

Home-based vs supervised rehabilitation programs following knee surgery: a systematic review

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Introduction: Following knee surgery, rehabilitation can dramatically affect the postoperative course and the final outcomes of the procedure. We systematically reviewed the current literature comparing clinical outcomes of home-based and outpatient supervised rehabilitation protocols following knee surgery.

Sources of data: We searched Medline, CINAHL, Embase, Google Scholar, The Cochrane Library and SPORTDiscus. The reference lists of the previously selected articles were then examined by hand. Only studies comparing clinical outcomes of patients who had undergone knee surgery followed by different rehabilitation programs were selected. Then the methodological quality of each article was evaluated using the Coleman methodology score (CMS), a 10-criterion scoring list assessing the methodological quality of the selected studies.

Areas of agreement: Eighteen studies were evaluated in the present review. Three were retrospective studies. The remaining 15 studies were prospective randomized clinical trials. The supervised and home-based protocols did not show an overall significant difference in the outcomes achieved within the studies reviewed. The mean CMS was 77.2.

Areas of controversy: The heterogeneity of the rehabilitation protocols used in the studies reviewed makes it difficult to draw definite conclusion on the subject.

Growing points: Supervision and location does not seem to directly determine the final outcomes. Numerous variables, including comorbidities and motivation, could influence the results and deserve to be accounted for in future investigations.

Research: Better designed studies are needed to show a clear superiority of one rehabilitation approach over another and its applicability to the various surgical procedures involving the knee.

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Introduction

The goal of rehabilitation following orthopedic surgery is to restore muscle strength, joint stability and neuromuscular control. Following knee surgery, appropriate rehabilitation may definitely affect post-operative course and final outcomes.¹⁻³

The demand for cost-effectiveness in healthcare procedures has led to the increasing development and use of unsupervised rehabilitation protocols. Patients are individually charged with the responsibility to undertake exercises and maneuvers at a time and a place convenient to their needs and daily living schedules.⁴ Possible advantages of a home-based and patient-directed rehabilitation program are that patients do not have to pay for physiotherapist appointments and that they do not have to move from home to physiotherapy clinics, making rehabilitation more comfortable and lowering the risks of further injuries during the logistic transfer. These last points are especially crucial for the treatment of elderly patients often undergoing invasive procedures (i.e. total knee arthroplasties).

Critics claimed that low personal motivation and misunderstanding instructions to execute the program can negatively affect the outcome of an individual rehabilitation.⁵ Also, patients undergoing major procedures require closer monitoring during musculoskeletal recovery for complications or unsuccessful results to allow clinicians to be more responsive to sudden changes in functional status by taking early countermeasures and restore the correct healing process. These last points would suggest that supervision is still a key factor to achieve the best possible postoperative results in some populations, but may not be necessary for all patients.

To our knowledge, this is the first systematic review to compare the outcomes after the completion of a supervised rehabilitation program with an unsupervised home-based rehabilitation program. Clinical evidences available to date are still controversial, and there is confusion on the practical definition of 'home' and 'supervised' approaches; however, we try to define them and answer the following questions:

- Are there clinical differences in the final results of physical therapy performed at home rather than in a supervised environment after knee surgery?
- Can motivation affect the outcomes of a rehabilitation program?

- Are there clinical and/or demographic factors that suggest that home-based or supervised rehabilitation approaches would be more appropriate for particular patient groups?
- Are the results of these two approaches related to the specific knee surgery performed?
- Is the methodological quality of the studies adequate to draw definitive conclusions on this issue?

Materials and methods

Search strategy and study selection

For the materials and methods, the PRISMA guidelines have been followed as far as possible.

Medline (through www.pubmed.com), CINAHL (<http://www.ebscohost.com/cinahl/>), Embase Biomedical (<http://www.embase.com/>), Google Scholar (<http://scholar.google.com/>), The Cochrane Library (<http://www.thecochranelibrary.com/view/0/index.html>) and SPORTDiscus (<http://www.ebscohost.com/biomedical-libraries/sportdiscus-with-full-text>) databases were accessed on March 6, 2013 to perform a comprehensive research of articles published to that date about the subject investigated in our review. Our standard strategy was to perform different research using as basic keywords 'Home rehabilitation', 'Supervised rehabilitation', 'out-patient rehabilitation' and 'clinic rehabilitation' isolated or combined with other terms such as 'Knee', 'surgery' and 'rehabilitation' by using Boolean operators (AND, OR) and setting no limit regarding the year of publication. As for the language filter, we looked for articles in English, Spanish, French, Portuguese and Italian languages, given the linguistic capabilities of the research team.

