Physiotherapy

CANADA

ELECTROPHYSICAL AGENTS
Contraindications and Precautions: An Evidence-Based Approach to Clinical Decision Making in Physical Therapy

VOLUME 62 NUMBER 5 SPECIAL ISSUE 2010 ISSN-0300-0508 E-ISSN-1708-8313

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Key Words: adverse effects, adverse reaction, cold, complication, contraindications, cryotherapy, electrical stimulation, electrophysical agents (EPAs), heat, HVPC, IFC, low-level laser therapy, physical therapy, precautions, rehabilitation, risk, safety, side effect, TENS, therapeutic ultrasound, US

DOI:10.3138/ptc.62.5

Canadian Physiotherapy Association
Association canadienne de physiothérapie

Publisher
University of Toronto Press-Journals Division
5201 Dufferin St.
North York, ON M3H 5T8 Canada;
Tel.: 416-667-7810
Fax: 416-667-7881
E-mail: journals@utpress.utoronto.ca
www.utpjournals.com

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PRINTED IN CANADA

Foreword

Sandy Rennie

The importance of the guideline "Electrophysical Agents—Contraindications and Precautions: An Evidence-Based Approach to Clinical Decision Making in Physical Therapy" by Houghton, Nussbaum, and Hoens simply cannot be overstated. This excellent work is timely, relevant, and important both clinically and educationally; it could well become a seminal guide to contraindications and precautions in the use of electrophysical agents (EPAs) not only in Canada but internationally.

While Houghton et al. point out that their primary references were not acquired through a rigorous systematic review process, the thoroughness of the literature review is impressive. It provides a sound basis for examining why certain contraindications and precautions are still viable and appropriate in today's clinical practice. In addition to a comprehensive list of scientific articles, the authors consulted 17 textbooks that address contraindications and precautions for the EPAs; they examined and interpreted guidelines produced by the Chartered Society of Physiotherapy (UK) and the Australian Physiotherapy Association; and, perhaps most importantly from an academic perspective, they conducted a consensus exercise among North American (Canadian and US) and international experts through a direct survey, requesting their recommendations on contraindications and precautions for commonly used EPAs.

The authors' purpose in developing this document was to provide a resource that could guide clinical decision making for the safe and effective use of EPAs; evidence-based practice was at the forefront of their approach. Their purpose was not to address indications for the use of EPAs, but rather to describe the evidence and prevailing opinions on the most common contraindications to and precautions for the effective use of EPAs, and specifically six commonly used EPAs: cold (cryotherapy), heat (superficial thermal agents), electrical stimulation (TENS, NMES, HVPC), low-level laser therapy, short-wave diathermy, and therapeutic ultrasound. Unfortunately, not all examples of the agents used in these groupings are discussed; however, there is enough information that the reader can safely draw conclusions for the EPAs not described, with a few exceptions. These exceptions are discussed below.

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ULTRASOUND

In the section on effective duration of ultrasound, the authors describe using pulsed ultrasound for a minimum of 10 minutes, based on good evidence. However, they do not mention that continuous ultrasound should also be used for a minimum of 10 minutes (as described by Draper et al.)[1] in order to produce the tissue-temperature rise of 4°C required to achieve a thermal impact on the tissues.

ELECTRICAL STIMULATION

Houghton et al. have included several types of electrical stimulation in this section: transcutaneous electrical nerve stimulation (TENS), high-voltage pulsed current (HVPC), interferential current (IFC), and neuromuscular electrical stimulation (NMES). It might have been prudent to separate these currents according to their primary uses in physiotherapy practice, rather than combining them together. TENS and IFC are used primarily for pain relief; HVPC is used for wound care and sometimes for pain relief; and NMES is used for muscle-fibre recruitment. Therefore, while the majority of contraindications and precautions are similar, there are some exceptions.

Another precaution should be noted for the use of IFC with suction-cup application. Whether the suction is vacuum or positive pressure (Venturi system), the risk of skin damage is increased when this method of application is used. Therefore, it is important to ensure that the patient's skin condition is appropriately safe for IFC suction application.

Houghton et al. indicate that NMES is contraindicated "anywhere" on pregnant women; however, there appears to be no evidence for this. NMES is an effective tool for muscle recruitment, muscle strengthening, and functional activity.[2–4] Although it should not be used on the abdomen or lumbar spine,

NMES should be safe and effective for other situations when motor-unit recruitment (particularly peripherally) would be beneficial for pregnant women.

The authors dismiss myths around the use of electrical stimulation on patients with certain medical conditions, acknowledging that NMES can be used safely and effectively in patients with cancer, chronic obstructive pulmonary disease, and heart disease. Recent research[5–8] has shed more light on the use of electrical stimulation in these situations.

SUPERFICIAL HEATING AGENTS

In this section, the primary electrophysical agents discussed by Houghton et al. are those that fall into the category of superficial heating agents—that is, agents that heat tissues within 3 cm of the skin surface. These agents typically include paraffin wax baths, hydrocollator hot packs, and hydrotherapy. In recent years, another superficial heating agent has appeared on the over-the-counter market for consumers: the heat wrap. Commercially available, wearable heat wraps are air activated and can be worn for up to 8 hours at a time; they consist of cloth embedded with multiple discs made of iron powder, activated charcoal, sodium chloride, and water. These discs are spaced throughout the cloth's application surface; when the wrap is removed from its sealed pouch and exposed to air, the discs oxidize, undergoing an exothermic reaction and thus producing heat. These wearable heat wraps maintain a temperature of about 40°C (104°F), elevate tissue temperature, and can be worn during activities of daily living, at work, and during sleep. They are available in different sizes and shapes to accommodate body size and contour and location of application. Several studies have examined the effectiveness of these heat wraps.[9–12]

While practising physiotherapists may not use heat wraps in a clinic or department, they should be aware of these products and their risks for skin damage through burns and/or blisters. Since these products are being used more and more by patients, it is imperative that we understand their mechanism of use and the safety concerns around them, as patients will undoubtedly ask for our advice with respect to their use.

Another concern we often have with the use of superficial heating agents is the impact the heat may have on subcutaneous fatty tissue. In two recent articles, Petrofsky et al.[13,14] examined the effects of superficial heat on subjects with a high body mass index (BMI). In their experiments using hydrocollator hot packs on overweight subjects, they found that the change in muscle temperature was reduced, while the change in skin temperature was increased, relative to non-overweight patients. This temperature accumulation in the skin is potentially dangerous, particularly for obese patients who are older, have diabetes, or have impaired circulation and/or reduced skin thickness, as it may result in burns or skin damage.

SUPERFICIAL COOLING AGENTS

A hierarchy of cooling agents is provided by Houghton et al. Missing from their list, however, are combined cold and compression units such as the Cryo/Cuff. These units are designed to provide both cold and compression simultaneously, and they have been shown to be both safe and effective.[15–18] The authors' list of general contraindications and precautions for the use of cryotherapy would certainly also apply to these cold/compression units; however, an additional relevant precaution is that too much combined cold and compression can compromise tissues even more. The use of these devices is common in acute joint injuries, such as ankle sprains, to help control swelling and possible bleeding in the region. However, caution is advised when adding compression to a cryotherapy application to ensure that circulation and nerve(s) are not compromised.

SHORT-WAVE THERAPY

A primary concern raised by Houghton et al. about the use short-wave therapy (SWT) is that there should be no metal furniture within a 2 m distance of the operating SWT unit, nor should any items of furniture being used by the patient have any metal parts. While this safety approach seems plausible, it may not be possible in today's clinics and hospital physiotherapy departments. The majority of treatment plinths in current use are adjustable in height, with moveable parts to accommodate patients in various positions of support. These modern plinths are designed not only for better patient accessibility and comfort but also for the comfort and safety of the physiotherapist: because they can change the height and configuration of the plinth, physiotherapists are less likely to sustain joint, muscle, or back injuries. These plinths, which are adjustable manually (hydraulic) or electrically (footswitch), have metal frames and parts, and this, according to Houghton et al., makes them unusable for SWT. We may need to rethink this application restriction and find ways of applying SWT safely and effectively using adjustable treatment plinths. If precautions are taken to ensure that the patient is not touching any metal and that the SWT leads and electrode(s) are properly attached and not touching the plinth, treatment may be considered safe.

PROCEDURES FOR ALL ELECTROPHYSICAL AGENT TREATMENTS

A systematic and common-sense approach to the use of EPAs is described by Houghton et al.: ensuring patient safety through explanation, informed consent, sensation testing, and patient monitoring during treatment; reassessment using valid outcome measures; and ensuring completion of appropriate documentation.

CONCLUSION

''Electrophysical Agents—Contraindications and Precautions: An Evidence-Based Approach to Clinical Decision Making in Physical Therapy'' is a much-needed resource for physiotherapists in Canada and abroad and should be part of the education of future physiotherapists.

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ACKNOWLEDGEMENTS

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1. Introduction

This document was developed by three physical therapists dedicated to evidence-based practice in the use of electrophysical agents (EPAs), with the intent to provide a resource to guide safe practice using EPAs.

IMPETUS

This project began when the authors taught a workshop on EPAs prior to the 2007 World Congress of Physiotherapy in Vancouver, Canada. The workshop revealed considerable discrepancy between instructors and participants in terms of what was considered safe practice with respect to EPA contraindications and precautions. Furthermore, the authors found that they were frequently being contacted for guidance on EPA safety issues, yet their attempts to provide answers were complicated by conflicting or inadequate evidence in the literature. It was clear that there was a need for a resource to guide this important area of physiotherapy practice. The authors therefore sought to capture traditional EPA safe practice by examining the consensus of opinion among selected EPA experts and authors of recent book chapters and monographs, and to review the literature for evidence to support or refute the common view, with the goal of developing evidence-based recommendations for safe practice in the use of EPAs.

PURPOSE

The authors' intent in developing this resource was to provide the physical therapy community with a resource that could guide clinical decision making for safe practice in the use of EPAs, thereby reducing the incidence of adverse reactions.

This resource was developed with the following objectives:

1. To provide a compilation and synthesis of information from original research articles, reviews, and textbook resources about contraindications and precautions for EPAs.
2. To summarize expert opinion (North American and international, as represented by EPA guidelines of the Australian Physiotherapy Association and the UK Chartered Society of Physiotherapy) in order to highlight the degree of consensus with respect to contraindications and precautions for EPAs.
3. To make clear recommendations on EPA contraindications and precautions based on scientific evidence, physiological rationale, and/or ethical reasoning.
4. To provide a rationale for each recommendation to enable physiotherapists to make informed clinical decisions.

SCOPE

It is important to note that our focus here is restricted to the evidence and prevailing opinions for EPA *contraindications and precautions*; it does not address their *indications* (i.e., their clinical effectiveness). Accordingly, this guide should be used in conjunction with the three critical components of evidence-based practice: (1) best research evidence (i.e., clinical effectiveness studies), (2) clinical expertise, and (3) patient values.[1]

This resource focuses on the following commonly used electrophysical agents (EPAs):

- Superficial heat (hot packs, wax, and hydrotherapy)
- Cryotherapy (ice, ice baths, and cold packs)
- Therapeutic ultrasound (pulsed and continuous mode)
- Short-wave therapy (pulsed and continuous mode)
- Light therapy (low-level laser therapy and non-coherent light)
- Electrical stimulation therapy (E-stim) using surface electrodes: transcutaneous electrical stimulation (TENS), neuromuscular electrical stimulation (NMES), high-voltage pulsed current (HVPC), and interferential current (IFC)

The use of these energies (electrical, light, sound, and thermal) for diagnostic, medical, or surgical applications is not considered. Microwave diathermy, low-frequency pulsed electromagnetic fields (PEMFs), iontophoresis, electromyography (EMG) biofeedback, compression therapy, ultraviolet irradiation, and radiant heat are not included. This guide considers commonly encountered clinical conditions or patient scenarios

associated with the use of EPAs, rather than rare conditions and circumstances.

PROVISOS

The information provided here should be used in conjunction with the standards mandated by professional associations and regulatory bodies (e.g., Health Canada, the US Food and Drug Administration, provincial physiotherapy regulatory organizations). Contraindications and precautions are also listed in the operating manuals provided by equipment manufacturers, as required by Health Canada, although Health Canada does not vet these listings. In the event of a discrepancy between the information provided in this document and that provided by a manufacturer, the clinician is not bound by the manufacturer's recommendation.

Although this resource provides a review of the evidence, an expression of popular views, and informed recommendations for practice, it is ultimately the clinician who is responsible for making decisions about EPA application in a specific clinical situation. Clinical decisions should be based on weighing the evidence supporting use or non-use of a device and on an appreciation of the unique characteristics of the individual patient. In the absence of clear or substantive evidence of efficacy, and in the presence of potential adverse effects, it is recommended that clinicians err on the side of caution and avoid the use of the EPA.

METHODOLOGY

Consensus among North American and international experts was established by surveying experts within Canada and the United States, reviewing textbook resources, and interpreting guidelines from the Chartered Society of Physiotherapy in the United Kingdom and the Australian Physiotherapy Association. The findings are summarized in Appendix 1.

Canadian/US Expert Consensus

Eight physical therapists who instruct students on the use of EPAs within physical therapy programs in Canada and the United States and who are experienced in EPA practice were surveyed for their recommendations on commonly cited EPA contraindications. Many of these individuals are independent investigators with active research programmes in the field of EPA use, and their work is published in peer-reviewed journals. These eight individuals were invited to respond to a given list of conditions for the selected EPAs (see Appendix 1). For some conditions or specific body areas, fewer than eight responses were received. For the purposes of the present discussion, consensus among these experts is expressed as percent (raw) agreement that the particular EPA *should not* be used on patients with a given condition (i.e., that it is contraindicated). Raw percent agreement was determined by dividing the number of experts who stated that a condition was contraindicated by the total number of experts who provided a response. Experts were encouraged to give no response when they were unsure, rather than making an uninformed decision. When an expert did not register a response, the denominator and raw percent agreement were adjusted accordingly. Thus, higher percent agreement in this consensus process was considered stronger support for a recommendation that the EPA should be contraindicated for the given condition.

Resources

A total of 17 textbooks that included contraindications and precautions for one or more of the six EPAs addressed in this document were identified by reviewing the reference lists of English-language journal articles and by contacting academic and clinical colleagues. The most recent edition of each text was obtained by contacting publishers (see Appendix 2). Using these resources, a list was compiled of all medical conditions, scenarios, and body areas mentioned as contraindications. Percent (raw) agreement of contraindications for text resources was calculated as the number of resources listing the condition as a contraindication divided by the total number of resources that included a section on contraindications and precautions for the particular EPA. Where a textbook did not mention a particular condition or recommend treating the condition with caution (a precaution), it was assumed that the authors considered the condition safe to be treated (i.e., not contraindicated). Higher raw percentage values were considered to indicate stronger agreement among textbook resources that the EPA is contraindicated for a given condition. Overall, the consensus among authors of textbooks was quite low for most EPAs.

Guidelines of the Australian Physiotherapy Association (APA) and the Chartered Society of Physiotherapy (CSP)

Similar documents addressing this topic have been produced by Robertson et al. in Australia[2] and by the Chartered Society of Physiotherapy (CSP) in the United Kingdom.[3] These guidelines were reviewed by the present authors, and an interpretation of their recommendations is included here in order to give the reader an appreciation of the degree of international agreement on contraindications and precautions for the various EPA modalities. However,

caution is advised when comparing recommendations, as the differences in Australian, UK, and Canadian approaches to the topic required a degree of subjective interpretation. For example, the CSP guidelines do not consider TENS, NMES, IFC, and HVPC separately; therefore, the present authors have necessarily assumed that the list of contraindications and precautions pertains to all types of low-frequency E-stim. The APA guidelines group various conditions together (e.g., acute infection, malignancy, tuberculosis, and osteomyelitis are grouped in the category ''risk of dissemination''), which likewise requires an assumption that each of these conditions is a contraindication. In addition, terminology varies between the documents. For example, the CSP guidelines include a category termed ''local circulatory insufficiency,'' which was assumed to denote arterial insufficiency and to be similar to the category here termed ''impaired circulation''—and, moreover, to exclude other circulatory disturbances such as deep vein thrombus, venous congestion, and edema.

