Philadelphia Panel Evidence–Based Clinical Practice Guidelines on Selected Rehabilitation Interventions for Knee Pain

John Albright, Richard Allman, Richard Paul Bonfiglio, Alicia Conill, Bruce Dobkin, Andrew A Guccione, Scott Hasson, Randolph Russo, Paul Shekelle, Jeffrey L Susman, Lucie Brosseau, Peter Tugwell, George A Wells, Vivian A Robinson, Ian D Graham, Beverley J Shea, Manathip Osiri, Jessie McGowan, Joan Peterson, Hélène Corriveau, Lucie Pelland, Michelle Morin, Lucie Poulin, Michel Tousignant, Lucie Laferrière, Lynn Casimiro and Louis E Tremblay

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Special Issue

Philadelphia Panel Evidence-Based Clinical Practice Guidelines on Selected Rehabilitation Interventions for Knee Pain

Introduction. A structured and rigorous methodology was developed for the formulation of evidence-based clinical practice guidelines (EBCPGs), then was used to develop EBCPGs for selected rehabilitation interventions for the management of knee pain. Methods. Evidence from randomized controlled trials (RCTs) and observational studies were identified and synthesized using methods defined by the Cochrane Collaboration that minimize bias by using a systematic approach to literature search, study selection, data extraction, and data synthesis. Meta-analysis was conducted where possible. The strength of evidence was graded as level I for RCTs or level II for nonrandomized studies. Developing Recommendations. An expert panel was formed by inviting stakeholder professional organizations to nominate a representative. This panel developed a set of criteria for grading the strength of both the evidence and the recommendation. The panel decided that evidence of clinically important benefit (defined as 15% greater relative to a control based on panel expertise and empiric results) in patient-important outcomes was required for a recommendation. Statistical significance was also required but was insufficient alone. Patient-important outcomes were decided by consensus as being pain, function, patient global assessment, quality of life, and return to work, providing that these outcomes were assessed with a scale for which measurement reliability and validity have been established. Validating the Recommendations. A feedback survey questionnaire was sent to 324 practitioners from 6 professional organizations. The response rate was 51%. Results. Two positive recommendations of clinical benefit were developed: (1) transcutaneous electrical nerve stimulation (TENS) and therapeutic exercises were beneficial for knee osteoarthritis, and (2) there was good agreement with these recommendations from practitioners (73% for TENS, 98% for exercises). For several interventions and indications (eg, thermotherapy, therapeutic ultrasound, massage, electrical stimulation), there was a lack of evidence regarding efficacy. Conclusions. This methodology of developing EBCPGs provides a structured approach to assessing the literature and developing EBCPGs that incorporates clinicians' feedback and is widely accetable to practicing clinicians. Further well-designed RCTs are warranted regarding the use of several interventions for patients with knee pain where evidence was insufficient to make recommendations. [Philadelphia Panel Evidence-Based Clinical Practice Guidelines on Selected Rehabilitation Interventions for Knee Pain. *Phys Ther.* 2001;81:1675–1700.]

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Key Words: *Clinical practice guidelines, Evidence-based practice, Knee, Meta-analysis, Physical therapy, Practitioner feedback survey, Rehabilitation, Systematic reviews.*

INTRODUCTION

Chronic knee pain is one of the most common reasons for visits to a family practitioner. Acute knee pain usually follows injury or surgery. Chronic knee pain can be related to disease such as osteoarthritis or associated with overuse or untreated injuries to muscles, ligaments, or tendons.

Prospective studies show that knee pain improves with time, regardless of therapy. The most common practice for general practitioners is a referral for a variable number of sessions of physical therapy. There is a need to provide clinicians with evidence for informed decision making regarding treatment options.

The Philadelphia Panel was convened to evaluate 8 selected rehabilitation interventions for knee pain: thermotherapy, therapeutic massage, therapeutic exercises, electromyographic (EMG) biofeedback, ultrasound, transcutaneous electrical nerve stimulation (TENS), electrical stimulation, and combined rehabilitation interventions.

Philadelphia Panel Members:

Clinical Specialty Experts:

John Albright, MD, (Orthopaedic Surgeon), American Academy of Orthopaedic Surgeons, USA
Richard Allman, MD (Internist, Rheumatologist), American College of Physicians, USA
Richard Paul Bonfiglio, MD (Physiatrist)
Alicia Conill, MD (Internist), University of Pennsylvania, Philadelphia. USA
Bruce Dobkin, MD (Neurologist), American Academy of Neurology, USA
Andrew A Guccione, PT, PhD, (Physical Therapist), American Physical Therapy Association, USA
Scott Hasson, PT, PhD, (Physical Therapist), American College of Rheumatology, Association of Health Professionals, USA
Randolph Russo, MD (Physiatrist), American Academy of Physical Medicine and Rehabilitation, USA
Paul Shekelle, MD, PhD (Internist), Cochrane Back Group, USA
Jeffrey L Susman, MD (Family Practice), American Academy of Family Physicians, USA

Ottawa Methods Group:

Lucie Brosseau, PhD (Public Health, specialization in epidemiology); Career Scientist, Ministry of Ontario Health (Canada), and Assistant Professor, Physiotherapy Program, School of Rehabilitation Sciences, University of Ottawa, Ottawa, Ontario, Canada

Peter Tugwell, MD, MSc (Epidemiology), Chair, Centre for Global Health, Institute of Population Health, Ottawa, Ontario, Canada

George A Wells, PhD (Epidemiology and Biostatistics), Professor and Chairman, Department of Epidemiology and Community Medicine, University of Ottawa, Ottawa, Ontario, Canada

Vivian A Robinson, MSc (Kinesiology), Research Associate, Clinical Epidemiology Unit, Ottawa Health Research Institute, Ottawa Hospital, Civic Campus, Ottawa, Ontario, Canada

Ian D Graham, PhD (Medical Sociology), Medical Research Council Scholar, Clinical Epidemiology Unit, Ottawa Health Research Institute, Ottawa Hospital, Civic Campus, Ottawa, Ontario, Canada

Beverley J Shea, RN, MSc (Epidemiology), Research Associate, Department of Medicine, University of Ottawa and Clinical Epidemiology Unit, Ottawa Health Research Institute, Ottawa Hospital, Civic Campus, Ottawa, Ontario, Canada

Manathip Osiri, MD, Research Fellow, Ottawa Hospital, General Campus, Ottawa, Ontario, Canada

Jessie McGowan, Director of the Medical Library, Ottawa Hospital, Ottawa, Ontario, Canada

Joan Peterson, Research Associate, Department of Medicine, Clinical Epidemiology Unit, Ottawa Health Research Institute, Ottawa Hospital, Civic Campus, Ottawa, Ontario, Canada

Hélène Corriveau, PhD; Lucie Pelland, PhD; Michelle Morin, BSc; Lucie Poulin, MSc; Michel Tousignant, PhD; Lucie Laferrière, MHA; Lynn Casimiro; Louis E Tremblay; Program of Physiotherapy, School of Rehabilitation Sciences, Faculty of Health Sciences, University of Ottawa, Ottawa, Ontario, Canada

Address all correspondence and requests for reprints to: Peter Tugwell, MD, MSc, Chair, Centre for Global Health, Institute of Population Health, 1 Stewart St, Rm 312, Ottawa, Ontario, Canada K1N 6N5 (ptugwell@uottawa.ca).

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The purpose of this article is to describe the evidence-based clinical practice guidelines (EBCPGs) developed by the panel about rehabilitation interventions for knee pain. The aim of the developing the EBCPGs was to improve appropriate use of rehabilitation interventions for knee pain. The target users of these guidelines are physical therapists, physiatrists, orthopedic surgeons, rheumatologists, family physicians, and neurologists.

METHODS

The detailed methods of the EBCPGs development process are summarized in an accompanying article in this issue ("Philadelphia Panel Evidence-Based Clinical Practice Guidelines on Selected Rehabilitation Interventions: Overview and Methodology"). Briefly, an *a priori* protocol was defined that was followed for the conduct of separate systematic reviews for each intervention.

Studies were eligible if they were randomized controlled trials (RCTs), nonrandomized controlled clinical trials (CCTs), or case control or cohort studies that evaluated the intervention of interest in a population with knee conditions including chondromalacia patellae (patellofemoral syndrome), postsurgical conditions, knee osteoarthritis, and tendinitis. Rheumatoid arthritis was excluded. The types of patients seen postsurgery included those who had meniscectomy, total knee replacement, anterior cruciate ligament reconstruction, and arthroscopic surgery for removal of loose bodies or plica.

The outcomes of interest were defined by the Philadelphia Panel as functional status, pain, ability to work, patient global assessment, patient satisfaction, and quality of life. The interventions included massage, thermal therapy (hot or cold packs), electrical stimulation, EMG biofeedback, TENS, therapeutic ultrasound, therapeutic exercises, and combinations of these rehabilitation interventions. Studies where control groups received active treatments were not considered sufficient evidence for recommendations. Concurrent treatments were allowed if they were given in the same way to both the experimental and control groups (eg, home exercises, educational booklets, advice on posture). However, concurrent therapy that was given to one group but not the other group was not accepted (eg, education by means of lectures for the control group were not accepted). No limitations based on methodological quality were imposed. Only English-, French-, and Spanish-language articles were accepted. Abstracts were not included.

Although most of these knee conditions have pain as the primary outcome, patients with these conditions also seek physical therapy for limitations other than pain such as functional limitations, instability, and weakness. The Philadelphia Panel evaluated the effects of interventions on outcomes considered to be clinically meaningful and validated, as described in the accompanying methods paper ("Philadelphia Panel Evidence-Based Clinical Practice Guidelines on Selected Rehabilitation Interventions: Overview and Methodology"). Some outcomes such as flexibility and strength were not considered by the members of the Philadelphia Panel to be sufficient evidence to warrant a clinical recommendation. However, functional assessment, quality of life, and patient global assessment were considered sufficient for a recommendation and have been evaluated when reported in the trials. If other outcomes were available, the results are described in the sections titled "Efficacy."

A structured literature search was developed based on the sensitive search strategy for RCTs recommended by the Cochrane Collaboration[1] and modifications proposed by Haynes et al.[2] The search strategy was expanded to identify case control, cohort, and nonrandomized studies. The search was conducted in the electronic databases of MEDLINE, EMBASE, Current Contents, CINAHL, and the Cochrane Controlled Trials Register up to July 1, 2000. In addition, the registries of the Cochrane Field of Rehabilitation and Related Therapies and the Cochrane Musculoskeletal Group and the Physiotherapy Evidence Database (PEDro) were searched. The references of all included trials were searched for relevant studies. Content experts were contacted for additional studies.

Two independent reviewers (VAR, JP) appraised the titles and abstracts of the literature search, using a checklist with the *a priori* defined selection criteria. Relevant studies were retrieved and the full articles were assessed for inclusion by 2 independent reviewers. Data were extracted by 2 independent reviewers from included articles, using predetermined extraction forms regarding the population characteristics, details of the interventions, trial design, allocation concealment, and outcomes. Methodological quality was assessed with a 5-point validated scale that assigns 2 points each for randomization and double-blinding and 1 point for description of withdrawals.[3,4] Differences in data extraction and quality assessment were resolved by consensus.

