Special Issue

Ottawa Panel Evidence-Based Clinical Practice Guidelines for Electrotherapy and Thermotherapy Interventions in the Management of Rheumatoid Arthritis in Adults

Background and Purpose. The purpose of this project was to create guidelines for electrotherapy and thermotherapy interventions in the management of adult patients (>18 years of age) with a diagnosis of rheumatoid arthritis according to the criteria of the American Rheumatism Association (1987). Methods. Using Cochrane Collaboration methods, the Ottawa Methods Group identified and synthesized evidence from comparative controlled trials. The group then formed an expert panel, which developed a set of criteria for grading the strength of the evidence and the recommendation. Patient-important outcomes were determined through consensus, provided that these outcomes were assessed with a validated and reliable scale. Results. The Ottawa Panel developed 8 positive recommendations of clinical benefit. Lack of evidence meant that the panel could not gauge the efficacy of electrical stimulation. Discussion and Conclusion. The Ottawa Panel recommends the use of low-level laser therapy, therapeutic ultrasound, thermotherapy, electrical stimulation, and transcutaneous electrical nerve stimulation for the management of rheumatoid arthritis. [Ottawa Panel Evidence-Based Clinical Practice Guidelines for Electrotherapy and Thermotherapy Interventions in the Management of Rheumatoid Arthritis in Adults. *Phys Ther.* 2004;84:1016–1043.]

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Key Words: *Clinical practice guidelines, Electrotherapy, Epidemiology, Evidence-based practice, Physical rehabilitation, Rheumatology, Rheumatoid arthritis, Thermotherapy.*

Introduction

Rheumatoid arthritis (RA) affects a large proportion of the population. The Arthritis Foundation reported that more than 2.1 million Americans have the disease.[1] The prevalence of RA is increasing with the aging population in industrial countries.[2] Rheumatoid arthritis is recognized as an important source of disability and handicap, which leads to considerable socioeconomic costs resulting from medical and surgical interventions and from frequent absences from work.[2,3]

Ottawa Panel Members:

Ottawa Methods Group:

Lucie Brosseau, PhD, Physiotherapy Program, School of Rehabilitation Sciences, Faculty of Health Sciences, University of Ottawa, Ottawa, Ontario, Canada
George A Wells, PhD, Department of Epidemiology and Community Medicine, University of Ottawa
Peter Tugwell, MD, MSc, Centre for Global Health, Institute of Population Health, Ottawa, Ontario, Canada
Mary Egan, PhD, Occupational Therapy Program, School of Rehabilitation Sciences, Faculty of Health Sciences, University of Ottawa
Claire-Jehanne Dubouloz, PhD, Occupational Therapy Program, School of Rehabilitation Sciences, Faculty of Health Sciences, University of Ottawa
Lynn Casimiro, MA, Physiotherapy Program, School of Rehabilitation Sciences, Faculty of Health Sciences, University of Ottawa
Vivian A Robinson, MSc, Centre for Global Health, Institute of Population Health
Lucie Pelland, PhD, Physiotherapy Program, School of Rehabilitation Sciences, Faculty of Health Sciences, University of Ottawa
Jessie McGowan, MLIS, Director, Medical Library, Centre for Global Health, Institute of Population Health

External Experts:

Mary Bell, MD (Rheumatologist), Sunnybrook and Women's College Health Sciences Centre, Toronto, Ontario, Canada
Hillel M Finestone, MD (Physiatrist), Sisters of Charity of Ottawa Health Service, Ottawa, Ontario, Canada
France Légaré, MD (Evidence-Based Practice in Family Medicine), University of Laval, Québec City, Québec, Canada
Catherine Caron, MD (Family Physician), Sisters of Charity of Ottawa Health Service
Sydney Lineker, PT, MSc, The Arthritis Society, Ontario Division, Research Co-ordinator, Toronto, Ontario, Canada
Angela Haines-Wangda, PT, MSc, Ottawa Hospital, General Campus, Ottawa, Ontario, Canada
Marion Russell-Doreleyers, PT who practices acupuncture, MSc, Canadian Physiotherapy Association and Ottawa Arthritis Rehabilitation and Education Program, Ottawa, Ontario, Canada
Martha Hall, OT, MPA, Canadian Association of Occupational Therapists and Ottawa Arthritis Rehabilitation and Education Program
Paddy Cedar, patient with rheumatoid arthritis (named with her written permission)

Assistant Manuscript Writer:

Marnie Lamb, MA, School of Rehabilitation Sciences, Faculty of Health Sciences, University of Ottawa

Address all correspondence and requests for reprints to: Lucie Brosseau, PhD, Physiotherapy Program, School of Rehabilitation Sciences, Faculty of Health Sciences, 451 Smyth Rd, University of Ottawa, Ottawa, Ontario, Canada K1H 8M5(lbrossea@uottawa.ca).

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A patient is said to have RA if he or she satisfies at least 4 of the following 7 American Rheumatism Association (ARA) criteria: (1) morning stiffness, (2) arthritis of 3 or more joints, (3) arthritis of the hand joints, (4) symmetric arthritis, (5) rheumatoid nodules, (6) serum rheumatoid factor, or (7) radiologic changes.[4] A classification of functional capacity frequently used in patients with RA is described as: (I) complete functional capacity with ability to carry out all usual duties without handicaps, (II) functional capacity adequate to conduct normal activities despite handicap of discomfort or limited mobility of one or more joints, (III) functional capacity adequate to perform only a few or none of the duties of usual occupation or of self-care, or (IV) largely or wholly incapacitated with patient bedridden or wheelchair-bound, permitting little or no self-care.[2]

The rehabilitation approach to the management of RA[5] has 9 goals: (1) to decrease pain, (2) to decrease effusion (joint swelling), (3) to decrease stiffness, (4) to correct or prevent joint deformity, (5) to increase range of motion (ROM), (6) to increase muscle force, or decrease weakness, (7) to improve mobility and walking, (8) to increase physical fitness or reduce fatigue, and (9) to increase functional status.

Electrotherapeutic modalities and thermotherapy physical agents are used as part of a rehabilitation program offered mainly for pain and inflammation relief in the management of various musculoskeletal conditions.[2,6,7] The electrotherapeutic modalities and thermal agents have been used primarily to reduce pain, effusion, and stiffness in RA. These therapeutic interventions also indirectly contribute to increased ROM, muscle force, mobility, walking ability, functional status, and physical fitness. Thus, electrotherapy and thermotherapy are promising interventions, especially for inflammatory polyarthritis such as RA, which could present subacute and chronic inflammatory symptoms depending on the stage of the disease (eg, chronic stage >1 year).

Electrotherapy and thermotherapy offer several advantages. They are noninvasive interventions that present very few adverse side effects and contraindications compared with a large number of pharmacologic interventions. Electrotherapy and thermotherapy are rapid to administer and are convenient for community-based settings; the modalities and agents either can be found at home (eg, ice packs) or are portable (for instance, the electrotherapy devices for transcutaneous electrical nerve stimulation [TENS] or low-level laser therapy [LLLT]). The effectiveness of electrotherapy and thermotherapy in the management of RA has been reported in systematic or literature reviews.[8–18]

Trials on the efficacy of LLLT have been systematically reviewed for RA.[12,13] The experimental and placebo groups in the reviewed studies showed a significant difference ($P<.05$), suggesting that LLLT is effective for reducing pain and morning stiffness and increasing ROM.[12,13] However, other reviews[8,9] that were not conducted systematically did not yield reports of any effect of LLLT for musculoskeletal pain relief.

To our knowledge, only one systematic review[17] exists on the efficacy of therapeutic ultrasound in the management of RA. The review, involving RA of the hand, found a significant difference ($P<.05$) between experimental and control groups on reduced number of painful and swollen joints. However, ultrasound combined with an exercise program was not effective for these outcome measures. Four other meta-analyses on the effects of therapeutic ultrasound[19–22] showed no evidence of clinically important or statistically significant results to support the effectiveness of therapeutic ultrasound in reducing musculoskeletal pain. However, these meta-analyses related to musculoskeletal or heel pain and not specifically to RA. They also have not been updated.

For thermotherapy for RA, the results of a systematic review[15] showed that the application of hot packs or ice packs had no effect on measures of disease activity, including joint swelling, pain, medication intake, ROM, grip force, and hand function compared with a control (no intervention). However, paraffin baths combined with therapeutic exercises for arthritic hands showed positive results on measures of pain on nonresisted motion, ROM, and stiffness, but not on grip force and pinch function, compared with a control after 4 consecutive weeks of intervention. No beneficial effects were observed for an application of paraffin alone compared with a control for any of these measures.

In a recent systematic review on the efficacy of TENS in the management of RA,[16] statistically significant results were observed for pain relief at rest for acupuncture-like (low frequency combined with high intensity) TENS compared with placebo. Conventional (high frequency combined with low intensity) TENS showed statistically significant benefit over a placebo for tenderness intensity. Similar results were obtained in previous review articles on pain management in musculoskeletal conditions[23,24] and in rheumatology conditions.[16,25] A systematic review conducted by Pelland et al[18] showed that electrical stimulation had effects on muscle force and endurance of the first dorsal interosseous muscle when compared with a control group that received no intervention.

To our knowledge, only 4 evidence-based clinical practice guidelines (EBCPGs) have been published specifi-

Table 1.
Included Studies for Low-Level Laser Therapy[a]

Study	Study Design	Population	Outcomes
Goats et al[34]	RCT	RA affecting 2 or more tibiofemoral, talocrural, subtalar, or MCP joints; mean age: Gr1= 57 y, Gr2=74 y	Pain, function, knee ROM, ankle ROM, morning stiffness, rheumatoid factor positive, suprapatellar swelling, and walking speed
Hall et al[35]	RCT	RA class II or III; active synovitis of some or all of the MCP and PIP joints; mean age: Gr1=67.1 y, Gr2=60.9 y	Pain, tender joints, function, MCP and PIP joint ROM, grip force, MCP and PIP joint swelling, and morning stiffness duration
Johannsen et al[36]	RCT	RA class I or II; mean age: Gr1=59 y, Gr2=62 y	Pain, flexibility (fingertip-to-palm distance), morning stiffness not improved, and grip force
Palmgren et al[37]	RCT	RA class I or II; mean age: Gr1 males=66 y, Gr1 females=61.1 y, Gr2 males=68 y, Gr2 females=57.5 y	Flexibility (fingertip-to-palm distance), morning stiffness, grip force, PIP joint swelling, and morning stiffness duration
Walker et al[38]	RCT	RA; mean age: Gr1=61.5 y, Gr2=60 7	Pain

[a] RCT=randomized controlled trial, RA=rheumatoid arthritis, MCP=metacarpophalangeal, PIP=proximal interphalangeal, ROM=range of motion, Gr1=group 1, Gr2=group 2.

cally on electrotherapy and thermotherapy interventions for RA: The RA Management Protocol,[5] the American College of Rheumatology's guidelines,[26] the American Pain Society's guidelines,[27] and guidelines for occupational therapists[28] (Appendix 1). Because it offers no specific recommendations for practitioners, the RA Management Protocol[5] can be categorized as somewhere between an exhaustive literature review and a guideline for each specific physical agent mentioned in this article. Regardless, the 4 sets of guidelines have several drawbacks: (1) they were developed for limited clinical practice areas; (2) although the EBCPGs were based on the current scientific literature, a nonstandardized approach was used to synthesize the scientific results, meaning that the evidence of intervention efficacy was not clear or precise, especially when conflicting results were present; (3) the raw data of each article were not analyzed and synthesized using Cochrane Collaboration systematic methods; (4) the studies reviewed were not based on a systematic literature search; (5) the scientific results of each study were reviewed, but no synthesis was carried out; (6) no rigorous grading system was used to assess the evidence; and (7) no recent updating has been completed for most of the guidelines.