Afterwards, two authors (S.D. and A.T.) independently reviewed the text of each abstract of the records obtained with the above-mentioned strategy. All journals were considered, and all relevant articles were retrieved. Papers were considered eligible to be further investigated or excluded according to their abstract. If abstract was not available, the article was excluded. Then full-text of the articles were obtained to decide whether they were definitely suitable to the purpose of our study. Moreover, the reference lists of the selected articles were reviewed by hand to identify articles not found through the electronic search in order to obtain full articles for these as well. The selection criteria (Fig. 1) were applied independently by all authors prior to an eventual discussion with senior authors. In case of controversy about the inclusion of an article, the senior authors (R.P. or S.V.) made a consensus decision. Only studies comparing clinical outcomes of patients who had knee surgery followed

INCLUSION CRITERIA	EXCLUSION CRITERIA
<ul style="list-style-type: none"> • Knee surgery (ACL, Meniscectomy, TKA) • Scores and validate scales • Fisioterapic scores • Comparison between two different types of physiotherapy 	<ul style="list-style-type: none"> • Reviews • Anatomical studies • Technical notes • Biomechanical studies • Letters to the editor • Instructional course

Fig. 1 Inclusion and exclusion criteria.

by different rehabilitation programs were selected. Literature reviews, technical notes, letters to editors and instructional course were also excluded.

Quality assessment

According to the Coleman methodological score, information is extracted from each included article on: (i) characteristics of participants (including demographic data and clinical condition), along with trial's inclusion and exclusion criteria; (ii) type of surgery (including details such as approach, duration, technique used); (iii) type of rehabilitation (location, presence of supervision, economical expenses) and (iv) type of outcome measures (including validated scales, absence from work, length of follow-up, possible complications rates).

Assessment of risk of bias

To determine the methodological features of each study, two investigators (R.P. and S.D.) independently evaluated each study, according to the Coleman methodology score (CMS), a 10-criterion validated scoring system (CMS) judging their methodology, with final score ranging from 0 to 100 (Table 1). A perfect score of 100 would represent a perfectly designed study excluding biases of any kind. The two investigators discussed scores where more than two-point difference was evident until consensus was reached.

Each investigator rated the CMS assessment and together they discussed scores where more than a two-point difference was evident, until consensus was reached. The two authors scored the methodological quality of the studies more than once in order. The reliability of the scores achieved was assessed using intra-class correlation for inter-observer reliability, achieving an intra-class correlation coefficient of 0.90 (95% CI = 0.84–0.94).

An arbitrary rating of the CMS scores was developed to rank the quality of the reviewed studies (Fig. 2).

Table 1 Coleman methodology score

Studies	Study size	Mean duration of follow-up	No. of surgical procedures	Type of study	Diagnostic certainty	Description of surgical procedure	Description of postoperative rehabilitation	Outcome measurements	Outcome assessment	Selection process	Total score
Goodwin <i>et al.</i> ¹¹	10	0	10	15	5	3	10	10	13	13	89
Grant <i>et al.</i> ¹²	10	0	10	15	5	3	10	9	13	5	80
Grant <i>et al.</i> ¹³	10	5	10	15	5	3	10	9	13	13	93
Forster <i>et al.</i> ⁴	10	0	10	15	5	3	10	9	10	10	82
Hohmann <i>et al.</i> ¹⁴	4	2	10	15	5	3	10	8	13	13	83
Jokl <i>et al.</i> ¹⁵	4	0	10	15	5	3	10	6	13	5	71
Beard <i>et al.</i> ⁹	4	0	10	15	5	3	10	10	13	5	75
Rockborn <i>et al.</i> ⁷	10	2	7	0	5	5	10	8	10	10	67
Ugutmen <i>et al.</i> ²⁰	10	5	10	15	5	5	10	10	13	7	90
Vervest <i>et al.</i> ²¹	4	0	10	15	5	3	5	10	13	5	70
De Carlo <i>et al.</i> ⁶	10	2	10	0	5	3	10	9	10	10	69
Kramer <i>et al.</i> ¹⁶	10	2	10	15	5	0	10	10	12	5	79
Moffet <i>et al.</i> ¹⁷	4	0	10	15	5	0	10	6	13	8	71
Rajan <i>et al.</i> ²²	10	2	10	15	5	0	0	6	9	15	72
Revenas <i>et al.</i> ¹⁸	7	2	10	15	5	3	10	10	15	13	90
Schenck <i>et al.</i> ¹⁹	4	2	10	10	5	3	10	10	13	3	70
Fischer <i>et al.</i> ¹⁰	7	0	10	15	5	3	10	10	13	5	78
Treacy <i>et al.</i> ⁸	10	0	10	0	5	3	10	6	8	8	60

METODOLOGICAL QUALITY	CMS SCORE
Poor	<40
Acceptable	41-60
Good	61-80
Excellent	81-100

Fig. 2 CMS scores methodological quality classification.

