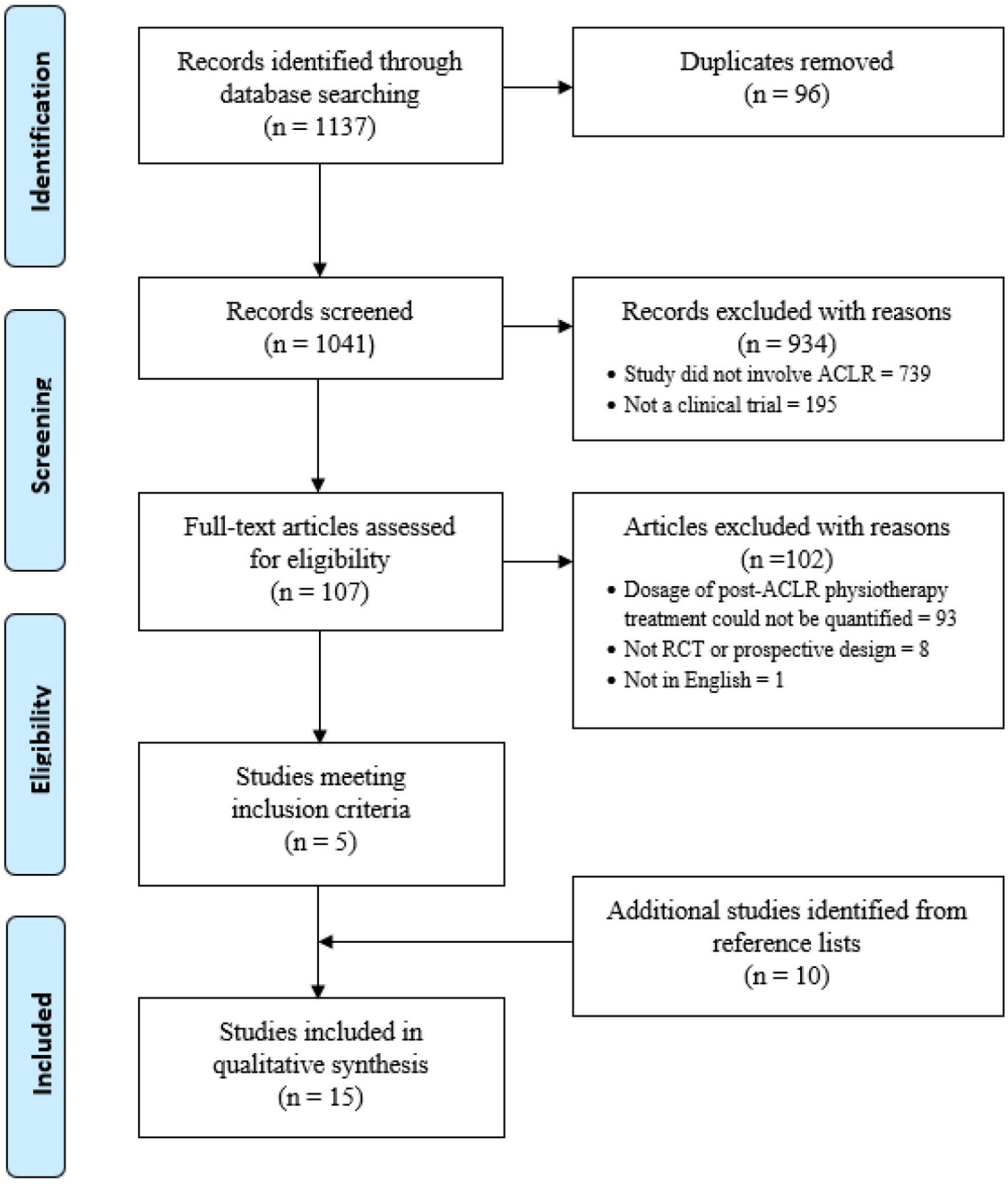

Figure 2. PRISMA flow diagram of study selection process.

effects of the *Duration* of post-ACLR physiotherapy treatment on patient outcomes ($n = 4$).

Study characteristics

The 11 *Quantity* studies consisted of nine randomised controlled trials (RCTs) and two prospective cohort studies (Table 2). The four *Duration* studies consisted of two RCTs and two prospective cohort studies (Table 3).

Participants

For *Quantity* studies, participant numbers ranged from 26 [47, 48] to 145 [49], with the total number of participants being 651 (30% female) (Table 2). The average age of participants across the 22 study groups was 28 years (range 21–39 years). Eight of 11 *Quantity* studies reported an average time between ACL injury and ACLR, which ranged from less than 12 weeks to 52 months, with one study reporting up

Table 2. Characteristics of selected studies reporting the effects of the quantity of physiotherapy treatment on patient outcomes following ACLR.

Author/Study Type	Participant Demographics	Intervention	Control	Outcome Measures	Results	Downs and Black Quality Assessment
(Schenck et al.. 1997) Randomised controlled trial	All subjects underwent arthroscopic bone-patella tendon-bone ACLR Average age of all subjects = 24 Subject activity level = Recreational athletes Time from ACL injury to ACLR = not stated Subjects: *N* = 37 (9 female) Clinic-based rehabilitation group *N* = 15 Home-based rehabilitation group *N* = 22	Clinic-based group Completed clinic-based functional rehabilitation Average number of PT treatments = 14 (range 6-40) Home-based group Completed an exercise-based functional program, monitored by a PT as required Average number of PT treatments = 3 (range 0-6)	None	1. Knee joint ROM 2. Knee joint laxity 3. Lysholm score 4. VAS pain scale 5. Sickness Impact Profile questionnaire 6. Single-leg hop for distance Average follow-up was 21.6 months (range 12 to 48 months)	No difference between Home-based rehabilitation versus Clinic-based rehabilitation for all outcomes	Total score x/28 = 8 Quality Index = 29% Quality Index Category = Limited
(Beard & Dodd, 1998) Randomised controlled trial	All subjects underwent arthroscopic bone-patella tendon-bone ACLR Subject activity level = not stated Home-based rehabilitation group *N* = 13 (3 female) Average age at ACLR = 27 Average time from ACL injury to ACLR = 47 months Supervised rehabilitation group *N* = 13 (2 female) Average age at ACLR = 29 Average time from ACL injury to ACLR = 52 months	All subjects completed same rehabilitation for first 4-6 weeks post-ACLR, then randomised to either Supervised or Home-based rehabilitation group Supervised group Performed an identical programme to the Home-based group, but also attended a supervised PT-led exercise class twice weekly. Median number of classes attended = 16 (range 10-22) out of a possible 32 Home-based group Performed rehabilitation exercises either at home or using commercial/private facilities. Attended the PT department for assessment, education, modification, and	None	1. IKDC score 2. Lysholm score 3. Tegner activity score 4. VAS for sports participation and activities of daily living 5. Isokinetic strength of the thigh muscles 6. Passive anterior sagittal translation of the knee joint Outcome measures recorded pre-ACLR, and 3- and 6-months post-ACLR	No difference between Home-based rehabilitation versus Supervised rehabilitation for all outcomes	Total score x/28 = 20 Quality Index = 71% Quality Index Category = Moderate

(*continued*)

Table 2. Continued.