The generally positive results from the recent meta-analyses and the lack of up-to-date and rigorously developed EBCPGs on electrotherapy and thermotherapy suggest a need for the development of better-quality EBCPGs for these interventions. Evidence suggests that quality of care can be improved through the use of EBCPGs.[29–32] The aim of developing these guidelines was to promote appropriate use of electrotherapy and thermotherapy in the management of RA. These guidelines are aimed at various users, including physical therapists, physicians, and patients. This article discusses only LLLT, therapeutic ultrasound, TENS, electrical stimulation, and thermotherapy (including, for the purposes of this article, both cryotherapy and heat therapy).

Methods

For this project, we used the same methods that were used in a previous study conducted by the Ottawa Panel on therapeutic exercises.[33] The methods have been explained in full in a previous article,[33] which discusses all relevant areas: population, trial designs, outcomes, theoretical framework, literature search, selection criteria, statistical analysis, and guideline review. Briefly, an a priori protocol was defined, and it guided separate systematic reviews for each intervention. Positive recommendations were sent to 5 practitioners—a physical therapist, an occupational therapist, a physiatrist, a family physician, and a rheumatologist—for comments.

Results of Literature Search

The literature search identified 14,111 potential RA-related articles for electrotherapy and thermotherapy. Of these, several publications were considered potentially relevant based on the selection criteria checklist: (1) for LLLT, 11 articles[34–44] (Tabs. 1 and 2) were initially considered relevant and 5 randomized controlled trials (RCTs) involving 204 patients with RA[34–38] were ultimately included; (2) for therapeutic ultrasound, 8 studies[45–52] (Tabs. 3 and 4) were initially included and 1 RCT involving 50 patients[45] was ultimately included; (3) for thermotherapy, 23 trials were initially included[47,49,53–74] (Tabs. 5 and 6) and 2 RCTs involving 76 patients[53,54] were ultimately included; and (4) for TENS, 9 articles were initially included[50,75–82] (Tabs. 7 and 8) and 3 RCTs involving 78 patients[75–77] were ultimately included (Appendixes 2–5).

Low-Level Laser Therapy (LLLT)

LLLT applied to the foot, knee, or hand versus a placebo, level I (RCT): grade A for pain at 3 months (clinically important benefit); grade C for function, tender joints, muscle force, and ROM at 3 and 6 months (no benefit). Patients with chronic RA.

Summary of trials. Five placebo-controlled RCTs were included (Tab. 1).[34–38] In these RCTs, the LLLT treatment schedule ranged from 2 to 3 sessions a week and from 4 to 10 consecutive weeks. The dosage ranged between 2.7 and 8.1 J/cm^2. All RCTs used a gallium-aluminum-arsenide laser medium,[34–37] except for that of Walker et al,[38] who used a helium-neon type of laser. Walker et al[38] also used LLLT to irradiate both painful RA joints and the appropriate superficial nerve, whereas other investigators[34–37] treated only the RA joints (Appendix 2). Four trials[39–42] were excluded because of the lack of an appropriate control group, one trial[43] was excluded because the abstract did not provide enough statistical data to be analyzed, and one trial[44] was excluded because it was a duplicate of an included study (Tab. 2).

Table 2.
Excluded Studies for Low-Level Laser Therapy (LLLT)

Study	Reason for Exclusion
Asada et al[39]	No control group
Bliddal et al[40]	Subjects served as their own control—LLLT potential systemic effect
Goldman et al[41]	Subjects served as their own control—LLLT potential systemic effect
Heussler et al[42]	Subjects served as their own control—LLLT potential systemic effect
Oyamada et al[43]	The abstract did not provide enough statistical data to be analyzed
Walker et al[44]	Duplicate of Walker et al[38]

Table 3.
Included Studies for Therapeutic Ultrasound[a]

Study	Study Design	Population	Outcomes
Konrad[45]	RCT	Classical or definite RA of both hands; pain, swelling, and limitation of movement	Change in the following: ROM, grip force, number of painful articulations, number of swollen articulations, circumference of the PIP joints, and duration of morning stiffness

[a] RCT=randomized controlled trial, RA=rheumatoid arthritis, PIP=proximal interphalangeal, ROM=range of motion.

Efficacy. A clinically important benefit was demonstrated for pain relief. Four RCTs[34–36,38] (n=169) demonstrated a significant difference (weighted mean difference [WMD]=−1.05 cm on a 10-cm visual analog scale [VAS], 95% confidence interval [CI]=−1.58 to −0.53 cm) and percentage reductions in pain relative to a control group. Relative reductions in pain were −28% in patients with RA affecting 2 or more groups of joints,[34] −25% in patients at a chronic stage,[35] −19% in patients with RA according to ARA criteria,[38] and −22% in patients with active RA[36] (Tab. 9, Fig. 1). For consistency in Figures 1 through 4, the results obtained for the intervention groups are presented on the left of the central vertical line representing no difference (value 0) between groups compared and the results obtained for the control or placebo groups are presented on the right of the central vertical line representing no difference (value=0) between groups compared. Two RCTs[36,37] (n=57) demonstrated a difference in favor of LLLT compared with a placebo (WMD=−1.26 cm, 95% CI=−1.72 to −0.85 cm) in increasing ROM in the hand (−76% to −142% relative difference). The trial by Palmgren et al[37] involved only patients with RA. However, the tip-to-palm distance measurement was not considered a valid outcome according to the American Society of Hand Therapists[83] (Tab. 10, Fig. 1). No clinically important benefit was shown for tender joints (Ritchie Articular Index) or function (Fig. 1), and the results for grip force conflicted (Tab. 11, Fig. 1).

Table 4.
Excluded Studies for Therapeutic Ultrasound

Study	Reason for Exclusion
Berliner and Piegsa[46]	Subjects without known pathology or impairments
Bromley et al[47]	Subjects without known pathology or impairments
El-Hadidi and El-Garf[48]	Measures effect of medication
Hawkes et al[49]	Head-to-head study
Herrera-Lasso et al[50]	No patients with rheumatoid arthritis
Kitchen and Partridge[51]	Literature review
Nykanen[52]	No patients with rheumatoid arthritis

Strength of published evidence compared with other guidelines. The Ottawa Panel found good evidence (level I, RCT) suggesting that LLLT alone in the management of RA of the foot, knee, or hand is beneficial for pain relief. The strength of evidence has not been assessed by other RA guidelines (Appendix 1).

Table 5.
Included Studies for Thermotherapy[a]

Study	Study Design	Population	Outcomes
Bulstrode et al[53]	RCT	Classical or definite RA; effusion of 1 or both knee joints	Swelling/inflammation and joint circumference
Dellhag et al[54]	RCT	RA class I and II and hand problems (decreased ROM or grip force); age: no older than 70 y	Flexion and extension of the dominant hand (ROM), grip force, pain (nonresisted motion with both hands), and stiffness (both hands)

[a] RCT=randomized controlled trial, RA=rheumatoid arthritis, ROM=range of motion.

Table 6.
Excluded Studies for Thermotherapy

Study	Reason for Exclusion
Abramson et al[55]	No clinical outcome
Amundson[56]	Not a clinical trial
Bromley et al[47]	Subjects without known pathology or impairments
Curkovic et al[57]	No sufficient statistical data
Devereaux et al[58]	No control group
DonTigny and Sheldon[59]	No subjects with rheumatoid arthritis
Feibel and Fast[60]	Not a clinical trial
Haines[61]	No subjects with rheumatoid arthritis; survey to estimate the number of hospitals that find it worthwhile to use cold therapy
Halliday et al[62]	No control group
Harris and Millard[63]	No description of the statistical procedure used, no *P* values, and no standard deviations available
Hawkes et al[49]	Head-to-head study
Hoyrup and Kjorvel[64]	Subjects with traumas
Ivey et al[65]	Head-to-head study
Kirk and Kersley[66]	Head-to-head study
Mainardi et al[67]	No control group; subjects served as their own controls
Oosterveld et al[68]	Subjects without known pathology or impairments
Oosterveld and Rasker[69]	Mixed population, with rheumatoid arthritis in minority
Oosterveld and Rasker[70]	Literature review
Rembe[71]	Patients postsurgery
Weinberger et al[72]	No clinical outcome
Whipple-Ellsworth et al[73]	Subjects without known pathology or impairments
Williams et al[74]	Head-to-head study

Clinical recommendations compared with other guidelines. The Ottawa Panel believes that the evidence supports the inclusion of LLLT applied to the foot, knee, or hand as an intervention for the reduction of pain associated with RA (grade A for pain). Low-level laser therapy has not been assessed by other RA guidelines (Appendix 1).

Practitioners' response to Ottawa Panel guidelines. All surveyed practitioners found the Ottawa Panel's recommendation for LLLT clear. Two practitioners agreed with the recommendation, and 1 practitioner disagreed with the recommendation (although the Ottawa Methods Group sent the recommendations to 5 practitioners, only 3 practitioners responded in this case).

Therapeutic Ultrasound

Therapeutic ultrasound performed on the hand in water versus a placebo, level I (RCT): grade A for tender joints at 10 weeks (clinically important benefit); grade C for swollen joints and morning stiffness at 10 weeks (no benefit). Patients with RA involving the hand (functional class I or II, chronic stage).

Summary of trials. One placebo-controlled RCT of therapeutic ultrasound[45] (n=50) was included (Tab. 3, Appendix 3). One trial[47] was excluded because the sample contained both subjects with RA and subjects without known pathology or impairments, one trial[46] was excluded because it contained subjects without known pathology or impairments, and the other trials[48–52] were excluded for various reasons (Tab. 4).

Continuous-wave ultrasound was applied in water to the dorsal and palmar aspects of the hand at 0.5 W/cm^2. The therapeutic session lasted 10 minutes on alternate days for 3 weeks for a total of 10 sessions (Appendix 3).