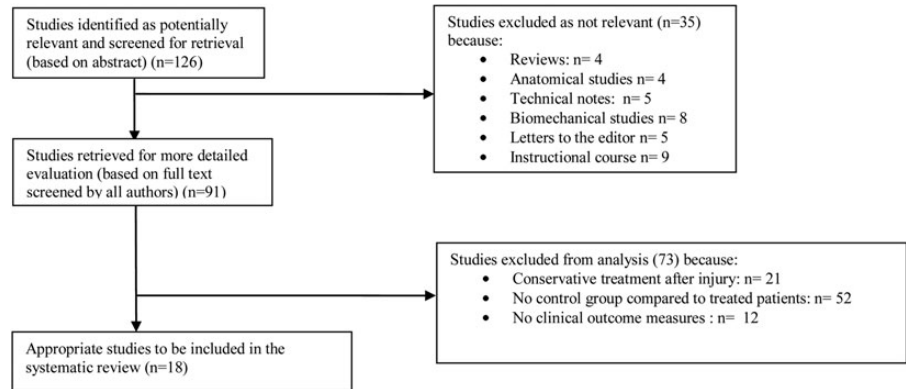


Fig. 3 Process of inclusion of the studies.

Statistical analysis

We analyzed the correlation between the CMS score of the articles and their year of publication by plotting data on a diagram and then by digitally calculating the Pearson correlation coefficient (*r*) between the two variables.

Results

Study selection

At the first electronic search, 246 articles were identified. 126 studies investigating the results of home-based or supervised rehabilitation were identified. All these articles were reviewed and discussed by all the authors to avoid bias: 52 articles were excluded because they did not compare the studied rehabilitation setting with a control group and 12 articles were not included because they presented measurements other than clinical (economic, sociologic, etc.) as the only comparison data. Finally, 18 publications relevant to the topic were included (Fig. 3).

Eighteen studies were evaluated in the present review. Three⁶⁻⁸ were retrospective studies, while 15^{4,9-22} were prospective randomized clinical trials (RCTs).

Study features and overall methodological quality

The mean CMS was 77.2 (range from 60⁸ to 93¹²). The lowest scores were recorded in the following categories: description of surgical procedures, duration of follow-up, outcome measurements. The total CMS and the CMS for each criterion are shown in Table 1. The CMSs did not show a significant association with the year of publication as measured by the Pearson correlation coefficient ($r = 0.49$). Eleven^{4,6-8,11,12,14,17,18,21,22} (61.1%) of the 18 selected studies offered a satisfactory description of subjects selection criteria as shown by the scores in the CMS appropriate category (Table 1).

Demographic data

According to values reported by the authors, the mean age at knee surgery was 35.3 years (range 23¹⁸–68.5²²).

The total of patients in the selected studies was 1489, range 180⁶–20.²¹ The number of reported males were 879 (59.0%) and that of the reported females 457 (30.7%). For the remaining 153 patients (10.3%), the sex was unstated. The average follow-up length was 11.4 months (Table 2).

Surgical technique and postoperative management

Ten^{6,8-10,12-14,18-20} procedures (55.6%) were ACL reconstructions, in five studies^{4,7,11,15,17} (27.8%) meniscectomy was performed, while in the remaining two^{16,22} studies (11.1%) patients underwent knee arthroplasty. A complete description of procedures is given in Table 2. The description of the surgical technique criteria scored the maximum rating of CMS (5 points) only 2^{7,20} studies (11%), but at least 3 points were obtained in 13 of them^{4,6,8-15,18,19,21} (72.2%).

In those articles that did not ranked the maximum score, the surgical technique was only stated without further elaboration and details such as description of the procedure and details on the materials involved.

On the other hand, since all authors focused on this point, almost all reviewed studies obtained maximum score in the CMS category regarding the description of rehabilitation process. Only one study⁷ received <10 points. In this pool of evaluated studies, whether the programs were prescribed by a physical therapists or a physician was not clearly reported; anyhow, a brief description of the features of home or supervised rehabilitation protocols for each study is presented in Table 3.