Author/Study Type	Participant Demographics	Intervention	Control	Outcome Measures	Results	Downs and Black Quality Assessment
		progression of rehabilitation programme				
(Fischer et al.. 1998) Randomised controlled trial	All subjects underwent arthroscopic bone-patella tendon-bone ACLR. Time from ACL injury to ACLR for all subjects ranged from 1.5 to 216 months Subject activity level = not stated Home-based rehabilitation group *N* = 27 (11 female) Average age at ACLR = 32 Clinic-based rehabilitation group *N* = 27 (14 female) Average age at ACLR = 27	Home-based group Prescribed 6 PT treatments in the first 12 weeks post-ACLR – subjects averaged 5 (range 3-7) PT treatments Clinic-based group Subjects averaged 20 (range 10-28) PT treatment sessions	None	6/12/24 weeks Knee ROM Thigh girth Manual tests for knee stability Knee joint laxity 12/24 weeks Lysholm score 24 weeks Hop test battery (1 -leg hop for distance, timed 6-metre hop, triple hop for distance, triple slalom hop for distance) HSQ	No difference between Home-based rehabilitation versus Clinic-based rehabilitation for all outcomes	Total score x/28 = 17 Quality Index = 61% Quality Index Category = Moderate
(Grant et al.. 2005) Randomised controlled trial	All subjects underwent arthroscopic bone-patella tendon-bone ACLR Subject activity level = not stated Home based rehabilitation group *N* = 73 (26 female) Average age at injury = 26 Average time from ACL injury to ACLR = 17 months Supervised rehabilitation group *N* = 72 (34 female) Average age at injury = 26 Average time from ACL injury to ACLR = 20 months	Home-based group Subjects averaged 3 ± 1 (range 0-8) PT treatment sessions following ACLR Supervised group Subjects averaged 14 ± 4 (range 2-20) PT treatment sessions following ACLR	None	1. ACL-QOL questionnaire 2. Knee joint ROM 3. Knee joint ROM during walking 4. Knee joint laxity 5. Isokinetic quadriceps and hamstrings strength All outcome measures recorded 6- and 12-weeks post-ACLR	Higher percentage of patients in Home-based rehabilitation group recorded acceptable knee joint ROM at 12-week follow up No difference between Home-based rehabilitation versus Supervised rehabilitation for ROM during walking, joint laxity, and knee strength at 12-week follow-up	Total score x/28 = 25 Quality Index = 89% Quality Index Category = Strong
(Ugutmen et al.. 2008) Randomised controlled trial	All subjects underwent arthroscopic ACLR with hamstring graft Gender Male = 103 Female = 1	All subjects received weekly instruction on exercises for 6 weeks post-ACLR Home-based group Subjects seen 14 times by physiotherapists and the	None	1. Hospital of Special Surgery score 2. IKDC score 3. Lysholm score 4. Thigh atrophy 5. Knee joint laxity 6. Knee joint ROM	No difference between Home-based rehabilitation versus Clinic-based rehabilitation for all outcomes	Total score x/28 = 10 Quality Index = 36% Quality Index Category = Limited

(*continued*)

Table 2. Continued.

Author/Study Type	Participant Demographics	Intervention	Control	Outcome Measures	Results	Downs and Black Quality Assessment
	Average age of all subjects = 31.5 years Average time between ACL injury and ACLR for all subjects = 34.3 months (range 2-144 months) Subject activity level = not stated Home-based rehabilitation group *N* = 52 Clinic-based rehabilitation group *N* = 52	orthopaedic surgeon for physical examination and measurements Clinic-based group Number of PT treatments not stated		7. Clinical tests for knee stability 8. VAS pain scale Average follow-up time = 31.1 months (range 12-66 months).		
(Revenäs et al.. 2009) Randomised controlled trial	Subjects underwent arthroscopic bone-patella tendon-bone or hamstring tendon ACLR Guided Therapy group *N* = 27 (11 female) Average age = 24 (16-40) Subjects with pre-injury Tegner score 9-10 = 52% Average time from ACL injury to ACLR = 22 months (range 4-177) Knee Class group *N* = 24 (7 female) Average age = 21 (16-39) Subjects with pre-injury Tegner score 9-10 = 67% Average time from ACL injury to ACLR = 9 months (range 3-44)	Guided Therapy group Individual rehabilitation programme at least 2 x weekly, from 7-24 weeks post-ACLR, with PT review as required Median number of PT visits = 3 (range 0-8) Knee Class group Individual rehabilitation programme at least 2 x weekly, plus PT-led Knee Class 2 x weekly from 7-24 weeks post-ACLR Median number of Knee Class visits = 15 (range 13-36)	None	1. IKDC score 2. Lysholm score 3. Tegner activity score 4. Isometric quadriceps strength 5. Single leg hop for distance 6. Knee joint ROM Outcome measures recorded 6- and 12-months post-ACLR	Guided Therapy rehabilitation group reported higher Lysholm score at 6-month follow-up Guided Therapy rehabilitation group reported greater increase in Lysholm score at 12-month follow-up Knee Class rehabilitation group reported higher Tegner activity score at 12-month follow-up Non-compliant subjects in Knee Class rehabilitation group reported greater change in Lysholm score than compliant subjects	Total score x/28 = 20 Quality Index = 71% Quality Index Category = Moderate
(Grant & Mohtadi, 2010) Randomised controlled trial	All subjects underwent arthroscopic bone-patella tendon-bone ACLR Subject activity level = not stated	Home-based group Subjects averaged 3 ± 1 (range 0-8) PT treatment sessions following ACLR Supervised group	None	1. ACL-QOL questionnaire 2. IKDC score 3. Knee joint ROM 4. Knee joint laxity	Home-based rehabilitation group reported significantly higher ACL-QOL scores No difference between	Total score x/28 = 26 Quality Index = 93% Quality Index Category = Strong

(*continued*)

Table 2. Continued.