Efficacy. Pain relief demonstrated a clinically important difference (−19% relative difference [Tab. 12]) and statistically significant benefits (WMD=1.20 for change in number of tender joints, 95% CI=0.45–1.95).[45] No clinically important difference was shown for swollen joints (−3% [Tab. 12]). A clinically important difference could not be calculated for grip force or ROM in patients with RA of the hand (functional class I or II, chronic stage). No clinically important difference was found for reduction of morning stiffness (−41% [Tab. 12], Fig. 2) because morning stiffness was not measured using a validated scale.[84,85]

Strength of published evidence compared with other guidelines. The Ottawa Panel found good evidence (level I, RCT) of the effects of therapeutic ultrasound for RA of

Table 7.
Included Studies for Transcutaneous Electrical Nerve Stimulation[a]

Study	Study Design	Population	Outcomes
Abelson et al[75]	RCT	Chronic RA and chronic wrist involvement; mean age: Gr1: 57 y, Gr2: 55 y	Pain and muscle force
Langley et al[76]	RCT	Chronic RA with hand involvement and pain in 1 or both hands; mean age: Gr1=54.9 y, Gr2=53.4 y	Pain, joint tenderness score, and number of tender joints
Mannheimer et al[77]	RCT	RA with spontaneous pain or pain on resistance from the wrist, MCP, and PIP joints; age: 20–69 y	Patient global (patient's assessment of overall disease activity or improvement[33]): number of patients improved

[a] RCT=randomized controlled trial, RA=rheumatoid arthritis, MCP=metacarpophalangeal, PIP=proximal interphalangeal, Gr1=group 1, Gr2=group 2.

Table 8.
Excluded Studies for Transcutaneous Electrical Nerve Stimulation

Study	Reason for Exclusion
Angulo and Colwell[78]	Majority of subjects had osteoarthritis
Bruce et al[79]	Only 2 subjects per group
Herrera-Lasso et al[50]	No subjects with rheumatoid arthritis
Kumar and Redford[80]	Subjects served as their own control
Levy et al[81]	Not rheumatoid arthritis population—rabbit joints
Moystad et al[82]	Data could not be used

the hand. The strength of evidence has not been graded in other guidelines (Appendix 1).

Clinical recommendations compared with other guidelines. The Ottawa Panel believes there is good evidence that therapeutic ultrasound alone performed on the hand in water should be included as an intervention for RA (grade A for tender joints, grade C for swollen joints and morning stiffness). To our knowledge, no EBCPGs in the scientific literature have dealt with therapeutic ultrasound (Appendix 1).

Practitioners' response to Ottawa Panel guidelines. All surveyed practitioners agreed with the Ottawa Panel's recommendation for therapeutic ultrasound and found it clear.

Thermotherapy

Cryotherapy applied to the knee joint versus a control, level I (RCT): grade C for thermographic index (measurement [in degrees Celsius] obtained using infrared thermography of the joint) at 5 days (no benefit). Patients with chronic RA, and with obvious effusion of joints.

Wax applied to the hand and wrist versus a control, level I (RCT): grade C for pain, ROM, muscle force, and function at 1 month (no benefit). Patients with functional class I or II with hands affected.

Wax applied to the hand or wrist and hand exercises versus a control, level I (RCT): grade A for ROM at 1 month (clinically important benefit), grade C+ for pain and stiffness at 1 month (clinical benefit), grade C for muscle force and function at 1 month (no benefit). Patients with functional class I or II with hands affected.

Summary of trials. Two RCTs[53,54] (n=76) evaluated controls versus 3 different types of thermotherapy for RA-affected upper- and lower-extremity joints: (1) cryotherapy (n=24), (2) wax (n=52), and (3) wax combined with exercise (n=52) (Tab. 5, Appendix 4). The treatment duration ranged from 5 consecutive days to 3 times a week for 4 weeks. The treatment session ranged from 10 to 20 minutes (Appendix 4).

Eight RCTs were excluded for the following reasons: the absence of a control group,[58,62] the inclusion of patients postsurgery,[70] the use of patients as their own controls,[67] or the use of individuals without known pathology or impairments as controls.[47,68,69,73] Two other studies[57,63] were excluded because they had no numerical data to be analyzed. Four head-to-head studies (involving comparison of 2 groups of subjects receiving active treatments; no placebo or control group)[49,65,66,74] were not accepted, and other studies[55,56,59–61,64,67,71,72] were excluded for various reasons (Tab. 6).

Efficacy. For cryotherapy versus a control (n=24),[53] no statistically significant difference or clinically important benefits were observed for thermographic index for patients with chronic RA and obvious effusion of joints (Tab. 13, Fig. 3a). No other outcomes were reported.

No statistically significant difference or clinically important benefit was shown for patients with functional class I or II with hands affected for reducing pain or for improving ROM, muscle force, or function (Tab. 14) in wax versus a control (n=26).[54]

Wax combined with exercise versus a control (n=26)[54] demonstrated a clinically important benefit for improving ROM in finger flexion (−21% relative difference [Tab. 15]) in patients with pain resulting from the latter

Table 9.
Low-Level Laser Therapy (LLLT) Versus Placebo: Pain at 10 Weeks

Study	Intervention Group	Outcome	No. of Subjects	Baseline Mean	End-of-Study Mean	Absolute Benefit	Relative Difference in Change From Baseline
Goats et al[34]	LLLT	Pain 10-cm VAS	25	5.52	5.16	−1.47	−28%
	Placebo	Pain 10-cm VAS	10	4.83	5.94		
Hall et al[35]	LLLT	Pain on activity 10-cm VAS	20	5.20	4.00	−1.20	−25%
	Placebo	Pain on activity 10-cm VAS	20	4.30	4.30		
Walker et al[38]	LLLT	Pain 10-cm VAS	34	4.58	3.67	−0.91	−19%
	Placebo	Pain 10-cm VAS	38	5.21	5.21		
Johannsen et al[36]	LLLT	Pain: 0–12 scale	10	7.00	4.50	−1.50	−22%
	Placebo	Pain: 0–12 scale	12	6.50	5.50		

[a] VAS=visual analog scale.

type of RA. Clinically important benefits without statistical significance were shown for pain and stiffness (−44% and −23%, respectively [Tab. 15, Fig. 3b]). No clinically important benefit was shown for muscle force or the pinch function test. No statistical difference was observed in any outcome measured except for ROM in finger flexion (WMD=8.30°, 95% CI=0.44°–16.16°).

Strength of published evidence compared with other guidelines. The Ottawa Panel found good evidence (level I, RCT) showing that thermotherapy, especially wax combined with exercise, benefits ROM, pain, and stiffness in the management of RA. The strength of evidence has been either not graded by or not reported in other RA guidelines (Appendix 1).

Clinical recommendations compared with other guidelines. The Ottawa Panel found good evidence (grade A for ROM; grade C+ for pain and stiffness) that thermotherapy, especially wax combined with exercise for the hand and wrist, should be included as an intervention for patients with RA. This recommendation concurs with all existing guidelines (Appendix 1).[5,25,27]

Practitioners' response to Ottawa Panel guidelines. All practitioners surveyed agreed with the recommendations for thermotherapy and found them clear.

Transcutaneous Electrical Nerve Stimulation (TENS)

Low-frequency TENS applied to the hand and wrist versus no stimulation, level I (RCT): grade A for pain at 3 weeks (clinically important benefit), grade C+ for power at 3 weeks (clinical benefit), grade C for work at 3 weeks (no benefit). Patients with chronic RA.

High-frequency TENS applied to the hand and wrist versus placebo, level I (RCT): grade C for pain and joint tenderness, same day (no benefit). Patients with chronic RA.

High- versus low-frequency TENS applied to the hand and wrist, level I (RCT): grade C+ for global patient (patient's assessment of overall disease activity or improvement)[33] at 2 weeks (clinical benefit). Patients with chronic RA.

Summary of trials. Three placebo-controlled RCTs involving TENS (n=78)[75–77] were included (Tab. 7, Appendix 5). Three types of TENS were prescribed: (1) low-frequency (0–70 Hz), acupuncture-like TENS versus no stimulation (n=26),[75] (2) high-frequency (70–100 Hz), conventional TENS versus a placebo (n=33),[76] and (3) high- versus low-frequency TENS (n=19).[77] Thus, both high-frequency TENS[76,77] and low-frequency TENS[75,77] were provided to patients with RA. The therapeutic application of TENS ranged from 5 to 20 minutes a session and from 1 to 15 consecutive sessions for up to 3 consecutive weeks (Appendix 5).

One trial[79] with a sample size of fewer than 5 patients per group was excluded. One trial[80] was excluded because the enrolled patients were the control, one trial[78] was excluded because it involved a sample of patients with total knee replacement who had preoperative osteoarthritis or RA of the knee, another trial[82] was excluded because it offered no numerical data to be analyzed, and other trials[50,81] were excluded for different reasons (Tab. 8).

Efficacy. For low-frequency TENS versus no stimulation,[75] a clinically important benefit was demonstrated for pain relief (−67% relative difference [Tab. 16]), and this outcome was statistically significant (WMD=−59.50

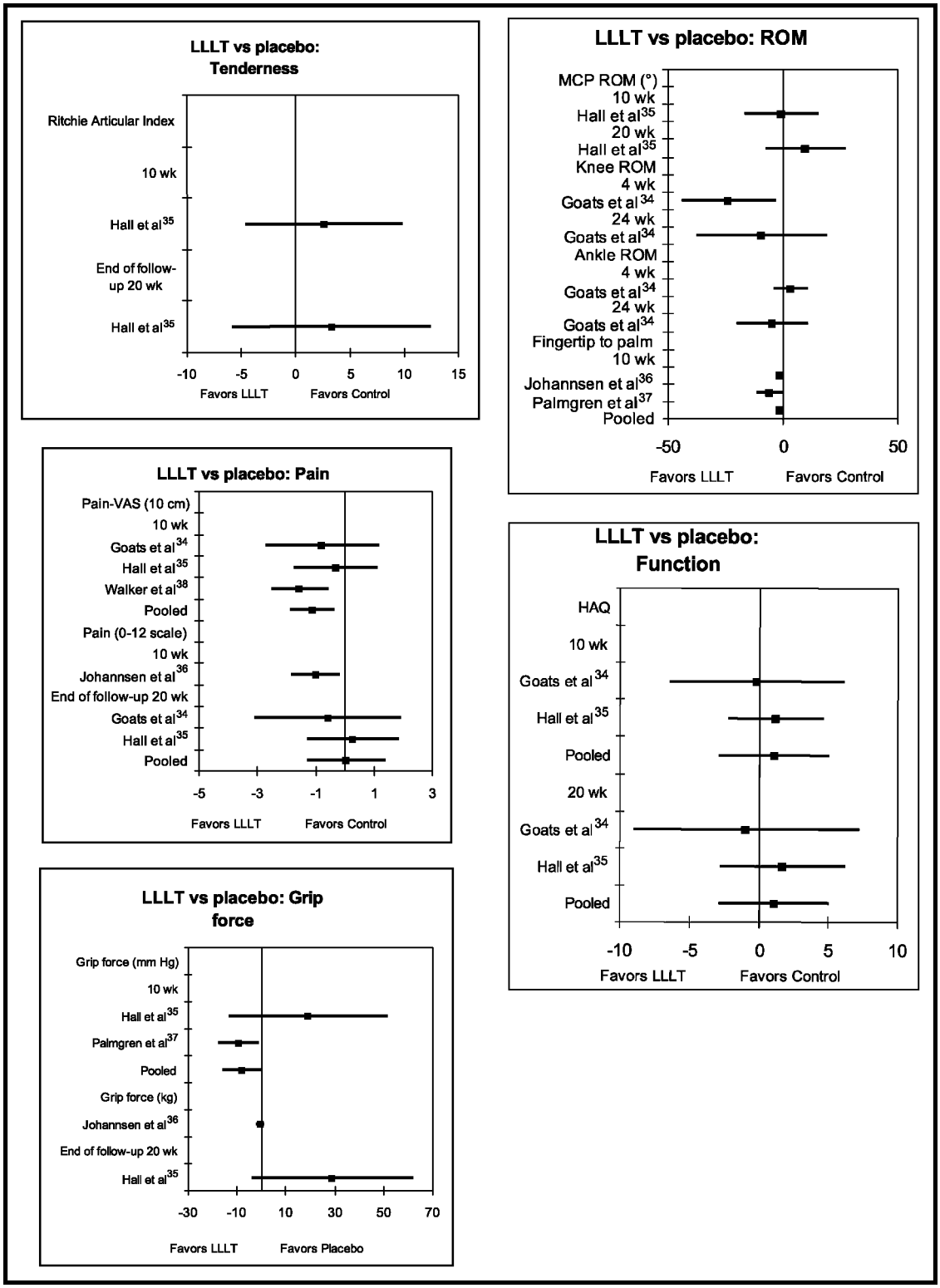

Figure 1.
Low-level laser therapy (LLLT) versus placebo. ROM=range of motion, VAS=visual analog scale, HAQ=Health Assessment Questionnaire, MCP=metacarpophalangeal joint.