Table 2 Demographic data and information about surgeries

Studies	Level of evidence*	No. Patients treated	M	W	Mean follow-up (months)	Mean age at surgery† (years)	Type of surgery
		Av = 82.7 SD = 52.4	Av = 54.9 SD = 40.4	Av = 28.6 SD = 28.6	Av = 11.4 SD = 10.4	Av = 35.3 SD = 13.3	
Goodwin <i>et al.</i> ¹¹	2	86	74	12	2	39	Partial meniscectomy
Grant <i>et al.</i> ¹²	1	145	75	70	3	29.3	ACL reconstruction (BPTB autograft)
Grant <i>et al.</i> ¹³	1	88	50	38	38.8	33.7	ACL reconstruction (BPTB autograft)
Forster <i>et al.</i> ⁴	2	84	N/A	N/A	6	30.5	Open medial meniscectomy
Hohmann <i>et al.</i> ¹⁴	2	40	30	10	12	27.5	ACL reconstruction
Jokl <i>et al.</i> ¹⁵	2	30	23	7	2	32.1	Partial medial meniscectomy
Beard <i>et al.</i> ⁹	2	26	21	5	6	28	ACL reconstruction
Rockborn <i>et al.</i> ⁷	3	168	142	26	10	37	Partial meniscectomy (medial and lateral)
Ugutmen <i>et al.</i> ²⁰	2	104	103	1	31.1	31.5	ACL reconstruction (hamstring autograft)
Vervest <i>et al.</i> ²¹	2	20	14	6	1	33.4	Partial meniscectomy
De Carlo <i>et al.</i> ⁶	3	180	130	50	12	25.4	ACL reconstruction
Kramer <i>et al.</i> ¹⁶	2	160	69	91	12	68	Total knee arthroplasty
Moffet <i>et al.</i> ¹⁷	2	31	31	0	6	39.9	Meniscectomy
Rajan <i>et al.</i> ²²	1	116	43	73	12	68.5	Total knee arthroplasty
Revenas <i>et al.</i> ¹⁸	1	51	18	33	12	23	ACL reconstruction
Schenck <i>et al.</i> ¹⁹	2	37	28	9	21.6	24.1	ACL reconstruction (BPTB autograft)
Fischer <i>et al.</i> ¹⁰	2	54	28	26	6	30	ACL reconstruction (BPTB autograft/allograft)
Treacy <i>et al.</i> ⁸	3	69	N/A	N/A	N/A	N/A	ACL reconstruction (BPTB autograft)

*According to the instruction for authors of the Journal of Bone and Joint Surgery (American Edition) <http://jbjs.org/public/instructionsauthors.aspx#LevelofEvidence>.

†Mean age ACL reconstruction: 28 years, Mean age meniscectomy: 35.3 years, Mean age total knee arthroplasty: 68.25 years.

Knee function assessments

To evaluate the clinical outcomes of the postoperative rehabilitation, most studies used validated functional scores (Fig. 4). Outcome scores offering adequate reliability and sensitivity were reported in 13 publications^{4,6,7,9-13,16,18-21} (72.2%). The Lysholm knee scoring scale was used in 7 of 18 studies^{7,9,14,18-21} (38.9%), Tegner activity scale in 5 studies^{8,9,14,18,21} (27.8%) and the range of motion in knee flexion and extension in 8 studies (44.4%).^{4,6,12,13,16,18,19,22}

Total knee arthroplasty

RCTs

Rajan *et al.*²² designed a trial to evaluate, using knee ROM as the main outcome, the need for outpatient physiotherapy following total knee arthroplasty (TKA) in patients aged from 55 to 90 who suffered from monoarticular osteoarthritis. They all underwent initially inpatient physiotherapy after surgery, and then they were divided into two groups: one attending outpatient rehabilitation and the other following instructions on home rehabilitation. No statistically significant difference was found at any time (3/6/12 months). The largest mean difference was found at 6 months (2.82°, $P = 0.07$), but it was considered of no clinical significance.

Kramer *et al.*¹⁶ also showed similar conclusions comparing patients who completed the whole postoperative rehabilitation protocol at home monitored periodically by phone calls from the physiotherapist once a week vs those who followed a clinic-based protocol under direct supervision two times a week in addition to execution of basic unsupervised exercise. They used nine criteria among questionnaires and functional test to evaluate the results of the approaches, and they all produced very similar results at any time during 52 weeks' follow-up ($P \geq 0.01$).