Author/Study Type	Participant Demographics	Intervention	Control	Outcome Measures	Results	Downs and Black Quality Assessment
	Home based rehabilitation group *N* = 40 (13 female) Average age at injury = 26 Average time from ACL injury to ACLR = 17 months Supervised rehabilitation group *N* = 48 (25 female) Average age at injury = 26 Average time from ACL injury to ACLR = 20 months	Subjects averaged 14 ± 4 (range 2-20) PT treatment sessions following ACLR		5. Isokinetic quadriceps and hamstrings strength Outcome measures recorded at an average of 38 months (range 26-52) post-ACLR	Home-based rehabilitation versus Supervised rehabilitation for IKDC score, ROM, joint laxity, or quadriceps and hamstrings strength	
(Hohmann et al.. 2011) Randomised controlled trial	All subjects underwent arthroscopic bone-patella tendon-bone ACLR Subject activity level = "physically active" Supervised rehabilitation group *N* = 20 (4 female) Average age at injury = 28 Average time from ACL injury to ACLR = <3 months Home based rehabilitation group *N* = 20 (6 female) Average age at injury = 27 Average time from ACL injury to ACLR = <3 months	Supervised group Prescribed 18 PT sessions following ACLR Home-based group Subjects given handout with rehabilitation protocol following ACLR, with no PT sessions prescribed.	None	1. Lysholm score 2. Tegner activity score 3. Isokinetic quadriceps and hamstring strength 4. Hop test battery (single hop for distance, timed hop and vertical jump) All outcome measures recorded pre-ACLR, then 3-, 6-, 9-, and 12-months post-ACLR	Home-based rehabilitation group recorded greater isometric knee extensor strength at 3-month follow-up Supervised rehabilitation group recorded greater isokinetic knee extensor strength at 6-month follow-up No difference between Home-based rehabilitation versus Supervised rehabilitation for Lysholm score, Tegner activity score, and hop test battery.	Total score x/28 = 19 Quality Index = 68% Quality Index Category = Moderate
(Lim et al.. 2019) Randomised controlled trial	All subjects underwent arthroscopic ACLR with hamstring graft Subject activity level = not stated Supervised rehabilitation group *N* = 15 (5 female) Average age = 32 Average time from ACL injury to ACLR = >3 months Home based rehabilitation group *N* = 15 (6 female)	Supervised group Prescribed 44 PT-supervised rehabilitation sessions post-ACLR. No home-based exercises performed Home-based group Advised to complete rehabilitation exercises twice per week following ACLR. Weekly follow-up with physiotherapist *via* phone	None	1. Isokinetic quadriceps and hamstring strength 2. Proprioception (Biodex Stability System) Outcome measures recorded pre-ACLR and 24 weeks post-ACLR	No difference between Home-based rehabilitation versus Supervised rehabilitation for quadriceps and hamstring strength Supervised rehabilitation group recorded increase in proprioception	Total score x/28 = 18 Quality Index = 64% Quality Index Category = Moderate

(*continued*)

Table 2. Continued.

Author/Study Type	Participant Demographics	Intervention	Control	Outcome Measures	Results	Downs and Black Quality Assessment
	Average age = 39 Average time from ACL injury to ACLR = >3 months					
(Przybylak et al.. 2019) Prospective cohort – non-randomised	Hamstring tendon ACLR *N* = 39 Bone-patella tendon-bone ACLR *N* = 11 Subject activity level = Amateur recreational athletes Supervised rehabilitation group *N* = 25 (7 female) Average age = 34 Average time from ACL injury to ACLR = >6 months Home-based rehabilitation group *N* = 25 (6 female) Average age = 27 Average time from ACL injury to ACLR = >6 months	Supervised group Prescribed 46 PT-supervised rehabilitation sessions following ACLR Home-based group Prescribed 5 PT-supervised rehabilitation sessions following ACLR	None	1. Kujala Anterior Knee Pain Questionnaire 2. Tegner activity score 3. KOOS 4. Knee joint ROM 5. Functional Movement Screen Outcome measures recorded pre-ACLR and 12-months post-ACLR	Supervised rehabilitation group reported greater increases in the KOOS Symptoms, QoL, and Sport subscales, Tegner score, and Functional Movement Screen score	Total score x/28 = 13 Quality Index = 46% Quality Index Category = Limited
(Rhim et al.. 2021) Prospective cohort – non-randomised	All subjects underwent arthroscopic ACLR with hamstring graft Subject activity level = not stated Time from ACL injury to ACLR = not stated Supervised rehabilitation group *N* = 13 (3 female) Average age = 27 years Home-based rehabilitation group *N* = 13 (4 female) Average age = 29 years	Supervised group Subjects received 12 PT treatments in the first 12 weeks post-ACLR, then bi-weekly treatments at the discretion at the PT for an unspecified duration Home-based group Subjects received instruction on post-ACLR rehabilitation exercises as an in-patient, and then underwent PT review at 2, 6, 12, and 24 weeks post-ACLR	None	1. Isokinetic quadriceps and hamstring strength 2. Dynamic postural stability (Biodex Stability System) 3. Lysholm score All outcome measures recorded pre-ACLR, and 6- and 12-months post-ACLR	Supervised rehabilitation group recorded greater hamstring strength at 12-month follow-up Supervised rehabilitation group demonstrated greater postural stability at 6- and 12-month follow-up Supervised rehabilitation group reported higher Lysholm scores at 12-month follow-up	Total score x/28 = 17 Quality Index = 61% Quality Index Category = Moderate

Abbreviations: ACLR = anterior cruciate ligament reconstruction; VAS = visual analogue scale; IKDC = International Knee Documentation Committee; PT = physiotherapy/ist; KOOS = Knee Injury and Osteoarthritis Outcome Score; ROM = range of motion; QOL = quality of life; VAS = visual analogue scale; HSQ = Health Status Questionnaire.

to an 18-year interval between ACL injury and ACLR for some participants [50].

For *Duration* studies, participant numbers ranged from 22 [51] to 60 [52], with the total number of participants being 173 (14% female) (Table 3). The average age of participants across the 10 study groups was 28 years (range 23–35 years). The average time from ACL injury to ACLR ranged from 56 days to 33 weeks, with one study not reporting the time between ACL injury and ACLR [53].

No *Quantity* study reported an objective measure of pre-injury activity level for participants. Two of four *Duration* studies reported a pre-injury activity level for participants, with Tegner Activity Scale score ranging from five to eight [51, 52].

Interventions

Rehabilitation interventions for the *Quantity* studies are summarised in Table 2. The average number of post-ACLR physiotherapy treatments for the lesser treatment groups was 3 (range 0-14). Four studies did not clearly report the duration of physiotherapy treatment for the lesser treatment group. The average number of post-ACLR physiotherapy treatments for the greater treatment groups was 21 (range 12-46).

Rehabilitation interventions for the *Duration* studies are summarised in Table 3. Post-ACLR physiotherapy treatment duration across all study groups ranged from 8 to 19 weeks for shorter duration groups and from 27 to 32 weeks for longer duration groups. In both studies by Beynnon and colleagues, where participants in the 19- and 32-week groups completed the same rehabilitation programme, the 19-week group completed the same volume of rehabilitation in a shorter time [51, 54]. In both studies by Królikowska and colleagues, participants in the shorter duration groups elected to discontinue physiotherapist-supervised rehabilitation but were advised to continue with home-based rehabilitation [52, 53].