Data were analyzed at 3 approximate time points posttherapy: 1 month, 6 months, and 12 months. If outcomes were reported at different intervals, the closest time was used for these time points.

Because several etiologies of knee pain exist, different conditions were analyzed separately. Chondromalacia patellae (patellofemoral pain syndrome), postsurgical conditions, osteoarthritis, and tendinitis were analyzed separately.

Table 1.
Details of Philadelphia Panel Classification System

	Clinical Importance	Statistical Significance	Study Design[a]
Grade A	>15%	$P<.05$	RCT (single or meta-analysis)
Grade B	>15%	$P<.05$	CCT or observational (single or meta-analysis), with a quality score of 3 or more on the 5-point Jadad methodologic quality checklist
Grade C+	>15%	Not significant	RCT or CCT or observational (single or meta-analysis)
Grade C	<15%	Unimportant[b]	Any study design
Grade D	<0% (favors control)		Well-designed RCT with >100 patients

[a] RCT=randomized controlled trial, CCT=controlled clinical trial.
[b] For grade C, statistical significance is unimportant (ie, clinical importance is not met; therefore, statistical significance is irrelevant).

STATISTICAL ANALYSIS

Where possible, data from individual trials were combined using meta-analysis. Data were analyzed using the Review Manager (RevMan) computer program, Version 4.1 for Windows.* Continuous data were analyzed using weighted mean differences (WMDs) between the treatment and control groups at the end of study, where the weight is the inverse of the variance. Where an outcome was measured with different scales (eg, pain, functional status), the data were analyzed with standardized mean differences, calculated using the mean and standard deviation. Dichotomous data were analyzed using relative risks. Heterogeneity was tested using a chi-square statistic. When heterogeneity was not significant, fixed-effects models were used. With significant heterogeneity, random-effects models were used.

To calculate clinical improvement (defined as 15% improvement relative to a control), the absolute benefit and the relative difference in the change from baseline were calculated. Absolute benefit was calculated as the improvement in the treatment group less the improvement in the control group, in the original units. Relative difference in the change from baseline was calculated as the absolute benefit divided by the baseline mean (weighted for the treatment and control groups). For dichotomous data, the relative percentage of improvement was calculated as the difference in the percentage of improvement in the treatment and control groups.

The recommendations were graded by their level of evidence (I or II) and by the strength of evidence (A, B, or C). This grading system is shown in Table 1 and is described more fully elsewhere (see article titled "Philadelphia Panel Evidence-Based Clinical Practice Guidelines on Selected Rehabilitation Interventions: Overview and Methodology"). Briefly, grade A recommendations indicate that a clinically important benefit was shown in one or more RCTs. Grade B recommendations were assigned for interventions with a clinically important benefit shown in nonrandomized trials. Because there is less confidence in the results of nonrandomized studies, grade B recommendations required that the study be assigned a quality score of 3 or more out of 5. Grade C recommendations were assigned to interventions that have been compared with a control and have shown no evidence of effect in controlled trials. A master grid showing each rehabilitation intervention assessed and the strength and level of evidence is presented in Table 2. The report follows the same order as this grid (from left to right, top to bottom) for these interventions for which eligible studies where found.

A clinically important benefit was shown for 2 interventions for knee osteoarthritis (TENS and exercise) (Tab. 3). No evidence of clinically important benefit was shown in studies of 5 other interventions (Tab. 4). Insufficient data were available for 9 interventions (Tab. 5). The Philadelphia Panel EBCPGs are compared with other published guidelines in Appendix 1.

A survey questionnaire was sent to 324 practitioners for feedback on the 2 grade A recommendations. Their comments were reviewed by the Philadelphia Panel and were incorporated into this EBCPG document. Of the 324 practitioners surveyed from the American Academy of Family Physicians (AAFP), American Academy of Orthopaedic Surgeons (AAOS), American College of Physicians (ACP), American Physical Therapy Association (APTA), American College of Rheumatology Health Professionals (ARHP), and Physiatric Association of Spine, Sports, and Occupational Rehabilitation (PASSOR), 9 were inappropriately sampled (wrong specialty) and 21 could not be reached due to incorrect addresses. Of the 294 practitioners who were appropriately sampled and received the questionnaire, 149 responded (51% response rate). Of these, 11 refused to participate (4%) and 138 completed the survey (47%).

* Oxford, England: The Cochrane Collaboration, 2000.

Table 2.
Master Grid of Knee Pain Guidelines[a]

	Patello-femoral Pain Syndrome	Post-surgery	Osteoarthritis	Knee Tendinitis
Exercise	ID	✔ C	✔ A	ID
Massage	nd	nd	nd	✔ C
Thermotherapy	nd	✔ C	✔ C	nd
Therapeutic ultrasound	✔ C	nd	✔ C	nd
Transcutaneous electrical nerve stimulation	nd	✔ C	✔ A	nd
Electrical stimulation	nd	ID	✔ C	nd
Electromyographic biofeedback	nd	ID	nd	nd
Combined rehabilitation modalities interventions	nd	ID	nd	nd

[a] ✔=evidence-based recommendation formulated, A=based on randomized controlled trial (RCT) showing >15% benefit and statistically significant, B=based on controlled clinical trial (CCT) showing >15% benefit and statistically significant, C=based on RCT or CCT and showing no evidence of benefit, C+=based on RCT or CCT and showing >15% benefit but not statistically significant, ID=insufficient data due to lack of placebo, lack of relevant outcomes, nd=no data.

RESULTS

Literature Search

The literature search identified 5,330 articles related to the knee conditions described above. Of these articles, 184 were considered potentially relevant based on the selection criteria checklist. Of these 184 articles, 29 met the selection criteria and were included (Appendix 2). The included trials are shown for each of the interventions for knee pain in the "cityscape" shown in Figure 1.

PATELLOFEMORAL PAIN SYNDROME

Therapeutic Ultrasound for Patellofemoral Pain Syndrome, Level I (RCT), Grade C for Patient Global Assessment (No Evidence of Clinically Important Benefit)

Summary of Trials: One RCT (N=29) of ice and therapeutic ultrasound versus ice alone was included.[5] All patients had palpable tenderness on extension.

Efficacy: None demonstrated. There was no difference in number of patients who rated their knee pain as improved with continuous therapeutic ultrasound and ice therapy compared with ice alone (Fig. 2). There was a large loss to follow-up (45%, 19 of 42 patients).

Strength of Published Evidence in Comparison With Other Guidelines: The Philadelphia Panel found good scientific evidence (level I, RCT) regarding therapeutic ultrasound for patellofemoral pain. Therapeutic ultrasound has not been assessed by other guidelines for patellofemoral pain syndrome.

Clinical Recommendations Compared With Other Guidelines: The Philadelphia Panel recommends that there is poor evidence to include or exclude therapeutic ultrasound alone (grade C for patient global assessment) as an intervention for patellofemoral pain syndrome.

POSTSURGERY KNEE PAIN

Preoperative Exercises for Postsurgery Knee Pain, Level I (RCT), Grade C for Pain and Function (No Clinically Important Benefit)

Summary of Trials: One RCT (N=20) was identified of preoperative strengthening and stretching versus usual care prior to unilateral knee replacement in patients with rheumatoid arthritis or osteoarthritis.[6] One RCT was excluded due to lack of a control group (closed versus open kinetic chain exercises).[7]

Efficacy: None demonstrated. The only outcome measure was a knee rating scale (0–100) that measures pain, function, range of motion (ROM), muscle strength, flexion deformity, and instability. There was no difference in the knee rating between the usual care and strengthening exercise groups at 3, 12, 24, or 48 weeks postsurgery (Fig. 3).

Strength of Published Evidence in Comparison With Other Guidelines: The Philadelphia Panel found good scientific evidence (level I, RCT) regarding preoperative strengthening exercises in patients undergoing unilateral knee arthroplasty.

Clinical Recommendations Compared With Other Guidelines: The Philadelphia Panel recommends that there is poor evidence to include or exclude preoperative strengthening exercises alone (grade C for pain and function) prior to unilateral knee arthroplasty surgery.

Thermotherapy for Postsurgery Knee Pain, Level I (RCT), Grade C for Pain (No Evidence of Clinically Important Benefit)

Summary of Trials: One RCT (N=45) of cold gel packs in patients who had been prescribed home exercises after knee surgery was included.[8]

Table 3.
Grade A Rehabilitation Interventions: Clinically Important Benefit Demonstrated[a]

Guideline	Recommendation	Outcomes	Relative Difference	Study Design (No. of Patients)
Therapeutic exercises for knee osteoarthritis	Grade A	Pain	16%–78%	3 RCTs
	Grade C+	Function	7%–26%	(N=293)
	Grade A	Patient global assessment	21%	
TENS for knee osteoarthritis	Grade A	Pain	40%	4 RCTs
	Grade A	Patient global assessment	18%–22%	(N=184)

[a] TENS=transcutaneous electrical nerve stimulation, RCT=randomized controlled trial.

Table 4.
Grade C Rehabilitation Interventions: No Evidence of Clinically Important Benefit[a]

Guideline	Recommendation	Outcomes	Relative Difference	Study Design (No. of Patients)
Therapeutic ultrasound for patellofemoral pain syndrome	Grade C	Patient global assessment	None	1 RCT (N=64)
Preoperative exercises for postsurgery knee conditions	Grade C	Pain	None	1 RCT (N-20)
	Grade C	Function		
Thermotherapy for postsurgery knee conditions	Grade C	Pain	None	1 RCT (N=45)
TENS for postsurgery rehabilitation	Grade C	Pain	None	1 RCT (N=60)
	Grade C	Function		
Therapeutic ultrasound for knee osteoarthritis	Grade C	Pain	None	1 RCT (N=74)
Electrical stimulation for knee osteoarthritis	Grade C	Function	Less than 15%	1 RCT (N=30)
Massage for knee tendinitis	Grade C	Pain	None	1 RCT (N=20)

[a] TENS=transcutaneous electrical nerve stimulation, RCT=randomized controlled trial.

Efficacy: None demonstrated. There was no difference after 1 week of therapy between cold packs and no cold pack therapy on the McGill Pain Scale (Fig. 4), for ROM or strength.

Strength of Published Evidence in Comparison With Other Guidelines: The Philadelphia Panel found good scientific evidence (level I, RCT) regarding ice packs, but none for hot packs. No other guidelines have assessed thermotherapy postsurgery.

Clinical Recommendations Compared With Other Guidelines: The Philadelphia Panel recommends that there is poor evidence to include or exclude cryotherapy (grade C for pain) as an adjunct intervention to home exercises after knee surgery.