RECOMMENDATIONS

Within this document, clear recommendations are provided for the safe use of EPAs in specific conditions, together with a rationale and supporting literature for each condition. Tables at the beginning of each section summarize these recommendations. These tables are not meant to stand alone; rather, users of this resource are strongly encouraged to refer to the text, where recommendations are clarified, the rationale underlying the recommendation is provided, and the level of evidence supporting the recommendation is evaluated.

Rationale

A key feature of these guidelines is a discussion of the underlying biophysical mechanisms and concerns related to each recommendation. When adverse reactions are theorized but no evidence of such an adverse effect could be found in the literature, the rationale is hypothesized based on known physical principles and biological effects of the relevant EPA. In cases of controversy as to the relative risks and benefits of using an EPA, alternative viewpoints are presented. It is hoped that this information will assist clinicians in making their own decisions about EPA use in particular circumstances.

Research Evidence

Original articles addressing contraindications, precautions, and adverse reactions related to use of EPAs were identified by searching several electronic databases (CINAHL, Medline, and PubMed) for papers published between 1966 and January 2007. A secondary search of all references in book chapters, review articles, and articles located via the database search was also performed. An updated search was performed in March 2008 using the CINAHL, EMBASE, EBM Reviews, and PubMed databases and the following search terms: *contraindication*, *adverse reaction*, *side effect*, *complication*, *safety*, *rehabilitation*, *physical therapy*, *physiotherapeutic*, *ultrasound*, *therapy*, *laser*, *LLLT*, *LILT*, *light*, *heat*, *cold*, *cryotherapy*, *electrical stimulation*, *TENS*, *EMS*, *high voltage pulsed current*, *HVPC*, *interferential current*, *IFC*, and *electrotherapy*. The studies included in the literature review were original research articles, experimental research (animal models, cell culture studies, and trials using healthy human subjects), and clinical reports (case reports, Phase I clinical trials that reported adverse reactions as a primary outcome) published in English. Primary sources are referred to whenever possible in these guidelines to support or refute the suggested contraindication, precaution, or recommendation for safe practice.

Recommendations

The authors have made a clear recommendation for each condition considered here. These recommendations are based on specific criteria that have been applied consistently across all EPAs and all conditions considered (see chart below). Criteria include the seriousness of the potential adverse reaction, the level of research evidence supporting the recommendation, and the degree of consensus among North American and international experts. Because consensus among experts and resources was generally poor, however, the consensus data seldom informed the authors' recommendation for practice. Note that the authors have chosen to consider any condition that has the potential for a serious adverse reaction as a contraindication, regardless of the research evidence.

Summaries

Table 1 summarizes the authors' recommendations for the six EPAs discussed here. Thereafter, each EPA-specific section begins with a list that summarizes all recommendations specific to that EPA. This is followed by a table providing the percent (raw) agreement on contraindications among the North American experts and the authors of the textbook chapters consulted, an interpretation of the recommendations found in the APA and CSP guidelines, the seriousness of potential adverse reactions, the level of research evidence, and the authors' recommendations. For the rationale and supporting evidence for these recommendations, the reader is

Symbol	Definition	Criteria
	**CONTRAINDICATION** DO NOT use the EPA with this condition or in this body location.	• Potential for serious adverse reaction • Moderate to strong research evidence • Consensus among experts and resources
	**PRECAUTION** Experienced clinicians may elect to treat this condition/location with extra caution (e.g., using lower intensities and/or more frequent monitoring).	• Potential for moderate to minor adverse reaction • Low to moderate research evidence
	**SAFE** This condition or body location is NOT contraindicated.	• Potential for minor adverse reaction • Absent to low research evidence (no adverse reactions have been reported with clinical use)

strongly urged to consult the detailed condition-specific discussions presented under the heading "Recommendation, Rationale, and References" in each section. These detailed discussions may include a few conditions not covered in the summary of recommendations or in the tables. Each section concludes with recommendations for safe practice (under the heading "Safe Practice"), followed by a list of references cited in the text and tables.

Throughout this document, the above symbols are used in summary tables and detailed recommendations.

CRITERIA FOR ASSIGNING THE SERIOUSNESS OF ADVERSE REACTION AND LEVEL OF RESEARCH EVIDENCE

Seriousness of Adverse Reaction

Serious

Potential adverse reaction could be catastrophic, is potentially life threatening, or could result in permanent deformity, discomfort, or disability (e.g., cardiac dysfunction, coma, fetal abnormality).

Moderate

Potential adverse reaction could be a major inconvenience for the individual and could require medical attention; however, the reaction is temporary and not likely to compromise the individual's overall medical health (e.g., deep skin burn, systemic infection, tissue necrosis).

Minor

Potential adverse reaction could be a minor inconvenience to the patient and would resolve spontaneously (e.g., increased pain, superficial burn).

Level of Research Evidence

Strong

Clinical reports are consistent and suggest a potential for adverse reactions should the EPA be used in the presence of this condition or on this body area. These clinical reports are supported by experimental evidence and/or by a strong biophysical rationale for the adverse reaction.

Moderate

The potential harmful effect has been demonstrated in experimental research using appropriate cell culture or animal models or when applied to healthy human subjects; however, clinical evidence is either lacking or conflicting.

Low

There is a sound biophysical rationale to explain how the EPA might cause an adverse reaction; however, there is no research evidence, either animal or clinical, to substantiate this response, *or* the existing evidence is contradictory.

Absent

No research, either experimental or clinical, has been found, and there is no known biophysical rationale to explain how the adverse reaction might occur.

LIMITATIONS

1. Primary resources included in this document were retrieved up to September 2009. It is probable that more current information is available. This document will need to be updated frequently (at least every 5 years).

2. The primary references included in this document were not acquired through a rigorous systematic review process; it is possible, therefore, that other pertinent evidence was overlooked. Moreover, there was no concomitant systematic evaluation of the methodological quality of the cited studies.
3. The recommendations for each condition and EPA considered in this document are the opinions of the authors. Bias on the part of the authors and contributors was not rigorously controlled; however, given that one of the objectives was to provide readers with information on the degree of consensus of opinion, the authors considered it important not to control for bias. With respect to author bias in formulating the recommendations, it should be noted that consensus was reached by discussion and only after review of the literature.
4. International opinion was taken into account by reviewing guidelines published by Australian and UK physiotherapy societies/associations. The authors also recorded contraindications and precautions listed in textbook chapters written by international experts. However, the authors did not contact the individual authors of these documents directly to gather their opinions.
5. Not all recommendations are based on strong clinical evidence. However, the authors of this document maintain that this is necessary practice when, in the absence of strong clinical evidence (especially where there are ethical issues that preclude undertaking a clinical trial), pre-clinical evidence (e.g., animal studies) or common sense must be relied upon.[4]

DEFINITION OF TERMS

Adverse reaction: an undesirable response that is potentially harmful to the patient or that could delay recovery from his or her condition.

Active deep vein thrombosis (DVT): For the purpose of this document, a deep vein thrombosis is considered ''active'' during its early development (i.e., thrombus is recent and not completely organized), when there is greater risk of embolization. Following anticoagulation therapy, a DVT is considered to have dissolved and been reabsorbed.

Contraindication: a specific situation in which a drug, procedure, or surgery should *not* be used because it may be harmful to the patient.

Contraindication (local): a situation in which application of the EPA over a specific location or region of the body could be harmful and thus the EPA should not be used at this location/region.

Cryotherapy: the use of a cold conductive agent that is applied, directly or through an insulating layer, to the skin. Ice packs, ice baths, cold gel packs, and ice massage are included in this category.

Electrical stimulation therapy (E-stim): E-stim includes forms of electrical energy that are applied via surface electrodes to stimulate superficial nerves or tissues in order to promote healing, reduce pain, or activate muscles. This category includes *TENS, IFC, HVPC,* and *NMES* (see definitions below). Direct current, defined as unidirectional flow of current for at least 1 second, typically used only for the delivery of drugs across the skin (iontophoresis), is not addressed in this document.

Electrophysical agent (EPA): physical energy (electrical, electromagnetic, thermal, light, or sound) used in a therapeutic manner to reduce impairments or promote recovery of function. EPAs are sometimes referred to as ''modalities,'' ''thermal agents,'' or ''electrotherapy.''

Experts: the three authors plus five North American physical therapists who provided their opinions on contraindications for EPAs. Authors of chapters in EPA textbooks consulted by the authors are termed ''international experts.''

High-voltage pulsed current (HVPC): also called ''pulsed galvanic current'' and properly named ''twin-peaked monophasic pulsed current.'' For the purpose of this document, HVPC is considered as it is used to reduce edema, improve perfusion, promote tissue repair, and treat chronic wounds. Typically, it is applied locally over the target site (e.g., wound) at a sensory or submotor level of intensity.

Interferential current (IFC): the use of medium-frequency (1,000–10,000 Hz) alternating current. Application can be via two independent channels using four electrodes (quadripolar) arranged around the target site in a crossfire pattern to produce an amplitude-modulated interference pattern of electrical energy in the tissues. Alternatively, IFC devices can deliver an amplitude-modulated alternating current via a single channel (bipolar, premodulated).

Low-level laser therapy/non-coherent light (LLLT): photoirradiation that includes Class II and III lasers and other non-coherent light sources used to stimulate or promote biological function (500 mW or less power). Other terms used for this therapy are *photon therapy* or *phototherapy*, *low-intensity laser therapy* (*LILT*), *cold laser therapy*, *laser irradiation*, and *low-intensity laser irradiation* (*LILI*). High-power medical lasers are excluded. Therapies using invisible radiation, specifically ultraviolet and radiant heat, are also excluded.

Neuromuscular electrical stimulation (NMES): the use of pulsed currents to stimulate motor nerves, which in turn produce a fused tetanic muscle contraction with or without joint movement.

Precaution: a situation in which a patient is at some risk of experiencing an adverse event. In this case treatment should proceed with caution. Proactive measures should be taken to reduce the risk of harm; such measures might include adjusting treatment parameters (lower intensity) or treatment schedule (treatment duration or frequency of application) and/or closer monitoring of patient response to the treatment.

Resources: chapters written by international experts for EPA textbooks or monographs that were consulted in the development of this document (see Appendix 2).

Risk: an unwanted response that may occur but that could not be predicted prior to commencing the treatment. Although safe practices help to reduce the likelihood of such events, there are some risks that can never be entirely eliminated (e.g., consequences of equipment malfunction).

Short-wave therapy (SWT): the use of electromagnetic fields at a radio frequency of 27.12 MHz. *Thermal SWT:* For the purposes of this document, *thermal* SWT means that perceptible skin warming is produced and subcutaneous or deep tissue temperature is increased at least 1°C; this is considered likely at mean power output in the range of 35–40 W or higher. Thermal SWT can be produced using continuous-mode SWT or pulsed short wave (PSW), including PSW treatments often referred to as ''pulsed radiofrequency energy'' (PRFE). *Non-thermal SWT:* For the purposes of this document, *non-thermal* SWT means that perceptible skin warming is *not* produced, although subcutaneous/deep tissue temperature may be slightly increased; this is considered likely at mean power output in the range

of 32–34 W or lower. Non-thermal SWT can be produced using continuous-mode SWT or PSW (including PRFE). Temperature change in an electromagnetic field depends on mean power of the treatment rather than on the use of continuous or pulsed mode. The authors recognize that the estimated mean power outputs for producing thermal versus non-thermal effects used in this document may be considerably different in persons of very low body mass index (BMI) and in obese persons, depending also on size and spacing of electrodes. Pulsed electromagnetic fields (PEMFs) using low-energy magnetic fields alternating at frequencies in the range of 1–100 Hz are not addressed in this manual.

Superficial heating agents: the use of a hot conductive agent applied to the skin to temporarily increase temperature of skin and subcutaneous structures. Hot packs, paraffin wax, and hydrotherapy tanks are included in this category. These heating agents typically increase the temperature of skin and of subcutaneous structures within 3 cm of the skin surface.

Transcutaneous electrical nerve stimulation (TENS): the use of electrical currents to produce analgesia or hypoalgesia. A variety of pulsed waveforms are used, with frequencies typically in the range of 1–100 Hz. Intensities are set to produce sensory stimulation alone or combined with motor stimulation to produce muscle twitches (acupuncture-like TENS).

Tuberculosis (TB): is considered ''active'' when there is no immune control over the disease process and the patient manifests signs and symptoms. In ''latent'' TB, the person is infected but there are no signs or symptoms, as the immune system is able to control the disease. In active TB, the infection may be isolated or walled off in a specific location (loculated or encapsulated) or may be widely distributed (disseminated). Risk of exacerbation of the disease process is greatest when there is active TB that is not being medically managed. The effect of EPAs on either latent or active forms of TB is not known, and the potential to spread or activate the TB lesions is considered serious. Therefore, throughout this document, the application of EPAs over tissues affected by TB (latent or active) is specified as contraindicated.

Ultrasound: therapeutic ultrasound at high frequency (0.5–3 MHz) and low intensity (0.1–3.0 W/cm^2) used to induce or promote tissue processes. Both continuous- and pulsed-mode ultrasound are considered in this document. Diagnostic ultrasound, low-frequency kHz ultrasound, and diathermy ultrasound used for tissue ablation are not included.

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ABBREVIATIONS

APA	Australian Physiotherapy Association guidelines
A-TENS	acupuncture-like TENS
C	contraindication (EPA should not be used)
C-local	EPA should not be used directly over the involved area
Cold	cryotherapy (ice, cold gel packs, etc.)
Cont	continuous
CSP	Chartered Society of Physiotherapy guidelines
DVT	deep vein thrombosis
ECG	electrocardiogram
EPA	electrophysical agent
E-stim	electrical stimulation considered generically, including TENS, NMES, HVPC, IFC and Russian current but excluding electrical stimulation for wound healing, direct current and iontophoresis
FDA	US Food and Drug Administration
Heat	superficial heating agents (wax, hot packs, etc.)
HVPC	high-voltage pulsed current
NA	Not addressed because the resource or experts did not give an opinion
NMES	neuromuscular electrical stimulation
P	precaution (EPA can be applied with caution)
PRFE	pulsed radio-frequency energy
PSW	pulsed short wave
S	safe (no individual considered this a contraindication or precaution)
SWT	short-wave therapy
TB	tuberculosis (including active and latent forms of the disease)
TENS	transcutaneous electrical nerve stimulation
US Cont	continuous-mode ultrasound (i.e., 100% duty cycle) likely to produce tissue heating
US Pulsed	pulsed-mode ultrasound (20–50% duty cycle) with minimal tissue heating

2. Summary of Recommendations

Table 1 Summary of Authors' Recommendations for Use of EPAs in the Presence of Certain Conditions or Over Specific Body Areas

	Ultrasound		Electrical Stimulation			LLLT Light	Heat	Cold	SWT Therm	SWT Non
	Cont	Pulsed	TENS	NMES	HVPC					
Conditions										
Active deep vein thrombosis or thrombophlebitis	C-local	C-local	C	C	C	C-local	C	C	C	C
Active epiphysis	P	P	P	P	P	S	P	S	P	P
Acute injury / inflammation	C-local	P	S	S	S	S	C-local	S	C-local	S
Cardiac failure	S	S	C-local	C-local	C-local	S	P	P	P	S
Chronic wound	P	S	S	S	S	S	S	C	P	S
Cold hypersensitivity (e.g. Raynaud's, cryoglobulinemia, hemoglobulinemia)	S	S	S	S	S	S	S	C	S	S
Cold urticaria	S	S	S	S	S	S	S	C	S	S
Damaged or at-risk skin	P	P	C-local	C-local	C-local	S	C-local	P	P	S
Haemorrhagic conditions	C	C	C	C	C	C	C	C	C	C
Hypertension	S	S	S	S	S	S	S	P	S	S
Impaired circulation	C-local	P	P	C-local	P	S	C-local	C-local	C-local	P
Impaired sensation	C-local	P	C-local	P	P	S	C-local	P	C-local	S
Impaired cognition or communication	C	P	C	P	P	P	C	C	C	P
Infection	C-local	P	C-local	C-local	C-local	P	C-local	P	C-local	P
Malignancy	C-local	C-local	C-local	C-local	C-local	C-local	C-local	S	C-local	C-local
Photosensitivity or systemic lupus erythematosis	S	S	S	S	S	P	S	S	S	S
Pregnancy	C-local	C-local	C-local	C	C-local	C-local	P	S	C	C
Recently radiated tissue	C-local	C-local	C-local	C-local	C-local	P	C-local	S	C-local	C-local
Skin disease (e.g., eczema)	C-local	P	P	P	P	S	C-local	S	C-local	P
Tuberculosis	C-local	C-local	C-local	C-local	C-local	C-local	C-local	C-local	C-local	C-local

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	Ultrasound		Electrical Stimulation			LLLT Light	Heat	Cold	SWT Therm	SWT Non
	Cont	Pulsed	TENS	NMES	HVPC					
Implants										
Electronic device	C-local	C-local	C-local	C-local	C-local	S	S	S	C	C
Metal implant	S	S	S	S	S	S	S	S	C	S
Plastic, cement implant	C-local	P	S	S	S	S	S	S	C	S
Local Areas										
Eyes	C	C	C	C	C	C	P	P	C	P
Anterior neck, carotid sinus	C	C	C	C	C	P	P	C	C	C
Chest, heart	S	S	P	C	P	S	S	S	C	C
Head	S	S	C	C	C	S	S	S	S	S
Regenerating nerves	P	P	C	P	P	S	S	C	C	P
Reproductive organs	C	C	C	C	C	C	C	S	C	S

Note: This table is not meant to be used in isolation. Readers should consult sections 3–8. A comprehensive list of contraindications and precautions for each EPA is provided at the beginning of each of these sections, which also provide specific details about the authors' recommendations.