Meniscectomy

Retrospective studies

Rockborn *et al.*⁷ reported the outcomes of a series of meniscectomies they performed in 1995 and compared the results of these patients with historic controls from 1980 in order to evaluate whether the evolution of the surgical technique over the years and the different rehabilitation adopted for the two series of patients produced better results and a more efficient cost control. They concluded that the patients they treated, who rehabilitated totally by themselves at home, achieved the same functional

Table 3 Rehabilitation programs definition for each study

Studies	Supervised group	Home group
Goodwin <i>et al.</i> ¹¹	Supervised physical therapy from a standardized protocol 3 times a week for 6 weeks	Discharged from hospital without rehabilitation protocol
Grant <i>et al.</i> ¹²	Two sessions per week of supervised physical therapy for Weeks 2 through 7 and once per week for Weeks 8 through 12 after surgery for a total of 17 sessions within the first 3 postoperative months	Four phases requiring activity at home, ranging from at least 5 times per day in phase 1 to 4 to 7 times per week in phase 4
Grant <i>et al.</i> ¹³	Seventeen supervised physical therapy sessions following a standardized rehabilitation program	Four physical therapy sessions of activity at home in the first 3 months after primary following a standardized rehabilitation program
Forster <i>et al.</i> ⁴	Inpatient physiotherapy then 3 visits weekly for 4 weeks of supervised physical therapy (could be made slightly longer or shorter)	Inpatient physiotherapy then advised on how to work on exercises to carry out at home
Hohmann <i>et al.</i> ¹⁴	Weekly control for the first six postoperative weeks followed by biweekly visits until 6 months and monthly until 9 months after surgery	Rehabilitation protocol performed at home under the guidance of written instruction over 6 months divided into 5 stages of activity at home
Jokl <i>et al.</i> ¹⁵	Three times per week control with about 45 min spent at each supervised rehabilitation session.	Diagrammatic representation of how the exercises were to be done alone. Activity at home consisting of 3 sets of 10 repetitions for each exercise each day
Beard <i>et al.</i> ⁹	Based predominantly on the 'proprioceptive' or functional exercise under the supervision of a physiotherapist in a class therapy 2 times a week in addition to the exercises done at home.	Exercises performed either at home or using alternative commercial/private facilities, attending physical therapy department only for assessment, education, modification and progression of the treatment plan
Rockborn <i>et al.</i> ⁷	Patients were followed as outpatients. It is not well clarified how rehabilitation protocol was.	Patients performed the exercises alone at home. It is not well clarified how rehabilitation protocol was.
Ugutmen <i>et al.</i> ²⁰	Six supervised exercise phases over 8 months total. Exercises for the first three phases demonstrated to patients during weekly follow-ups	Home rehabilitation booklet containing descriptions and diagrams of the exercises
Vervest <i>et al.</i> ²¹	Protocol of 9 exercises of 30 min each in 3 weeks under the supervision of a physiotherapist	Standard treatment comprising oral and written advices to do at home
De Carlo <i>et al.</i> ⁶	Patients referred to a physical therapy clinic near their home for convenient follow-up and rehabilitation. Patients at visit routinely educated on philosophy of treatment. More routine physical therapy sessions to monitor the patients' progresses	Visits at scheduled intervals after surgery (typically at 1 week, 2 weeks, 5 weeks, 2 months, 4 months, 6 months and 1 year postoperatively). Meanwhile programs outlined for the patients to carry out their rehabilitation goals independently
Kramer <i>et al.</i> ¹⁶	Standard inpatient physical therapy twice daily for 20 min on each occasion in a class therapy and also outpatient physical therapy 2 sessions per week/10 weeks for ~1 h per session	Standard inpatient physical therapy twice daily for 20 min on each occasion. Then, telephonic assistance when needed

Continued

Table 3 Continued

Studies	Supervised group	Home group
Moffet <i>et al.</i> ¹⁷	Combination of standardized home exercise program with a series of 9 supervised PT treatments provided at hospital after surgery	Following home rehabilitation booklet and instructions on the use of rehabilitative systems alone
Rajan <i>et al.</i> ²²	Inpatient and outpatient physiotherapy, followed by home exercises. Supervised physical therapy consisting in a mean 4–6 visits	Inpatient physiotherapy only
	During the first 6 post-operative weeks, all patients received the same individual treatment.	
Revenas <i>et al.</i> ¹⁸	Therapy group classes performing exercise program together with other patients with knee injuries and surgery, under the supervision of a physiotherapist	The home rehabilitation protocol consisting in exercises that could be accomplished individually in any location (a gym if particular gears and instruments were required) and with occasional presence of a physiotherapist to instruct patient on how to execute exercises correctly.
Schenck <i>et al.</i> ¹⁹	Inpatient physiotherapy, then 3 visits weekly for 6 weeks of supervised physical therapy	Patients, after receiving instructions, perform exercises alone at home and the number of physiotherapist visits was at the discretion of the patient and his condition. The meeting consisted primarily in giving instructions on how to do the exercises at home.
Fischer <i>et al.</i> ¹⁰	Twenty-four physical therapy supervised appointments in clinic in the first 6 months	Six supervised physical therapy visits primarily for knowing about patients' condition and giving instructions on the exercises at home.
Treacy <i>et al.</i> ⁸	N/A	N/A

NA, not available data from the author's paper.