Controls

None of the 11 *Quantity* studies included a control group, with all studies comparing results between groups of participants receiving different quantities of post-ACLR physiotherapy treatment (Table 2). Two *Duration* studies included a control group where participants had not undergone ACLR and received no rehabilitation, with two studies comparing results between groups of participants undergoing post-ACLR physiotherapy treatment of different durations (Table 3).

Methodological quality

The methodological quality and Quality Index (% and categorisation) of the *Quantity* and *Duration* studies are presented as tables in Appendices 1 and 2 respectively. For *Quantity* studies, the average quality score was 17/28 (range 8-26), with an average Quality Index of 63% (range 21-93%). Regarding methodological quality, two studies rated 'strong', six rated 'moderate', and three rated 'limited'. Scores ranged from 3-11/11 in the Reporting section, from 0-3/3 in the External Validity section, from 2-6/7 in the Internal Validity (Bias) section, and from 1-6/6 in the Internal Validity (Confounding) section. Only six of 11 *Quantity* studies reported a power analysis.

For *Duration* studies, the average score was 15/28 (range 10-20), with an average Quality Index of 53.5% (range 36-71%). Two studies rated 'moderate' methodological quality and two rated 'limited' methodological quality. Scores ranged from 8-10/11 in the Reporting section, from 0-1/3 in the External Validity section, from 3-5/7 in the Internal Validity (Bias) section, and from 2-6/6 in the Internal Validity (Confounding) section. Two of four *Duration* studies reported a power analysis.

Outcomes

A wide range of patient-reported, clinical, and functional outcome measures were used in the *Quantity* studies (Table 2). For patient-reported outcome measures, two studies reported a positive effect for a greater quantity of physiotherapy treatment [48, 55], one study reported a positive effect for a lesser quantity of treatment [56], and one study reported a positive effect for both greater and lesser quantities of physiotherapy treatment [57]. For clinical outcome measures, two studies reported a positive effect for a greater quantity of physiotherapy treatment [48, 58], one study reported a positive effect for less treatment [49], and one study reported a positive effect for both greater and lesser quantities of physiotherapy treatment [59]. For functional outcome measures, two studies reported a positive effect for a greater quantity of physiotherapy treatment [48, 55]. Four studies reported the quantity of post-ACLR physiotherapy treatment had no significant effect on any outcome measure [47, 50, 60, 61]. Average follow up periods across all *Quantity* study groups ranged from 12 weeks [49] to 38 months [56].

A range of patient-reported, clinical, and functional outcome measures were also used in the *Duration* studies (Table 3). The duration of post-ACLR physiotherapy treatment had no effect on patient-reported outcome measures (IKDC, KOOS,

Table 3. Characteristics of selected studies reporting the effects of the duration of physiotherapy treatment on patient outcomes following ACLR.

Author/Study Type	Participant Demographics	Intervention	Control	Outcome Measures	Results	Downs and Black Quality Assessment
(Beynnon et al.. 2005) Randomised controlled trial	All subjects underwent arthroscopic bone-patella tendon-bone ACLR. Subject activity level = Moderately active (Pre-injury Tegner score = ≥5) Accelerated rehabilitation group *N* = 10 (5 female) Average age at ACLR = 30 Average time from ACL injury to ACLR = 91 days Non-accelerated rehabilitation group *N* = 12 (6 female) Average age at ACLR = 35 Average time from ACL injury to ACLR = 124 days	Both groups attended supervised rehabilitation sessions with a PT 3x/week and performed home exercises on other days Both rehabilitation programmes included the same exercises/activities Accelerated group Post-ACLR rehabilitation lasted 19 weeks Non-accelerated group Post-ACLR rehabilitation lasted 32 weeks	None	1. IKDC score 2. KOOS 3. Tegner activity score 4. Knee joint laxity 5. Single leg hop for distance Outcome measures recorded at 3-, 6-, 12- and 24-months post-ACLR	No difference between Accelerated rehabilitation versus Non-accelerated rehabilitation for all outcomes	Total score x/28 = 19 Quality Index = 68% Quality Index Category = Moderate
(Beynnon et al.. 2011) Randomised controlled trial	All subjects underwent arthroscopic bone-patella tendon-bone ACLR. Subject activity level = not stated Accelerated rehabilitation group *N* = 19 (6 female) Average age at ACLR = 30 Average time from ACL injury to ACLR = 56 days Non-accelerated rehabilitation group *N* = 17 (8 female) Average age at ACLR = 30 Average time from ACL injury to ACLR = 66 days	Both groups attended supervised rehabilitation sessions with a PT 3x/week and performed home exercises on other days. Both groups competed the same volume of post-ACLR rehabilitation Accelerated group Post-ACLR rehabilitation lasted 19 weeks Non-accelerated group Post-ACLR rehabilitation lasted 32 weeks	None	1. IKDC score 2. KOOS 3. Tegner activity score 4. Knee joint laxity 5. Single leg hop for distance 6. Isokinetic quadriceps and hamstrings strength 7. Proprioception Outcome measures recorded pre-ACLR, then at 3-, 6-, 12- and 24-months post-ACLR	Accelerated rehabilitation group recorded greater quadriceps strength at 3-month follow-up No difference between Accelerated rehabilitation versus Non-accelerated rehabilitation for all other outcomes	Total score x/28 = 20 Quality Index = 71% Quality Index Category = Moderate
(Królikowska et al.. 2018) Prospective cohort – non-randomised	All subjects in Groups 1 and 2 underwent arthroscopic ACLR with hamstring graft	Group 1 Average of 28 weeks PT-supervised rehabilitation post-ACLR	Group 3 No rehabilitation	1. Vertical ground reaction force during one- and two-legged vertical jumps	Group 1 recorded greater limb symmetry during two-legged vertical jump compared to Group 2	Total score x/28 = 10 Quality Index = 36% Quality Index Category = Limited

(*continued*)

Table 3. Continued.