C = contraindication; C-local = contraindication over the site; P = precaution; S = safe; Ultrasound Cont = continuous-mode ultrasound (has 100% duty cycle and may produce perceptible skin warming); Ultrasound Pulsed = pulsed-mode ultrasound (has duty cycle less than 50% and usually does not produce perceptible skin warming); HVPC = high-voltage pulsed current (electrical stimulation used to stimulate healing of chronic wounds, applied in the area of affected tissues at a subsensory or sensory level of stimulation); NMES = neuromuscular electrical nerve stimulation (electrical stimulation applied using stimulus parameters sufficient to produce a tetanic muscle contraction); TENS = transcutaneous electrical nerve stimulation (electrical stimulation applied at sensory levels [produces pins-and-needles sensation]) to produce analgesia or hypoalgesia (includes interferential current [IFC]); LLLT/Light = low-level laser therapy (includes all Class II and III lasers and non-coherent light sources); Heat = hot packs, wax, and other superficial conductive heating agents that heat tissues within 3 cm of the skin surface; Cold = all forms of cryotherapy (cold packs, ice bags, ice bath, ice massage, etc.); SWT = short-wave therapy; Therm = Thermal SWT (produces perceptible skin warming and tissue temperature increases at least 1°C); Non = Non-thermal SWT (does *not* produce perceptible warmth but may increase tissue temperature slightly)

3. Continuous and Pulsed Ultrasound

SUMMARY OF RECOMMENDATIONS

C Do NOT use the EPA to treat in the presence of this condition or in this body location.	**Neither continuous nor pulsed ultrasound should be applied** • to the low back or abdomen of pregnant women • to regions of known or suspected malignancy • over electronic devices • to actively bleeding tissue or persons with untreated haemorrhagic disorders • to regions with active deep vein thrombosis or thrombophlebitis • over recently radiated tissues • to areas with myositis ossificans • to eyes • to anterior neck or carotid sinus • to reproductive organs (testes) • over tissues infected with tuberculosis **In addition, continuous ultrasound that produces tissue heating should not be applied** • to persons with cognition or communication impairments sufficient to prevent them from giving accurate and timely feedback • to infected tissues that are under tension (abscess) • to tissues inflamed as result of recent injury or exacerbation of chronic inflammatory condition • to areas with impaired circulation • to areas of impaired sensation that prevent persons from giving accurate and timely feedback • over areas affected by heat-sensitive skin diseases (e.g., eczema) • to intact skin overlying implants containing cement or plastic components
P Experienced clinicians may elect to treat this condition/location with caution (e.g., lower intensity, more frequent monitoring)	**Pulsed or continuous ultrasound may be applied with caution to** • spinal cord or superficial peripheral nerves • regenerating nerves • active epiphysis • "at risk" or fragile skin **Pulsed ultrasound may be applied with caution** • to intact skin overlying implants containing cement or plastic components • to areas of impaired sensation that prevent patients from giving accurate and timely feedback • to patients with cognition or communication impairments sufficient to prevent them from giving accurate and timely feedback • to areas with impaired circulation, provided pain is not exacerbated • over areas affected by heat-sensitive skin diseases (e.g., eczema) • to infected tissues with open drainage • to areas with regenerating nerves • to tissues inflamed as result of recent injury or exacerbation of chronic inflammatory condition
S This condition/scenario or body location is NOT contraindicated.	**Pulsed or continuous ultrasound can be used on** • intact skin overlying metal implants • the head • the chest wall, provided the ribcage is intact • persons with cardiac failure or hypertension **Pulsed ultrasound can be used on** • areas near or over chronic wounds

Continuous ultrasound has 100% duty cycle and may produce perceptible skin warming; *pulsed ultrasound* has duty cycle less than or equal to 50% and usually does not produce perceptible skin warming.

Table 2a Consensus and Recommendations on Continuous Ultrasound*

	Resources % ($n = 12$)	Can/US %	APA	CSP	Adverse Reaction**	Research Evidence**	Recommendation	For Details See
Conditions								
Pregnancy	100	100 ($n = 8$)	C	C- local	Serious	Moderate	C	3-1
Malignancy	83	100 ($n = 8$)	C	C-local	Serious	Strong	C	3-2
Active epiphysis	50	N/A	N/A	C- local	Moderate	Moderate	C	3-3
Myositis ossificans	S	N/A	N/A	N/A	Moderate	Absent	C	3-3
Deep vein thrombosis Thrombophlebitis	75	100 ($n = 8$)	N/A	P	Serious	Low	C	3-7
Infection Tuberculosis	75	100 ($n = 8$)	C	C	Moderate	Moderate	C	3-8
Acute injury Inflammation	25	100 ($n = 8$)	C	N/A	Minor	Low	C	3-9
Haemorrhagic conditions	58	75 ($n = 8$)	C	C	Serious	Moderate	C	3-10
Recently radiated tissue	42	88 ($n = 8$)	C	P	Serious	Low	C	3-11
Impaired sensation	58	63 ($n = 8$)	S	P	Moderate	Absent	C	3-12
Impaired cognition or communication	S	63 ($n = 8$)	C	C	Moderate	Absent	C	3-13
Impaired circulation	50	88 ($n = 8$)	C	P	Moderate	Moderate	C	3-14
Skin disease Damaged or at-risk skin	8	86 ($n = 7$)	C	P	Minor	Absent	C	3-15
Implants								
Plastic/cement implant	42	50 ($n = 8$)	N/A	N/A	Moderate	Moderate	P	3-4
Metal implant	S	P ($n = 8$)	N/A	C	Minor	Strong	S	3-5
Electronic implant Cardiac pacemaker	83	88 ($n = 8$)	C-local	C-local	Serious	Low	C	3-6

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	Resources % ($n = 12$)	Can/US %	APA	CSP	Adverse Reaction**	Research Evidence**	Recommendation	For Details See
Local Areas								
Reproductive organs	92	75 ($n = 8$)	C	C-local	Serious	Absent	C	3-16
Eyes	100	100 ($n = 8$)	C	C-local	Serious	Absent	C	3-17
Neck	S	N/A	N/A	N/A	Serious	Strong	C	3-18
Spinal cord Superficial/regenerating nerves	75	N/A	N/A	N/A	Minor	Low	P	3-19 3-20
Chest, heart Head	58	N/A	N/A	N/A	Moderate	Low	S	3-21

APA = Australian Physiotherapy Association guideline; Can/US = results of survey of North American experts; CSP = Chartered Society of Physiotherapy guideline (UK); C = contraindication; C-local = contraindication over the site; N/A = not addressed; P = precaution; S = safe

* This table shows the percent (raw) agreement of commonly cited contraindications for continuous ultrasound (duty cycle = 100%) by North American experts (Can/US; $n \leq 8$) and authors of textbooks (Resources; $n = 12$). An interpretation of the Australian (APA) and UK Chartered Society of Physiotherapy (CSP) guidelines is shown. A recommendation is given for each condition based on an interpretation of the risk of adverse reactions and the strength of the supporting evidence.

** Readers should consult the Introduction for criteria used to rank adverse reactions, research evidence, and recommendations.

Table 2b Consensus and Recommendations on Pulsed Ultrasound*

	Resources % ($n = 12$)	Can/US %	APA	CSP	Adverse Reaction**	Research Evidence**	Recommendation	For Details See
Conditions								
Pregnancy	100	100 ($n = 8$)	C-local	C-local	Serious	Moderate	C	3-1
Malignancy	83	88 ($n = 8$)	P	C-local	Serious	Strong	C	3-2
Active epiphysis	50	N/A	N/A	C-local	Moderate	Moderate	P	3-3
Myositis ossificans	S	N/A	N/A	N/A	Moderate	Absent	C	3-3
Deep vein thrombosis Thrombophlebitis	67	100 ($n = 8$)	N/A	P	Serious	Low	C	3-7
Infection	75	75 ($n = 8$)	P	C	Moderate	Moderate	P	3-8
Acute injury Inflammation	11	P ($n = 8$)	P	N/A	Minor	Low	P	3-9
Haemorrhagic conditions	58	63 ($n = 8$)	P	C	Serious	Moderate	C	3-10
Recently radiated tissue	42	75 ($n = 8$)	P	P	Serious	Low	C	3-11

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	Resources % ($n = 12$)	Can/US %	APA	CSP	Adverse Reaction**	Research Evidence**	Recommendation	For Details See
Impaired cognition or communication	S	P ($n = 8$)	P	C	Minor	Absent	P	3-13
Impaired sensation	42	P ($n = 8$)	P	P	Minor	Absent	P	3-12
Impaired circulation	50	P ($n = 8$)	P	P	Minor	Moderate	P	3-14
Skin disease Damaged or at-risk skin	8	57 ($n = 7$)	P	P	Minor	Absent	P	3-15
Implants								
Plastic/cement implant	33	38 ($n = 8$)	N/A	N/A	Moderate	Moderate	P	3-4
Metal implant	S	S ($n = 8$)	N/A	S	Minor	Strong	S	3-5
Electronic implant	83	88 ($n = 8$)	C-local	C-local	Serious	Low	C	3-6
Local Areas								
Reproductive organs	92	75 ($n = 8$)	C	C-local	Serious	Absent	C	3-16
Eyes	100	100 ($n = 8$)	C	C-local	Serious	Absent	C	3-17
Spinal cord Superficial/regenerating nerves	75	N/A	N/A	N/A	Minor	Low	P	3-19 3-20
Chest, heart Head	58	N/A	N/A	N/A	Moderate	Low	S	3-21
Anterior neck Carotid sinus	S	N/A	N/A	C	Serious	Absent	C	3-18

APA = Australian Physiotherapy Association guideline; Can/US = results of survey of North American experts; CSP = Chartered Society of Physiotherapists (UK) guideline; C = contraindication; C-local = contraindication over the site; N/A = not addressed; P = precaution; S = safe.

* This table shows the percent (raw) agreement of commonly cited contraindications for pulsed ultrasound (duty cycle $\leq$ 50%) by North American experts (Can/US; $n \leq 8$) and authors of textbooks (Resources; $n = 12$). An interpretation of the Australian (APA) and Chartered Society of Physiotherapy (CSP) guideline is shown. A recommendation is given for each condition based on an interpretation of the risk of adverse reactions and the strength of the supporting evidence.

** Readers should consult the Introduction for criteria used to rank adverse reactions, research evidence, and recommendations.

ULTRASOUND: RECOMMENDATIONS, RATIONALE, AND REFERENCES

3-1 Pregnancy

Recommendation C	Continuous and pulsed ultrasound should not be used over the low back, abdomen, or uterus. High-intensity, lower-frequency waves administered in continuous mode are potentially the most dangerous because they produce the greatest penetration and tissue heating.
Rationale	Sound waves transmit through amniotic fluid and could cause fetal malformations, including growth retardation, micropthalmia, exencephaly, microencephaly, neural tube defects, and myelodyplasia. Teratogenic effects of ultrasound are greater if tissue heating occurs or if maternal core temperature is elevated.
Research Evidence **MODERATE**	Diagnostic ultrasound is thought to be safe for human fetal development at levels below 0.1 W/cm^2 spatial average temporal peak (SATP) and at increases in temperature of embryonic and fetal tissue of no more than 1.5°C above normal physiological levels (37°C).[1–5] However, therapeutic ultrasound has produced malformations in fetal tissue models.[6–8]

3-2 Malignancy

Recommendation C	Pulsed and continuous ultrasound should not be used over suspected or confirmed malignancy. Abnormal growth should be regarded as malignant until diagnosis has been confirmed. Use caution when a patient with a history of cancer within the last 5 years has pain of undiagnosed origin.
Rationale	Sound waves applied to tumour cells can stimulate growth and induce new blood-vessel growth, which helps provide fuel for further tumour growth and potentially promotes metastases.
Research Evidence **MODERATE**	Ultrasound increased tumour growth and the incidence of metastases in animal models; effects were thought to be due to ultrasound-enhanced angiogenesis.[9–16] The literature is not consistent in these findings. Therapeutic ultrasound equipment should not be used to induce hyperthermia for the purpose of tumour ablation.[17–18]

3-3 Active Epiphysis, Myositis Ossificans

Recommendation P **Active Epiphysis** C **Myositis Ossificans**	Continuous and pulsed ultrasound can be used over bone-growth plates in adolescents using low intensities. There should be no discomfort during or after treatment. Continuous and pulsed ultrasound should not be applied in the vicinity of myositis ossificans.
Rationale	Ultrasound over unfused epiphyseal growth plates may alter bone growth. About 75% of ultrasound energy is reflected at tissue/bone interfaces, and the transmitted portion is largely absorbed by periosteum. Intensities that could produce unwanted bone growth are likely to cause pain as a result of the periosteal absorption. Therefore, ultrasound over bone using parameters and techniques that avoid painful stimulation is unlikely to produce adverse effects. Ultrasound over ectopic bone (myositis ossificans, hypertropic ossification) could stimulate further bone growth and exacerbate impairments.
Research Evidence **MODERATE**	Early studies in animal models that demonstrated abnormal bone growth following ultrasound used extraordinarily high ultrasound intensity and a stationary sound head.[19–26] The pre-clinical research is therefore not relevant to normal clinical practice. Ultrasound stimulates osteoblast function and has been shown to promote repair of bone fractures. However, the effective parameters (1.5 MHz, 0.15 W/cm^2, SATP, and a mark:space ratio of 1:4) are different from those typically used with therapeutic ultrasound.[27]

3-4 Plastic and Cement Implants

Recommendation C **US Cont** P **US Pulsed**	Continuous ultrasound should be avoided directly over joint replacements or prostheses constructed of cement or plastic. Low-intensity pulsed ultrasound may be used with caution over areas containing plastic/cement implants.
Rationale	Most plastic materials have a high coefficient of ultrasound absorption. Methyl methacrylate cement and plastic are rapidly heated by ultrasound. Water-saturated acrylic bone cement used to fixate endoprostheses becomes rubbery and soft if heated to 60–70°C. However, this degree of heating would never occur using typical therapeutic ultrasound.
Research Evidence **MODERATE**	Therapeutic ultrasound applied to animal models has been shown to alter the mechanical properties of plastic and cement components of surgical implants.[28–31]

3-5 Metal Implants

Recommendation S	Continuous and pulsed ultrasound are not contraindicated over metal implants. Application requires precautions to avoid standing waves and unstable cavitation.
Rationale	Metal reflects about 90% of incident ultrasound—slightly more than is reflected by bone.
Research Evidence **STRONG**	Metal is not heated by ultrasound, and sound waves do not loosen screws or plates.[31–36]

3-6 Electronic Devices

Recommendation C	Continuous and pulsed ultrasound should not be applied directly over the site of implanted pacemakers or other electronic devices (defibrillators, neuromuscular devices). This means that ultrasound should be used only when the exact location of device components is known. This contraindication applies regardless of whether or not the device is in use. Monitor patients closely when applying ultrasound at sites remote from the components of implanted systems.
Rationale	Sound waves reflected at a device–tissue interface could possibly cause tissue heating; the risk of an adverse effect would depend on the location of the implanted components and the intensity and duration of the exposure. The CSP guidelines recommend that only thermal ultrasound (continuous mode) be avoided over electronic implants.
Research Evidence **LOW**	The effect of therapeutic ultrasound waves on function of pacemakers and electronic stimulators is not known. No adverse effects have been reported in the literature. Various organizations have issued alerts about the definite risk of serious injury or death if patients with implanted electrical leads are exposed to *ultrasound diathermy*;[37–39] however, ultrasound diathermy is not a device used by physiotherapists.