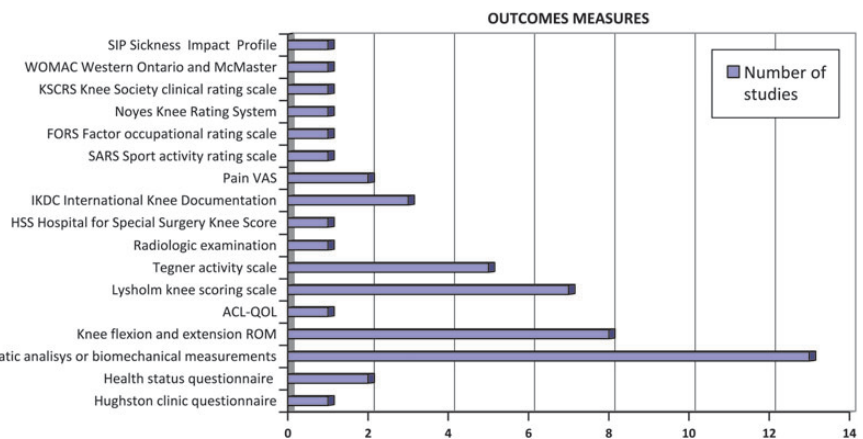


Fig. 4 Scores used to assess the outcomes.

outcomes and eventually took the same time to fully recover from surgery as the ones operated earlier who instead were supervised during exercises by physicians at the hospital. Anyhow it is unclear how the difference in surgical technique might have influenced their deduction.

RCTs

Forster and Frost⁴ evaluated clinical outcome measuring quadriceps circumference and knee ROM of patients receiving supervised physiotherapy three times a week during the first postoperative month after medial meniscectomy compared with a group of patients who exercised alone. At final follow-up 26 weeks after surgery, mean inter-group difference in muscle circumference was 0.5 cm and knee ROM showed no significant difference as well (0.3°).

Goodwin *et al.*¹¹ examined patients undergoing rehabilitation through physical therapist supervised intervention plus written and verbal instructions and compared this with written and verbal instructions alone. At 6 weeks similar scores were shown by Hughston clinic questionnaire (27.7 vs 24.8), SF-36 single index score (0.75 vs 0.76) and EQ-5D (0.75 vs 0.81), and therefore, the authors suggested that there is no benefit in receiving a mean standardized treatment sessions post surgery over written and verbal advice on how to exercise at home.

Jokl *et al.*¹⁵ in their 1989 trial even found that patients rehabilitating on their own after arthroscopic medial meniscectomy tended to perform slightly better on isokinetic testing measuring knee muscular strength ($P = 0.145$), ROM ($P = 0.986$) and endurance ($P = 0.059$) than a group receiving supervision in a private outpatient rehabilitation facility at 2, 4 and 8 weeks after surgery.

Knee extensor work and a knee function questionnaire were measured by Moffet *et al.*¹⁷ on 15 subjects (PT group) who participated in physical therapy sessions in addition to individual exercise compared with a control group of 16 patients who received only general advice to exercise on their own. They remarkably found that at last follow-up the PT group had better knee extensor recovery than the patients exercising at home. However, follow-up was only 3 weeks long. Similarly, Vervest *et al.*²¹ recorded higher values in patients who performed postoperative rehabilitation exercises under the supervision of a physiotherapist compared with subject exercising at home following written and verbal advice. Any considered outcome measures showed significant mean inter-group difference at last control (VAS 14.2 vs 6.6, Lysholm score 14.3 vs 22.3, Tegner score 2.1 vs 2.8 etc.), but this study has a very short follow-up as well (4 weeks).

ACL reconstruction

Retrospective

Treacy *et al.*⁸ reported data over the 6 months from two groups of patients, the first having minimal supervision through a few outpatient rehabilitation appointments, whom we considered substantially home-based, and those who attended extensive supervised rehabilitation conducted mostly in clinic. At any control time, the home-based study subgroup was equivalent to the fully supervised control group in Lysholm score, patient satisfaction and return to preoperative activity level. A study by De Carlo *et al.*⁶ was similarly designed, comparing recovery of patients rehabilitating for the most part at their home and patients who attended regular visits to physical therapy, showing equivalent modified Noyes scores at 12 months (88.7 vs 90.5 $P = 0.33$).