TENS for Postsurgery Rehabilitation, Level I (RCT), Grade C for Pain (No Evidence of Clinically Important Benefit)

Summary of Trials: One RCT (N=90) of TENS (70 Hz) compared with placebo TENS and with a group that received no therapy was included.[9]

Table 5.
Rehabilitation Interventions With Insufficient Data

Intervention and Indication	Details
Combined rehabilitation interventions for postsurgery knee pain	Due to different interventions and poorly defined interventions, the panel decided that it was impossible to draw conclusions
Therapeutic exercises for knee tendinitis	No relevant outcomes
Electrical stimulation for knee postsurgery	Insufficient sample size (n=5 per group)[39]
Therapeutic exercises for patellofemoral pain	Head-to-head trials
Therapeutic exercises for postsurgery knee rehabilitation	Head-to-head trials
Electromyographic biofeedback for knee postsurgery	Head-to-head trials

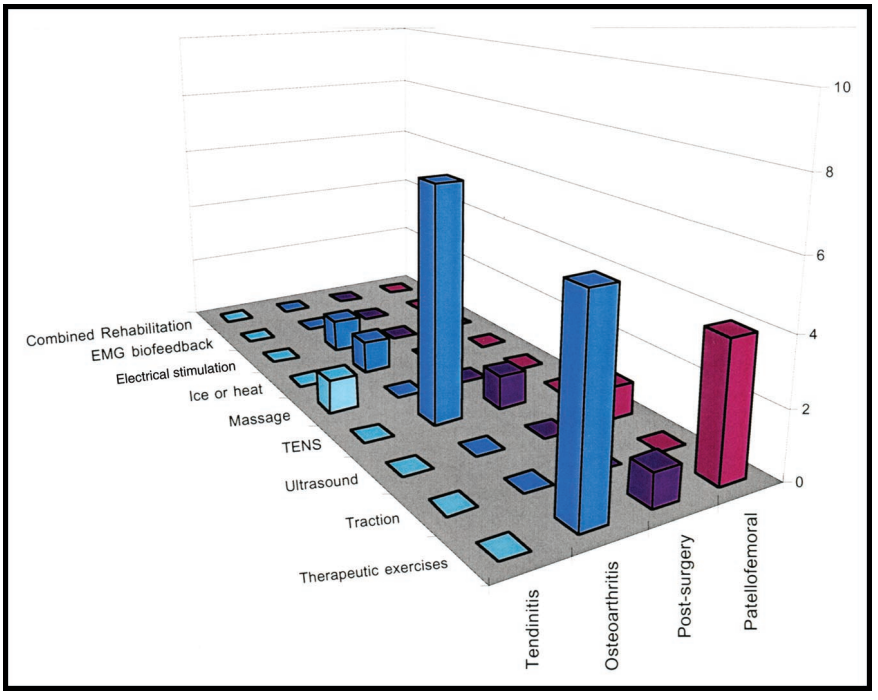

Figure 1.
Cityscape, showing included trials for each type of knee pain. EMG=electromyographic, TENS=transcutaneous electrical nerve stimulation.

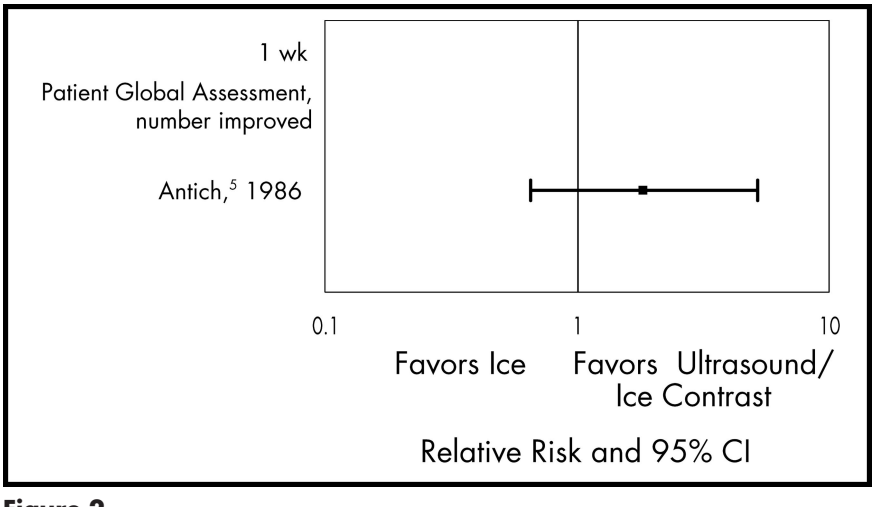

Figure 2.
Therapeutic ultrasound for patellofemoral pain syndrome. CI=confidence interval.

Efficacy: None demonstrated. The trial demonstrated that there was no significant difference between TENS and placebo for pain, ROM, or muscle force. However, there was a significant benefit of TENS on pain relief compared with no therapy. The data from this trial cannot be presented graphically due to lack of data (standard deviations not reported).

Strength of Published Evidence in Comparison With Other Guidelines: The Philadelphia Panel found good scientific evidence (level I, RCT) regarding TENS after knee surgery. Transcutaneous electrical nerve stimulation after knee surgery has not been assessed by other guidelines.

Clinical Recommendations Compared With Other Guidelines: The Philadelphia Panel recommends that there is poor evidence to include or exclude TENS alone (grade C for pain) as an intervention after knee surgery.

KNEE OSTEOARTHRITIS

Therapeutic Exercises, Level I (RCT), Grade A for Pain and Patient Global Assessment, Grade C+ for Function (Clinically Important Benefit)

Summary of Trials: Four RCTs (N=318) of strengthening, stretching, and functional exercises versus no therapy were included.[10–13] One RCT (N=201) of strength exercise versus usual general practitioner care was included.[14] One RCT (N=41) of repeated straight leg raises was included.[15]

Three RCTs (N=79) were excluded because no outcomes were included that met the Philadelphia Panel criteria for clinical importance and validity (strength outcomes only).[16–18] One RCT was excluded because manual therapy was used as the comparison intervention.[19]

Efficacy: Clinically important benefit on pain and patient global assessment. Pain relief was 38% greater with strength exercises relative to placebo in one RCT (N=201).[14] Similarly, pain relief was greater with strengthening exercises relative to untreated control groups by 16%,[13] 42%,[12] and 78%[10] ($P<.05$, Tab. 6, Fig. 5).

The improvement in patient-assessed global disease activity was clinically important relative to a control in 2 RCTs (N=268), with risk differences of 21%[11] and 27%[20] (Tab. 7, Fig. 6).

Functional status did not show a clinically important benefit consistently across all trials (7%,[12] 18%,[13]

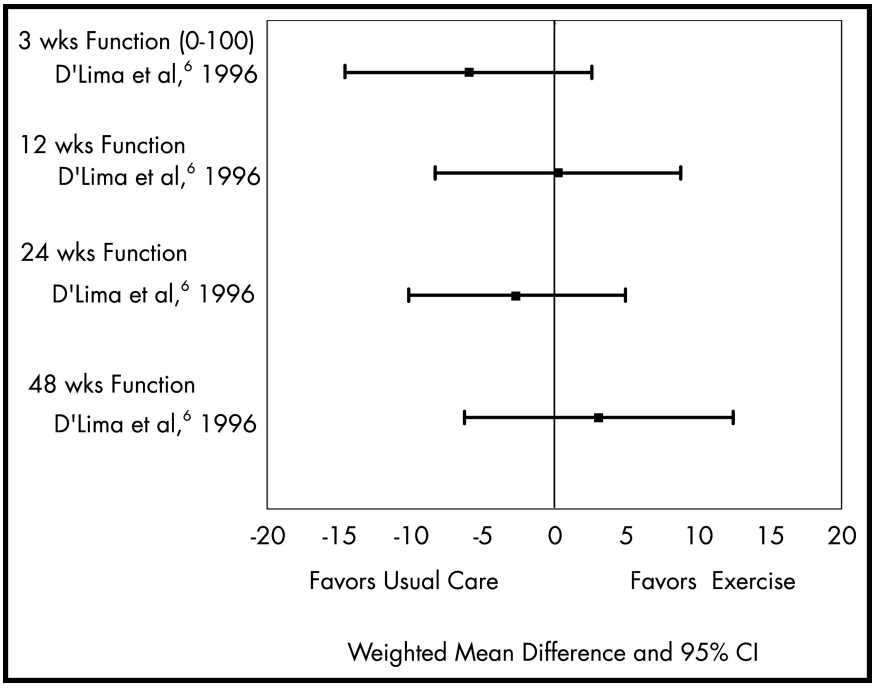

Figure 3.
Preoperative strengthening for knee replacement. CI=confidence interval.

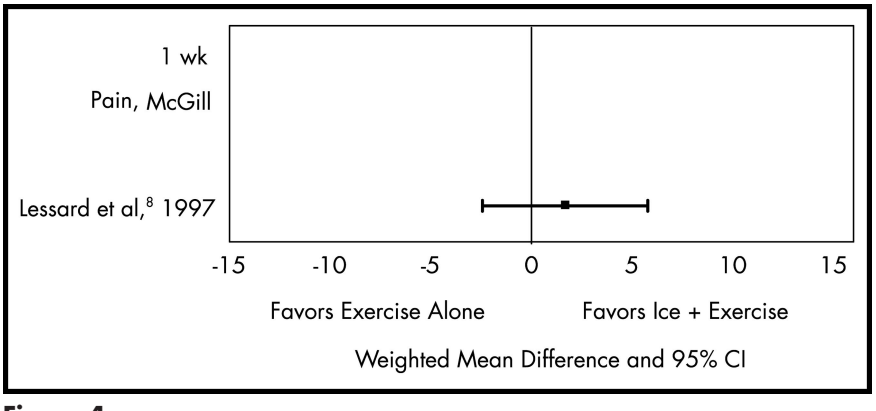

Figure 4.
Cold packs for postsurgery knee. CI=confidence interval.

26%[11]). Furthermore, the results of the pooled meta-analysis were not statistically significant.

One RCT of straight leg raises for knee osteoarthritis showed a clinically important improvement in function relative to a control (24%).[15]

Strength of Published Evidence in Comparison With Other Guidelines: The Philadelphia Panel found level I (RCT) evidence that showed a clinically important benefit of strength exercises on knee osteoarthritis pain. The *British Medical Journal* (BMJ)[21] guidelines reported that there was limited evidence of benefit, with few well-designed RCTs. They based this finding on 3 systematic reviews (with 1997 as the most recent search date) and 3 RCTs. The RCTs were excluded from the Philadelphia Panel systematic review because they did not include a placebo group (2 trials) or included manual therapy (1 trial).

Clinical Recommendations Compared With Other Guidelines: The Philadelphia Panel recommends that there is good evidence to include strengthening, stretching, and functional exercises alone (grade A for pain and patient global assessment, grade C+ for function) as interventions for knee osteoarthritis pain. This recommendation agrees with American College of Rheumatology (ACR) guidelines for the management of osteoarthritis that recommend the use of ROM, strength exercise, and aerobic exercise.[22] The BMJ guidelines[21] based their results on a published meta-analysis[14] and concluded that exercises are likely to be beneficial for both pain relief and function.