Author/Study Type	Participant Demographics	Intervention	Control	Outcome Measures	Results	Downs and Black Quality Assessment
	Subject activity level = not stated Group 1 *N* = 20 (0 female) Average age = 26 Average time from ACL injury to ACLR = not reported Group 2 *N* = 15 (0 female) Average age = 27 Average time from ACL injury to ACLR = not reported Group 3 *N* = 20 (0 female) Average age = 23 No known orthopaedic problems	Group 2 Average of 11 weeks PT-supervised rehabilitation post-ACLR, then continued with home-based, unsupervised rehabilitation Compliance/adherence to home-based rehabilitation not recorded		Group 1 Final evaluation at 28 weeks post-ACLR Group 2 Final evaluation at 32 weeks post-ACLR		
(Królikowska et al.. 2018) Prospective cohort – non-randomised	All subjects in Groups 1 and 2 underwent arthroscopic ACLR with hamstring graft Subject activity level = Pre-injury Tegner activity score >4 and <9 Group 1 *N* = 15 (0 female) Average age = 25 Average time from ACL injury to ACLR = 33 weeks Group 2 *N* = 15 (0 female) Average age = 28 Average time from ACL injury to ACLR = 33 weeks Group 3 *N* = 30 (0 female) Average age = 25 No known orthopaedic problems	Group 1 Average of 27 weeks of PT-supervised rehabilitation following ACLR Group 2 Average of 8 weeks of PT-supervised rehabilitation following ACLR, then continued with home-based, unsupervised rehabilitation Compliance/adherence to home-based rehabilitation not recorded	Group 3 No rehabilitation	1. IKDC score 2. Knee joint circumference 3. Thigh circumference 4. Knee joint ROM 5. VAS pain scale 6. Agility run test Group 1 Final evaluation 27 weeks post-ACLR Group 2 Final evaluation 33 weeks post-ACLR	Group 2 recorded worse performance on agility run test than Groups 1 and 3 Duration of supervised rehabilitation significantly correlated with agility run test performance	Total score x/28 = 11 Quality Index = 39% Quality Index Category = Limited

Abbreviations: ACL = anterior cruciate ligament; ACLR = anterior cruciate ligament reconstruction; VAS = visual analogue scale; IKDC = International Knee Documentation Committee; PT = physiotherapist; KOOS = Knee Injury and Osteoarthritis Outcome Score; ROM = range of motion.

Table 4. Overall levels of evidence.

Level of Evidence	Requirement
Strong	Consistent findings among multiple high quality randomised controlled trials (RCTs)
Moderate	Consistent findings among multiple low quality RCTs and/or case-controlled 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 CCT)

Tegner score, VAS pain score). A longer duration of physiotherapy treatment had a positive effect on functional outcomes (vertical jump performance, agility run performance) [52, 53] and clinical outcomes (quadriceps strength, thigh circumference) [52, 54]. Follow up periods across all *Duration* study groups ranged from 27 weeks [52] to 24 months [51, 54].

Strength of evidence

Meta-analysis was not possible due to the heterogeneity of the selected studies. A synthesis of the overall evidence was therefore performed using the criteria described in Table 4 [62].

For *Quantity* studies, the two studies rated 'strong' methodological quality either reported superior outcomes for a group of ACLR patients receiving a lower number of physiotherapy treatments compared to a group receiving a higher number, or no difference in outcomes between the groups. Of the six studies rated 'moderate' methodological quality, two reported the quantity of post-ACLR physiotherapy treatment had no effect on patient outcomes, two reported the quantity of post-ACLR physiotherapy treatment had conflicting effects on patient outcomes, and two reported the quantity of post-ACLR physiotherapy treatment had a positive effect on patient outcomes. Of the three studies rated 'limited' methodological quality, one reported the quantity of post-ACLR physiotherapy treatment had a positive effect on patient outcomes, and two reported the quantity of post-ACLR physiotherapy treatment had no effect on patient outcomes. Overall, the level of evidence for the *Quantity* studies is best described as 'Conflicting' [62].

For *Duration* studies, the two studies rated 'moderate' methodological quality reported the duration of post-ACLR physiotherapy treatment had no effect on patient outcomes. The two studies rated 'limited' methodological quality reported a longer duration of post-ACLR physiotherapy treatment was associated with better patient outcomes. Overall, the level of evidence for the *Duration* studies is best described as 'Conflicting' [62].

Discussion

Summary of main findings

The literature search identified 15 articles where post-ACLR physiotherapy treatment data could be extracted from and used to determine the relationship between the quantity and duration of physiotherapy treatment and patient outcomes following ACLR. Based on the findings of the selected studies, it is not clear if the quantity and duration of physiotherapy treatment significantly influences patient outcomes following ACLR. Considerable heterogeneity in the methodologies of the selected studies regarding sample size, time from ACL injury to ACLR, the dosage of post-ACLR physiotherapy treatment, outcome measures used, and final evaluation timeframes likely contributed to the inconclusive findings.

Comparison to existing literature

Previous systematic reviews have reported the quantity of physiotherapy supervision during post-operative rehabilitation following ACLR does not significantly influence patient outcomes [21, 22, 42, 63–66]. All seven reviews included at least three studies from the current review, and all highlighted significant methodological inadequacies in the selected studies, including small sample sizes, absence of sample size calculation, inadequate randomisation, non-blinding of assessors, gender bias, and no reporting of compliance.

As part of wider systematic reviews on post-operative rehabilitation following various knee surgeries, a clear benefit of supervised rehabilitation over unsupervised/home-based rehabilitation following ACLR could not be established [67, 68]. A recent scoping review on the frequency and duration of supervised rehabilitation following ACLR, which included 11 of the 15 studies from the current review, concluded moderately or minimally supervised rehabilitation is at least as effective as fully supervised high-frequency rehabilitation, and at least 6 months of supervised rehabilitation is associated with more favourable outcomes after ACLR [43].

Several inconsistencies were noted between previous reviews and the current review regarding assessment of methodological quality for selected studies. For example, the study by Grant et al. (2010) was scored 4/10 by Gamble et al. (2021), indicating a lower quality study, but the current review scored Grant et al. (2010) at 93%, indicating a high-quality study. The study by Ugutmen et al. (2008) scored 90/100 by Papalia et al. (2013), which suggests a low risk of bias, whereas the Quality Index of Ugutmen

et al. (2008) in the current review was scored as 36%, which suggests a high risk of bias. As different quality assessment tools assess different biases [69], whichever tool is chosen to assess the methodological quality of selected studies has the potential to significantly influence the overall findings of the review.

Nine of the 11 *Quantity* studies compared clinic-based, physiotherapy-led rehabilitation with home-based rehabilitation. The average quantity and duration of physiotherapy for clinic-based rehabilitation and home-based rehabilitation was 21 treatments over 26 weeks and 4 treatments over 25 weeks respectively. In the 12 months following ACLR in New Zealand, patients receive an average of 10-12 physiotherapy treatments, over an average duration of 143-161 days [20]. The majority of Flemish physical therapists use 41-60 treatments over 6-7 months following ACLR [70]. Therefore, the quantity and duration of physiotherapy treatment in the selected studies may not be an accurate reflection of everyday physiotherapy practice. To increase external validity, future research on ACLR rehabilitation should include interventions that replicate usual physiotherapy practice.

In the first 12 weeks following ACLR, 25-38 rehabilitation sessions have been recommended [23], with a physiotherapist review at least every two weeks to ensure adequate progress is maintained [26]. Up to 35 physiotherapy treatments may be required in the 12 months following ACLR [20]. The optimal frequency of rehabilitation supervision has yet to be determined [43], and the number of physiotherapy treatments required is likely dependent on the progress of the individual patient [26].