RCTs

Grant *et al.* contributed to the subject with two studies^{12,13} both providing important results. In fact in 2005,¹³ they found that a higher number of patients from a group who executed a home-based exercise protocol achieved acceptable outcomes for ROM than controls who were supervised outpatiently (97% vs 83%, $P = 0.02$ for extension; 67% vs 47%, $P = 0.03$ for flexion). Five years later, they presented results from long-term follow-up of the same trial, confirming their previous findings and this time reporting the better outcomes of the home-based rehabilitation programs measured also with the ACL-QOL questionnaire (80.0 ± 16.2 vs 69.9 ± 22.0 , $P = 0.02$) 38 months postoperatively.

Beard *et al.*⁹ evaluated post-operative outcomes in a group of patients who attended regular supervised sessions of physical therapy supplemental to a basic individual training, compared with those of patients fully exercising at home on their own. Lysholm scores ($P = 0.57$), modified Tegner Scores ($P = 0.4$) and IKDC scale scores ($P = 0.4$) recorded equivalent values for both approaches.

Fischer *et al.*¹⁰ found equivalent outcome scores on Lysholm score, health status questionnaires and knee ROM on all patients of their trial, claiming that rehabilitation performed individually at home is as safe and reliable as a protocol performed with outpatient supervision.

Also Hohmann *et al.*¹⁴ obtained similar outcomes by exercising either at home or in clinic following a physiotherapy-guided program. The two branches of treated patients scored equally on Lysholm (97 vs 94) and Tegner Activity Scale (4 vs 5) as well as at the hopping test measured by combined mean symmetry indices (86.8 ± 11.1 vs 88.3 ± 10.9).

Schenck *et al.*¹⁹ reported no differences in functional or subjective outcomes (Lysholm, VAS, knee ROM) in their two postoperative rehabilitation strategies changing location and supervision (minimally

supervised home-based, and controlled clinic-based), with both groups reporting high satisfaction and improved quality of life and knee function. Nevertheless they highlight that cost savings in the home rehabilitation group were significant.

Ugutmen *et al.*²⁰ measured validated scores at 31 months' mean follow-up for patients allocated randomly either to a home-based or to a clinic-based postoperative rehabilitation protocol. No statistical differences were seen in the combined Lysholm (92.3 vs 93.4) HSS (89.7 vs 90.4) and IKDC evaluation measured at last visit.

Finally Revenas *et al.*¹⁸ compared patients who, after an common basic exercise program in the first 6 weeks after surgery, were assigned for the whole rehabilitation period remaining (12 months postoperative follow-up) either to physiotherapy classes to attend frequently or to a protocol where exercises could be accomplished individually in any location (a gym if particular gears and instruments were required) and with occasional presence of a physiotherapist to instruct the patient on how to execute exercises correctly. They concluded how the results achieved at 12 months in Lysholm scores (89 vs 84) and on the Tegner scale (3 vs 3) might indicate that an individual exercise program that could be easily administered at home by the patient with very limited physiotherapy might be as effective as a program requiring intense physiotherapeutic supervision and exercise classes. This was supported also by the evidence that patients considered non-compliant to the supervised group allocation because of poor attendance (thus comparable with home rehabilitating patients) achieved functional scores fully equivalent to those who attended all the appointments of programmed physiotherapy.

Discussion

Rehabilitation exerts a major impact in the progression of recovery following a knee injury.²³ This systematic review examined the available evidence to determine how much supervision patients need to perform rehabilitation in the safest and most reliable way. A comprehensive search of published studies was performed, and we evaluated their methodological quality with the Coleman Methodological Score (CMS). The CMS score was originally developed to assess methodological quality of studies investigating the clinical outcomes of patients with patellar tendinopathy.²⁴ Since then, the CMS has been used to evaluate studies reporting data about many orthopedic conditions and therapy such as cartilage injuries,²⁵ knee arthroplasty,²⁶ combined anterior cruciate and medial collateral ligaments injury²⁷ and augmentation techniques for rotator cuff repair.²⁸

We tried and answer the following questions:

- Is there a clinical difference in the final results of physical therapy performed at home rather than in supervised environment?

All the studies included in this systematic review compared the efficacy of two rehabilitation protocols differing by the degree of supervision applied to the execution of the exercise program.