Practitioner Agreement

- Response rate for this EBCPG: 49%
- Percentage of practitioners giving comments for this EBCPG: 19%
- Agree with recommendation: 98%
- Think a majority of my colleagues would agree: 94%
- Will (or already) follow this recommendation: 96%

Practitioner Comments

1. Exercises should be modified to avoid exacerbation, especially if patient is obese or has pronated feet; may need to consider aquatic exercises.

2. Other options for knee osteoarthritis are better.

3. Consider RCT by Deyle et al.[19]

Panel's Response: Modifications based on individual needs were not described in the included trials and therefore cannot be addressed in this guideline. The Philadelphia Panel assessed only selected rehabilitation interventions. Furthermore, the Philadelphia Panel did not rank therapies, but rather evaluated whether the evidence supports the use of the interventions assessed

Table 6.
Pain After 1 Month of Exercise Therapy for Knee Osteoarthritis[a]

Study	Treatment Group	Outcome	No. of Patients	Baseline Mean	End of Study Mean	Absolute Benefit	Relative Difference in Change From Baseline
Bautch et al,[10] 1997	E: strength and stretch	Pain, 0–10 VAS	15	3.49	2.19	−1.92 (I) on 10-cm VAS	−78% (I)[b]
	C: untreated		15	1.46	2.08		
O'Reilly et al,[13] 1999	E: strength	Pain: WOMAC, 0–20 VAS	108	6.45	5.00	−1.03 (I) on 20-cm VAS	−16% (I)
	C: untreated		72	6.75	6.33		
Rogind et al,[12] 1998	E: strength and stretch	Pain, 0–10 VAS	11	5	2	−2.00 (I) on 10-cm VAS	−42% (I)
	C: untreated		12	4.5	3.5		
van Baar et al,[20] 1998	E: strength, stretch, functional	Pain, 0–100 VAS	93	46.9	24.1	−17.10 (I) on 100-mm VAS	−38% (I)
	C: usual care		98	43.1	37.4		

[a] E=experimental group, C=control group, VAS=visual analog scale.
[b] This study shows a large relative difference in change from baseline due to baseline differences.

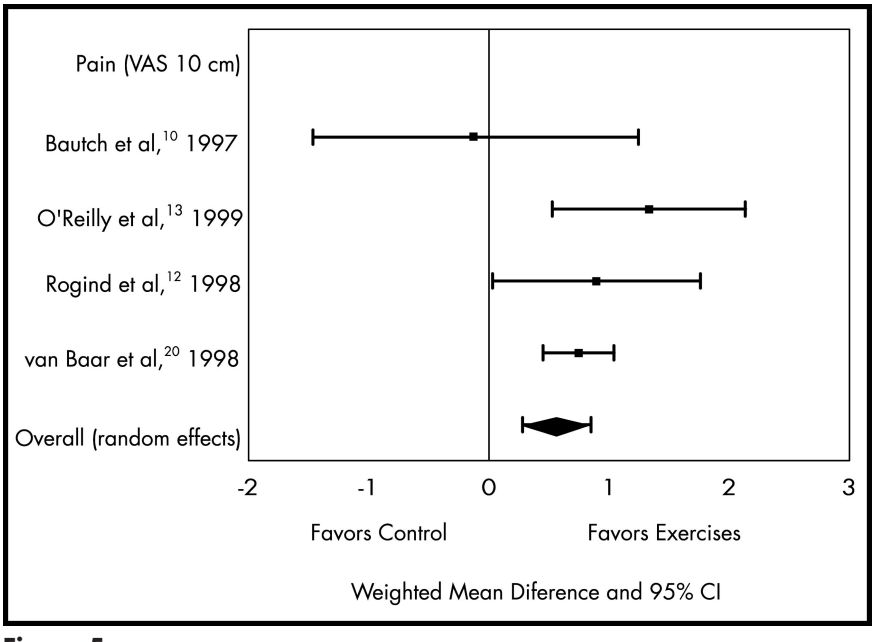

Figure 5.
Exercise versus control for knee osteoarthritis: pain (as measured with a visual analog scale [VAS]) at 3 months. CI=confidence internal.

when compared with no therapy or a placebo. The trial by Deyle et al[19] was excluded because the intervention group received manual therapy.

Thermotherapy for Knee Osteoarthritis, Level I (RCT), Grade C for Pain (No Evidence of Clinically Important Benefit)

Summary of Trials: One RCT (N=50) of ice massage versus a placebo for knee osteoarthritis was identified.[23] The treatment was applied 5 times per week for 20 minutes each session for 2 weeks.

Efficacy: None demonstrated. Ice massage of 4 acupoints (SP-9 yinlingquan, GB-34 yanglingquan, ST-34 liangqui, and ST-35 dubi) using a wood block was not different from placebo TENS for pain or stiffness relief (Tab. 8).

Strength of Published Evidence in Comparison With Other Guidelines: The Philadelphia Panel found good evidence (level I, RCT) of no effect of ice massage on acupoints in knee osteoarthritis pain. Ice massage on acupoints has not been assessed by other knee osteoarthritis pain guidelines.

Clinical Recommendations Compared With Other Guidelines: The Philadelphia Panel recommends that there is poor evidence to include or exclude ice massage alone (grade C for pain) as an intervention for knee osteoarthritis.

Therapeutic Ultrasound for Knee Osteoarthritis, Level I (RCT), Grade C for Pain (No Evidence of Clinically Important Benefit)

Summary of Trials: One RCT (N=74) of therapeutic ultrasound versus a placebo for knee osteoarthritis was

Table 7.
Patient Global Assessment and Function After 1 Month of Exercise Therapy for Knee Osteoarthritis

Study	Treatment Group[a]	Outcome	No. Improved	No. of Patients	Risk (% Occurrence)	Risk Difference
Borjesson et al,[11] 1996	E: strength and stretch	Patient global assessment	20	34	59%	56%
	C: control		1	34	3%	
van Baar et al,[20] 1998	E: strength, stretch, functional	Patient global assessment	44	98	45%	27%
	C: control		18	102	18%	

[a] E=experimental group, C=control group.

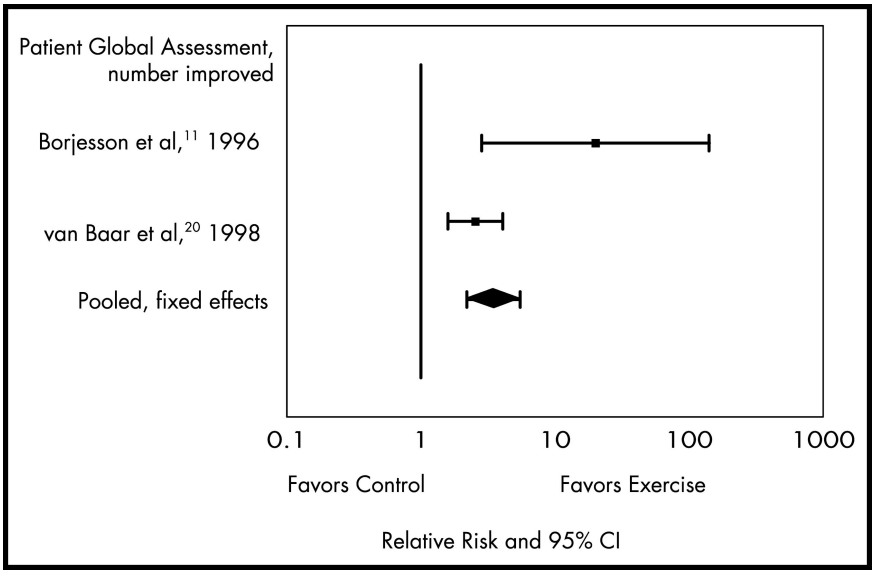

Figure 6.
Exercise versus control for knee osteoarthritis: patient global assessment at 3 months. CI-confidence interval.

Clinical Recommendations Compared With Other Guidelines: The Philadelphia Panel recommends that there is poor evidence to include or exclude therapeutic ultrasound alone (grade C for pain) as an intervention for knee osteoarthritis.

TENS for Knee Osteoarthritis, Level I (RCT), Grade A for Pain and Patient Global Assessment (Clinically Important Benefit)

Summary of Trials: Seven placebo-controlled RCTs (N=184) evaluated TENS versus a placebo for knee osteoarthritis.[23,26–31] Four RCTs were excluded due to inappropriate populations of patients with postsurgery knee conditions,[9] myalgia,[32] and low back pain.[33] One RCT used of a non-TENS device, described as producing "pulsed electrical stimulation."[34]

identified.[24] One CCT (N=120) was excluded because the comparison intervention was "galvanic current."[25]

Efficacy: None demonstrated. The therapeutic ultrasound group reported less pain than the placebo group after 4 weeks of therapy, but the difference was not statistically significant (WMD=1.3 cm on a 10-cm VAS, 95% confidence interval [CI] = −0.07 to 2.7 cm). This difference corresponded to an 11% relative difference between groups in the change from baseline. At 3 months follow-up, there was no difference between groups.

Strength of Published Evidence in Comparison With Other Guidelines: The Philadelphia Panel found good evidence (level I, RCT) of the effects of therapeutic ultrasound in knee osteoarthritis. Therapeutic ultrasound has not been assessed by other knee osteoarthritis guidelines.

Efficacy: Clinically important benefit on pain and patient global assessment. Three RCTs (N= 87) demonstrated a significant difference in number of patients with pain improvement of 20% to 46% relative to the control group after 1 month of therapy[30,31,35] (Tab. 9). Pain assessed by visual analog scale was statistically significantly improved in our meta-analysis of the 5 RCTs of greater than 3 weeks' duration. The pooled estimate was equivalent to an improvement in pain of 41% from baseline relative to placebo[23] (Tab. 10, Fig. 7). The absolute change from baseline ranged from 57% to 83% of baseline in the TENS group. One RCT of the immediate effects of 30 minutes of TENS showed that there was no difference between TENS and placebo TENS on immediate pain relief.[27] Three RCTs demonstrated clinically important and statistically significant improvements in patient-assessed overall improvement relative to a control of 29% at 1 month,[29] 17% at 1 month,[28] and 48% at 3 months[4] (Tab. 11, Fig. 8). Functional status was not assessed using validated measurement scales such as the

Table 8.
Ice Massage for Knee Osteoarthritis: Pain Relief[a]

Study	Treatment Group	Outcome	No. of Patients	Baseline Mean	End-of-Study Mean	Absolute Benefit	Relative Difference in Change From Baseline
Yurtkuran and Kocagil,[23] 1999	Ice massage	Pain, 1–5 PPI 1=mild 2=moderate 3=severe 4=very severe 5=excruciating	25	0.7	0.4	−0.10 (I) on 5-point Likert scale	−14%(I)
	Placebo TENS		25	0.7	0.5		

[a] TENS=transcutaneous electrical nerve stimulation, PPI=present pain intensity.