3-7 Active Deep Vein Thrombosis, Thrombophlebitis

Recommendation C	Continuous and pulsed ultrasound should not be applied over the area of an active deep vein thrombus (DVT). The area overlying a previous DVT that has been treated with anticoagulant therapy can be treated with caution.
Rationale	Ultrasound could dislodge or cause partial disintegration of a thrombus, potentially blocking circulation to vital organs. Mechanisms by which this may occur include disintegration of existing blood clots induced by mechanical effects of ultrasound and possible increased local blood flow. There is no risk of ultrasound-induced emboli when anticoagulative therapy has resolved the clot(s).
Research Evidence **LOW**	Ultrasound caused red blood cell stasis in a chick embryo model and has also been shown to cause partial disintegration of a thrombus.[40,41] Studies that examined the effects of continuous and pulsed ultrasound on local blood flow produced inconsistent and inconclusive findings.[42–44]

3-8 Infection, Tuberculosis (TB)

Recommendation C **US Cont** P **US Pulsed** C **TB**	Ultrasound heat should not be applied to infected tissue that is under tension (e.g., abscess). However, infection with open drainage can be treated using very low intensity pulsed ultrasound. Ultrasound should be discontinued if an increase in any signs of inflammation (redness, heat, pain, and swelling) occurs. Tuberculous lesions should not be treated with either pulsed or continuous ultrasound.
Rationale	Heating may lead to increased swelling in closed spaces and, therefore, to increased pain. In diffuse infection that has no open drainage, heat may cause further spread of infection via increased circulation. This would be particularly undesirable in cases of TB.
Research Evidence **LOW**	It is uncertain whether pulsed or continuous ultrasound can increase regional blood flow and thereby spread infection.[42–44] The effect of ultrasound on bacterial growth is unknown. Pro-inflammatory effects of ultrasound may assist in the defence against infection.[45–49]

3-9 Acute Injury, Inflammation

Recommendation C **US Cont** P **US Pulsed**	Continuous-mode ultrasound that might increase tissue temperature should not be applied to already inflamed tissue. Pulsed ultrasound can be applied to inflamed tissues provided that cardinal signs of inflammation (redness, swelling, heat, pain) are not exacerbated.
Rationale	Metabolic and vascular changes are induced by local heat that may exacerbate inflammation and increase swelling.
Research Evidence **LOW**	Pulsed ultrasound is purported to activate cellular processes of inflammation, without heating and without increasing swelling, to promote faster resolution of the inflammatory phase of healing and, overall, to speed repair of injury.[45–47,50–53] Pulsed ultrasound has been used in several clinical studies to treat acute injuries; no adverse reactions have been reported.[50–53]

3-10 Haemorrhagic Conditions

Recommendation C	Neither continuous nor pulsed ultrasound should be applied to actively bleeding tissues. Ultrasound can be used to help resolve bruising following haemostasis. Ultrasound can be used on persons with bleeding disorders (haemophilia) after replacement factor has been administered and coagulopathy has resolved.
Rationale	Mechanical vibration produced by ultrasound can disrupt platelet plug formation and cause uncontrolled blood loss or bleeding into surrounding tissues. Heating-induced increase in local blood flow (continuous ultrasound) may also interfere with haemostasis. Some resources suggest that ultrasound applied over the pelvic region of menstruating women may increase blood loss.
Research Evidence **MODERATE**	Ultrasound is known to alter platelet degranulation and aggregation.[42] The literature is inconclusive with respect to the effects of ultrasound on local blood flow.[42–44] Ultrasound appears to have resolved haematoma formation.[54]

3-11 Recently Radiated Tissue

Recommendation C	Continuous and pulsed ultrasound should not be applied to tissues that have received radiation therapy within the previous 6 months.
Rationale	There is a potential risk of stimulating growth of any remaining malignant cells. Recently radiated tissues may respond atypically to ultrasound because of the presence of radiation-induced inflammation or scar tissue or cellular and circulatory effects.
Research Evidence LOW	The ability of ultrasound to stimulate the growth of cancer cells is well established.[9–18] There is little information on how previous radiation therapy might affect tissue response to ultrasound.[55]

3-12 Impaired Sensation

Recommendation C **US Cont** P **US Pulsed**	Avoid using continuous thermal ultrasound or high-temporal-peak-intensity pulsed ultrasound ($\geq$2.0 W/cm^2, SATP, 1:4) on body areas with impaired pain or heat sensation or with patients who cannot provide appropriate and timely feedback due to an altered level of consciousness or impaired cognition. Perform a sensory discrimination test (refer to the section on US safe practice).
Rationale	When adjustment of ultrasound parameters requires feedback from the client, it must be confirmed that the client can perceive heat and pain and is able to communicate appropriately. Communication between therapist and client is most often required when adjusting continuous-mode ultrasound intensity and rate of applicator movement to produce a moderate, comfortable level of tissue heating, or when insonating over superficial bone. Tissue heating depends on a number of factors specific to the individual client (e.g., tissue perfusion, body type, proximity of bone). Therefore, use of standard ultrasound heating protocols without patient feedback is associated with a significant risk of burns or unstable cavitation, both of which can result in significant tissue damage.
Research Evidence ABSENT	No reference found.

3-13 Impaired Cognition or Communication

For recommendation see *Impaired Sensation* (above)

3-14 Impaired Circulation

Recommendation C **US Cont** P **US Pulsed**	Avoid tissue heating through use of continuous ultrasound or high-temporal-peak-intensity pulsed ultrasound. Ultrasound should be discontinued if pain increases during or following treatment. Continuous and pulsed ultrasound should not be used when arterial circulation is *severely* compromised.
Rationale	Adequate circulation is required to dissipate heat produced by both continuous and pulsed ultrasound. Incapacity of the arterial system to dissipate heat produced by ultrasound may lead to further ischemia, pain, and possibly blister formation. There is evidence that pulsed ultrasound is safe when circulation is somewhat compromised.
Research Evidence LOW	Low-intensity pulsed ultrasound has been used without adverse effect on venous ulcers.[56–58]

3-15 Skin Disease, Damaged or "At Risk" Skin, Chronic Wounds

Recommendation C **US Cont** P **US Pulsed**	Continuous- and pulsed-mode ultrasound should not be applied using a gel-coupling in-contact method to areas of skin loss or skin at risk of breakdown. Continuous ultrasound producing heat should not be applied over dermatological conditions (eczema, psoriasis, or other heat sensitive skin disorders). Pulsed ultrasound can be used to treat open wounds.
Rationale	Transducer contact may further irritate or traumatize at-risk skin. Ultrasound delivered using a water bath is a safe alternative method of application to avoid physical trauma to skin.
Research Evidence ABSENT	Ultrasound has been applied using a water-immersion method to chronic venous leg ulcers without adverse reactions.[57–59]

3-16 Reproductive Organs

Recommendation C	Continuous and pulsed ultrasound should not be applied directly over the reproductive organs.
Rationale	Ultrasound may contribute to infertility by affecting gamete production, especially heat-sensitive spermatogenesis in the testes.
Research Evidence ABSENT	No reference found.

3-17 Eyes

Recommendation C	Continuous and pulsed ultrasound should not be applied directly to eyes.
Rationale	Unstable cavitation could occur in ocular fluid as a result of standing wave formation, leading to retinal damage.
Research Evidence ABSENT	No reference found.

3-18 Anterior Neck, Carotid Sinus

Recommendation C	Continuous- and pulsed-mode ultrasound should not be applied to anterior neck region over carotid sinus.
Rationale	The effects of ultrasound on these excitable tissues are unknown.
Research Evidence ABSENT	No reference found.

3-19 Spinal Cord

Recommendation P	Continuous- and pulsed-mode ultrasound should be used with caution following recent laminectomy above L2 level and in individuals with spina bifida, and should be avoided directly over the area where the spinal cord might be exposed to ultrasound waves.
Rationale	Unstable cavitation may occur in cerebrospinal fluid. Normally, however, the central nervous system elements (brain and spinal cord) are protected by bone and are therefore unlikely to be affected by ultrasound waves.
Research Evidence LOW	Ultrasound may alter nerve conduction (see below).[60–65]

3-20 Peripheral and Regenerating Nerves

Recommendation P	Monitor patients for discomfort when applying ultrasound directly over large superficial peripheral or regenerating nerves. Ultrasound can produce the sensation of ''pins and needles'' at or distal to the treatment site (sometimes reported by patients when ultrasound is applied over the carpal tunnel area).
Rationale	There appears to be no clear rationale for avoiding ultrasound over large peripheral nerves. Some discomfort may be experienced by patients when superficial nerves are heated. This sensation is likely to be associated with continuous-mode ultrasound and to be due to heating of the nerve.
Research Evidence LOW	There is some evidence that continuous and pulsed ultrasound can alter nerve-conduction velocity in large superficial nerves; however, there are also contradictory findings.[60–65] In pre-clinical studies, pulsed ultrasound accelerated recovery after nerve injury, which suggests a potential clinical role for ultrasound after nerve injury. Adverse clinical outcomes have not been reported.[66–68]

3-21 Chest, Heart

Recommendation S	Pulsed or continuous ultrasound applied to the chest wall is safe provided that the transducer head is not stationary and the rib cage is intact. Ultrasound used below the ribcage should not be directed toward the heart and/or lungs.
Rationale	Ultrasound could potentially alter cardiac conduction and cause arrhythmias.
Research Evidence LOW	Ultrasound at 0.1 W/cm^2 spatial peak temporal average (SPTA) applied to the exposed thoracic cavity in small animals caused bleeding of the lungs and gut.[1,42] The clinical relevance of this research in small animals is questionable.

SAFE PRACTICE

Perform a Sensory Discrimination Test

Test sensory integrity by asking patients to differentiate between hot and cold stimuli *or* between light touch and painful stimulus. Temperature discrimination and pain (a sharp pricking quality) are conveyed by spinothalamic tracts, whereas light touch is conveyed mainly by dorsal columns; thus, it is not sufficient to test light touch only. This sensory test should always be performed when using continuous-mode ultrasound (refer to *Impaired Sensation* and *Impaired Communication*).

Inspect Skin Area

Avoid ultrasound on skin areas affected by psoriasis, eczema, and similar skin disorders. Ultrasound to open skin requires judicious use of universal precautions to ensure that infectious agents are not transferred between patients by the therapist or through contaminated ultrasound couplants.

Avoid Transfer of Infectious Agents

Ultrasound gel dispensers can become contaminated when exposed to an infected individual, and the bacterial agent can spread to subsequent patients

through exposure to the contaminated gel or equipment. Single-use gel containers can be used when treating open skin areas or infected individuals. Nonsterile gel applications to intact skin should include procedures that prevent contamination of stock solutions of gel (bottles) that are used for multiple patients. Preheating bottled ultrasound gel may increase patient comfort, but it provides no therapeutic benefit and may promote microbial growth.[39,69,70] Ultrasound transducers are a source of contamination and should therefore be cleaned before and after each use with an alcohol wipe or alternative sanitizer.[69]

Avoid Pre-treatment of the Area with Superficial Heating or Cooling Agents

Altering tissue temperature prior to ultrasound application modifies the amount of tissue heating produced by the ultrasound. The cumulative effect of a hot pack followed by thermal ultrasound can lead to skin damage.[71–73]

Avoid Unsupervised Self-Treatment by Clients or Treatment by Unqualified Persons

Inappropriate use of ultrasound may lead to severe pain, tissue damage, or bleeding in the treated area. Inappropriate technique may severely compromise delivery of ultrasound to the target tissues and therefore limit clinical effectiveness.[74]

Use Appropriate Ultrasound Couplants

Some couplants do not transmit, or reduce transmission of, ultrasound. For example, gel- or water-filled latex gloves interfere with transmission, as do certain creams, oils, and lotions.[75–77] In addition, inappropriate products may damage the ultrasound transducer. For example, gels used for electrode stimulation (electrode gels) may damage the transducer because of their high salt concentration.

Limit Thermal Ultrasound Treatment to Surface Areas $\leq$ 10 cm^2

Treating areas more than two times the effective radiating area (ERA) of the ultrasound transducer (about 10 cm^2) significantly reduces the thermal effectiveness of ultrasound because of continuing heat loss to adjacent cooler tissue.[78–80] Pulsed ultrasound can be applied to areas two to three times the ERA, but treatment time should be increased.