Results from this review, and previous reviews, suggest there is no singular optimal dosage of physiotherapy treatment following ACLR that can be applied to all patients. Contemporary ACLR rehabilitation is now less prescriptive, with progress through rehabilitation determined by the patient's achievement of functional milestones, not time from surgery [42, 71]. Similarly, the dosage of post-ACLR physiotherapy treatment should also not be predetermined, but instead be the end-product the quantity and duration of treatment required for the patient to achieve their post-operative goals [26].

Other person-related factors, such as age, gender, activity levels, and concomitant injury at ACLR potentially have a greater effect on post-operative outcomes than the dosage of physiotherapy treatment. The average age of participants across all 15 studies in the current review was 28 years, with 27% of participants female. Outcomes for patients over 30 years of age, and for female patients, are typically worse following ACLR [15, 72]. Therefore, a high percentage of male participants, and participants under 30 years of age, in a sample could result in an artificially high number of participants achieving better outcomes. However, a significant percentage of ACL injuries occur in females and in people over 30 years of age [73]. Therefore, future ACL research should ensure a distribution of participants related to age and gender that represents of the current demographic of ACL injury.

A higher activity level prior to ACL injury is associated with a higher activity level following ACLR [74]; however, it is not clear if patient activity level influences the dosage of physiotherapy treatment required following ACLR. Elite athletes may require more advanced rehabilitation and a greater level of supervision than recreational athletes, or conversely, elite athletes may possess a higher level of motivation to complete rehabilitation, leading to a lesser need for supervision [66]. For multiple reasons, including the dosage of post-ACLR physiotherapy, a greater percentage of elite athletes return to pre-injury activity levels compared to non-elite athletes [75]. Future research should investigate the dosage of physiotherapy required to achieve acceptable outcomes in ACLR patients who encompass the spectrum of activity levels.

Across 13 of the 15 studies in the current review, the time between ACL injury and ACLR ranged from 56 days to 18 years, with two studies not reporting a time [48, 60]. A longer time to ACLR is associated with an increased risk of secondary meniscal and chondral injury due to recurrent instability episodes [76, 77], and the presence of meniscal or chondral injury at the time of ACLR is associated with worse patient outcomes [78, 79]. Therefore, a longer time between injury and ACLR could negatively influence patient outcomes. Only seven of 15 studies in the current review reported excluding participants with concomitant meniscal or chondral injuries at the time of ACLR, which, when combined with the wide range of times between injury and surgery, could have influenced the results of the studies in this review.

Overall, findings from the current review add to the previous literature that indicates the quantity and duration of physiotherapy treatment following ACLR does not appear to significantly influence post-operative outcomes. Previous reviews have focused on the level of supervision during post-ACLR rehabilitation, or home-based verses clinic-based rehabilitation, than the actual quantity and duration of physiotherapy treatment. The current review is therefore unique, as it is the first review to specifically address the quantity and duration of physiotherapy treatment following ACLR.

Quality of selected studies

The average Downs and Black score for all studies in the current review was 16.9/28 (range 8-26), which equates to an average Quality Index of 60%. Overall, the level of evidence is best summarised as 'Conflicting' [62]. Several methodological issues can be identified within the selected studies. Regarding the *Quantity* studies, only one – Hohmann et al. (2011) – evaluated the effect of a physiotherapist-led rehabilitation program versus a fully unsupervised rehabilitation program. Across all other *Quantity* studies, both study groups received a degree of physiotherapist input during rehabilitation, with the quantity of that input differing between groups. It is possible the difference in the number of physiotherapy treatments between study groups was not sufficient to show any significant between-group differences [66]. The lack of outcome data for completely unsupervised subjects needs to be considered when evaluating the evidence that a home-based exercise program is equally effective as a clinic-based program [65].

Only 25% of studies in the current review reported, or attempted to measure, participant compliance with rehabilitation protocols. Increased compliance with rehabilitation following ACLR is associated with better patient outcomes [27, 80]. Compliance data is an important variable due to the dose-response relationship for effectiveness [21]. Measuring participant compliance with unsupervised rehabilitation may enable a more accurate comparison with patient outcomes following supervised rehabilitation.

Studies published more recently have shown a positive association between the quantity of post-ACLR rehabilitation and patient outcomes [43], and results of the current review support that finding. Three *Quantity* studies in the current review were published from 2019 onwards [48, 55, 58] – all reported a greater quantity of post-ACLR physiotherapy treatment was associated with improved patient outcomes. Six *Quantity* studies in the current review were published prior to 2010 [47, 49, 50, 57, 60, 61] – none reported an association between a greater amount of post-ACLR physiotherapy treatment and improved patient outcomes. There is little difference between the methodological quality of the newer verses the older studies, with the average Quality Index of the post-2019 studies being 57% (range 46-64%), and the average Quality Index of the pre-2010 studies being 59.5% (range 29-89%).

There was no clear relationship between methodological quality and the overall findings of the *Quantity* studies. Four *Quantity* studies scored greater than 70% on the Quality Index. One study reported the quantity of post-ACLR physiotherapy treatment had no effect on patient outcomes [47], with three reporting equivocal findings regarding the quantity of post-ACLR physiotherapy treatment and patient outcomes [49, 56, 57]. Three studies scored less than 50% on the Quality Index – two reported the quantity of post-ACLR physiotherapy treatment had no effect on patient outcomes [60, 61] and one reported a greater amount of post-ACLR physiotherapy treatment was associated with improved patient outcomes [55].

The timing of the final evaluation following a post-ACLR intervention could influence the overall findings of a study. If the final evaluation was performed when subjects are unlikely to have achieved optimum function, then the final evaluation may not fully capture the total effects of any intervention. Functional measures can improve for up to two years after ACLR [81]. Four *Quantity* studies reported results with a follow-up period of six months or less after ACLR – two reported the quantity of post-ACLR physiotherapy treatment had no effect on outcomes [47, 50], one reported less physiotherapy treatment resulted in better outcomes [49], and one reported more physiotherapy treatment resulted in better outcomes [58]. The remaining seven *Quantity* studies used follow-up periods of 12 months or greater (range 12-38 months) – two studies reported the quantity of post-ACLR physiotherapy treatment had no effect on outcomes [60, 61], two reported more physiotherapy treatment is associated with improved patient outcomes [48, 55], one reported less physiotherapy treatment is associated with improved outcomes [56], and two reported improved outcomes with more and less physiotherapy treatment [57, 59]. Overall, our results indicate the timing of the final subject evaluation following post-ACLR rehabilitation has little influence on the results of the *Quantity* studies.

With regards to *Duration* studies, two reported the duration of post-ACLR physiotherapy treatment had no effect on patient outcomes – both were rated as 'Moderate' quality, were published earlier, and had longer follow-up periods (24 months) [51, 54]. Two studies reported a longer duration of post-ACLR physiotherapy treatment resulted in better outcomes – both were rated 'Limited' quality, were published later, and had shorter follow-up periods (27-33 weeks) [52, 53]. Due to lack of published studies, it is not possible to conclude if study quality, date of publication, and the timing of the final subject evaluation influenced the findings of the *Duration* studies.