Table 9.
Pain at 1 to 3 Months After Transcutaneous Electrical Nerve Stimulation (TENS) for Knee Osteoarthritis[a]

Study	Treatment Group	Outcome	No. Improved	No. of Patients	Risk (% Occurrence)	Risk Difference
Fargas-Babjak et al,[35] 1992	E: TENS, 4 Hz LF, acupoints	Pain, 6 wk	14	19	74%	46%
	C: placebo		5	18	28%	
Smith et al,[30] 1983	E: TENS, 32–50 Hz on tender points (usually acupoints)	Pain, 8 wk	7	15	47%	20%
	C: placebo		4	15	27%	
Taylor et al,[31] 1981	E: TENS, frequency NR, 4 points around knee	Pain, 4 wk	8	10	80%	40%
	C: placebo		4	10	40%	

[a] HF=high frequency, LF=low frequency, NR=not reported.

Health Assessment Questionnaire (HAQ), Lee Index, WOMAC, or Arthritis Impact and Measurement Scale (AIMS) in any of the included trials.

Strength of Published Evidence in Comparison With Other Guidelines: There is good evidence (level I, RCT) of TENS alone for the management of knee osteoarthritis that showed a benefit on pain and patient global assessment. Transcutaneous electrical nerve stimulation has not been assessed by other guidelines for knee osteoarthritis.

Clinical Recommendations Compared With Other Guidelines: The Philadelphia Panel recommends that there is good evidence to include TENS as an intervention for pain associated with knee osteoarthritis (grade A for pain and patient global assessment).

Practitioner Agreement

- Response rate for this EBCPG: 49%
- Percentage of practitioners giving comments for this EBCPG: 36%
- Agree with recommendation: 73%
- Think a majority of my colleagues would agree: 50%
- Will (or already) follow this recommendation: 56%

Practitioner Comments

1. Other interventions are better (eg, exercises, nonsteroidal anti-inflammatory drugs); use TENS only if these interventions fail.
2. Other studies of TENS for other types of chronic pain have shown no effect.
3. No lasting effect of TENS.
4. Limited evidence for improvements in functional status (only patient global assessment improved).

Panel's Response: Practitioner agreement is lower than with other guidelines (73%), possibly because there is more conflicting evidence (ie, some trials showed no statistical significance). Specifically, the grade A rating was achieved only for patient global assessment, and the effect on pain was not statistically significant (grade

Table 10.
Transcutaneous Electrical Nerve Stimulation (TENS) for Knee Osteoarthritis: Pain Relief on Continuous Scales[a]

Study	Treatment Group	Outcome	No. of Patients	Baseline Mean	End-of-Study Mean	Absolute Benefit	Relative Difference in Change From Baseline
Lewis et al,[29] 1984	E: TENS, 70-Hz HF, 4 acupoints	Pain, VAS 10 cm, 0=no pain relief, 10=complete pain relief	31	3.5	5.5	0.7 (I) on 10-cm VAS	20% (I)[b]
	C: placebo		28	3.5	4.8		
Lewis et al,[28] 1994	E: TENS, 70-Hz HF, 4 acupoints	Pain, VAS 100 mm, 0=no relief, 100=complete pain relief	29	NA	48.1	5.1 (I) on 100-mm VAS	10.6% (I)[b]
	C: placebo		29	NA	43.2		
Fargas-Babjak et al,[35] 1992	E: TENS, 4-Hz LF, 7 acupoints	Pain, VAS 100 mm 0=no relief, 100=complete pain relief	18	NA	56.05	45.33 (I) on 100-mm VAS	NA[b]
	C: placebo		19	NA	10.72		
Taylor et al,[31] 1981	E: TENS, frequency NR, 4 points around knee	Pain, VAS 10 cm 0=no pain, 10=extreme pain	10	NA	0.9	0.1 on 10-cm VAS (I)	NA
	C: placebo		10	NA	0.8		
Yurtkuran and Kocagil,[23] 1999	TENS	Pain, 1–5 PPI 1=mild 2=moderate 3=severe 4=very severe 5=excruciating	25	1.2	0.2	−0.80 (I) on 5-point Likert scale	−84% (I)
	Placebo TENS		25	0.7	0.5		

[a] E=experimental group, C=control group, HF=high frequency, LF=low frequency, NR=not reported, VAS=visual analog scale, NA=not applicable, PPI=present pain intensity.
[b] Study had pain scale where a higher score indicates greater pain relief.

C+). These guidelines do not rank interventions in comparison with each other, but rather indicate the efficacy when compared with a placebo. The Philadelphia Panel has also shown no effect of TENS on other types of chronic pain (eg, postsurgery knee pain, chronic low back pain). This difference in efficacy may relate to the method of TENS application. In particular, the trials that used low-frequency, high-intensity TENS on acupoints[23,35] demonstrated the greatest benefit on pain and patient global assessment. Acupuncture-like TENS was not used in the trials of chronic low back pain. The EBCPGs have been modified to specify the length of follow-up in these trials. Benefit is specified for pain and patient global assessment, but not for functional status.

Electrical Stimulation for Knee Osteoarthritis, Level I (RCT), Grade C for Function (No Clinically Important Benefit Demonstrated)

Summary of Trials: One RCT (N=30) of patterned neuromuscular electrical stimulation of the quadriceps femoris muscle in elderly patients with knee osteoarthritis was included.[36]

Efficacy: None demonstrated. The timed sit-to-stand test and walking velocity were statistically significantly improved when compared with placebo stimulation. However, the percentage of change from baseline was less than 15%, thus not meeting the criteria for clinical relevance. The results cannot be displayed graphically because inadequate data were reported (standard deviations were printed in graphical format only). No strength outcomes were reported.

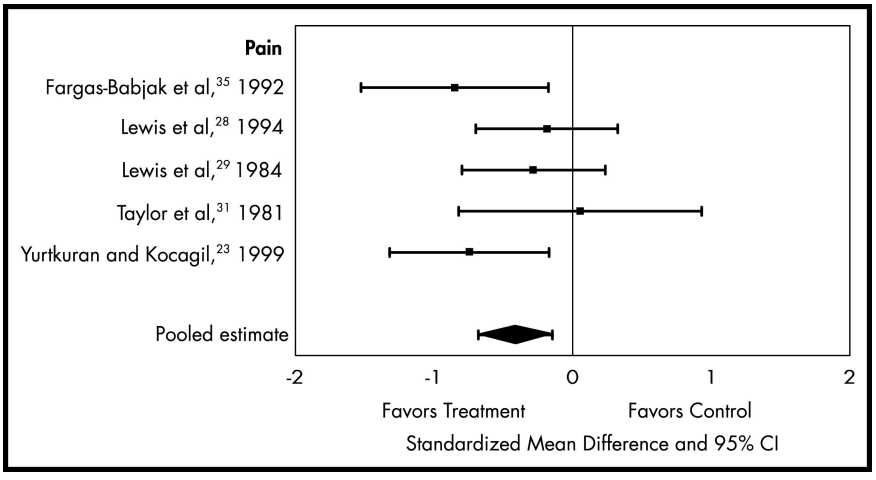

Figure 7.
Transcutaneous electrical nerve stimulation (TENS) versus placebo for knee osteoarthritis: pain at 1 month. CI=confidence interval.

Strength of Published Evidence in Comparison With Other Guidelines: The Philadelphia Panel found good evidence (level I, RCT) of the effects of electrical stimulation in knee osteoarthritis. Electrical stimulation has not been assessed by other knee osteoarthritis guidelines.

Clinical Recommendations Compared With Other Guidelines: The Philadelphia Panel recommends that there is poor evidence to include or exclude electrical stimulation alone (grade C for function) as an intervention for knee osteoarthritis. Because electrical stimulation is usually used to improve strength, this recommendation is inconclusive until evidence of effects on strength have been shown in clinical trials.

TENDINITIS

Massage for Knee Tendinitis, Level I (RCT), Grade C for Pain (No Evidence of Clinically Important Benefit)

Summary of Trials: One RCT (N=20) of deep transverse friction massage compared with no therapy for patients with iliotibial band syndrome was included.[37]

Efficacy: None demonstrated. Pain while running was not different between groups that received massage and no treatment. A daily pain diary showed a clinically unimportant difference in pain of 8% between groups (Fig. 9).

Strength of Published Evidence in Comparison With Other Guidelines: The Philadelphia Panel found good scientific evidence (level I, RCT) regarding deep friction massage for iliotibial tendinitis. There were no other clinical practice guidelines for tendinitis. There was no evidence regarding other types of massage for different types of tendinitis (eg, patellar tendinitis).

Clinical Recommendations Compared With Other Guidelines: The Philadelphia Panel recommends that there is poor evidence to include or exclude deep friction massage alone (grade C for pain) as an intervention for iliotibial band syndrome.

Insufficient Evidence

Therapeutic exercises for knee tendinitis have been assessed in one RCT, but no validated, clinically relevant outcomes (as defined by the Philadelphia Panel) were measured.[38]

Electrical stimulation for the knee postsurgery has been compared with exercises and EMG biofeedback but has not been compared with a placebo with sufficient sample size.[39]

For chondromalacia patellae (patellofemoral pain syndrome), different types of therapeutic exercises (isokinetic, isometric, closed chain, open chain) have been compared.[40] However, the only RCT with an untreated control group did not measure any outcomes of interest (ROM and strength only).[41]

After knee surgery, several types of therapeutic exercise have been compared: closed versus open kinetic chain,[42] functional versus isometric exercises,[43] and exercise versus electrical stimulation.[18] However, there have been no comparisons with placebo (or untreated) control groups.

Electromyographic biofeedback after knee surgery lacks placebo-controlled trials.[44,45]

DISCUSSION

A standardized, rigorous methodology was applied to developing EBCPGs based on Cochrane systematic reviews of the literature, and using a transdisciplinary expert panel and methods group. Practitioner feedback has been included in the guidelines. Two EBCPGs were developed by the Philadelphia Panel based on the clinically important benefits found with TENS for knee osteoarthritis and therapeutic exercises for knee osteoarthritis.

The major implication of this work is that there is methodologically poor evidence to support the use of a

Table 11.
Patient Global Assessment at 1 and 3 Months After Transcutaneous Electrical Nerve Stimulation (TENS) for Knee Osteoarthritis[a]

Study	Treatment Group	Outcome	No. Improved	No. of Patients	Risk (% Occurrence)	Risk Difference
Lewis et al,[29] 1984	E: TENS, 70-Hz HF, 4 acupoints	Patient global assessment, 3 wk	12	28	43%	29%
	C: placebo		4	28	14%	
Lewis et al,[28] 1994	E: TENS, 70-Hz HF, 4 acupoints	Patient global assessment, 3 wk	7	29	24%	17%
	C: placebo		2	29	7%	
Fargas-Babjak et al,[35] 1992	E: TENS, 4 Hz LF, 7 acupoints	Patient global assessment, 12 wk	9	15	60%	48%
	C: placebo		2	17	12%	

[a] E=experimental group, C=control group, HF=high frequency, LF=low frequency.