Table 10.
Low-Level Laser Therapy (LLLT) Versus Placebo: Fingertip-to-Palm Distance

Study	Intervention Group	Outcome	No. of Subjects	Baseline Mean	End-of-Study Mean	Absolute Benefit	Relative Difference in Change from Baseline
Johannsen et al[36]	LLLT	Fingertip-to-palm distance (cm)	10	0.25	0	−0.5	−76%
	Placebo	Fingertip-to-palm distance (cm)	12	1	1.25		
Palmgren et al[37]	LLLT	Finger pulp-to-palm distance (mm)	19	7	0	−8.0	−142%
	Placebo	Finger pulp-to-palm distance (mm)	16	5	6		

Table 11.
Low-Level Laser Therapy (LLLT) Versus Placebo: Grip Force

Study	Intervention Group	Outcome	No. of Subjects	Baseline Mean	End-of-Study Mean	Absolute Benefit	Relative Difference in Change From Baseline
Palmgren et al[37]	LLLT	Grip force (kPa) at 10 wk	19	2.5	3.3	1.1	47%
	Placebo	Grip force (kPa) at 10 wk	16	2.1	1.8		
Hall et al[35]	LLLT	Grip force (mm Hg) at 10 wk	20	80	86	−4.0	−7% (favors placebo)
	Placebo	Grip force (mm Hg) at 10 wk	20	95	105		
Johannsen et al[36]	LLLT	Grip force (kg) at 10 wk	10	6.2	7	−0.4	−7% (favors placebo)
	Placebo	Grip force (kg) at 10 wk	12	5.3	6.5		

mm on a 100-mm VAS, 95% CI=−76.58 to −42.42 mm; Fig. 4a) for patients with chronic RA. Power (in watts) was improved by 55% compared with baseline. This outcome, however, was not statistically significant in TENS compared with a placebo at 3 weeks. Work (in joules) scores showed little difference between TENS and a control (Tab. 17, Fig. 4a).

Neither statistical significance nor a clinically important benefit was found in high-frequency TENS versus a placebo for pain relief in patients experiencing the aforementioned type of RA (Fig. 4b).[76] A statistically significant result was obtained for the reduction of joint tenderness, but no clinically important benefit was found (Tab. 18, Fig. 4b).[76]

For high- versus low-frequency TENS, no statistically significant difference in patient assessment of overall disease improvement was determined, but a clinically important benefit (21% risk difference) was observed in patients with RA, in favor of high-frequency TENS (Tab. 19, Fig. 4c).[77]

Strength of published evidence compared with other guidelines. The Ottawa Panel found good evidence (level I, RCT) of the effects of TENS for management of RA in the hand and wrist. The strength of evidence has been graded by the American Pain Society,[26] which also reported good-quality evidence for TENS (Appendix 1).

Clinical recommendations compared with other guidelines. According to the Ottawa Panel, there is good evidence (grade A for pain, grade C+ for global patient and power) suggesting that TENS alone should be included as an intervention for management of RA in the hand and wrist. The Ottawa Panel partially agrees with The Arthritis Society,[5] which recommends the use of TENS for pain and joint swelling in patients with RA.

Table 12.
Ultrasound Versus Placebo: Grip Force, Range of Motion (ROM), Swollen Joints, Tender Joints, and Morning Stiffness at 10 Weeks

Study	Intervention Group	Outcome	No. of Subjects	Baseline Mean	End-of-Study Mean	Absolute Benefit	Relative Difference in Change From Baseline
Konrad[45]	Ultrasound	Painful articulations (tender joints)	25	6.2	4.8	−1.20	−9%
	Placebo	Painful articulations (tender joints)	25	6.2	6.0		
Konrad[45]	Ultrasound	Swollen articulations (swollen joints)	25	6.12	4.84	−1.02	−3%
	Placebo	Swollen articulations (swollen joints)	25	6.12	5.86		
Konrad[45]	Ultrasound	Morning stiffness (min)	25	69.6	31.4	−28.54	−41%
	Placebo	Morning stiffness (min)	25	69.6	59.94		
Konrad[45]	Ultrasound	Dorsal flexion of wrist (ROM in degrees)	25	Not available	Not available	1.90	
	Placebo	Dorsal flexion of wrist (ROM in degrees)	25	Not available	Not available		
Konrad[45]	Ultrasound	Grip force	25	Not available	Not available	28.07	
	Placebo	Grip force	25	Not available	Not available		

The American Pain Society[26] gives TENS a fair recommendation for pain relief (Appendix 1).

Practitioners' response to Ottawa Panel guidelines. All practitioners surveyed agreed with the Ottawa Panel's TENS recommendations and found them clear.

Electrical Stimulation of Muscle

Evidence with acceptable research design, interventions, group comparisons, or outcomes could not be identified to guide the development of recommendations for electrical stimulation of muscle. To our knowledge, no EBCPGs exist on electrical stimulation for RA conditions.

Discussion

In the area of rehabilitation for RA, evidence-based practice is gaining popularity.[5,7,25–27,86,87] The Ottawa Panel's systematic review revealed that one or more controlled clinical trials (CCTs) demonstrated some clinically important benefits of electrotherapy and thermotherapy interventions for patients with RA. The Ottawa Panel developed several EBCPGs (n=8 with grade A, B, or C+ recommendations) for these interventions. However, other current clinical interventions for RA still need this evidence to prove their effectiveness (n=16 with grade C recommendations and n=4 with insufficient data).

Credibility of Guidelines

The Ottawa Panel's EBCPGs on electrotherapy and thermotherapy (grouped together in Appendix 6) for the management of RA are generally in accordance with other EBCPGs (Appendix 1). An earlier expert panel (the Philadelphia Panel) agreed on a systematic grading of the evidence for EBCPGs, and the Ottawa Panel's EBCPGs were based on this grading system. The evidence for the Ottawa Panel's EBCPGs came from systematic reviews and meta-analyses that used Cochrane Collaboration methods or similar methods. To ensure that the guidelines were applicable and easy for clinicians to use, several practitioners sat on the Ottawa Panel. Their involvement supports the credibility of the guidelines.

The development of the draft EBCPGs was done in accordance with Appraisal of Guidelines Research and Evaluation (AGREE) criteria.[88] On dimensions 1 (purpose), 2 (stakeholder involvement), 4 (clarity), and 6 (editorial independence), the guidelines received excellent scores. Dimensions 3 (rigor of development) and 5 (applicability) received lower scores. Inadequate reporting of side effects and risks, which were not reported in the primary trials and therefore not included in the guidelines, lowered the rigor of development score. In identifying cost implications, potential organizational barriers, and methods of applying and monitoring the guidelines, the EBCPGs' applicability was low. Exact scores and a decision aid tool are available on the University of Ottawa School of Rehabilitation Sciences' Web page (http://www.health.uottawa.ca/EBCpg/english/main.htm).

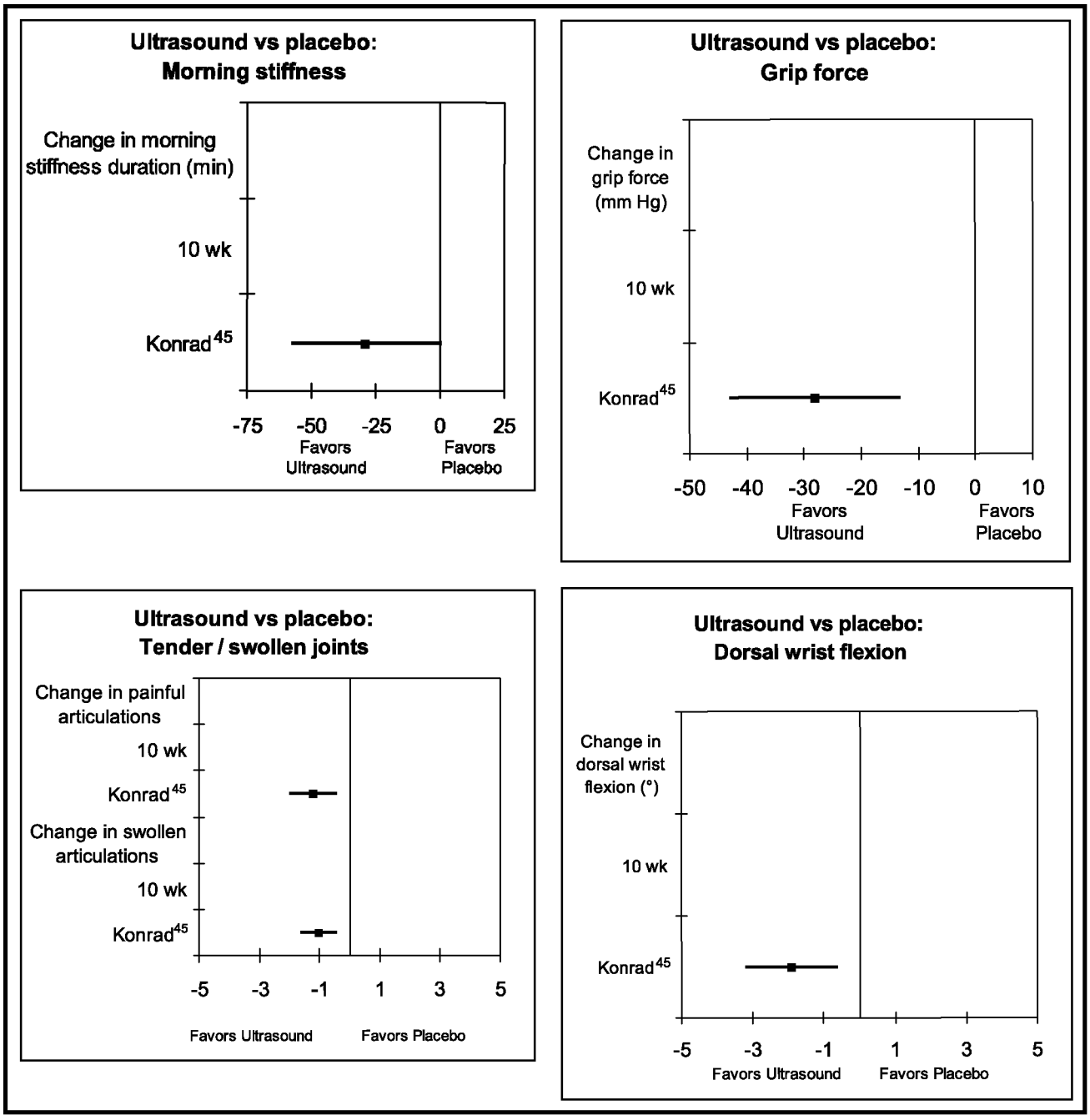

Figure 2.
Ultrasound versus placebo.