Apply Ultrasound Using Effective Treatment Duration ($\geq$10 minutes)

Clinical trials of pulsed ultrasound have usually not shown benefit when treatment duration was less than 10 minutes. Pulsed ultrasound is delivered intermittently; using an on:off cycle of 1:4 or 1:1 (mark:space ratio) results in an 80% or 50% reduction, respectively, in total energy delivered relative to the same intensity delivered for the same duration in continuous mode. Therefore, it is recommended that pulsed ultrasound treatments be applied for a minimum of 10 minutes.[70,81,82]

Adjust Parameters When Applying Ultrasound in Water

Water temperature should be as close as possible to normal skin temperature. Ultrasound intensity should be increased when ultrasound is applied in water to achieve tissue temperatures similar to those produced when ultrasound is applied using a gel couplant.[76] In addition, ultrasound intensity should be increased whenever treatment is applied under water with the transducer at a distance $>$1 cm from the treated surface.[83] There is some controversy about the type of basin that should be used for ultrasound in water. Historically, a metal basin was considered to be contraindicated; however, a recent study showed that use of a metal basin produces more efficient heating, since metal reflects about 99% of incident ultrasound energy back into the water, where it can be absorbed by the tissues. By contrast, plastic absorbs ultrasound, decreasing the energy available for tissue absorption. Use of a metal basin requires careful monitoring of patient response in order to achieve a sensation of mild skin warmth while avoiding periosteal pain, which would indicate too much heating.[31]

Ensure Regular Maintenance and Calibration of Machines (every 6 months recommended)

Ultrasound units should be checked regularly for malfunction. In addition, systems require calibration to ensure that the delivered intensity coincides with the displayed intensity. Previous studies have found that between 10% and 90% of clinical ultrasound units assessed were not functioning at acceptable levels.[84–86]

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4. Electrical Stimulation

SUMMARY OF RECOMMENDATIONS

 Do NOT use the EPA to treat in the presence of this condition or in this body location.	**Electrical stimulation (all forms) should not be applied** • to areas where it could cause malfunction of electronic devices, including cardiac pacemakers • to the low back or abdomen of pregnant women • to acupuncture points of pregnant women • to regions of known or suspected malignancy • to persons with active deep vein thrombosis or thrombophlebitis • to actively bleeding tissue or to persons with untreated hemorrhagic disorders • to infected tissues, tuberculosis, or wounds with underlying osteomyelitis • to recently radiated tissues • to the chest in persons with cardiac disease, arrhythmias, or heart failure • to the neck or head region of persons known to have seizures • transcranially without specialized training • to areas near reproductive organs or genitalia without specialized training • to areas near or over eyes • to anterior neck or carotid sinus • to damaged or at-risk skin areas that would result in uneven conduction of current (excluding open wounds where the specific intent is to use electrical stimulation for tissue healing) **TENS should not be applied to** • areas that have impaired sensory awareness • persons with cognition or communication impairments sufficient to prevent them from giving accurate and timely feedback **NMES should not be applied to** • pregnant women (anywhere) • areas with impaired circulation • any area unstable due to recent surgery, bone fracture, or osteoporosis • the chest or the intercostal muscles • the lower abdomen
 Experienced clinicians may elect to treat this condition/location with caution (e.g., at lower intensities and/or with more frequent monitoring).	**Electrical stimulation (all forms) can be applied with caution to** • active epiphysis • persons with skin diseases (e.g., eczema, psoriasis) **HVPC can be applied with caution to** • persons with cognition or communication impairments sufficient to prevent them from giving accurate and timely feedback • areas of impaired sensation that prevent people from giving accurate and timely feedback • areas with impaired circulation, provided that pain is not exacerbated • superficial regenerating nerves • the chest wall or lower abdomen **NMES can be applied with caution to** • persons with cognition or communication impairments sufficient to prevent them from giving accurate and timely feedback • areas of impaired sensation that prevent accurate and timely feedback **TENS can be applied with caution to** • areas with impaired circulation, provided that pain is not exacerbated • the anterior chest wall or lower abdomen

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S This condition/scenario or body location is NOT contraindicated.	**Electrical stimulation (all forms) can be used on** • intact skin overlying implants containing metal, plastic, or cement • tissues inflamed as a result of recent injury or exacerbation of a chronic inflammatory condition **TENS and HVPC can be used on** • any area unstable due to recent surgery, bone fracture, or osteoporosis • areas around or within chronic wounds of known etiology or open wounds with localized infection

EPA = electrophysical agent; HVPC = electrical stimulation used to stimulate healing of chronic wounds (applied in the area of affected tissues at a sub-sensory or sensory level of stimulation); NMES = electrical stimulation applied using stimulus parameters sufficient to produce a tetanic muscle contraction; TENS = electrical stimulation applied at sensory levels (produces pins-and-needles sensation) to produce analgesia/hypoalgesia (includes interferential current (IFC)).

Table 3 Consensus and Recommendations on Electrical Stimulation (TENS, NMES, HVPC)*

	Resources % ($n = 11$)	Can/US %	APA	CSP	Adverse Reaction**	Research Evidence**	Recommendation	For Details See
Conditions								
Pregnancy	82	86 ($n = 7$)	C-local	C-local	Serious	Moderate	C	4-2
Malignancy	45	100 ($n = 7$)	P	C-local	Serious	Low	C	4-3
Deep vein thrombosis	27	100 ($n = 7$)	N/A	P	Serious	Moderate	C	4-4
Haemorrhagic conditions	18	100 ($n = 7$)	P	C	Serious	Moderate	C	4-5
Infection Tuberculosis Osteomyelitis	9	86 ($n = 7$)	P	N/A	Moderate	Low	C	4-6
Recently radiated tissue	9	86 ($n = 7$)	P	P	Serious	Moderate	C	4-7
Skin disease Damaged or at-risk skin	27	71 ($n = 6$)	P	P	Minor	Strong	C	4-8
Impaired circulation	9	43 ($n = 7$)	P	P	Minor	Low	C NMES P TENS/HVPC	4-9
Impaired sensation	18	57 ($n = 7$)	P	P	Minor	Moderate	C TENS P NMES/HVPC	4-10

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	Resources % ($n = 11$)	Can/US %	APA	CSP	Adverse Reaction**	Research Evidence**	Recommendation	For Details See
Impaired cognition or communication	9	57 ($n = 7$)	P	C	Minor	Moderate	C TENS P NMES/HVPC	4-11
Recent fracture or suture Osteoporosis	18	N/A	N/A	N/A	Moderate	Moderate	C NMES S HVPC/TENS	4-13
Seizure/epilepsy	9	N/A	N/A	C	Moderate	Moderate	C	4-14
Implants								
Electronic implant	100	86 ($n = 7$)	C-local	C	Serious	Moderate	C	4-1
Metal implant	S	29 ($n = 7$)	N/A	S	Minor	Low	S	4-12
Local Areas								
Anterior neck Carotid sinus region	91	N/A	N/A	C	Serious	Low	C	4-15
Chest Intercostal muscles Heart	18	N/A	C	P	Minor	Moderate	C NMES P TENS/HVPC	4-16
Head, transcranially	S	N/A	S	C	Serious	Moderate	C	4-17
Reproductive organs	S	29 ($n = 7$)	S	C	Moderate	Absent	C	4-18
Eyes	S	86 ($n = 7$)	S	C	Serious	Absent	C	4-19
Lower abdomen	S	N/A	N/A	N/A	Moderate	Moderate	C NMES P TENS/HVPC	4-20

APA = Australian Physiotherapy Association guidelines; Can/US = results of survey of North American experts; CSP = Chartered Society of Physiotherapy guidelines; C = contraindication; C-local = contraindication over the site; N/A = not addressed; P = precaution; S = safe; HVPC = electrical stimulation used to stimulate healing of chronic wounds (applied to the area of affected tissues at a sub-sensory or sensory level of stimulation); NMES = electrical stimulation applied using stimulus parameters sufficient to produce a tetanic muscle contraction; TENS = electrical stimulation applied at sensory levels (produces pins-and-needles sensation) to produce analgesia/hypoalgesia (includes interferential current (IFC)).

* This table shows the percent (raw) agreement of commonly cited contraindications for electrical stimulation (TENS, NMES, HVPC, IFC) by North American experts (Can/US; $n \leq 8$) and authors of textbooks (Resources; $n = 11$). An interpretation of the Australian (APA) and Chartered Society of Physiotherapy (CSP) guideline is shown. A recommendation is given for each condition based on an interpretation of the risk of adverse reactions and the strength of the supporting evidence.

** Readers should consult the Introduction for criteria used to rank adverse reactions, research evidence, and recommendations.

ELECTRICAL STIMULATION (E-STIM): RECOMMENDATIONS, RATIONALE, AND REFERENCES

4-1 Electronic Devices

Recommendation C	E-stim should not be applied in a location where it may cause malfunction of implanted electronic devices (e.g., pacemakers, cardioverter defibrillator, neurostimulators implanted in spinal cord or brain, bone-growth stimulators). Malfunction of these devices could be life threatening or require surgical replacement of the device. An ECG should be obtained during E-stim to determine whether there is interference with the cardiac pacemaker function and whether E-stim affects the patient's heart rate or other vital signs. Whenever an ECG is recorded during E-stim treatment, the relevant physicians should be advised so that stimulus artefacts produced by TENS do not result in misinterpretation of the ECG findings, leading to the patient undergoing unnecessary assessments or treatments.
Rationale	E-stim applied over the chest wall or near leads connected to electronic devices could cause fibrillation; changes in heart rate, cardiac output, and blood pressure; and perfusion of vital organs, including the brain. Demand-type pacemakers, the type most commonly implanted, pace heart rate based on feedback from the patient's own heart and are therefore more susceptible to external stimuli produced by E-stim. Less commonly used fixed-rate cardiac pacemakers pace heart rate continuously and are less likely to be influenced by external E-stim such as TENS. Some cardiac pacemakers can be filtered to block interference by external electronic devices such as TENS.
Research Evidence **MODERATE**	There are documented cases in which E-stim application caused atrial fibrillation and alterations in heart function.[1–11] Some authors recommend that E-stim not be applied directly over implanted devices (C-local), whereas others suggest that E-stim is contraindicated in any body location for people with implanted electronic devices. The literature is not clear on whether these advisories pertain to TENS treatments only or to all types of electrical currents. E-stim has produced ECG artefacts in persons with cardiac pacemakers, and in one case this resulted in unnecessary treatment.[12–15] However, when 20 different TENS models, representing five different manufacturers, were evaluated on 51 patients using demand-type pacemakers, with four or more body sites tested on each patient, the TENS produced no episodes of pacemaker interference, inhibition, or reprogramming.[16]

4-2 Pregnancy

Recommendation C	Avoid any type of E-stim over the low back, pelvis, or abdomen during pregnancy. Sensory-level TENS is safe during labour to help alleviate mild to moderate pain. Avoid use of E-stim on acupuncture points (A-TENS) or NMES activation of large muscle groups during pregnancy.
Rationale	E-stim applied directly over the lower abdomen may lead to unwanted uterine contractions and, potentially, to miscarriage or premature labour when applied during the first and third trimesters respectively. A majority of resources state that TENS can safely be applied to body sites remote from the uterus. Some suggest that E-stim is safe even when applied to surface areas overlying the uterus, since the current does not penetrate to the depth of uterine muscle. The direct effects of electrical current on fetal development are not clear. However, because any fetal effects could potentially be devastating, extra caution is required.
Research Evidence **MODERATE**	A-TENS significantly increased frequency and intensity of uterine contractions during labour.[17] Endogenous opiates, which can be released with electrically induced muscle contractions, are potent stimulators of myometrial contractions.[18–20] E-stim increased uterine contractility and uterine pressures in non-pregnant women.[17] TENS has been used successfully to treat LBP during pregnancy, and no adverse effects on the newborn were reported.[18–20] A document published by the Chartered Society of Physiotherapy in the UK (2007) states that it is permissible to apply TENS to the low back during pregnancy in certain circumstances.[21]

4-3 Malignancy

Recommendation C	E-stim should be avoided over a confirmed or suspected malignancy. Abnormal growth should be regarded as malignant until it has been diagnosed. Caution is advisable in the presence of undiagnosed pain in patients with a history of cancer within the last 5 years. TENS may be used for pain management for patients in palliative care. NMES may improve quality of life in end-stage malignant and non-malignant diseases.
Rationale	E-stim may stimulate growth and promote spread of cancer cells. Bone is a common metastatic site for many types of cancer; the analgesic effects of TENS may mask pain and early signs of metastatic disease.
Research Evidence LOW	E-stim can stimulate DNA synthesis and cell replication and, therefore, potentially increase tumour cell growth. Angiogenic effects of E-stim may promote the spread of tumours. However, application of direct current to animal models has also been shown to reduce tumour growth. This inhibition has been attributed to interference with mitotic spindle formation during cell division.[22] Thus, E-stim does influence cancer cell growth; however, whether this influence will promote or inhibit tumour growth is not clear. In advanced disease, improvements in quality of life afforded by E-stim may outweigh any possible risks associated with treatment. TENS has been used to help ameliorate pain, and NMES has relieved breathlessness and improved strength for the use of walking aids in persons with advanced malignancy.[22–26]

4-4 Active Deep Vein Thrombosis (DVT), Thrombophlebitis

Recommendation C	All forms of E-stim are contraindicated, both locally and at remote sites, in cases of active or suspected DVT and thrombophlebitis. E-stim can be applied with caution to persons with a past history of DVT treated with anticoagulant therapy.
Rationale	Muscle contraction induced by NMES applied near a DVT could dislodge a thrombus that could then embolize a vital organ, causing infarction, shortness of breath, stroke, or major organ failure. Reflex vasodilatation and increased blood flow to contralateral limbs and/or peripheral sites induced by E-stim could also embolize a blood clot. The CSP guidelines and many of the resources suggest that E-stim is safe provided that treatment of the DVT affected limb is avoided (C-local). Although the risk of E-stim's dislodging a thrombus is low, the consequences of a thrombus's travelling to a vital organ could be catastrophic.
Research Evidence MODERATE	E-stim applied to remote acupuncture points has been shown to significantly increase blood flow to the feet.[27] Research has demonstrated that electrically induced muscle contractions increased blood flow, while sensory-level IFC had no effects on blood flow.[28–32] Research has suggested that NMES may be beneficial for preventing DVT when applied prophylactically prior to clot formation.[33]

4-5 Haemorrhagic Conditions

Recommendation C	E-stim should not be applied to areas of uncontrolled bleeding or after recent injuries or surgeries that resulted in blood loss. E-stim can be used on persons with bleeding disorders (haemophilia) after replacement factor has been administered and coagulopathy has resolved.
Rationale	E-stim applied in haemorrhagic conditions may cause uncontrolled bleeding.
Research Evidence MODERATE	E-stim stimulates regional blood flow, causes release of inflammatory mediators and vasoactive substances, and reduces platelet aggregation.[34] These effects could exacerbate bleeding when haemostasis has not been established.[27] TENS and NMES have been used to decrease pain and improve muscle strength, respectively, without increased bleeding in people with haemophilia.[35,36]

4-6 Infection, Osteomyelitis, Tuberculosis

Recommendation C	Do not apply E-stim in the presence of localized abscess formations, tuberculosis, or chronic wounds with possible underlying osteomyelitis. E-stim may be applied in conjunction with antimicrobial therapy to superficially infected open wounds; however, in treating infected lesions, care must be taken to reduce the risk of cross-contamination through equipment or therapist contact (see ''Safe Practices'' below).
Rationale	E-stim may result in the spread of compartmentalized infections (abscess, TB). E-stim should not be used to promote skin closure in wounds with underlying osteomyelitis, because an exit site is required for drainage. CSP guidelines state that E-stim treatment should not be applied in cases of TB.
Research Evidence LOW	*In vitro* studies show that E-stim may inhibit bacterial growth.[37–39] HVPC increases local blood flow, which may improve defence against infection in persons with impaired circulation. Electrically induced improvements in regional blood flow have been documented in people with diabetes, spinal-cord injury, and chronic wounds.[27,40–44] Therefore, it is possible that E-stim may be beneficial when applied to infected open wounds. Laboratory study has demonstrated that bacteria are readily transferred from contaminated skin to areas of sterile skin through inadequately cleaned IFC sponges.[45]

4-7 Recently Radiated Tissue

Recommendation C	Do not apply E-stim to tissues that have received radiation therapy within the previous 6 months.
Rationale	E-stim could possibly stimulate growth of remaining malignant cells. Recently radiated tissue may respond atypically because of the presence of radiation-induced inflammation or scar tissue and/or because of the cellular or circulatory effects of radiation therapy.
Research Evidence MODERATE	E-stim can stimulate DNA synthesis and cell replication and, therefore, could potentially increase tumour-cell growth. However, application of direct current in animals has also resulted in reduced tumour growth. This inhibiting effect has been attributed to interference with mitotic spindle formation during cell division.[22] E-stim-induced increases in angiogenesis and local blood flow would promote the spread of tumours.[27,40–44]

4-8 Skin Disease, Damaged or At-Risk Skin

Recommendation C	E-stim should be applied only over healthy skin; therefore, the intended electrode application area should be examined for lesions, signs of irritation, and/or allergic reactions. Monitor patients with skin diseases for exacerbation of symptoms following E-stim application.
Rationale	Intact skin offers greater resistance to current flow than does broken skin. Uneven current flow under electrodes as a result of skin damage increases the risk of tissue burns. E-stim could stimulate inflammatory processes associated with dermatitis (eczema, contact dermatitis). Using self-adhesive electrodes on compromised skin or grossly edematous tissue could result in skin loss.
Research Evidence STRONG	Skin disorders are the most common adverse effect of E-stim.[46–50] See ''Safe Practices'' below for guidance on reducing the risk of E-stim-induced skin allergy or burn.