The statistical analysis between groups could not be performed, since this review did not intend to provide a meta-analysis of the data available in the literature, but an overall summary of the available evidences. Anyway, given the conclusion reached by the authors according to the data collected during their investigations, only four studies^{12,13,15} presented a statistically relevant difference in outcomes following the two different approaches. Two of them,^{12,13} both by Grant *et al*, presented data that suggested superiority of a home-based rehabilitation, Vervest *et al*.²¹ and Moffet *et al*.¹⁶, on the other hand, advocated superiority in the results of supervised physiotherapy. It must be noted how studies claiming better results achieved by home-based approaches measured outcomes at reasonable follow-up times (3 and 38 months), while the last two studies, which supported inpatient physiotherapy, reported data from a very short follow-up (3 and 4 weeks). This criterion might have biased the conclusion drawn by the mentioned studies likely because the first weeks after surgery are the most critical of the whole rehabilitation period because patients exercising on their own still need to fully comprehend the protocol instructions and their compliance with the exercise routine can be negatively affected by the pain they still experience during movements from surgery. Therefore, the absence of a skilled supervisor granting the full observance of the rehabilitation protocol might have had an invalidating impact on very short-term outcomes, which, however, is not influential on the final functional assessments over a long period of time by any of the other studies we reviewed.

Finally, 78% of the studies (14^{4,6-11,14-16,18-20,22} of the total 18 reviewed studies) came to the conclusion that only irrelevant improvement, if any, could be achieved by adding supervision and outpatient appointments to rehabilitation programs following ACL reconstructions, meniscectomy and TKA; both home-based and supervised rehabilitations demonstrated to be equally solid and positive approaches to reach best results in patients' recovery.

- Is motivation able to affect the outcomes of a rehabilitation program?

In programs without or with minor supervision, outcomes could be influenced by the compliance of the patients and by their expectations. There are no validated predicting factors of the long-term compliance of patients with the instructions they received by the therapist to

rehabilitate postoperatively.²⁹ This makes it unknown how patients' motivation varies during a long-term exercise program. Therefore, most of the studies reviewed just mentioned this issue^{8-10,16,18,19} but did not provide any valid measurements. Only one study¹⁸ attempted to measure the patients' compliance by collecting and reporting the number of outpatient appointments attended by each patients. Although this remains a vague measure of the motivational status of the studied population, it is not possible to establish the power of this variable on the rehabilitation program and the following outcome assessments.

- Are there clinical or demographic and social factors that suggest outpatient rehabilitation rather than a home-based one?

None of the studies reviewed identified precise characteristics that a patient should have to undertake outpatient physiotherapy rather than relying on a more manageable home-based program.³⁰ The demographic and social aspects dramatically change from cohort to cohort, and therefore, it is not possible to draw accurate conclusions on which characteristic may be related to the need of supervision. Similarities can be outlined in functional achievements even between young, most frequently undergoing ligament reconstruction surgery, and elderly patients who mainly received knee replacement (as shown in the bottom of Table 2): in fact full comparability of these group is evident from the fully equivalent outcomes achieved following both rehabilitation approaches without showing any influence whatsoever from the mean age of the patients treated during the trials we reviewed.

Forster⁴ and Rockborn⁷ performed a detailed analysis of economic aspects and cost-effectiveness: they support an unsupervised rehabilitation approach after surgery, since expenses for both patients and healthcare systems drop dramatically without compromising the final outcome.

- Are the results of these two approaches related to the specific knee surgery performed?

Most of the studies for each three categories of surgery concluded that results achieved by different protocols were equivalent. Specifically TKA always showed no inter-group difference in all measured outcomes in the included studies. Significant differences were noticed only by studies^{12,13,15,17,21} reporting on outcomes after ACL reconstruction and meniscectomy procedures. The only remarkable aspect we can report is that all but one¹⁵ studies reporting on outcomes from meniscectomy supported the higher benefit of supervision during rehabilitation,^{17,21} while studies advising home-based protocols^{12,13} were both about ACL reconstruction (Table 3).

- Is the methodological quality of the studies adequate to draw definitive conclusions on this issue?

The high average CMS scores (77.1) of the clinical studies demonstrate an acceptable quality of the studies included in this systematic review. All but three studies^{6–8} presented level of evidence 1 or 2. 9^{9,10,13,15–17,19,21,22} of the 15 were RCT of good quality while 6^{4,11,12,14,18,20} of 15 RCT were of excellent quality according to the criteria shown in Figure 2. On the other hand, the different instructions provided by the authors to execute rehabilitation programs and the dissimilarity of the clinical scores used to evaluate the outcomes make it difficult to undertake a comparative analysis between different studies.

Despite the lack of evidences to draw definitive conclusions, the current available data allow to advance that the degree of supervision may not directly determine the final outcomes. Numerous variables such as comorbidities and motivation could influence the results and deserve to be better investigated. Therefore, given the rising demand for cost-effectiveness in healthcare and the data collectable in current literature, reliable and compliant patients can successfully rehabilitate following a home-based protocol achieving the same results of a supervised outpatient approach.

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