Table 13.
Ice Packs Versus Control at 5 Days

Study	Intervention Group	Outcome	No. of Subjects	Baseline Mean	End-of-Study Mean	Absolute Benefit	Relative Difference in Change From Baseline
Bulstrode et al[53]	Ice packs	Thermographic index	15	5.0	4.6	−0.3	−6%
	Control	Thermographic index	9	5.3	5.2		

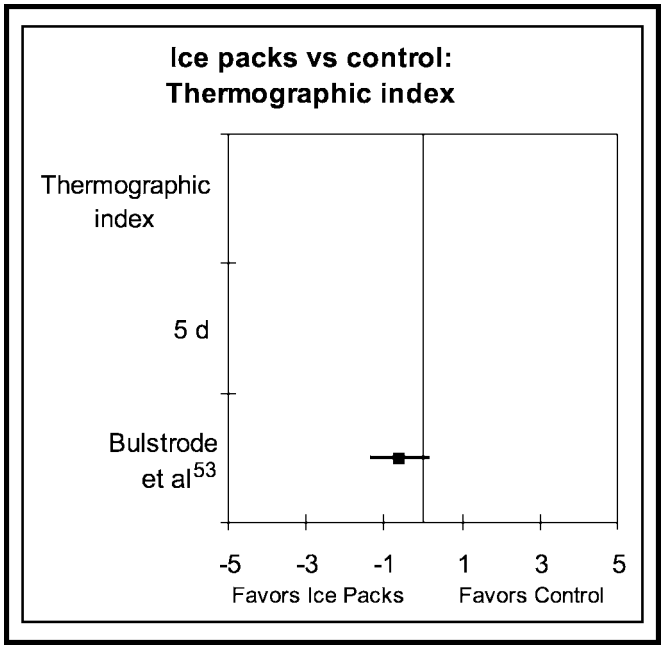

Figure 3a.
Cryotherapy versus control.

LLLT

According to the Ottawa Panel, there is good evidence suggesting that LLLT should be included as an intervention for reducing RA-related pain. The use of this modality fulfills one intervention goal of the RA Management Protocol.[5] The Ottawa Panel's position agrees with those of previous systematic reviews.[12,13]

Several physiological studies confirm the pain relief observed among patients with RA managed with LLLT. Low-level laser therapy irradiation positively modifies the peripheral nerve activity and provides a reduction in the sensation of the pain,[7] particularly in long-standing pain such as that associated with RA.[89] One proposed animal model theory is that LLLT enhances the action of superoxide dismutase, which prevents the proliferation of prostaglandin E.[90] Other physiological studies in rats[91] and in humans[92–94] suggest a plausible mechanism of action for LLLT stimulation-produced analgesia. This beneficial physiological effect was observed in humans both at the end of intervention and at 1- and 3-month follow-up examinations.[94] Physiological studies concerned with the inflammatory process suggest that exposure to LLLT results in anti-inflammatory and analgesic effects,[95] normalization of the permeability of the synovial membrane,[95] enhancement of regional microcirculation, reduction of exudative and infiltrative fluids, increased synovial membrane fibrosis,[96] and increased protein synthesis of synovial cells, a synthesis that indicates a regenerative process in the damaged synovial membrane.[97,98]

The evidence suggests that LLLT could be applied without the addition of other physical therapy interventions to solve a specific RA pain-related problem. Because LLLT is rapid to administer and portable devices are available, it offers advantages for community-based services such as the Arthritis Rehabilitation and Education Program of The Arthritis Society (Canada). Further studies are needed to determine the optimal LLLT wavelength, dosage, application techniques, and duration of intervention and to determine long-term effects in patients with RA.[99]

Therapeutic Ultrasound

According to the Ottawa Panel, therapeutic ultrasound without the addition of other physical therapy interventions is effective for reducing joint tenderness caused by RA. Our results do not seem to concur fully with those of previous systematic reviews[19–22] conducted for all musculoskeletal conditions. Perhaps continuous ultrasound[100] is more effective for patients with RA whose condition is chronic and marked by a medium level of disease activity[45] than for individuals with acute musculoskeletal conditions.

The use of continuous ultrasound is supported by its documented physiological effects.[7,100,101] The mechanical effect of both pulsed and continuous ultrasound increases skin permeability, thus decreasing inflammatory response, reducing pain, and facilitating the soft tissue healing process. Furthermore, both pulsed and continuous ultrasound reduce nerve conduction velocity of pain nerve fibers. Continuous ultrasound, however, has thermal effects that reduce muscle spasms and pain.

Table 14.
Wax Only Versus Control at 1 Month: Range of Motion (ROM), Grip, Pain, Stiffness[a]

Study	Intervention Group	Outcome	No. of Subjects	Baseline Mean	End-of-Study Mean	Absolute Benefit	Relative Difference in Change From Baseline
Dellhag et al[54]	E: Wax only	ROM: flexion in dominant hand (in millimeters)	15	43.0	42.9	−2.7	−5%
	C: Untreated	ROM: flexion in dominant hand (in millimeters)	13	59.4	62.0		
Dellhag et al[54]	E: Wax only	Grip function test: 0–80 points	15	75.5	75.0	−0.3	−1%
	C: Untreated	Grip function test: 0–80 points	13	75.2	75.0		
Dellhag et al[54]	E: Wax only	Pinch function test: 0–32 points	15	29.3	28.3	−0.7	−2%
	C: Untreated	Pinch function test: 0–32 points	13	29.5	29.2		
Dellhag et al[54]	E: Wax only	Grip force (in newtons) (average of dominant hand)	15	72.9	75.9	0.2	0%
	C: Untreated	Grip force (in newtons] (average of dominant hand)	13	82.6	85.4		
Dellhag et al[54]	E: Wax only	Pain on nonresisted motion: both hands, 0–100-mm VAS	15	20.3	25.9	0.2	1%
	C: Untreated	Pain on nonresisted motion: both hands, 0–100-mm VAS	13	27.7	33.1		
Dellhag et al[54]	E: Wax only	Stiffness: both hands, 0–100-mm VAS	15	23.7	27.0	9.1	31% (favors control)
	C: Untreated	Stiffness: both hands, 0–100-mm VAS	13	36.0	30.2		

[a] E=experimental group, C=control group, VAS=visual analog scale.

The thermal effects also cause vasodilation, which enhances the excretion of chronic inflammatory cells.[7,100]

Thermotherapy

The Ottawa Panel found good evidence that thermotherapy, especially paraffin baths combined with exercise, should be included as an intervention for patients with RA to improve ROM and decrease pain and hand stiffness. This recommendation agrees with all existing guidelines[5,25–27] on improving pain and is partially supported by Nicholas,[102] who concluded that the current literature in rheumatology does not provide clinicians with precise information on dosage or duration, or specific indications for heat or cold therapy in therapeutic application.

The Ottawa Panel found insufficient evidence on the efficacy of cryotherapy, although physiological studies have shown effects on circulatory and temperature responses, muscle spasms, and inflamed tissue.[9,103] Cryotherapy's mechanism of action has not yet been fully elucidated.[103] Whether these physiological effects translate to important clinical outcomes (such as pain and functional status) is unknown.

The beneficial effects observed for paraffin baths combined with therapeutic exercises for arthritic hands—effects on measures of ROM, stiffness, and pain on nonresisted motion—concur with the physiological and therapeutic effects such as facilitation of soft tissue healing, decrease of pain by reducing muscle spasms, and reduction of joint stiffness.[7] Thermotherapy using paraffin baths combined with exercise for RA is more effective as an adjunct therapy than it is alone. The combination of several concurrent therapies within the same treatment session reflects current physical therapist practice[6] where heat therapy is used for its reflex vasodilative effect, which increases cell metabolism and blood flow[7] for an optimal muscle preparation before hand exercises. The combination of wax and exercises can introduce confounders. Indeed, endorphin and enkephalin production is stimulated by exercise.[104] The reduction of arthritic pain also could be observed when exercise is combined with a thermotherapy modality.[15]

Table 15.
Wax and Exercise Versus Control at 1 Month: Range of Motion (ROM), Grip, Pain, Stiffness[a]

Study	Intervention Group	Outcome	No. of Subjects	Baseline Mean	End-of-Study Mean	Absolute Benefit	Relative Difference in Change From Baseline
Dellhag et al[54]	E: Wax and exercise	ROM: flexion in dominant hand (in millimeters)	13	62.3	52.1	−12.8	−21%
	C: Untreated	ROM: flexion in dominant hand (in millimeters)	13	59.4	62.0		
Dellhag et al[54]	E: Wax and exercise	Grip function test: 0–80 points	13	72.3	74.8	2.7	5%
	C: Untreated	Grip function test: 0–80 points	13	75.2	75.0		
Dellhag et al[54]	E: Wax and exercise	Pinch function test: 0–32 points	13	27.4	29.3	2.2	8%
	C: Untreated	Pinch function test: 0–32 points	13	29.5	29.2		
Dellhag et al[54]	E: Wax and exercise	Grip force (in newtons) (average of dominant hand)	13	72.4	79.2	4	5%
	C: Untreated	Grip force (in newtons) (average of dominant hand)	13	82.6	85.4		
Dellhag et al[54]	E: Wax and exercise	Pain on nonresisted motion: both hands, 0–100-mm VAS	13	29.3	22.1	−12.6	−44%
	C: Untreated	Pain on nonresisted motion: both hands, 0–100-mm VAS	13	27.7	33.1		
Dellhag et al[54]	E: Wax and exercise	Pain on nonresisted motion: both hands, 0–100-mm VAS	13	39.3	24.9	−8.6	−23%
	C: Untreated	Pain on nonresisted motion: both hands, 0–100-mm VAS	13	36	30.2		

[a] E=experimental group, C=control group, VAS=visual analog scale.