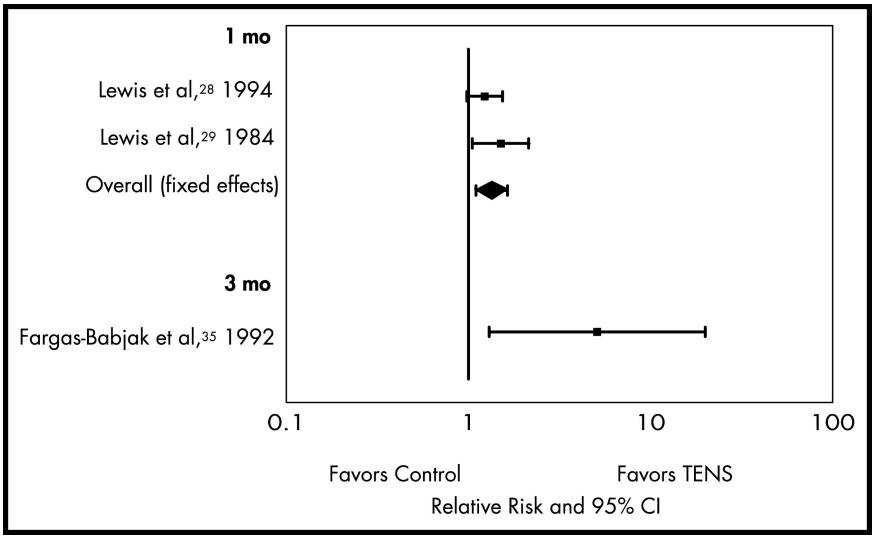

Figure 8.
Transcutaneous electrical nerve stimulation (TENS) versus placebo for knee osteoarthritis: patient global assessment at 1 and 3 months. CI=confidence interval.

number of widely accepted interventions. The trials identified were often inconclusive because of lack of a placebo group, use of nonvalidated outcomes, use of population diagnoses that are not widely applicable to the population, and inadequate sample size.

Within specific interventions, the characteristics of the intervention also may play a role in the lack of a clinically important benefit. For example, deep friction massage was evaluated for knee iliotibial tendinitis. However, several other forms of massage that are in use in practice (eg, effleurage, acupressure, trigger point therapy) have not been evaluated. As another example, therapeutic ultrasound for patellofemoral pain syndrome has been evaluated in a trial where all patients received ice. It is possible that therapeutic ultrasound alone would have beneficial effects compared with placebo therapeutic ultrasound. This highlights the need to investigate the specific mode of use that is used in clinical practice and most likely to show benefits.

The presence of home exercises as an adjunct intervention for many of these trials complicates the interpretation of results, particularly because the adherence to a program of home exercises is rarely reported in the trials. Differential adherence may confound the treatment effect.

The therapeutic application of several rehabilitation interventions is based on empirical experience.[46–48] Research on rehabilitation interventions is further complicated by the multitreatment model used in clinical practice. A patient usually receives several rehabilitation interventions in one session. Furthermore, the types of therapy will be chosen according to the phase of recovery. For example, the first phase of recovery for an acute injury is characterized by rest, ice, and compression. The second phase is characterized by stretching, mobility exercises, and electrotherapy such as therapeutic ultrasound or TENS to relieve pain and inflammation.[46] The third phase involves strengthening, continued stretching, and continued use of electrotherapy for the breakup of scar tissue. The practice of rehabilitation requires a better theoretical basis[49,50] and well-designed controlled research.[51]

The measurement of the effects of rehabilitation interventions is complex.[52,53] Standardized measurement of outcomes is needed to facilitate scientific advances in clinical care for knee conditions.[14,54] The Philadelphia Panel agreed that the primary outcomes of clinical importance are: pain, functional status, patient global assessment, quality of life, return to work, and patient satisfaction. Furthermore, the Philadelphia Panel

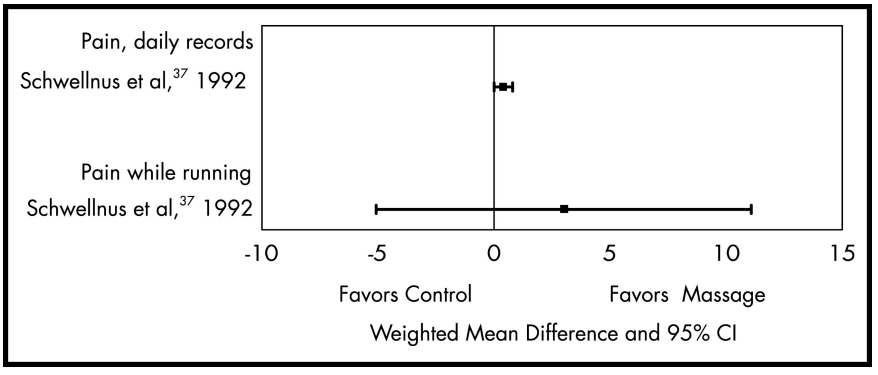

Figure 9.
Friction massage for knee tendinitis. CI=confidence interval.

required that these outcomes be measured with a scale whose measurements have established reliability and validity. Although pain is usually the primary outcome, other limitations such as reduced ROM, swelling, and muscle weakness and instability affect patients with various knee conditions. These limitations are sometimes the primary cause for physical therapist consultation. These limitations are captured by the Philadelphia Panel outcomes for functional status, patient global assessment, quality of life, and return to work.

Physical factors[55–57] and psychosocial factors[20,58,59] have an impact on the effectiveness of rehabilitation interventions for knee pain. Because of these factors, a multidimensional clinical evaluation is recommended in knee pain management, especially among patients with osteoarthritis and rheumatoid arthritis.[58–60] It was not possible to examine these risk factors in this review.

Potential methodological biases could have been introduced in trials on effectiveness of rehabilitation interventions for the management of knee pain. A misclassification bias related to the knee condition studied is present with the lack of precise medical and physical therapy diagnoses observed.[57,61–66] Selection bias could have occurred with the presence of heterogeneity of clinical characteristics such as age, prevalent versus incident cases, stages of the disease, level of pain, and presence or absence of inflammation. However, differences in disease duration were minimized in these guidelines by excluding studies with a mix of acute and chronic conditions or mixed diagnoses. Characteristics of the device parameters and of the therapeutic application[49] also could make a difference in the effect size. Publication bias may be a problem if only trials with positive findings have been published.[67] The effect of publication bias could not be assessed because of the small number of trials. A language bias was introduced because the Philadelphia Panel reviewed only studies published in English, French, or Spanish.

The methodological quality of studies on knee pain rarely reached 3 out of 5 or greater on the Jadad scale[3,4] (Appendix 2). Randomization (17/31 studies) was rarely fully adequate (ie, performed using computerized random number lists). Insufficient information was noted in several RCTs regarding the treatment assignment procedure. Inappropriate blinding (21/31 studies) also could lead to information bias. Blinding is an issue with physical rehabilitation interventions. Complete blinding is difficult to achieve because of visual and other sensory differences between treatment and placebo groups as well as unintended communication between patient and evaluator.[68] The use of an unblinded, untreated control group can lead to an overestimate of the treatment effect. This was demonstrated by one trial reviewed for these guidelines that showed no difference between TENS and placebo TENS but demonstrated a significant benefit on pain relief of TENS compared with an untreated, unblinded control group.[9] Few investigators (13/31 studies) reported adequate information regarding withdrawals and loss to follow-up or indicated whether they were considered in the data analysis. These weaknesses contribute to the lower-quality assessment scores in many of the systematic reviews conducted on rehabilitation interventions for knee pain.

The Philadelphia Panel agreed that clinical importance be defined as an improvement of 15% or more relative to a control (see article titled "Philadelphia Panel Evidence-Based Clinical Practice Guidelines on Selected Rehabilitation Interventions: Overview and Methodology" in this issue). Both clinical importance and statistical significance were required for grade A or B recommendations. With these requirements, inconclusive results were reached for several interventions (grade C).

Ottenbacher[69] lists several difficulties for rehabilitation specialists: (1) discrimination between clinical and statistical significance, (2) low statistical power in detecting minimal clinically important differences (MCIDs), and (3) lack of replication of rehabilitation studies to strengthen evidence-based practice. Some studies (18/25 studies) did not use adequate sample sizes to detect important differences with confidence (Appendix 2). These issues have led to inconclusive results in other systematic reviews.[14,54]

The Philadelphia Panel EBCPGs for the management of knee pain are mainly in agreement with previous and recent EBCPGs[21,23] and clinical practice guidelines[70] for

knee pain described in Tables 8 and 9, especially for therapeutic exercises. The Philadelphia Panel EBCPGs for knee pain have the advantage that they were developed based on a systematic grading of the evidence determined by an expert panel, and the evidence was derived from systematic reviews and meta-analyses using the Cochrane Collaboration methodology. The finalized EBCPGs were circulated for feedback from practitioners to verify their applicability and ease of use for practicing clinicians. This rigorous methodological procedure provides considerable credibility for rehabilitation specialists who intend to use these EBCPGs for knee management in their daily practice.

Therapeutic Exercises

The main aim of therapeutic exercises is to improve functional status by increasing muscle strength, improving flexibility, and increasing pulmonary function of the client, depending on the type of exercise (usually functionally specific). Our meta-analysis showed that traditional therapeutic exercises are beneficial for pain relief and patient global assessment in people with knee osteoarthritis (grade A for pain and patient global assessment). Improved function was shown in 3 RCTs, but did not reach statistical significance, and was assigned a grade C+ recommendation. These exercises included combinations of strengthening, stretching, and functional exercises.[71–74] In contrast, preoperative strengthening exercises showed no benefit on postsurgery knee function. There was no evidence regarding acute knee pain. The current results for knee conditions are in agreement with recent reviews for traditional therapeutical exercises.[14,74–78] Furthermore, the feedback survey showed that 98% of the respondents agreed with the guideline.

Therapeutic exercises may compensate for arthrogenic impairment in quadriceps femoris muscle sensorimotor function, diminished proprioceptive acuity, and decreased postural stability associated with reduced functional performance of patients with osteoarthritis.[55] Strengthening exercises also improve gait and attenuate knee pain in activities of daily living among patients with osteoarthritis.[79] Types of exercises, intensity, and progression need to be clarified according to patient-specific classification of physical dysfunction, needs, treatment goals, and outcomes.[14,54,72,78,80–84] The lack of a statistically significant effect on function warrants further research because therapeutic exercises are often prescribed to address functional limitations, muscle weakness, and instability. Insufficient evidence was found for use of therapeutic exercise for knee tendinitis and chondromalacia patellae.

Therapeutic Ultrasound

Therapeutic ultrasound did not demonstrate a clinically important benefit for osteoarthritis of the knee or for patellofemoral pain syndrome.[5,24] No studies were found for postsurgery or acute conditions. Other research work is obviously needed for knee pain at different stages and for different conditions. The BMJ[21] and ACR[23] guidelines did not evaluate therapeutic ultrasound for knee pain.