Limitations

This review is not without limitations. Of the 15 included studies, only two *Duration* studies were

conducted with the expressed aim of prospectively examining the effects of the quantity or duration of post-ACLR physiotherapy treatments on patient outcomes. None of the 11 *Quantity* studies specifically investigated the effects of the quantity of post-ACLR physiotherapy treatment on patient outcomes. Although the intended purpose of the majority of included studies did not completely align with the intended purpose of the review, it was considered appropriate to include them, as the dosage of post-ACLR physiotherapy treatment could be extracted from the articles. As such, the conclusions of this review regarding the effects of the quantity and duration of post-ACLR physiotherapy treatment are based on data that was not collected for the purpose for which it has been used. The literature search was completed up to March 2021, and therefore we cannot exclude the possibility further studies have been published since this date that may provide additional insights into the research question. As we excluded articles not published in English and did not search for unpublished studies, we may not have captured all the relevant literature. Considerable heterogeneity between the included studies precluded quantitative meta-analysis, while preventing any between-study comparison of interventions and outcomes.

Conclusions

The current review has not clearly established the quantity and duration of physiotherapy treatment following ACLR has a significant effect on patient outcomes. Similar outcomes are achieved irrespective of the dosage of physiotherapy treatment. This review adds to the findings of previous reviews that have shown no clear benefit of supervised rehabilitation over home-based or unsupervised rehabilitation following ACLR. Constant monitoring of post-ACLR rehabilitation by a physiotherapist does not appear necessary, although regular therapist review allows for ongoing patient assessment, education, and progression. High-quality RCTs investigating the optimal dosage of physiotherapy treatment following ACLR, or the level of supervision required during post-ACLR rehabilitation, to achieve acceptable patient outcomes are lacking.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

The author(s) reported there is no funding associated with the work featured in this article.

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Appendices

Appendix 1. Modified Downs and Black scores for studies reporting the effect of the quantity of post-ACLR physiotherapy treatment on patient outcomes.

	Schenk et al. (1997)	Beard & Dodd (1985)	Fischer et al. (1998)	Grant et al. 2005)	Ugutmen et al. (2008)	Revenas et al. (2009)	Grant et al. 2010)	Hohmann et al. (2011)	Lim et al. (2019)	Przybylak et al. (2019)	Rhim et al. (2020)
Reporting											
1. Is the hypothesis/aim/objective of the study clearly described? (yes = 1, no = 0)	1	1	1	1	0	1	1	1	1	1	1
2. Are the main outcomes to be measured clearly described in the Introduction or Methods section? (yes = 1, no = 0)	1	1	1	1	1	1	1	1	1	1	1
3. Are the characteristics of the patients included in the study clearly described? (yes = 1, no = 0)	0	0	1	1	0	1	1	1	1	1	1
4. Are the interventions of interest clearly described? (yes = 1, no = 0)	1	1	1	1	0	1	1	1	1	1	1
5. Are the distributions of principal confounders in each group of subjects to be compared clearly described? (yes = 2, partially = 1, no = 0)	0	1	0	2	0	2	2	0	1	0	1
6. Are the main findings of the study clearly described? (yes = 1, no = 0)	1	1	1	1	1	1	1	1	1	1	1
7. Does the study provide estimates of the random variability in the data for the main outcomes? (yes = 1, no = 0)	0	1	1	1	0	0	1	1	1	1	1
8. Have all important adverse events that may be a consequence of the intervention been reported? (yes = 1, no = 0)	0	0	0	0	0	0	1	0	0	0	0
9. Have the characteristics of patients lost to follow-up been described? (yes = 1, no = 0)	0	0	1	1	1	1	1	1	1	0	0
10. Have actual probability values been reported (e.g. 0.035 rather than <0.05) for the main outcomes except where the probability value is less than 0.001? (yes = 1, no = 0)	0	0	0	1	0	1	1	1	1	1	1
Reporting Score x/11	4	6	7	10	3	9	11	8	9	7	8
External validity											
11. Were the subjects asked to participate in the study representative of the entire population from which they were recruited? (yes = 1, unable to determine = 0, no = 0)	0	0	0	1	0	1	1	1	0	0	0
12. Were those subjects who were prepared to participate representative of the entire population from which	0	0	0	0	0	0	1	0	0	0	0

(*continued*)

Appendix 1. Continued.

	Schenk et al. (1997)	Beard & Dodd (1985)	Fischer et al. (1998)	Grant et al. 2005)	Ugutmen et al. (2008)	Revenas et al. (2009)	Grant et al. 2010)	Hohmann et al. (2011)	Lim et al. (2019)	Przybylak et al. (2019)	Rhim et al. (2020)
they were recruited? (yes = 1, unable to determine = 0, no = 0)											
13. Were the staff, places, and facilities where the patients were treated, representative of the treatment the majority of patients receive? (yes = 1, unable to determine = 0, no = 0)	1	1	1	1	1	0	1	1	0	0	1
External Validity Score x/3	1	1	1	2	1	1	3	2	0	0	1
Internal validity - Bias											
14. Was an attempt made to blind study subjects to the intervention they have received? (yes = 1, unable to determine = 0, no = 0)	0	0	0	0	0	0	0	0	0	0	0
15. Was an attempt made to blind those measuring the main outcomes of the intervention? (yes = 1, unable to determine = 0, no = 0)	1	1	0	1	0	1	1	1	1	0	0
16. If any of the results of the study were based on "data dredging", was this made clear? (yes = 1, unable to determine = 0, no = 0)	0	1	1	1	0	1	1	0	1	1	1
17. In trials and cohort studies, do the analyses adjust for different lengths of follow-up of patients, or in case-control studies, is the time period between the intervention and outcome the same for cases and controls? (yes = 1, unable to determine = 0, no = 0)	0	1	1	1	0	1	0	1	1	1	1
18. Were the statistical tests used to assess the main outcomes appropriate? (yes = 1, unable to determine = 0, no = 0)	0	1	1	1	1	1	1	1	1	1	1
19. Was compliance with the intervention/s reliable? (yes = 1, unable to determine = 0, no = 0)	0	1	1	1	0	0	1	0	0	0	0
20. Were the main outcome measures used accurate (valid and reliable)? (yes = 1, unable to determine = 0, no = 0)	1	1	1	1	1	1	1	1	1	1	1
Internal Validity – Bias Score x/7	2	6	5	6	2	5	5	4	5	4	4
Internal validity – Confounding (selection bias)											
21. Were the patients in different intervention groups (trials and cohort studies) or were the cases and controls (case-control studies) recruited	0	1	1	1	1	1	1	1	0	0	1

(*continued*)

Appendix 1. Continued.