TENS

According to the Ottawa Panel, there is good evidence showing that acupuncture-like TENS alone should be included as an intervention for RA to decrease pain and improve power. However, patients with RA seem to prefer conventional TENS application compared with acupuncture-like TENS.[77] The Ottawa Panel partly agrees with The Arthritis Society,[5] which views TENS as beneficial for pain and joint swelling in patients with RA. Our results concur with the conclusions of several descriptive literature reviews.[16,23,24,102]

The neuroregulatory peripheral and central effects[89,105–107] of TENS have been proposed to be more effective with higher-intensity applications.[75] This effect was observed in the study involving acupuncture-like (higher-intensity) application compared with a placebo.[75] However, both conventional and acupuncture-like TENS excite afferent fibers in the A-alpha-beta range.[108] The plausible effect is explained by the activation of intrinsic pain-suppressive systems[109,110] and the concomitant release of opiate observed in both animals[111] and humans.[105] The importance of the stimulation parameters in TENS analgesia is shown in animal and human research. Changes in frequency recruit different opioid receptors, for example, and therefore an awareness of the parameters used during TENS treatments is essential.[112,113] Several investigators[114–116] have recommended that vibrator stimulation be part of TENS application,

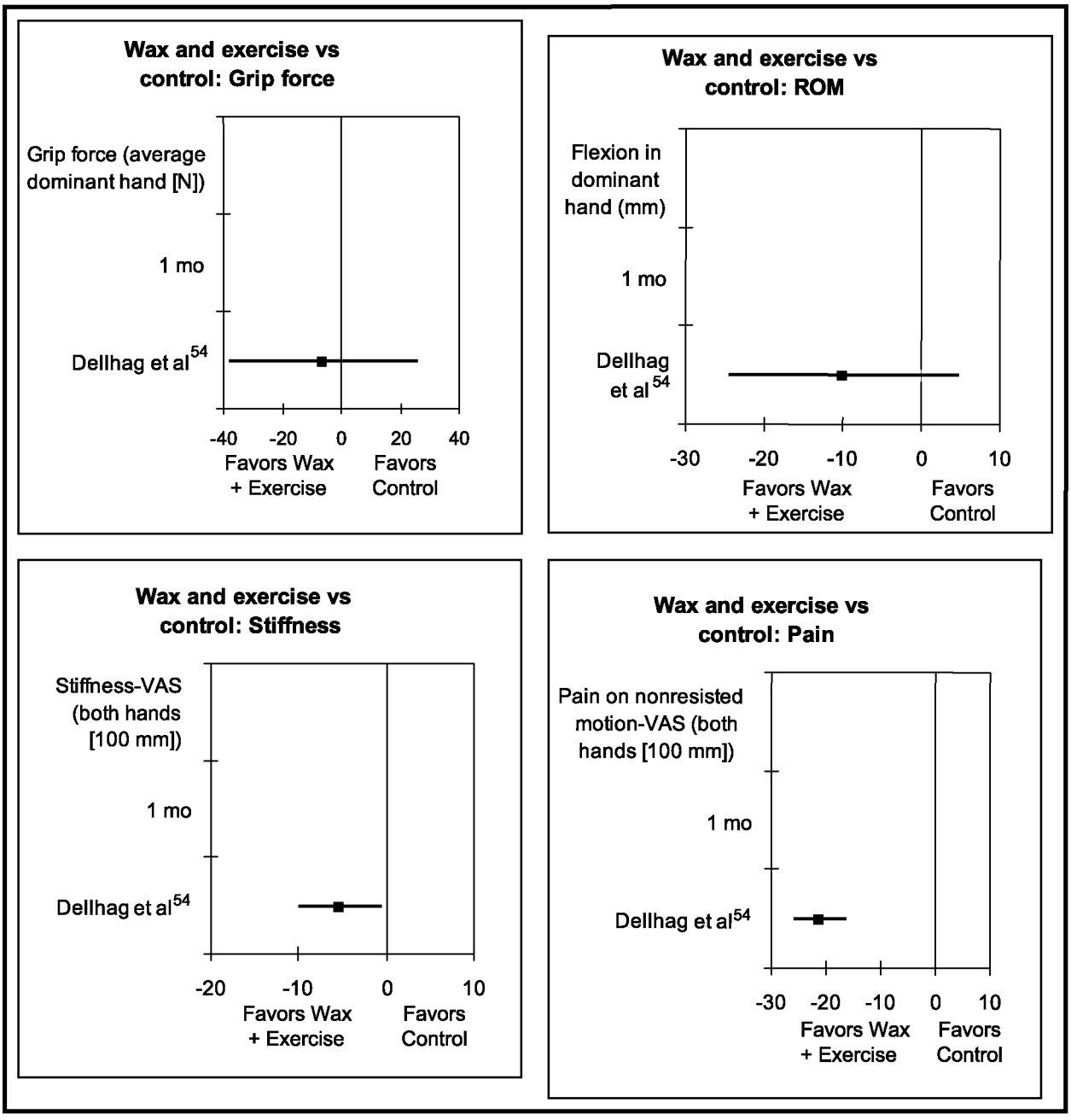

Figure 3b.
Wax and exercise versus control. ROM=range of motion, VAS=visual analog scale.

Table 16.
Transcutaneous Electrical Nerve Stimulation (TENS) Versus Control (No TENS): Pain at 3 Weeks[a]

Study	Intervention Group	Outcome	No. of Subjects	Baseline Mean	End-of-Study Mean	Absolute Benefit	Relative Difference in Change From Baseline
Abelson et al[75]	TENS	Pain VAS 100 mm	18	60.5	18.5	−45	−67%
	Placebo	Pain VAS 100 mm	16	75.0	78.0		

[a] VAS=visual analog scale.

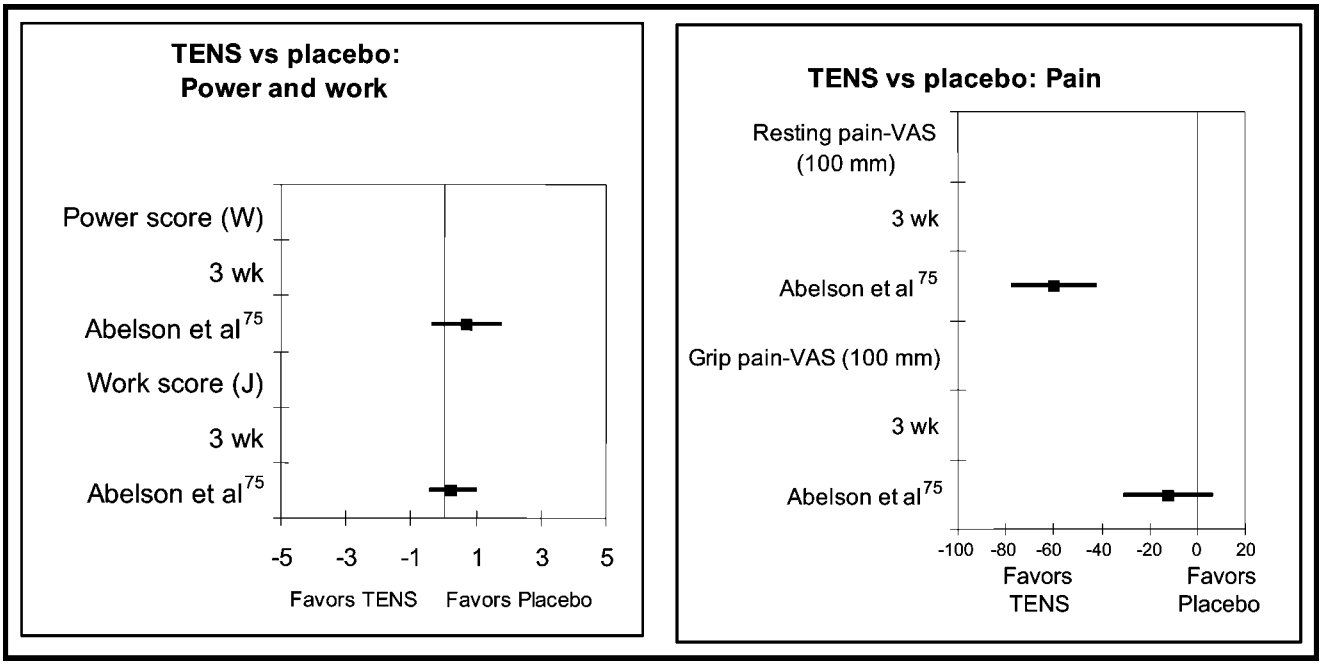

Figure 4a.
High-frequency transcutaneous electrical nerve stimulation (TENS) versus placebo (no TENS). VAS=visual analog scale.

especially when TENS is being applied for relief of chronic pain.

Electrical Stimulation of Muscle

Electrical stimulation of muscle is one of the therapeutic interventions available to minimize the loss of joint mobility and function by enhancing muscle performance in patients with RA.[18,117] However, despite the potential benefits of electrical stimulation in RA management, only one CCT[117] was identified for this intervention, and the study was ultimately rejected because the control group included fewer than 5 patients, indicating a very low statistical power. This CCT[117] is also considered a head-to-head study because 2 methods of stimulation were compared.

Clinically, electrical stimulation is used to facilitate effective muscle force and endurance in situations involving a decrease in the voluntary recruitment of the muscle. Electrical stimulation helps to increase this recruitment in subjects without known pathology or impairments. However, patients with RA are not able to voluntarily recruit motor units to the level required for the performance of high-intensity exercises needed to enhance muscle function,[18] and electrical stimulation does not help these patients, who have chronic muscle weakness. Furthermore, the Ottawa Panel does not recommend high-intensity exercises for patients with RA.[33] Musculoskeletal dysfunction, including pain and muscle disuse atrophy that are observed in patients with RA, may cause decreased voluntary recruitment.

Table 17.
Transcutaneous Electrical Nerve Stimulation (TENS) Versus Control (No TENS): Power and Work Scores

Study	Intervention Group	Outcome	No. of Subjects	Baseline Mean	End-of-Study Mean	Absolute Benefit	Relative Difference in Change From Baseline
Abelson et al[75]	TENS	Power (in watts) for hand muscles (not precise) at 3 wk	18	1.64	2.38	0.98	55%
	Placebo	Power (in watts) for hand muscles (not precise) at 3 wk	16	1.91	1.67		
Abelson et al[75]	TENS	Work score (in joules) for hand muscles (not precise) at 3 wk	18	0.82	0.96	0.16	5%
	Placebo	Work score (in joules) for hand muscles (not precise) at 3 wk	16	0.69	0.67		

Table 18.
High-Frequency Transcutaneous Electrical Nerve Stimulation (TENS) Versus Placebo (No TENS): Joint Tenderness

Study	Intervention Group	Outcome	No. of Subjects	Baseline Mean	End-of-Study Mean	Absolute Benefit	Relative Difference in Change From Baseline
Langley et al[76]	High-frequency TENS	Joint tenderness scale (0–22)[a]	11	28	15	0	0%
	Placebo	Joint tenderness scale (0–22)[a]	11	48	35		

[a] The scale from 0 to 22 is not consistent with baseline and final scores >22.