One trial[5] used continuous therapeutic ultrasound, which generates vasodilatation,[85] combined with a 2-minute ice application, which induces vasoconstriction.[86] Other confounding variables such as randomization method, characteristics of the device, size of the applicator, and study duration might have contributed to the lack of effect of therapeutic ultrasound for patellofemoral pain syndrome found by this trial.[46,49] These results concur with those of previous reviews.[46,78,87] Puett and Griffin[78] also conclude that no support exists in the literature for therapeutic ultrasound treatment prior to therapeutic exercise in management of knee osteoarthritis.

TENS

Clinical benefit was demonstrated in our meta-analysis of TENS for knee osteoarthritis.[9,28,30,31,35,88] In contrast, our meta-analysis of TENS after knee surgery showed no benefit (level I, grade C). Other reviews of TENS have not found evidence of benefit.[78,89] One of these reviews[78] did not use Cochrane Collaboration methodology and considered only 3 of the 6 studies included in our meta-analysis.[28,31,35] The other review did not specifically study the effectiveness of TENS for knee osteoarthritis; the investigators included various conditions involving pain.[89]

Transcutaneous electrical nerve stimulation is thought to generate neuroregulatory peripheral and central effects[90–93] and modulate pain transmission.[94–96] The Philadelphia Panel EBCPGs (level I, grade A) cannot be compared with BMJ[21] and ACR[23] guidelines because these guidelines did not evaluate TENS for pain relief.

Therapeutic Massage

There were insufficient data for the Philadelphia Panel to make a recommendation regarding therapeutic massage (Cyriax's deep transverse frictions) as an intervention alone for knee tendinitis. There are no other systematic reviews on massage for knee pain. The Philadelphia Panel recommendation cannot be compared with the BMJ,[21] ACR,[23] or Manal and Snyder-Mackler[70] guidelines because they did not evaluate massage as an intervention for knee pain.

There are a number of confounding variables related to the therapeutic application of massage. For example, the effectiveness of massage is influenced by the types of maneuvers used, the massage approach adopted, years of experience of the therapist, number and size of the muscles involved, patient position, pressure, rhythm and progression, and frequency and duration of the treatment sessions.[97]

Thermotherapy

The Philadelphia Panel concluded that there was poor evidence to include or exclude thermotherapy for post-surgery knee pain. This recommendation is based on only one RCT of cryotherapy (with cold gel packs) in which both groups received therapeutic stretching and isometric strengthening exercises.[8] We also found poor evidence to include or exclude ice massage for knee osteoarthritis; however, this finding was based on a trial that used ice massage applied to acupoints.[23] There was insufficient evidence to make a recommendation regarding thermotherapy for patellofemoral pain syndrome. These results are in agreement with a recent systematic review[78] for osteoarthritis of the knee. The BMJ,[21] ACR,[23] and Manal and Snyder-Mackler[70] guidelines did not evaluate thermotherapy for knee pain.

Physiological studies have shown significant effects of cryotherapy on circulatory and temperature responses, muscle spasm, and inflammation,[86,87] but its mechanism of action has not yet been fully elucidated.[86] It is unknown whether these physiological effects translate to important effects on clinical outcomes (such as pain and functional status).

EMG Biofeedback, Electrical Stimulation, and Combined Rehabilitation Interventions

Despite the positive physiological effect of these interventions,[98] either there are no clinical data or there is insufficient clinical information on the effectiveness of EMG biofeedback, electrical stimulation, and combined rehabilitation interventions for acute and chronic knee pain.

The Philadelphia Panel was unable to make clinical recommendations regarding these specific interventions. Similarly, the BMJ[21] and ACR[23] guidelines did not evaluate these modalities.

Overall

The main difficulty in determining the effectiveness of rehabilitation interventions is the lack of well-designed prospective RCTs. An enormous research effort is needed to conduct RCTs for almost every rehabilitation intervention for knee pain. This situation is critical compared with the growing knee research area. There is a pressing need for further work on other rehabilitation interventions for knee pain, particularly considering the increased use of physical therapists in North America. Furthermore, these trials need to use standardized and validated outcomes, describe fully the intervention and its characteristics, and consider evaluating subgroups of particular interest.

CONCLUSION

We have used structured methodology and a transdisciplinary expert panel and practitioner feedback to develop rigorous EBCPGs for the use of selected rehabilitation interventions for managing knee conditions. This process has resulted in 2 clear recommendations of clinical benefit of TENS and exercise for knee osteoarthritis. There is a lack of evidence at present regarding whether to include or exclude the use of thermotherapy, therapeutic massage, EMG biofeedback, therapeutic ultrasound, electrical stimulation, and combined rehabilitation interventions in the daily practice of physical rehabilitation for knee pain.

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Appendix 1.
Strength of Published Evidence and Clinical Recommendations of Previous Evidence-Based Clinical Practice Guidelines (EBCPGs) for Knee Pain[a]

Rehabilitation Intervention		The Philadelphia Panel (2001)	Manal and Snyder-Mackler[70] (1996)
Previous EBCPGs for Postsurgery of the Knee			
Therapeutic exercises	Strength of published evidence in comparison with other guidelines	Good scientific evidence Level I for preoperative exercises	Common practice, but no scientific evidence for ACL postsurgery
	Clinical recommendations compared with other guidelines	Poor evidence to include or exclude (grade C for pain and function) preoperative strengthening exercises alone as an intervention prior to unilateral knee replacement surgery	Preoperative and postsurgery exercises are listed as option to increase strength, ROM, and endurance
Therapeutic ultrasound	Strength of published evidence in comparison with other guidelines	N/A	N/C
	Clinical recommendations compared with other guidelines	No data found	N/C
TENS	Strength of published evidence in comparison with other guidelines	Good scientific evidence Level I for TENS	N/C
	Clinical recommendations compared with other guidelines	Poor evidence to include or exclude (grade C for pain) TENS alone as an intervention for postsurgery rehabilitation	N/C
EMG biofeedback	Strength of published evidence in comparison with other guidelines	Insufficient scientific evidence (grade ID) for EMG biofeedback	N/C
	Clinical recommendations compared with other guidelines	Insufficient evidence to include or exclude (grade ID) EMG biofeedback alone as an intervention for postsurgery knee pain	N/C
Therapeutic massage	Strength of published evidence in comparison with other guidelines	N/A	N/C
	Clinical recommendations compared with other guidelines	No data found	N/C
Thermotherapy	Strength of published evidence in comparison with other guidelines	Good scientific evidence (level I) for cryotherapy	N/C
	Clinical recommendations compared with other guidelines	Poor evidence to include or exclude (grade C for pain) cryotherapy alone as an intervention for postsurgery knee pain	N/C
Electrical stimulation	Strength of published evidence in comparison with other guidelines	Insufficient scientific evidence (grade ID) for electrical stimulation	N/C
	Clinical recommendations compared with other guidelines	Insufficient evidence to include or exclude (grade ID) electrical stimulation alone as an intervention for postsurgery knee pain	N/C
Combined rehabilitation interventions	Strength of published evidence in comparison with other guidelines	Insufficient scientific evidence (grade ID) for combined rehabilitation interventions	N/C
	Clinical recommendations compared with other guidelines	Insufficient evidence to include or exclude (grade ID) for combined rehabilitation interventions for postsurgery knee pain	N/C

Note: No previous EBCPGs for RA, for patellofemoral pain syndrome, and for tendinitis of the knee.

Appendix 1.
Continued

Rehabilitation Intervention		The Philadelphia Panel (2001)	ACR Knee OA[22] (1995)	BMJ[21] (2000)
Previous EBCPGs for Osteoarthritis of the Knee				
Therapeutic exercises	Strength of published evidence in comparison with other guidelines	Good scientific evidence Level I for therapeutic exercises	Not reported (N/R)	Likely to be beneficial
	Clinical recommendations compared with other guidelines	Good evidence (grade A for pain, patient global assessment, grade C+ for function) to include strengthening and stretching exercises alone as an intervention for knee OA	Recommend ROM, quadriceps femoris muscle strengthening, and aerobic exercise programs	Likely to be beneficial (pain relief and improved function)
Therapeutic ultrasound	Strength of published evidence in comparison with other guidelines	Good scientific evidence Level I for therapeutic ultrasound	N/C	N/C
	Clinical recommendations compared with other guidelines	Poor evidence to include or exclude (grade C for pain) therapeutic ultrasound alone as an intervention for knee OA	N/C	N/C
TENS	Strength of published evidence in comparison with other guidelines	Good scientific evidence Level I for TENS	N/C	N/C
	Clinical recommendations compared with other guidelines	Good evidence (grade A for pain and patient global assessment) to include TENS alone as an intervention for knee OA	N/C	N/C
EMG biofeedback	Strength of published evidence in comparison with other guidelines	N/A	N/C	N/C
	Clinical recommendations compared with other guidelines	No data found	N/C	N/C
Therapeutic massage	Strength of published evidence in comparison with other guidelines	N/A	N/C	N/C
	Clinical recommendations compared with other guidelines	No data found	N/C	N/C
Thermotherapy	Strength of published evidence in comparison with other guidelines	Good scientific evidence (level 1, RCT) for ice massage	N/C	N/C
	Clinical recommendations compared with other guidelines	Poor evidence to include or exclude (grade C for pain) thermotherapy alone as an intervention for knee OA	N/C	N/C
Electrical stimulation	Strength of published evidence in comparison with other guidelines	Good scientific evidence Level I for electrical stimulation	N/C	N/C
	Clinical recommendations compared with other guidelines	Poor evidence to include or exclude (grade C for function) electrical stimulation alone as an intervention for knee OA	N/C	N/C
Combined rehabilitation interventions	Strength of published evidence in comparison with other guidelines	N/A	N/C	N/C
	Clinical recommendations compared with other guidelines	No data found	N/C	N/C

Note: No previous EBCPGs for patellofemoral pain syndrome or tendinitis of the knee.
[a] ACL=anterior cruciate ligament, ROM=range of motion, N/A=not applicable, N/C=no comparison, N/R=not reported, TENS=transcutaneous electrical nerve stimulation, EMG=electromyographic, OA=osteoarthritis, CPG=clinical practice guideline, ID=insufficient data, ACR=American College of Rheumatology, BMJ=*British Medial Journal.*

Appendix 2.
Characteristics of Included Trials[a]