4-9 Impaired Circulation

Recommendation C **NMES** P **HVPC/TENS**	E-stim may be beneficial in the presence of moderate arterial disease. In the presence of severe arterial disease, however, electrical current can induce ischemia, exacerbate pain, and potentially damage fragile tissue. HVPC/TENS can be applied by experienced clinicians to improve wound healing and reduce claudication in people with arterial disease.
Rationale	Increasing cellular activity increases metabolic demand; in cases of severely compromised circulation, the demand may exceed oxygen supply, resulting in increased pain. Continued treatment may lead to tissue ischemia and necrosis. Deficiency in either arterial or venous circulation is associated with skin deterioration and edema. Applying E-stim electrodes over compromised skin may cause skin breakdown, which is difficult to heal and can potentially lead to chronic wounds. Intact skin offers greater resistance to current flow than does broken skin; uneven current flow under electrodes as a result of skin loss or damage increases the risk of tissue burns.
Research Evidence LOW	Electrically induced improvements in regional blood flow and tissue oxygenation have been documented in people with diabetes, spinal-cord injury, and chronic wounds.[27,40–44] NMES applied to calf muscles improved functional capacity of people with claudication due to advanced arterial disease. HVPC and A-TENS have been used safely to treat patients with arterial insufficiency.[41–44]

4-10 Impaired Sensation

Recommendation C **TENS** P **NMES, HVPC**	TENS and IFC should not be applied when impaired sensation (touch or pain) interferes with the patient's ability to appreciate the prescribed and/or maximum safe level of current intensity. Experienced therapists may apply E-stim (HVPC or NMES) to anaesthetic areas to improve healing and/or increase muscle strength in persons with neurological injuries (e.g., spinal-cord injury, stroke). In these instances, stimulus parameters should be tested on an area of the body with intact sensation if possible; stimulus parameters should be carefully selected and patients closely monitored for early signs of adverse reactions. Types of electrical currents that are associated with greater risk of skin burns (direct current) should not be applied to anaesthetic areas.
Rationale	Impaired sensation interferes with E-stim that requires patient feedback to set treatment intensity (TENS, IFC, NMES) and thus increases the risk of an E-stim-induced adverse event.[51] Analgesic effects of TENS and IFC require intact afferent nerves.
Research Evidence MODERATE	Peripheral nerve block is known to abolish the analgesic effects of TENS. Ice applied concomitantly with IFC abolishes perception of IFC within 2–8 minutes of ice application.[52] Conversely, HVPC and NMES have been used successfully in individuals with neurological conditions that interfere with sensory awareness (e.g., spinal-cord injury).[53–55]

4-11 Impaired Cognition or Communication

Recommendation C **TENS** P **HVPC, NMES**	TENS and IFC should not be applied when altered consciousness or other cognitive impairment could interfere with the patient's ability to appreciate the prescribed and/or maximum safe intensity of current. Provided that informed consent is obtained, experienced therapists may elect to apply HVPC or NMES to patients who are unable to provide reliable feedback, using carefully selected stimulus parameters and closely monitoring the person for early signs of adverse reactions.
Rationale	When feedback is required to set stimulus parameters, misunderstood instructions may result in ineffective treatment and increased risk of a skin burn. Application of E-stim for wound healing (HVPC) or muscle re-education (NMES) often involves using preset protocols that do not require patient feedback.
Research Evidence MODERATE	E-stim is commonly used to treat wounds (HVPC) and to stimulate muscle contraction (NMES) in patients who are unable to perceive the stimulation (e.g., in cases of spinal-cord injury).[51,52,54,55]

4-12 Metal Implants

Recommendation S	Tissues overlying metal implants can be treated with all forms of E-stim. However, E-stim should not be applied over skin staples or to tissues treated with dressings or topical agents containing metal ions (silver, zinc).
Rationale	Some experts suggest that applying E-stim to skin overlying superficial implanted metal creates a risk of burn. However, there is little consensus among experts on how near the skin the metal must be in order to influence current flow. Resources generally agree that the conduction of electrical current is not likely to be affected by most metal components, including surgical implants of the type used in joint-replacement surgery.
Research Evidence **LOW**	Persons with joint replacements that include metal components have been treated with E-stim with benefit and without adverse reactions.[56–58]

4-13 Recent Surgery, Unstable Fracture, Osteoporosis

Recommendation C **TENS** S **HVPC, TENS**	High-intensity NMES should not be used on recent postoperative ligament or tendon repairs, skin flaps, joint replacements, or fracture stabilization. Consult with the surgeon to determine the safety of NMES in the presence of injured or recently repaired tissue.
Rationale	Forceful muscle contraction produced by NMES could cause fracture displacement, tear recent tendon or skin sutures, disrupt staples, or disturb an incision site or graft.
Research Evidence **MODERATE**	In one study, electrically induced high-force muscle contractions produced an avulsion fracture.[59]

4-14 Seizure Disorders, Epilepsy

Recommendation C **head, trunk** P **neck, limbs**	Avoid neck and transcranial placement of electrodes in individuals with epilepsy; apply E-stim cautiously to the trunk and limbs in persons who are known to have seizures.
Rationale	E-stim may induce seizures. CSP guidelines state that electrodes placed on the neck are contraindicated in patients with epilepsy.
Research Evidence **MODERATE**	Epileptic seizures have occurred following TENS treatment in a person post stroke and in a boy known to have seizures.[60,61] In contrast, research using an animal model of epilepsy suggests that A-TENS applied to a *limb* may help reduce epileptic activity.[62]

4-15 Anterior Neck, Carotid Sinus

Recommendation C	Direct application of any type of E-stim using surface electrodes over the anterior neck is not advisable.
Rationale	Stimulation in this area may reflexively stimulate the vagus or phrenic nerves, which may induce a rapid fall in blood pressure, causing the patient to faint. Stimulation may also cause laryngeal spasm. Resources generally recommend that this body region should be avoided.
Research Evidence **LOW**	The FDA advises that E-stim is contraindicated in this region. CSP guidelines state that electrodes placed on the neck are contraindicated in patients with epilepsy.

4-16 Chest, Heart, Cardiac Failure

Recommendation C **NMES** P **HVPC, TENS**	TENS should be applied cautiously over the anterior chest and heart (using low-intensity and sensory-level stimulation only). This location should be avoided in patients with cardiac disease, arrhythmias, or a cardiac pacemaker. It is not advisable to apply NMES to intercostal muscles of the anterior chest wall. However, lower-extremity E-stim appears to be safe in patients with cardiac failure.
Rationale	Stimulation using relatively high current amplitude over the anterior chest area may cause heart arrhythmias or fibrillation. NMES of intercostal muscles may interfere with breathing. CSP guidelines suggest that electrical current be applied to the anterior chest area with great caution.
Research Evidence **MODERATE**	Development of respiratory distress has been reported as a result of applying E-stim to intercostal muscles.[63] However, TENS applied to the chest wall has been shown to significantly reduce mild to moderate postoperative pain following thoracotomy.[64] NMES applied to lower-limb muscles has been shown to benefit persons with advanced chronic obstructive pulmonary disease.[65–70]

4-17 Head, Transcranial Application

Recommendation C	Only therapists who have attained an advanced skill level should apply E-stim transcranially. Careful monitoring of patients after treatment is recommended.
Rationale	The risks of treating this body region are not fully understood. Transcranial application should be avoided in persons with epilepsy.
Research Evidence **MODERATE**	Epileptic seizures have occurred following TENS treatments, especially when electrical current was applied using electrodes placed transcranially.[60,61] However, TENS has been used transcranially to reduce tension headaches, with 10% of patients experiencing minor adverse reactions.[71]

4-18 Reproductive Organs

Recommendation C	E-stim near reproductive organs or genitalia requires specialized training and otherwise should be avoided.
Rationale	The risks of E-stim for gametogenesis are not known.
Research Evidence **ABSENT**	E-stim has been used successfully for electroejaculation in patients with spinal-cord injury with no serious adverse effects.[72] NMES is also successfully used to treat urinary incontinence, using conventional electrodes or specialized rectal or vaginal probes to activate pelvic floor muscles.[73,74]

4-19 Eyes

Recommendation C	Avoid applying E-stim to areas near or over the eyes.
Rationale	The risks of treating this body area are not known. There is no known clinical indication that requires eye stimulation.
Research Evidence **ABSENT**	No reference found

4-20 Lower Abdomen and Internal Organs

Recommendation C **NMES** P **HVPC, TENS**	Avoid high-intensity stimulation (NMES) or treatment using large electrodes over lower abdominal muscles.
Rationale	E-stim reaching intestines may stimulate smooth muscle surrounding gastrointestinal (GI) tract and increase GI motility.
Research Evidence MODERATE	Ischemic colitis has been reported in association with inappropriate self-applied NMES to the lower abdomen.[75]

SAFE PRACTICE

Perform a Sensory Discrimination Test

Test sensory integrity by asking patients to differentiate between hot and cold stimuli *or* between light touch and painful stimuli. Temperature discrimination and pain (a sharp pricking quality) are conveyed by spinothalamic tracts, whereas light touch is conveyed mainly by dorsal columns; thus, it is not sufficient to test light touch only.

Check and Prepare Skin Before Starting

Ensure that skin is intact at the intended electrode site. Wipe the skin surface with an alcohol swab and allow it to dry prior to applying electrodes. Cleaning the skin using warm water is also acceptable. Reduced skin impedance means that lower amplitude is required for effective treatment, which in turn increases patient comfort.

Monitor Skin for Signs of Irritation

Skin irritation is the most frequent complication of electrical stimulation treatment; it may develop gradually, and commonly occurs when self-adhesive electrodes are used, as a result of an allergic reaction to the self-adhesive gel.[47,76–82]

Avoid Repeated Use of Self-Adhesive Electrodes

Electrical conductivity is significantly reduced with successive uses of self-adhesive electrodes. This can cause uneven distribution and inadvertent concentration of current over the electrode area. Self-adhesive electrodes also have a limited lifespan and should be discarded when the adhesive surface is dry. Self-adhesive electrodes should not be shared among patients.

Monitor, Regulate, and Document Medication and Caffeine Consumption When Using E-stim for Pain Management

Opioid drugs and caffeine may interfere with the analgesic effects of E-stim. Repeated opioid medication can lead to opioid tolerance. High caffeine intake (200 mg/day, or three cups of coffee) blocks adenosine receptors; adenosine is thought to be a neurotransmitter in the C-fibre pathway.[83–85]

Monitor Patients Receiving IFC

A variety of adverse effects have been associated with E-stim, including fainting, nausea, burns, rashes, increased swelling, and pain. These effects occur more frequently with application of IFC than with other types of E-stim, such as TENS. Ice reduces, then abolishes, the sensation of IFC. Therefore, applying IFC in combination with ice increases the likelihood of an adverse effect, and particularly the risk of an electrical burn. Do not use small electrodes combined with high-amplitude current when applying IFC. Using high-intensity (high-concentration) IFC may lead to skin and tissue burns.[51,52,75,86–88]

Maintain a Regular Protocol for Disinfection of Sponges

Sponges and electrodes used for E-stim are commonly contaminated with microorganisms.[45] Soaking electrodes and/or sponges in a solution of dimethylbenzyl ammonium chloride diluted with water for 20 minutes, followed by 5 minutes of tap-water rinsing, removes about 95% of bacteria. Ensure a sufficient sponge supply to permit complete drying between uses.[89]

Use Suction Electrodes with Care

Carefully increase the amount of negative pressure used to hold electrodes in place in order to avoid

bruising the skin. Do not use suction electrodes over areas of pain or gross edema or on damaged skin. For patients on anticoagulant therapy, there may be added risk of causing bruising as a result of vigorous mechanical effects on skin capillaries.

Secure Electrodes with Even Pressure Distribution and Full Contact

Patients should be instructed prior to treatment about any need to maintain a particular position during the treatment. Electrodes coupled to the skin using electroconductive gel can be moved during NMES to search for the optimal location of a motor point. To ensure patients' comfort during this procedure, use sufficient gel, move the electrodes slowly, and keep the full surface of the carbon electrode in even contact with the skin.

Adjust Stimulus Parameters and Intensity with Care

At the end of treatment, slowly reduce stimulus intensity and then turn the machine off. E-stim machines that allow stimuli to be turned off without reducing intensity should be used with extreme caution. Check that the intensity dial registers zero current flow before turning the E-stim machine back on. Advise patients not to adjust the intensity or parameters of E-stim treatment without consulting a professional. Excessive duration or intensity of treatment can lead to injury.[75,88]

Maintain and Replace Carbon Electrodes

Carbon-impregnated rubber electrodes have a limited lifespan. Discard electrodes when the surface appears dull, because the impedance is likely too high for safety, effectiveness, and patient comfort (impedance should not exceed 300 ohms). When conductivity is low or uneven, there is a greater risk of skin burn. Protect the surface of conductive electrodes by avoiding abrasive materials, alcohol-based cleansers, and rough cleaning. Needles for intramuscular stimulation should be sterilized between uses according to the manufacturer's directions.

Maintain a Safe Distance between Electrical Stimulation Units and Short-Wave Equipment

High-frequency electromagnetic radiation, such as that produced by short-wave and microwave diathermy, can purportedly induce current flow in medium-frequency stimulators such as interferential devices, even when the power control in the medium-frequency device is set at zero. Electrical stimulators and diathermy units should operate at least 3 m from each other. Where space is limited, IFC and SWD devices should not be operated simultaneously.[90]

Observe the Special Requirements for E-stim Treatment of Wounds

Current should be delivered uniformly to the wound bed. Advanced training, appropriate techniques, and specialized equipment may be required. Aseptic technique (antibacterial hand wash, gloves, sterile supplies) should be employed to prevent cross-contamination between patients as well as between patients and therapists.

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5. Low-Level Laser Therapy (LLLT) / Non-coherent Light

SUMMARY OF RECOMMENDATIONS

 Do NOT use the EPA to treat in the presence of this condition or in this body location.	**LLLT/non-coherent light should not be applied to** • tissues infected with tuberculosis or other forms of virulent bacteria • the low back or abdomen of pregnant women • regions of known or suspected malignancy • actively bleeding tissue or persons with untreated haemorrhagic disorders • regions with active deep vein thrombosis or thrombophlebitis • eyes • reproductive organs (testes)
 Experienced clinicians may elect to treat this condition/location with caution (e.g., at lower intensities and/or with closer monitoring).	**LLLT/non-coherent light can be applied with caution to** • recently radiated tissues • persons with photosensitivity disorders (xeroderma pigmentosum) or systemic lupus erythematosus • persons with infections who have a compromised immune function • persons with cognition or communication impairments sufficient to prevent them from giving accurate and timely feedback • active epiphysis • anterior neck and carotid sinus
 This condition/scenario or body location is NOT contraindicated.	**LLLT/non-coherent light can be used on** • tissues infected with non-virulent bacteria • areas with impaired circulation • areas of impaired sensation that prevents patients from giving accurate and timely feedback • areas overlying regenerating nerves • persons with hypertension or cardiac failure • areas overlying electronic devices • intact skin overlying implants composed of metal, plastic, or cement • tissues inflamed as result of recent injury or exacerbation of chronic inflammatory condition • areas of damaged or "at risk" skin, areas affected by skin diseases, and chronic wounds • skin overlying active epiphysis

EPA = electrophysical agent; LLLT = low-level laser therapy including all Class II and III lasers and non-coherent light sources

Table 4 Consensus and Recommendations on Low-Level Laser Therapy / Non-coherent Light*

	Resources % ($n = 11$)	Can/US %	APA	CSP	Adverse Reaction**	Research Evidence**	Recommendation	For Details See
Conditions								
Pregnancy	91	86 ($n = 7$)	C-local	C-local	Serious	Low	C	5-2
Malignancy	82	100 ($n = 7$)	P	C-local	Serious	Moderate	C	5-3
Haemorrhagic conditions	46	33 ($n = 6$)	P	C	Serious	Low	C	5-4
Recently radiated tissue	18	86 ($n = 6$)	P	P	Moderate	Low	P	5-5
Infection Tuberculosis	9	71 ($n = 7$)	P	N/A	Serious	Moderate	C TB P Other	5-6
Impaired communication	9	P ($n = 7$)	P	C	Minor	Absent	P	5-7
Impaired sensation	9	S ($n = 7$)	S	P	Minor	Absent	S	N/A
Deep vein thrombosis Thrombophlebitis	9	43 ($n = 7$)	N/A	P	Serious	Absent	C	5-8
Impaired circulation	9	14 ($n = 7$)	S	S	Minor	Low	S	5-9
Acute injury Inflammation	S	14 ($n = 7$)	P	N/A	Minor	Moderate	S	5-10
Photosensitivity Systemic lupus erythematosus	27	N/A	N/A	C	Serious	Absent	P	5-11
Skin disease Damaged or at-risk skin Chronic wounds	S	S	N/A	NA	Minor	Absent	S	5-12
Active epiphysis	36	N/A	N/A	C-local	Moderate	Absent	S	N/A
Local Areas								
Eyes	100	100 ($n = 7$)	C	C	Serious	Strong	C	5-1
Reproductive organs (testes)	9	29 ($n = 6$)	S	C	Serious	Absent	C	5-13

APA = Australian Physiotherapy Association guidelines; Can/US = results of survey of North American experts; CSP = Chartered Society of Physiotherapy guidelines; C = contraindication; C-local = contraindication over the site; N/A = not addressed; P = precaution; S = safe; LLLT = low-level laser therapy, including Class II and III lasers and non-coherent light sources

* This table shows the percent (raw) agreement of commonly cited contraindications for low-level laser therapy / non-coherent light by North American experts (Can/US; $n \leq 8$) and authors of textbooks (Resources; $n = 11$). An interpretation of the Australian (APA) and Chartered Society of Physiotherapy (CSP) guideline is shown. A recommendation is given for each condition based on an interpretation of the risk of adverse reactions and the strength of the supporting evidence.