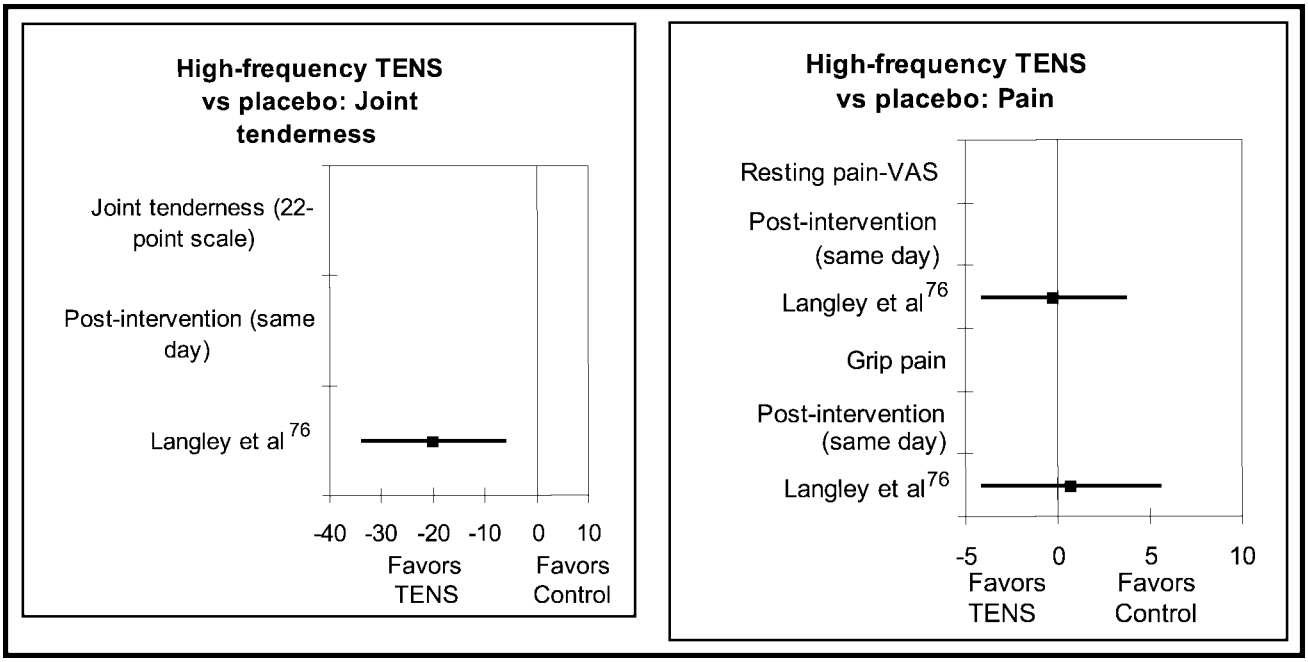

Figure 4b.
High-frequency transcutaneous electrical nerve stimulation (TENS) versus placebo (no TENS), after intervention, same day. VAS=visual analog scale.

Table 19.
High-Frequency Versus Low-Frequency Transcutaneous Electrical Nerve Stimulation (TENS): Patient Global (Patient's Assessment of Overall Disease Activity or Improvement[33]) at 2 Weeks

Author	Group[a]	Outcome	No. of Subjects Improved	Total N	Risk Occurrence	Risk Difference
Mannheimer et al[77]	E: High-frequency TENS	Patient global: number of subjects improved	18	19	95%	21%
	C: Low-frequency TENS	Patient global: number of subjects improved	14	19	74%	

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

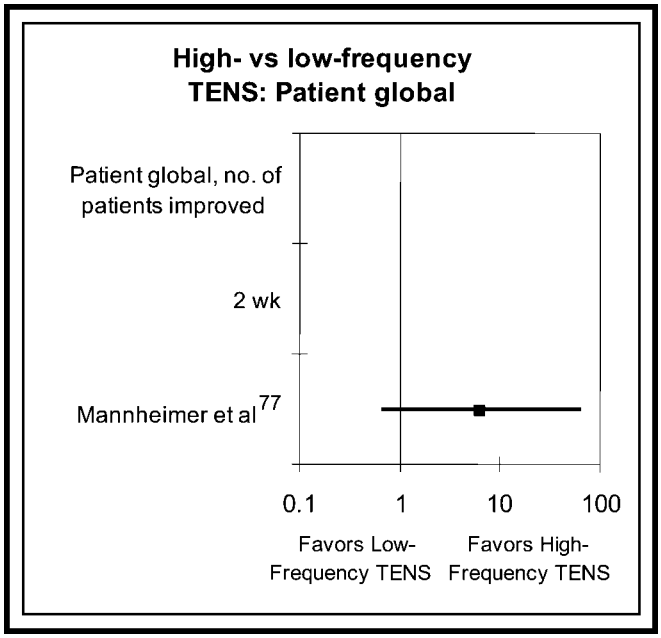

Figure 4c.
High- versus low-frequency transcutaneous electrical nerve stimulation (TENS), 2 weeks.

Although the biophysical actions of many physical therapy interventions are partially understood, further investigation needs to be undertaken in several areas of physical therapy research, particularly that involving rheumatology: the mechanism of action; the differential effects of dose, of wavelength, and of treatment duration[99]; disease staging and treatment combinations; and the relationship of pain, impairment, and disability. To reproduce the results of published RCTs, it is crucial that details on various kinds of characteristics be systematically reported. Characteristics include those of the device (eg, size of the ultrasound head or temperature of the paraffin); those of the therapeutic application (eg, specific area of application or mode of application); duration of the intervention; and schedule of intervention. Characteristics of the population such as age, sex, concurrent interventions, and disease status (eg, acuity and joint involvement) also must be reported.

Conclusion

Despite the fact that the scientific literature is limited in quantity, good-quality evidence exists to recommend and support the use of LLLT, ultrasound, thermotherapy, and TENS for the management of RA. Conversely, evidence is lacking as to whether the use of electrical stimulation should be included or excluded in physical rehabilitation for RA management.

The main difficulty in determining the effectiveness of rehabilitation interventions is the lack of well-designed prospective RCTs. Future research in physical therapy should adopt rigorous methods such as the use of an appropriate placebo (and double-blind procedure), adequate randomization, a homogeneous sample of patients based on rigorous selection and diagnostic criteria, and an adequate sample size to detect clinically important differences with confidence.

Unfortunately, at present, there is insufficient evidence to recommend or not recommend the use of several modalities and physical agents in certain clinical circumstances. The main difficulty is the lack of studies available and the methodological weaknesses in those studies: the variation in the quality of the included trials (sometimes because the randomization procedure is not described properly), the difficulty of masking patients to a physical agent or modality,[118] and the lack of standardized outcomes.[2,99]

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Appendix 1.
Previous Clinical Practice Guidelines for Rheumatoid Arthritis[a]

Intervention	Author	Quality of Scientific Evidence	Clinical Recommendations
LLLT	ACR[26]	N/C	N/C
	APS[27]	N/C	N/C
	Yasuda[28]	N/C	N/C
Therapeutic ultrasound	ACR[26]	N/C	N/C
	APS[27]	N/C	N/C
	Yasuda[28]	N/C	N/C
Thermotherapy	ACR[26]	N/R	Heat is recommended, especially just prior to exercise
	APS[27]	N/C	N/C
	Yasuda[28]	N/R	Physical agents, including paraffin bath, hot packs, and pain management techniques, are recommended
TENS	ACR[26]	N/C	N/C
	APS[27]	Good-quality evidence	TENS is given a fair recommendation for pain relief
	Yasuda[28]	N/C	N/C
Electrical stimulation	ACR[26]	N/C	N/C
	APS[27]	N/C	N/C
	Yasuda[28]	N/C	N/C

[a] LLLT=low-level laser therapy, ACR=American College of Rheumatology, N/C=not considered, APS=American Pain Society, N/R=not reported, TENS=transcutaneous electrical nerve stimulation.

Appendix 2.
Included Trials for LLLT[a]

Author/Year	Sample Size	Population Details	Symptom Duration	Age	Intervention	Comparison Group	Concurrent Therapy	Frequency and Duration	Follow-up Duration	Quality (R, B, W)
Goats et al,[34] 1996	RCT Total: 35 Gr1: 25 Gr2: 10	Inclusion criteria: patients who were aged 16 y or over and had RA affecting 2 or more of the following groups of joints: tibiofemoral, talocrural, subtalar, midtarsal, or metatarsophalangeal Exclusion criteria: patients receiving medication that might distort the planned assessments	Gr1: $\bar{X}$=7.54 y, SD=6.86 y Gr2: $\bar{X}$=9.8 y, SD=10.11 y	Gr1: $\bar{X}$=57 y, SD=14 y Gr2: $\bar{X}$=64 y, SD=8 y	Gr1: 5-kHz pulse repetition rate, spot size of 0.125 cm^2 in contact with the skin and 8.1 J/cm^2 applied to each aspect of the joint, Ga-Al-As LLLT	Gr2: placebo (identical in external appearance but having no output)	Patient's regular medication	2 times a week for 4 wk	3 and 6 mo	1, 2, 0
Hall et al,[35] 1994	RCT Total: 40 Gr1: 20 Gr2: 20	Inclusion criteria: patients with definite RA and active synovitis of all or some MCP or PIP joints Exclusion criteria: patients who had had a recent drug change (<30 d earlier) and were incapable of joint response (bony ankylosis, joint replacement, or tendon rupture)	Gr1: $\bar{X}$=12.2 y, range=1–33 y Gr2: $\bar{X}$=9.3 y, range=2–30 y	Gr1: $\bar{X}$=67.1 y, range=55–84 y Gr2: $\bar{X}$=60.9 y, range=43–77 y	Gr1: Ga-Al-As LLLT in contact with the skin for 18 min, wavelength of 820 nm (cluster and single), spot size of 0.1 cm^2 Single-probe: pulsing frequency of 5 kHz, actual output of 40 mW, irradiance of 400 mW/cm^2, applied at the radial, ulnar, and ventral aspects of the first to fifth MCP and PIP joints of the most affected hand, 90 s/joint (3.6 J/joint, 36 J/cm^2 for each joint) Cluster probe: 31 diodes (8×880 nm, 10×870 nm, 14×950 nm, 1×820 nm), total power output of 60 mW, applied over the dorsal and ventral aspects of the hand for 180 s (minimal exposure=2.7 J/cm^2, maximal exposure=4.5 J/cm^2)	Gr2: placebo	Patient's regular medication	3 times a week for 4 wk	2 and 4 mo	1, 2, 1

(continued)