	Schenk et al. (1997)	Beard & Dodd (1985)	Fischer et al. (1998)	Grant et al. 2005)	Ugutmen et al. (2008)	Revenas et al. (2009)	Grant et al. 2010)	Hohmann et al. (2011)	Lim et al. (2019)	Przybylak et al. (2019)	Rhim et al. (2020)
from the same population? (yes = 1, unable to determine = 0, no = 0)											
22. Were study subjects in different intervention groups (trials and cohort studies) or were the cases and controls (case-control studies) recruited over the same period of time? (yes = 1, unable to determine = 0, no = 0)	0	1	1	1	1	1	1	1	1	1	1
23. Were study subjects randomized to intervention groups? (yes = 1, unable to determine = 0, no = 0)	1	1	1	1	1	1	1	1	1	0	0
24. Was the randomized intervention assignment concealed from both patients and health care staff until recruitment was complete and irrevocable? (yes = 1, unable to determine = 0, no = 0)	0	1	0	1	0	0	1	0	0	0	0
25. Was there adequate adjustment for confounding in the analyses from which the main findings were drawn? (yes = 1, unable to determine = 0, no = 0)	0	1	0	1	0	0	1	0	1	1	1
26. Were losses of patients to follow-up taken into account? (yes = 1, unable to determine = 0, no = 0)	0	1	1	1	1	1	1	1	1	0	0
Internal Validity – Confounding Score x/6	1	6	4	6	4	4	6	4	4	2	3
Power											
27. Did the study have sufficient power to detect a clinically important effect where the probability value for a difference being due to chance is less than 5%? (yes = 1, unable to determine = 0, no = 0)	0	1	0	1	0	1	1	1	0	0	1
Total score x/28	8	20	17	25	10	20	26	19	18	13	17
Quality Index	29%	71%	61%	89%	36%	71%	93%	68%	64%	46%	61%
Quality Index Category	Limited	Moderate	Moderate	Strong	Limited	Moderate	Strong	Moderate	Moderate	Limited	Moderate

Appendix 2. Modified Downs and Black scores for studies reporting the effect of the duration of post-ACLR physiotherapy on patient outcomes.

	Beynnon et al. (2005)	Beynnon et al. (2011)	Królikowska et al. (2018a)	Królikowska et al. (2018b)
Reporting				
1. Is the hypothesis/aim/objective of the study clearly described? (yes = 1, no = 0)	1	1	1	1
1. Are the main outcomes to be measured clearly described in the Introduction or Methods section? (yes = 1, no = 0)	1	1	1	1
1. Are the characteristics of the patients included in the study clearly described? (yes = 1, no = 0)	1	1	1	1
1. Are the interventions of interest clearly described? (yes = 1, no = 0)	1	1	1	1
1. Are the distributions of principal confounders in each group of subjects to be compared clearly described? (yes = 2, partially = 1, no = 0)	2	2	1	1
1. Are the main findings of the study clearly described? (yes = 1, no = 0)	1	1	1	1
1. Does the study provide estimates of the random variability in the data for the main outcomes? (yes = 1, no = 0)	1	1	1	1
1. Have all important adverse events that may be a consequence of the intervention been reported? (yes = 1, no = 0)	0	0	0	0
1. Have the characteristics of patients lost to follow-up been described? (yes = 1, no = 0)	1	1	0	0
1. Have actual probability values been reported (e.g. 0.035 rather than <0.05) for the main outcomes except where the probability value is less than 0.001? (yes = 1, no = 0)	1	1	1	1
Reporting Score x/11	10	10	8	8
External Validity				
1. Were the subjects asked to participate in the study representative of the entire population from which they were recruited? (yes = 1, unable to determine = 0, no = 0)	1	1	0	0
1. Were those subjects who were prepared to participate representative of the entire population from which they were recruited? (yes = 1, unable to determine = 0, no = 0)	0	0	0	0
1. Were the staff, places, and facilities where the patients were treated, representative of the treatment the majority of patients receive? (yes = 1, unable to determine = 0, no = 0)	0	0	0	0
External Validity Score x/3	1	1	0	0
Internal Validity - Bias				
1. Was an attempt made to blind study subjects to the intervention they have received? (yes = 1, unable to determine = 0, no = 0)	0	0	0	0
1. Was an attempt made to blind those measuring the main outcomes of the intervention? (yes = 1, unable to determine = 0, no = 0)	0	1	0	0
1. If any of the results of the study were based on "data dredging", was this made clear? (yes = 1, unable to determine = 0, no = 0)	1	1	1	1
1. In trials and cohort studies, do the analyses adjust for different lengths of follow-up of patients, or in case-control studies, is the time period between the intervention and outcome the same for cases and controls? (yes = 1, unable to determine = 0, no = 0)	1	1	0	1
1. Were the statistical tests used to assess the main outcomes appropriate? (yes = 1, unable to determine = 0, no = 0)	1	1	1	1
1. Was compliance with the intervention/s reliable? (yes = 1, unable to determine = 0, no = 0)	0	0	0	0
1. Were the main outcome measures used accurate (valid and reliable)? (yes = 1, unable to determine = 0, no = 0)	1	1	1	1
Internal Validity – Bias Score x/7	4	5	3	4

(*continued*)

Appendix 2. Continued.

	Beynnon et al. (2005)	Beynnon et al. (2011)	Królikowska et al. (2018a)	Królikowska et al. (2018b)
Internal validity – Confounding (selection bias)				
1. Were the patients in different intervention groups (trials and cohort studies) or were the cases and controls (case-control studies) recruited from the same population? (yes = 1, unable to determine = 0, no = 0)	1	1	1	1
1. Were study subjects in different intervention groups (trials and cohort studies) or were the cases and controls (case-control studies) recruited over the same period of time? (yes = 1, unable to determine = 0, no = 0)	1	1	1	1
1. Were study subjects randomized to intervention groups? (yes = 1, unable to determine = 0, no = 0)	1	1	0	0
1. Was the randomized intervention assignment concealed from both patients and health care staff until recruitment was complete and irrevocable? (yes = 1, unable to determine = 0, no = 0)	1	1	0	0
1. Was there adequate adjustment for confounding in the analyses from which the main findings were drawn? (yes = 1, unable to determine = 0, no = 0)	1	1	0	0
1. Were losses of patients to follow-up taken into account? (yes = 1, unable to determine = 0, no = 0)	1	1	0	0
Internal Validity – Confounding Score x/6	6	6	2	2
Power				
1. Did the study have sufficient power to detect a clinically important effect where the probability value for a difference being due to chance is less than 5%? (yes = 1, unable to determine = 0, no = 0)	1	1	0	0
Total score x/28	19	20	10	11
Quality Index	68%	71%	36%	39%
Quality index Category	Moderate	Moderate	Limited	Limited