** Readers should consult the Introduction for criteria used to rank adverse reactions, research evidence, and recommendations.

LOW-LEVEL LASER THERAPY/NON-COHERENT LIGHT (LLLT): RECOMMENDATIONS, RATIONALE, AND REFERENCES

5-1 Eyes

Recommendation C	LLLT should not be applied to the orbital area.
Rationale	Approximately 1 second of *coherent* light passing through the pupil and striking the retina can cause permanent visual defects.
Research Evidence STRONG	In rhesus monkeys, the threshold for retinal damage (50% probability of detecting a lesion) was about 5.52 mJ of intra-ocular energy.[1–3]

5-2 Pregnancy

Recommendation C	LLLT should be avoided over the low back, abdomen, and pelvic region during the first 35 weeks of pregnancy.
Rationale	Recommendations are based on possible light-induced effects on fetal growth and/or fetal malformations. CSP guidelines also recommend using caution during pregnancy even when the target tissue is not in the pelvic region.
Research Evidence LOW	Adverse effects of LLLT on the fetus have not been shown. It is also not known whether LLLT applied to the pelvic region will reach the fetus. Most resources recommend that LLLT be avoided over the pregnant uterus because any fetal malformation could have long-term and devastating effects.[4] The types of lasers that are used for prenatal tissue coagulation/ablation should not be confused with low-intensity lasers used by physiotherapists.

5-3 Malignancy

Recommendation C	LLLT should not be used over confirmed or suspected malignancy. Abnormal growth should be regarded as malignant until diagnosis has been confirmed. Use caution when a patient with a history of cancer within the last 5 years has pain of undiagnosed origin.
Rationale	Applying LLLT directly to malignant cells may stimulate cancerous cell activity and growth; light-enhanced angiogenesis may play a role in sustaining tumour growth.
Research Evidence MODERATE	In cell-culture studies, LLLT has been shown to alter DNA synthesis and ATP production and to stimulate protein synthesis.[5] Dermal angiogenesis has been demonstrated after laser treatment.[6] These stimulating effects of light have not been studied in the context of tumour growth. There is no indication that LLLT could transform normal cells into malignant cells; on the contrary, the literature suggests that LLLT may promote repair of DNA.[4,7,8]

5-4 Haemorrhagic Conditions

Recommendation C	LLLT should not be applied to actively bleeding tissue. It can be used to promote resolution of haematoma once bleeding has ceased. LLLT can be used on persons with bleeding disorders (haemophilia) after replacement factor has been administered and coagulopathy has resolved.
Rationale	Although the risk of LLLT-induced exacerbation and/or prolongation of bleeding is probably minimal, the safe approach is not to irradiate, since the consequences of haemorrhage are potentially life threatening.
Research Evidence LOW	It is uncertain whether therapeutic light has adverse effects on coagulation.[9,10]

5-5 Recently Radiated Tissue

Recommendation 	LLLT may be used to treat tissues that have been treated with radiation therapy. Careful monitoring for signs of abnormal growth or tissue damage is recommended.
Rationale	Skin ulcers usually develop as an acute complication of ionizing irradiation, but they may persist for months or even years post radiation. LLLT has been used to promote healing of acute and chronic radiation ulcers; however, some authors suggest avoiding LLLT for 6 months following radiation therapy.
Research Evidence LOW	No evidence was found for adverse effects of using light to promote ulcer healing in radiation-damaged skin. In 5 patients 3 to 7 months post radiation therapy, radiogenic mastitis resolved,[11] and in one patient, a skin ulcer healed following laser therapy.[6,12] LLLT safely reduces duration and symptoms of chemotherapy-induced oral mucositis; however, this particular use of LLLT does not involve applying LLLT to previously radiated tissue.[13]

5-6 Infection, Tuberculosis

Recommendation  **TB**  **Other**	LLLT should not be used in persons with tuberculosis; other less virulent soft-tissue infections may be treated with caution. Bacterial growth should be analyzed at baseline and biweekly when treating infected open wounds. Patients who are immunocompromised should be closely monitored for spread of infection.
Rationale	LLLT is known to modulate the growth of some bacterial species; its effects on TB are not known. LLLT produces some effects via systemic mechanisms; thus, the safe approach is not to use LLLT at any location in persons with TB until it becomes clear whether LLLT can increase or spread TB infection. All patients should be monitored for signs of increased bacterial concentration or advancing infection when LLLT is used on infected tissues.
Research Evidence MODERATE	LLLT modulates in vitro growth of bacteria, depending on laser parameters as well as on the bacterial species.[14–19] Blue light has been shown to kill methicillin-resistant *Staphylococcus aureus* (MRSA); however, this wavelength is not commonly available in clinical practice at present.[19] Pre-clinical research shows that clearing wounds of all bacteria, including normal flora, does not necessarily produce improved wound healing. 808 nm light increased *S. aureus* growth in animal wounds.[20] Laser irradiation has been used with apparent effectiveness in cases of tissue gangrene and osteomyelitis.[21]

5-7 Impaired Cognition or Communication

Recommendation 	LLLT should be used cautiously if a patient is unable to understand treatment explanations or to follow instructions and warnings.
Rationale	LLLT is commonly used to treat conditions involving absent or reduced sensation in the treatment area. Although communication is not essential for the purpose of giving immediate sensory feedback, the patient must be able to comply with safety procedures.
Research Evidence ABSENT	LLLT has been used without reports of adverse effects in very elderly institutionalized persons and in individuals with diabetic neuropathy or sensory loss in the treatment area.[22–26]

5-8 Active Deep Vein Thrombosis, Thrombophlebitis

Recommendation 	LLLT should not be applied directly over an active or suspected DVT. The area overlying a previous DVT treated with anti-coagulant therapy can be treated with caution.
Rationale	The effects of LLLT on a thrombus are not known. LLLT has a modest effect on capillary blood flow, and thus the risk that LLLT will dislodge a thrombus is minimal. However, should a clot embolize, a vital organ could be compromised, with devastating results.
Research Evidence ABSENT	LLLT increased capillary blood flow in persons with diabetic microangiopathy and also in persons with Buerger's disease.[26,27] There appear to be no studies on LLLT's effects on the formation or dissolution of blood clots.

5-9 Impaired Circulation

Recommendation 	LLLT may be used to treat areas of impaired circulation (arterial disease or venous insufficiency).
Rationale	There is an extensive literature supporting the safe use of laser therapy in patients with circulatory impairment and no evidence that increasing cellular activity could increase existing ischemia.
Research Evidence LOW	Advantageous cellular effects of LLLT have been established, although there are some conflicting findings.[28] LLLT has been used safely to treat skin ulcers in individuals with diabetes and severe arterial insufficiency.[6,22,29] There is some evidence that episodic-type ischemia associated with connective tissue diseases or Raynaud's phenomenon improves after laser treatment of the hands.[30]

5-10 Acute Injury, Inflammation

Recommendation 	LLLT appears safe to use in the management of acute injury. Monitor the patient for exacerbation of symptoms after each treatment.
Rationale	It is prudent to monitor the response following each application, since the literature shows that results on acute injury are variable.
Research Evidence MODERATE	LLLT is known to attenuate the release of inflammatory mediators, including TNF-α, IL-1, and other cytokines, following acute soft-tissue injury.[31,32] Reducing such mediators may lead to less inflammation.[33,34] LLLT's effects on the development and resolution of inflammation may be wavelength and dose dependent.[35–37]

5-11 Photosensitivity, Systemic Lupus Erythematosus

Recommendation 	LLLT should be used cautiously in patients with diseases known to be light sensitive, including xeroderma pigmentosum, polymorphic light eruption (PLE), and systemic lupus erythematosus (SLE). It is advisable to use LLLT at low irradiance (power density) and low radiant exposure (energy density), to follow up with patients after the first application, and to allow a 2- to 3-day interval between applications.
Rationale	LLLT does not induce tissue heating or erythema and can therefore be used safely with persons who sunburn easily. For certain diseases of the skin, however, a cautious approach is advisable because of a potential atypical response to LLLT (SLE affects capillary blood flow, and microvasculitis is common).
Research Evidence MODERATE	Exposures to ultraviolet radiation (UV) and visible light sufficient to produce erythema are known to exacerbate skin lesions in individuals with SLE[38–40] and PLE.[41,42] Conversely, repeated low doses of UV (A1, A, and B wave bands) are used to reduce symptoms of SLE. No reports were found on the use of LLLT in persons with light-sensitivity conditions or SLE.

5-12 Skin Disease, Damaged or At-Risk Skin

Recommendation 	LLLT may be used over open wounds or damaged skin, provided that treatment parameters are appropriately adjusted.
Rationale	Light absorption will be altered based on a number of factors, including absence of skin, skin thickness, skin pigmentation, and skin perfusion (because red light is strongly absorbed by haemoglobin and melanin). Therefore, LLLT should be adjusted based on anticipated changes to light absorption. Monitoring patient response is important.
Research Evidence STRONG	LLLT has been used safely to treat many types of open wounds. Adverse effects have not been documented.[23,43] The effects of skin characteristics on light transmission have been established.[44]

5-13 Reproductive Organs (Testes)

Recommendation 	LLLT should not be applied to the testes.
Rationale	The effects of LLLT on reproductive organ function and spermatogenesis are not known.
Research Evidence ABSENT	No references found.

SAFE PRACTICE

Apply LLLT in a Safe Environment

Apply treatment in a separate cubicle to protect other persons in the area from unintended irradiation. Patients and therapists should use protective goggles specific to the wavelength of light in use. Notwithstanding the use of goggles, the laser applicator should be activated only when the probe tip or array surface is applied to the tissue surface. In some countries, users of LLLT are required to attend appropriate training in the safe use of lasers in health care. Many safety measures are recommended in the resources.[1–3] It has been said, however, that "laser safety has more to do with good operating procedure than with door interlocks and panic buttons. Almost without exception, the only item of protection required is eyewear."[3(p.1787)]

Restrict Use of Laser Devices to Qualified Personnel

Safety should be assured by providing only approved operators with a key to access Class II and III laser devices.

Clean and Disinfect Laser Applicators Regularly

Dust and skin debris accumulated at the laser tip may interfere with emission. Disinfect the applicator (using 70% alcohol) between patients. Plastic wrap can be applied to the applicator when treating open wounds (note that this produces a light-transmission loss of about 8%).[45] Other types of semi-transparent dressings can block up to 48% of incident light, and exposure duration should be increased to compensate for such loss.[45,46]

Plan Regular Equipment Maintenance and Calibration (every 6 months recommended)

Laser diodes are easily damaged, and their emission should be checked if the applicator is dropped. Laser output decreases over time. Output must be measured using a light meter of the appropriate wavelength. Treatment dosage should be calculated using actual output rather than the estimated output at the time of equipment purchase. Poor performance of laser diodes has been demonstrated: in one study, clinical devices emitted, on average, between 31% and 60% of manufacturers' rated output, and a few devices emitted no light at all.[47]

Monitor and Document Adverse Events Resulting from LLLT

Some individuals report feeling nauseated following light treatment; however, nausea appears to affect individuals receiving active LLLT and those receiving a placebo treatment at an equal rate. Increased pain, tingling, and numbness have also been reported following real and placebo LLLT.[48–52]

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6. Superficial Heat

SUMMARY OF RECOMMENDATIONS

 Do NOT use the EPA to treat in the presence of this condition or in this body location.	**Superficial heat should not be applied to** • large areas, or at sufficient intensity to raise core temperature, in pregnant women • regions of known or suspected malignancy • infected tissues or persons with tuberculosis • persons with active deep vein thrombosis or thrombophlebitis • areas of impaired sensation that prevent the patient from giving accurate and timely feedback • actively bleeding tissue or persons with untreated haemorrhagic disorders • recently radiated tissues • large areas, or at sufficient intensity to raise core temperature, in persons with severe cardiac disease or in cardiac failure • persons with cognition or communication impairments sufficient to prevent them from giving accurate and timely feedback • areas with impaired circulation • tissues inflamed as result of recent injury or exacerbation of chronic inflammatory condition • areas affected by heat-sensitive skin diseases (e.g., eczema) • areas of skin breakdown or damage producing uneven heat conduction across the skin • areas of severe edema • reproductive organs (testes)
 Experienced clinicians may elect to treat this condition/location with caution.	**Superficial heat can be applied with caution to** • areas near or over eyes • anterior neck and carotid sinus • pregnant women • people with cardiac failures
 This condition/scenario or body location is NOT contraindicated.	**Superficial heat can be used on** • intact skin overlying implants containing metal, plastic, or cement • areas over electronic devices • areas near chronic wounds • superficial or regenerating nerves • the head, chest, or heart • areas over active epiphysis • persons with hypertension

EPA = electrophysical agent; superficial heating agents include hot packs, wax, and other conductive agents that heat tissues within 3 cm of the skin surface.

Table 5 Consensus and Recommendations on Superficial Heating Agents*

	Resources % ($n = 9$)	Can/US % ($n = 8$)	APA	CSP**	Adverse Reaction***	Research Evidence***	Recommendation	For Details See
Conditions								
Impaired sensation	89	88	P	P	Minor	Strong	C	6-1
Impaired cognition or communication	67	50	P	C	Minor	Absent	C	6-2
Acute injury Inflammation	78	88	C	NA	Moderate	Moderate	C	6-3
Haemorrhagic conditions	78	100	C	C	Serious	Moderate	C	6-4
Impaired circulation	78	63	C	C	Minor	Strong	C	6-5
Malignancy	78	100	C	C-local	Serious	Moderate	C	6-6
Infection Tuberculosis	33	100	C	C	Serious	Moderate	C	6-7
Deep vein thrombosis Thrombophlebitis	33	100	C	C	Serious	Strong	C	6-8
Pregnancy	22	13	S	S	Serious	Moderate	C Systemic P Local	6-9
Skin disease Damaged or at-risk skin	33	100	C	C	Minor	Strong	C	6-10
Cardiac failure	22	NA	C	NA	Serious	Low	C Systemic P Local	6-11
Recently radiated tissue	22	75	C	P	Serious	Low	C	6-13
Severe edema	22	75	C	P	Minor	Low	C	N/A

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	Resources % ($n = 9$)	Can/US % ($n = 8$)	APA	CSP**	Adverse Reaction***	Research Evidence***	Recommendation	For Details See
Implants								
Metal implants	11	S	NA	P	Minor	Absent	S	6-12
Local Areas								
Reproductive organs	11	38	C	S	Serious	Low	C	6-14
Eyes	11	50	C	C	Moderate	Absent	P	6-15

APA = Australian Physiotherapy Association guidelines; Can/US = results of survey of North American experts; CSP = Chartered Society of Physiotherapy guidelines; C = contraindication; C-local = contraindication over the site; N/A = not addressed; P = precaution; S = safe; Systemic = the heating agent is applied in a manner that results in raising of core body temperature (sweating); Local = the superficial heating agent is applied to a relatively small, local area that is not likely to elevate core temperature (no sweating); Superficial Heating Agents include hot packs, wax, and other conductive agents that heat tissues within 3 cm of the skin surface.