Appendix 2.
Included Trials for LLLT[a] *(continued)*

Author/Year	Sample Size	Population Details	Symptom Duration	Age	Intervention	Comparison Group	Concurrent Therapy	Frequency and Duration	Follow-up Duration	Quality (R, B, W)
Johannsen et al,[36] 1994	RCT Total: 22 Gr1: 10 Gr2: 12	Inclusion criteria: patients who were aged 18–85 y, had active Steinbrocker functional class I or II RA, and had symmetrical involvement of the MCP joints Exclusion criteria: patients who had bony erosions or osteoarthritis of the MCP or PIP joints, were pregnant, or had an inflammatory rheumatic disease other than RA	N/A	Gr1: $\bar{X}$=59 y, range=36–76 y Gr2: $\bar{X}$=62 y, range=56–73 y	Gr1: Ga-Al-As LLLT, wavelength of 830 nm, continuous LLLT beam, spot size of 0.07 cm^2, effect of 21 mW, 23.2 J applied per treatment with 2.9 J on 4 points (2 anterolateral and 2 posterolateral) around each of the 2 most painful MCP joints on the most affected hand	Gr2: placebo	Patient's regular medication	3 times a week for 1 mo	None	2, 2, 1
Palmgren et al,[37] 1989	RCT Total: 35 Gr1: 19 Gr2: 16	Inclusion criteria: patients with classical RA	Gr1: $\bar{X}$=13.4 y, range=1–45 y Gr2: $\bar{X}$=15.5 y, range=4–30	Gr1: F: $\bar{X}$=61.1 y, range=29–76 y M: $\bar{X}$=66.0 y, range=56–73 y Gr2: F: $\bar{X}$=57.5 y, range=39–70 y M: $\bar{X}$=68.0 y, range=66–70	Gr1: LLLT, 820 nm, polarized, 15 mW, narrow profile Ga-Al-As semiconductor LLLT diode, continuous-wave; diode area of 0.1256 cm^2, applied for 60 s on each lateral side of the second to fifth MCP and PIP joints of the most affected hand	Gr2: placebo	Patient's regular medication	3 times a week for 4 wk	None	1, 2, 1
Walker et al,[38] 1987	RCT Total: 72 Gr1: 34 Gr2: 38	Inclusion criteria: patients with RA (according to ARA criteria)	Gr1: $\bar{X}$=11 y, range=1–40 y Gr2: $\bar{X}$=6 y, range=0.25–38 y	Gr1: $\bar{X}$=60 y, range=23–74 y Gr2: $\bar{X}$=61.5 y, range=35–73 y	Gr1: helium-neon LLLT, 632.5 nm, 1 mW, 20 Hz, maximal output of 0.95 mW at the fiber optic tip (spot size of 4 mm^2), actual output of 0.4776 mW, pulsed, applied bilaterally for 20 s on each site on the skin overlying the radial, median, and saphenous nerves, also applied on the skin overlying the painful joints (4 min total joint exposure for the first 4 wk, 6 min for the next 3 wk, and 8 min for the last 3 wk)	Gr2: placebo	N/A	3 times a week for 10 wk	None	1, 2, 1

[a] LLLT=low-level laser therapy, R=randomization: 2 points maximum (Jadad scale[33]), B=blinding: 2 points maximum (Jadad scale[33]), W=withdrawals: 1 point maximum (Jadad scale[33]), RCT=randomized controlled trial, Gr=group, RA=rheumatoid arthritis, MCP=metacarpophalangeal, PIP=proximal interphalangeal, Ga-Al-As=gallium-aluminum-arsenide, N/A=not available, F=female, M=male, ARA=American Rheumatism Association.

Appendix 3.
Included Trials for Therapeutic Ultrasound[a]

Author/ Year	Sample Size	Population Details	Symptom Duration	Age	Intervention	Comparison Group	Concurrent Therapy	Frequency and Duration	Follow-up Duration	Quality (R, B, W)
Konrad,[45] 1994	RCT 50 Gr1: 25 Gr2: 25	Inclusion criteria: patients with RA (onset of disease at least 1 y earlier, functional class I or II, medium activity of RA-erythrocyte sedimentation rate, C-reactive protein)	Gr1: $\bar{X}$=4 y, SD=1.5 y Gr2: $\bar{X}$=5 y, SD=1.75	Gr1: $\bar{X}$=7.3 y, SD=9 y Gr2: $\bar{X}$=5.9 y, SD=8.75 y	Gr1: US applied in water to the dorsal and palmar aspects of the hand, 0.5 W/cm^2, continuous with circular round head, 10 min on alternate days for 3 wk for a total of 10 sessions	Gr2: placebo (inactive US in water applied to the palmar and dorsal aspects of the hand)	N/A	10 sessions (3 wk)	None	1, 1, 1

[a] R=randomization: 2 points maximum (Jadad scale[33]), B=blinding: 2 points maximum (Jadad scale[33]), W=withdrawals: 1 point maximum (Jadad scale[33]), RCT=randomized controlled trial, Gr=group, RA=rheumatoid arthritis, US=ultrasound.

Appendix 4.
Included Trials for Thermotherapy[a]

Author/Year	Sample Size	Population Details	Symptom Duration	Age	Intervention	Comparison Group	Concurrent Therapy	Frequency and Duration	Follow-up Duration	Quality (R, B, W)
Bulstrode et al,[53] 1986	RCT Total: 24 Gr1: 15 Gr2: 9	Inclusion criteria: patients who had chronic RA (<1 y) and clinically obvious effusion of one or both knee joints	N/A	N/A	Gr1: ice packs	Gr2: control (no ice packs)	Supervised regimen of static quadriceps femoris muscle exercises 3 times daily	Once a day for 10 min	End of intervention after 5 d	1, 0, 0
Dellhag et al,[54] 1992	RCT Total: 52 Gr1: 13 Gr2: 11 Gr3: 15 Gr4: 13 F: 33 M: 19	Inclusion criteria: patients had to reside in the city of Gothenburg, be no older than 70 y, and have functional class I or II chronic RA, have hand problems defined as a decrease in ROM or grip force	6–10 y	F: $\bar{X}$=51.8 y M: $\bar{X}$=56.3 y	Gr1: wax bath and exercises Gr2: exercises only Gr3: wax bath only	Gr4: control (unknown intervention)	None	Five repetitions for the exercises (each session was 20 min) Wax bath: both hands dipped 5 times into wax, wrapped in paper, and fitted in quilt mittens for 20 min Intervention 3 times a week	End of intervention after 4 wk	1, 0, 0

[a] R=randomization: 2 points maximum (Jadad scale[33]), B=blinding: 2 points maximum (Jadad scale[33]), W=withdrawals: 1 point maximum (Jadad scale[33]), RCT=randomized controlled trial, Gr=group, RA=rheumatoid arthritis, N/A=not available, F=female, M=male, ROM=range of motion. The data in this table have been previously published in a table in another article (Brosseau L, Robinson V, Pelland L, et al. Efficacy of thermotherapy for rheumatoid arthritis: a meta-analysis. *Physical Therapy Reviews*. 2002;7:5–15) and are used here with permission of the publisher.

Appendix 5.
Included Trials for TENS[a]

Author/Year	Sample Size	Population Details	Symptom Duration	Age	Intervention	Comparison Group	Concurrent Therapy	Frequency and Duration	Follow-up Duration	Quality (R, B, W)
Abelson et al,[75] 1983	RCT 34 Gr1: 18 Gr2: 16	Inclusion criteria: patients with chronic RA (according to ARA criteria[4]) and chronic wrist involvement	Gr1: $\bar{X}$=12 y, SD=8 y Gr2: $\bar{X}$=13 y, SD=6.75 y	Gr1: $\bar{X}$=57 y, SD=8 y Gr2: $\bar{X}$=55 y, SD=7 y	Gr1: one TENS session a week for 3 wk	Gr2: placebo	N/A	1 session a week for 3 wk, 15 min per session	None	1, 1, 0
Langley et al,[76] 1984	RCT 22 Gr1: 11 Gr2: 11	Inclusion criteria: patients with chronic RA (according to ARA criteria[4]), chronic hand involvement, and pain in one or both hands	Gr1: $\bar{X}$=11.3 y, SD=7.5 y Gr2: $\bar{X}$=10.7 y, SD=10.7	Gr1: $\bar{X}$=54.9 y, SD=15.3 y Gr2: $\bar{X}$=53.4 y, SD=14.1 y	Gr1: 20 min of high-frequency TENS (continuous square wave pulses of 0.2 ms at 100 Hz), monophasic pulses via 2 surface electrodes. Electrodes were wet pad type with surface area of 9.08 cm^2. Electrodes were placed immediately proximal to the patient's wrist, with one electrode on the volar surface and the other electrode on the palmar surface.	Gr2: 20 min of placebo TENS	N/A	1 session	None	1, 2, 1
Mannheimer et al,[77] 1978	RCT 38 Gr1: 19 Gr2: 19	Inclusion criteria: patients with RA (including spontaneous pain or pain on loading from the wrist, the MCP joints, and the PIP joints)	Range: 1–44 y	Range: 20–69 y	Conventional HF/LF TENS, 5 min a day for 15 d, wrist (dorsal and volar) and back (either side of the spinal process), 0–120 V, 0.2 ms, 45–170 Hz, electrodes had area of 9 cm^2	Placebo controlled	N/A	15 sessions (one daily 5-min session)	None	1, 0, 0

[a] TENS=transcutaneous electrical nerve stimulation, R=randomization: 2 points maximum (Jadad scale[33]), B=blinding: 2 points maximum (Jadad scale[33]), W=withdrawals: 1 point maximum (Jadad scale[33]), RCT=randomized controlled trial, RA=rheumatoid arthritis, Gr=group, N/A=not available, MCP=metacarpophalangeal, PIP=proximal interphalangeal, HF=high frequency, LF=low frequency. The data in this table have been previously published in a table in another article (Brosseau L, Yonge K, Marchand S, et al. Efficacy of transcutaneous electrical nerve stimulation (TENS) for rheumatoid arthritis: a systematic review. *Physical Therapy Reviews*. 2003;7:199–208) and are used here with permission of the publisher.

Appendix 6.
Clinical Practice Guidelines

Low-level Laser Therapy (LLLT)

LLLT applied to the foot, knee, or hand versus a placebo, level I (RCT): grade A for pain at 3 months (clinically important benefit); grade C for function, tender joints, muscle force, and ROM at 3 and 6 months (no benefit). Patients with chronic RA.

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Therapeutic Ultrasound

Therapeutic ultrasound performed on the hand in water versus a placebo, level I (RCT): grade A for tender joints at 10 weeks (clinically important benefit); grade C for swollen joints and morning stiffness at 10 weeks (no benefit). Patients with RA involving the hand (functional class I or II, chronic stage).

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Thermotherapy

Cryotherapy applied to the knee joint versus a control, level I (RCT): grade C for thermographic index (measurement [in degrees Celsius] obtained using infrared thermography of the joint) at 5 days (no benefit). Patients with chronic RA, and with obvious effusion of joints.

Wax applied to the hand and wrist versus a control, level I (RCT): grade C for pain, ROM, muscle force, and function at 1 month (no benefit). Patients with functional class I or II with hands affected.

Wax applied to the hand or wrist and hand exercises versus a control, level I (RCT): grade A for ROM at 1 month (clinically important benefit), grade C+ for pain and stiffness at 1 month (clinical benefit), grade C for muscle force and function at 1 month (no benefit). Patients with functional class I or II with hands affected.

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Transcutaneous Electrical Nerve Stimulation (TENS)

Low-frequency TENS applied to the hand and wrist versus no stimulation, level I (RCT): grade A for pain at 3 weeks (clinically important benefit), grade C+ for power at 3 weeks (clinical benefit), grade C for work at 3 weeks (no benefit). Patients with chronic RA.

High-frequency TENS applied to the hand and wrist versus placebo, level I (RCT): grade C for pain and joint tenderness, same day (no benefit). Patients with chronic RA.

High- versus low-frequency TENS applied to the hand and wrist, level I (RCT): grade C+ for global patient (patient's assessment of overall disease activity or improvement)[33] at 2 weeks (clinical benefit). Patients with chronic RA.