Author/Year	Sample Size	Type of Surgery	Symptom Duration Prior to Surgery	Mean Age	Treatment	Comparison Group	Concurrent Therapy	Treatment Duration, Sessions/ Week	Follow-up	Quality[3,4] (R, B, W)
Antich,[5] 1986	86 knees, 64 patients	Tenderness on extension	Not reported	Not reported	Continuous US/ice massage contrast 3 sets of US for 3 min, ice massage for 2 min	Ice bag for 10 min	Isometric hip adduction QF setting, modified SLR, resisted short-arc QF exercise (2 sets of 10 repetitions)	10 d, total sessions=4	1.5 wk	1, 0, 0
Bautch et al,[10] 1997	17/17		Not reported	69 y	Strengthening and stretching	Untreated	Education	12 wk, 3×/ wk	None	1, 0, 0
Beard et al,[42] 1994	25/25	ACL reconstruction	13 mo	25 y	Proprioceptive: closed kinetic chain, functional exercises, progressed by decreasing stability of starting position and increasing repetitions and removing feedback	Open kinetic, traditional exercises, graduated weight-resisted with emphasis on hamstring muscles	None	7 wk, 2×/ wk supervised + daily home exercises	None	2, 1, 1
Borjesson et al,[11] 1996	34/34		7.5 y	64 y	Group exercise: strengthening and stretching	Control	None	5 wk, 3×/ wk	24 wk	1, 0, 1
Callaghan et al,[18] 1995	Control (n=9) Home (n=10) Exercise (n=8)		4 y	52 y	Strengthening	1. Sham electrical stimulation 2. Home exercises	None	4 wk, 2 ×/ wk	None	1, 0, 0
D'Lima et al,[6] 1996	10/10	Unilateral knee replacement	NA	69 y	Strengthening	Usual care	Usual care both preoperation and postoperation	6 wk prior to surgery, 3 ×/wk	48 wk postsurgery	2, 0, 0
Draper et al,[44] 1991	15/15	ACL reconstruction	Not reported	25 y	Visual, sound portable EMG feedback on QF during exercises	Electrical stimulation during QF exercises	Progressive strength and stretch	6 wk, 3 ×/d in first 4 wk, 2 ×/ wk in last 2 wk	None	1, 0, 1
Falconer et al,[24] 1992	37/37		>6 mo	67.5 y	Continuous US, 1 MHz, 10-cm^2 soundhead, 3 min per 100 cm^2 area, up to 2.5 W/cm^2, as tolerated	Sham US	Stretching and strengthening exercises	4–6 wk, 2–3×/wk	None	1, 2, 1
Fargas-Babjak,[35] 1992	56		>6 mo	29–81 y	TENS, 2×/day for 30 min, 4 Hz, electrodes placed on 13 acupuncture and tender points	Placebo TENS (0.2 Hz)	None	6 wk, 2 ×/d	24 wk	1, 1, 1

Appendix 2.
Continued

Author/Year	Sample Size	Type of Surgery	Symptom Duration Prior to Surgery	Mean Age	Treatment	Comparison Group	Concurrent Therapy	Treatment Duration, Sessions/ Week	Follow-up	Quality[3,4] (R, B, W)
Grimmer,[27] 1992	60		Mean=7.8 y	66 y	1. High-rate TENS, 80 Hz for 30 min 2. Strong-burst TENS 3-Hz trains of 80-Hz pulses for 30 min	Placebo TENS	Voluntary withholding analgesics, muscle relaxants, and anti-inflammatories for 48 h prior to test	30-min sessions, once (immediate pain relief)	None	2, 1, 1
Harrison et al,[40] 1999	Home (n=42) Supervised (n=34) Feedback (n=36)	Patellofemoral pain syndrome (no surgery)	Acute 25% Insidious 63% Traumatic 10%	21.8 y	Exercise, patellar taping by the patient + biofeedback on vastus medialis muscle, progressive increase in difficulty of exercises (more functional) and weights	1. Home exercises for 4 wk 2. Supervised stretching and strengthening exercises, 3 sets of 10 repetitions, progressive increase in weights	Education session	4 wk, 3 ×/2 wk	52 wk	2, 0, 0
Jan and Lai,[15] 1991	21/20		27 mo	62 y	SLR, 200/d	None	US, continuous mode, 10 min	10 wk, 4 ×/ wk	None	1, 0, 0
Jensen et al,[9] 1985	30/30	Arthroscopic partial meniscectomy	Not reported	Not reported	TENS, asymmetrical, bipolar, modified rectangular wave with negatively decaying spike, pulse width=180 ms, pulse duration=300 ms, pulse rate=70 Hz	Placebo TENS unit Untreated group	None	3–4 d	7 wk	1, 2, 0
Jensen et al,[88] 1991	20		>6 mo exercise-induced pain	75 y	TENS, high-frequency, 80 Hz, pulse width=150 μs for 30 min/d	TENS, low frequency, 2 high pulse trains for 30 min/d	Analgesics and NSAIDs allowed	1 wk, daily for 5 d	None	1, 0, 1
Lessard et al,[8] 1997	Ice+exercise (n=23) Ice alone (n=22)	Arthroscopic surgery for meniscectomy, chondromalacia, OA, plica or loose bodies	Not reported	42 y	Cryotherapy (2 cold gel packs for 20 min prior to exercise)	No ice packs	Home exercises: knee, ankle ROM; QF, hamstring muscle stretches, static QF exercise; Tylenol[b] as needed	1 wk, daily	None	1, 1, 0
Levitt et al,[45] 1995	26/25	Minor arthroscopic surgeries for meniscal tears, loose bodies, patellar chondromalacia	Not reported	45 y	Portable visual and sound biofeedback on QF during isokinetic and isometric contractions performed at home, 3 ×/d (adherence=54%)	Isokinetic and isometric contractions performed at home, 3 ×/d (adherence=54%) without biofeedback	Verbal instructions on home exercises for QF	2 wk, daily 3 ×/d	None	0, 0, 0

Appendix 2.
Continued

Author/Year	Sample Size	Type of Surgery	Symptom Duration Prior to Surgery	Mean Age	Treatment	Comparison Group	Concurrent Therapy	Treatment Duration, Sessions/ Week	Follow-up	Quality[3,4] (R, B, W)
Lewis et al,[28] 1994	36		>6 mo	NA	TENS, pulse frequency=70 Hz, placed on 4 acupuncture points	Placebo TENS	None	3 wk, 3 sessions daily	9 wk	1, 1, 0
Lewis et al,[29] 1984	30		>12 mo	61 y	TENS, self-administered, 70 Hz to classical Chinese acupuncture points for 30–60 min	Placebo TENS (no battery)	Analgesics	3 wk, 3 sessions daily	1 wk washout	0, 1, 1
Oldham et al,[36] 1995	30	On waiting list for knee replacement surgery	NR	69 y	Patterned electrical stimulation of QF, pulse width=300 μs, duty cycle=200%, self-administered	Sham stimulation of 300 μs impulse every 3 min		3 h/d for 6 wk	6 wk, 12 wk	1, 1, 0
O'Reilly et al,[13] 1999	Exercise (n=13) Control (n=78)		Not reported	62 y	Strengthening	None	Verbal advice on shoes, weight, fitness	12 wk, 3 in 12 wk	24 wk	2, 0, 1
Rogind et al,[12] 1998	Exercise (n=12) Control (n=13)		Not reported	69.3 y	Strengthening, stretching	Untreated	Medication hold constant except for acetaminophen	12 wk, 2 supervised + 5 ×/wk at home	52 wk	2, 0, 1
Schilke et al,[17] 1996	Exercise (n=10) Control (n=10)		<10 y	64 y	Strengthening	Usual care	None	8 wk, 3 ×/ wk	None	2, 0, 0
Schwellnus et al,[37] 1992	10/10	Iliotibial band syndrome	>4 wk Chronic	25 y Not reported	Deep transverse friction over most tender area, 2 min lightly, 8 min hard such that discomfort but not pain experienced	Untreated	Rest from running Ice, 20 min, twice daily Iliotibial band stretch daily US 1 MHz, 0.5 W/ cm/cm, 5–7 min, 6 d/wk	10 d	2 wk	1, 0, 1
Smith et al,[30] 1983	15/15		NR	65 years	TENS, 32–50 Hz on most tender areas around knee	Placebo	Some analgesics or NSAIDs	20 min/ session, 2 ×/wk for 8 wk	4 wk	1, 1, 1
Svarcova et al,[25] 1988	60/60		6.6 y	64 y	Continuous US	Galvanic current	None	3 wk, 3–4 ×2 wk	None	0, 0, 0

Appendix 2.
Continued

Author/Year	Sample Size	Type of Surgery	Symptom Duration Prior to Surgery	Mean Age	Treatment	Comparison Group	Concurrent Therapy	Treatment Duration, Sessions/ Week	Follow-up	Quality[3,4] (R, B, W)
Taylor et al,[31] 1981	12		NA	71.5 y	TENS, electrodes on anterior, posterior, lateral, and medical sides of knee	Placebo TENS	None	2 wk, daily for 30 min	52 wk	1, 2, 1
van Baar et al,[20] 1998	Exercise (n=99) Control (n=102)		48% <1 y	68.3 y	Strengthening stretching, and functional exercises	GP therapy	Education brochure, paracetamol to be used as little as possible	12 wk, 1–3 ×/wk	24 wk	2, 0, 1
Yurkuran and Kocagil,[23] 1999	TENS (n=25) Electroacupuncture (n=25) Ice massage (n=25) Placebo (n=25)		>6 mo	58.1 y	1. TENS, 0.4–2.5 V intermittent waveform at 4 Hz, pulse width=1,000 μs applied to 4 acupoints 2. Electroacupuncture, acupuncture needles 3. Ice massage,frozen wood used to massage 4 acupoints	Placebo TENS	None	20 min, 5 ×/wk for 2 wk	None	1, 2, 0
Zatterstrom et al,[43] 1992	Specific QF (n=9) Function at trunk and leg training (n=17)	Chronic ACL insufficiency	1–96 mo	27 y	Specific QF training, with static and dynamic contractions (10 repetitions)	Functional synergic training of trunk and leg muscles, progressing to more difficult, less stable positions	None	12 wk, 2 ×/ wk	None	0, 0, 1

[a] R: randomization, B=blinding, W=withdrawals, NA=not available, ACL=anterior cruciate ligament, QF=quadriceps femoris muscle, SLR=straight leg raise, US=therapeutic ultrasound, EMG=electromyographic, TENS=transcutaneous electrical nerve stimulation, NSAID=nonsteroidal anti-inflammatory drug, OA=osteoarthritis, ROM=range of motion, GP=general practitioner.
[b] McNeil Consumer Healthcare, Div of McNeil-PPC Inc, Camp Hill Rd, Fort Washington, PA 19034.

Philadelphia Panel Evidence–Based Clinical Practice Guidelines on Selected Rehabilitation Interventions for Knee Pain

John Albright, Richard Allman, Richard Paul Bonfiglio, Alicia Conill, Bruce Dobkin, Andrew A Guccione, Scott Hasson, Randolph Russo, Paul Shekelle, Jeffrey L Susman, Lucie Brosseau, Peter Tugwell, George A Wells, Vivian A Robinson, Ian D Graham, Beverley J Shea, Manathip Osiri, Jessie McGowan, Joan Peterson, Hélène Corriveau, Lucie Pelland, Michelle Morin, Lucie Poulin, Michel Tousignant, Lucie Laferrière, Lynn Casimiro and Louis E Tremblay

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