* This table shows the percent (raw) agreement of commonly cited contraindications for superficial heating agents (e.g., hot packs, wax) by North American experts (Can/US; $n = 8$) and authors of textbooks (Resources; $n = 9$). An interpretation of the Australian (APA) and Chartered Society of Physiotherapy (CSP) guidelines is shown. A recommendation is given for each condition based on an interpretation of the risk of adverse reactions and the strength of the supporting evidence.

** The CSP guidelines address different types of heating agents. The following tables provide more specific information on use of hot packs and wax.

*** Readers should consult the Introduction for criteria used to rank adverse reactions, research evidence, and recommendations.

SUPERFICIAL HEAT: RECOMMENDATIONS, RATIONALE, AND REFERENCES

6-1 Impaired Sensation

Recommendation C	Avoid use of superficial heat when the patient cannot provide appropriate and timely feedback. Normal skin sensation means that the patient can reliably discriminate between mild and moderate warmth (refer to the section on safe practice).
Rationale	It is important for the clinician to understand the degree of heat experienced by the patient. In the absence of appropriate feedback, a patient can easily be burned before the clinician realizes that there is a problem.
Research Evidence STRONG	There are several reports of skin burns' occurring during the use of superficial heating agents.[1–4]

6-2 Impaired Cognition or Communication

See explanation for Impaired Sensation (above)

6-3 Acute Injury, Inflammation

Recommendation C	Avoid heating acutely inflamed tissue.
Rationale	Inflammation occurs soon after injury (within 3 days) and can persist or reappear with exacerbation of chronic conditions. Therefore, the area should be examined regardless of time post injury to look for signs of inflammation: redness, heat, swelling, pain, and loss of function. Heat exacerbates inflammatory processes, which may extend the area of injury and prolong the recovery period.
Research Evidence MODERATE	Metabolic and vascular changes are induced by local heat, which perpetuates many inflammatory processes (increased blood perfusion, release of local inflammatory mediators, formation of tissue edema).[5] There is a risk of secondary hypoxic injury when the supply of oxygen is inadequate to meet tissue demands.

6-4 Haemorrhagic Conditions

Recommendation C	Avoid local use of superficial heat until haemorrhage has ceased. Avoid using heat anywhere on the body that is sufficient to cause a systemic response (sweating and general vasodilatation) in an individual who is at risk of haemorrhage. In persons with bleeding disorders (haemophilia), superficial heat can be used after replacement factor has been administered and coagulopathy has resolved.
Rationale	Heat-induced increase in local blood flow may prolong bleeding.
Research Evidence MODERATE	Tissue heating is known to cause vasodilatation and increased local and limb blood flow.[6]

6-5 Impaired Circulation

Recommendation C	Avoid heating tissues with circulatory insufficiency. Do not apply heating agents at an intensity sufficient to change core body temperature in persons with peripheral vascular disease (PVD). Examine distal extremities for signs of peripheral arterial disease prior to applying heating agents. Reduce dosage of heat to hands and feet.
Rationale	Adequate blood circulation is needed to avoid excessive heat accumulation in areas treated with superficial heating agents. Increasing the core body temperature in persons with PVD may lead to thrombus formation and can potentially compromise vital organs and cause heart attack or stroke. Distal extremities are most affected by arterial disease; therefore, it is important to check hands and feet for signs of arterial disease (thin, shiny, pale skin; cold to touch; thickened, brittle nails). Hands and feet are particularly susceptible to applied heat because their skin surface area is large in relation to the volume of tissue, which results in very efficient heat transfer. The CSP guidelines advise avoiding the use of hot packs over areas of impaired circulation and using wax with caution.
Research Evidence STRONG	There is a risk of burns if local circulation is insufficient to dissipate applied heat.[3,7,8] Increasing core body temperature to 39°C leads to haemoconcentration, an increase in platelet count, and a reduction in anti-thrombotic processes. This core temperature could be achieved with full-body immersion in 40°C water for about 50–60 min. At this temperature, the risk of a thrombotic event may be elevated in individuals with PVD.[9]

6-6 Malignancy

Recommendation C	Avoid using superficial heating agents on persons with cancer. Abnormal growth should be regarded as malignant until diagnosis has been confirmed. Use caution when a patient with a history of cancer within the last 5 years has pain of undiagnosed origin.
Rationale	Some sources advise not using superficial heat anywhere on the body for an individual with confirmed or suspected malignancy; the CSP guidelines, however, advise avoidance only over the malignant tissue. Local heat can increase tumour growth and increase incidence of metastases by increasing blood flow and/or by increasing metabolic rate. Applying heat anywhere on the body is a potential risk, according to some experts, because heating large surface areas may produce a systemic response (i.e., sweating and general vasodilatation) and because heating one limb may produce a reflex increase in blood flow in the contralateral limb.
Research Evidence MODERATE	Increasing tissue temperature stimulates metabolic activity of all types of cells. Heat-induced vasodilatation increases tissue perfusion.[6,10,11] The effects of superficial heat on tumour growth and metastatic processes have not been examined directly.

6-7 Infection, Tuberculosis

Recommendation C	Avoid applying heat directly over infected tissue (e.g., abscess, septic arthritis, TB, infected open wounds) or to large areas of the trunk or limbs remote from the infected site. When an individual's body temperature is higher than the physiological norm, avoid applying heat to large surface areas, as this may produce a further rise in core temperature.
Rationale	Applying heat to an area of tissue that is hot, red, and swollen as a result of infection can exacerbate swelling and pain. However, when a localized infection such as an abscess has an opening for drainage, mild local heat may help to resolve the infection by increasing blood flow. The CSP guidelines specifically recommend avoiding wax treatment.
Research Evidence MODERATE	There are clinical reports of heat-induced changes in limb blood flow.[6] The effects of applying heating agents to infected tissues have not been documented.

6-8 Active Deep Vein Thrombosis, Thrombophlebitis

Recommendation C	Avoid use of superficial heat directly over the site of an active DVT and to large surface areas of the trunk or to the unaffected contralateral limb of individuals with an active DVT. Individuals with a previous DVT that was successfully treated with anti-coagulant therapy can be treated with caution.
Rationale	Application of heat to large surface areas sufficient to produce sweating can produce generalized vasodilatation and increased blood flow at remote sites, which may dislodge a thrombus. The consequences of a thrombus travelling to a vital organ can be catastrophic. The CSP guidelines recommend that use of a hot pack is contraindicated, whereas the use of wax requires precautions. Application of wax to the hand is unlikely to cause general vasodilatation; as a precaution, however, the patient should be monitored during treatment for generalized increased body temperature (general sweating response), particularly when both hands are treated simultaneously.
Research Evidence STRONG	There are clinical reports of heat-induced changes in limb blood flow.[6] Experimental studies using healthy human subjects have shown that heating one hand produces reflex changes in blood flow in the contralateral limb.[10,11]

6-9 Pregnancy

Recommendation C **Systemic** P **Local**	Avoid applying heat that could elevate core temperature in pregnant women. Application of hot packs to the trunk or other surface areas or full-body immersion in hot water (hydrotherapy tanks) should be avoided. Heat can be safely applied to small areas of the extremities (e.g., wax to the hand). The patient should be monitored, and treatment should be discontinued if there is any sign of body-temperature elevation (central erythema, generalized sweating, etc.).
Rationale	Applying superficial heat to the low back is *not* likely to heat fetal tissues directly. However, increasing maternal body temperature could have devastating consequences. Although teratogenic effects of heat on the fetus are worst during the first trimester, heating fetal tissues later in pregnancy can also alter fetal growth and development. CSP guidelines recommend avoiding superficial heat until week 35 of pregnancy. Applying wax to hands or feet is unlikely to raise either maternal core temperature or fetal temperature.
Research Evidence MODERATE	Elevation of maternal body temperature (hyperthermia) is known to cause fetal malformations.[12,13] Whether or not superficial heating agents can induce changes in maternal and fetal temperature has not been established.

6-10 Skin Diseases, Damaged or At-Risk Skin, Chronic Wounds

Recommendation C **Diseases** C **Damaged skin** S **Wounds**	Heat (hot packs and wax) should not be applied over heat-sensitive skin diseases (e.g., eczema, psoriasis, vasculitis, dermatitis). Conductive heating agents should not be applied to damaged skin that would alter heat transfer. Tissues surrounding chronic wounds may be treated with mild heat, provided there is adequate local circulation.
Rationale	Heat exacerbates certain inflammatory-type skin diseases (e.g., eczema, psoriasis). The conductive property of skin should be consistent across the surface area that is in contact with the heating agent; heat conduction is uneven over damaged skin, which can potentially result in tissue burns. Heating skin that is poorly perfused (e.g., vasculitis, arterial ulcers) increases the risk of tissue burn. The CSP guidelines recommend not applying wax to diseased skin and using hot packs with caution. Applying heat to early-stage skin grafts before circulation is well established may cause graft failure.
Research Evidence **MODERATE**	Heat is known to exacerbate certain skin conditions.[1] Tissue heating also increases many inflammatory processes.[5] Increasing tissue temperature increases cell activity and the demand for oxygen and other nutrients, which may exacerbate tissue hypoxia. It should be noted that controlled warming that raises wound temperature by 1–2°C, but not above physiological temperature (37°C), may be an effective treatment for venous ulcers.[14] Wax has been used safely to reduce skin contractures after burn injury and once tissues have healed.[15–17]

6-11 Cardiac Failure, Hypertension

Recommendation C **Systemic** P **Local**	Applying superficial heat over the trunk or large surface areas sufficient to cause a systemic response to heat (sweating) is not recommended. Full-body heating (hydrotherapy tanks) should be avoided.
Rationale	Generalized peripheral vasodilatation is produced by heating a large surface area of the body or in response to an increase in core body temperature. This elevation in skin blood flow requires more cardiac output in order to maintain blood pressure. People with impaired heart function may not tolerate the increased cardiac demand.
Research Evidence **LOW**	No reference found.

6-12 Metal Implants

Recommendation S	Avoid use of heat directly over very superficial metal implants (e.g., staples in skin) or over metal jewellery.
Rationale	Metals have high thermal conductivity; therefore, there is high potential for thermal injury of tissues surrounding heated metal implants. Metal implants underlying thick subcutaneous or muscular layers pose a negligible risk, since superficial thermal agents are unlikely to raise resting temperature at such depths. The CSP advisory applies only to hot packs.
Research Evidence **ABSENT**	No reference found.

6-13 Recently Radiated Tissues

Recommendation C	Avoid heating tissues that have received radiation therapy during the last 6 months.
Rationale	Heat could stimulate growth of any residual malignant cells. Radiation alters cell metabolism, including that of endothelial cells and fibroblasts. The presence of radiation-induced inflammation, scar tissue, or circulatory effects may adversely affect tissue response, especially the ability to dissipate heat.
Research Evidence LOW	Increasing tissue temperature stimulates metabolic activity in all types of cells. The effects of heat therapy on radiated tissues have not been examined.

6-14 Reproductive Organs

Recommendation C	Heat should not be applied directly to testes.
Rationale	Heat is known to affect spermatogenesis and reduce fertility.
Research Evidence LOW	No references have examined the effect of physiotherapeutic heating agents on male reproductive function.

6-15 Eyes

Recommendation P	Heat application in the vicinity of the eyes should be undertaken with caution.
Rationale	There is no literature to guide practice in this area. Facial skin is normally highly sensitive; therefore, it is likely that potentially damaging heat would cause discomfort, prompting a patient to ask for treatment to be terminated.
Research Evidence ABSENT	No reference found.

SAFE PRACTICE

Perform a Sensory Discrimination Test

Test sensory integrity by asking patients to differentiate between hot and cold stimuli *or* between light touch and painful stimuli. Temperature discrimination and pain (a sharp pricking quality) are conveyed by spinothalamic tracts, whereas light touch is conveyed mainly by dorsal columns; thus, it is not sufficient to test light touch only.

Check Skin Integrity

Inspect target area for presence of skin disease and open lesions. Remove jewellery and clothing. Wash skin before applying wax.

Monitor for Systemic Temperature Change

An increase in core temperature is indicated by generalized sweating. Significant changes in core temperature may affect treatment effectiveness and/or compromise patient safety, especially in the frail elderly.

Check Skin Response under Heating Agents

Check skin a few times during the application and as frequently as every 5 minutes if a patient is receiving a particular treatment for the first time.[18] It may be unsafe to apply superficial heat to obese individuals. The risk of a burn increases with the amount of subcutaneous fat, because fat is an insulator, retaining heat rather than transferring (conducting) it to adjacent tissue layers. Patients should not lie on

top of hot packs or pads, as pressure sufficient to compress skin capillaries (> 32 mmHg) compromises the normal protective reflex vasodilatation response, a mechanism that protects skin from thermal injury.

Monitor Vital Signs and Watch for Sudden Changes in Blood Pressure and Syncope

Persons with orthostatic hypotension, recent traumatic injury, or history of cardiovascular deficiency are particularly susceptible to heat treatments that cause a sudden change in surface temperature (intense heat) and to applications that involve large areas of the body surface (hydrotherapy tanks).

Use a Bell and Timer

Provide enough instruction for the patient to understand the expected thermal sensation and how an unwanted response might manifest or feel. A bell that is sufficiently loud to attract your attention should be left within the patient's reach, with specific instructions as to when the bell should be used. A timer will remind you to return and check on the patient regularly. Take the timer with you if you are not likely to hear it when you leave the patient.

Observe Precautions When Treating Open Wounds

Discharge from open wounds can contaminate heating agents designed for multi-patient use. Opportunistic bacteria such as *Pseudomonas aeruginosa* inhabit hot tubs and may pose a risk to some individuals.[19] Avoid immersing hands and feet with open skin lesions in paraffin wax baths; instead, wax can be ladled over affected limbs once skin lesions have been covered with protective barriers.

Avoid Pre-treatment of the Area with Superficial Liniments

Monitor use of liniments before applying superficial heat. Many topical agents produce vasodilatation, and in such instances adding heat could lead to a burn. Wash skin before treatment, especially prior to applying paraffin wax.

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7. Cryotherapy

SUMMARY OF RECOMMENDATIONS

 Do NOT use the EPA to treat in this condition or body location.	**Superficial cold should not be applied** • to persons with cold urticaria (also called cold allergy or cold hypersensitivity) • to persons with Raynaud's disease • to persons with cryoglobulinemia • to persons with hemoglobulinemia • to areas of impaired circulation • to areas near chronic wounds • over regenerating nerves • to tissues affected by tuberculosis • to haemorrhaging tissue or in persons with untreated haemorrhagic disorders • to areas with impaired circulation • to persons with active deep vein thrombosis or thromophlebitis • to anterior neck and carotid sinus **Home cold-therapy programmes should NOT be prescribed for** • persons with cognition or communication problems that interfere with their ability to follow directions.
 Experienced clinicians may elect to treat this condition/location with caution (e.g., at lower intensities and/or with more frequent monitoring).	**Superficial cold can be applied with caution to** • areas of impaired sensation that prevent people from giving accurate and timely feedback • infected tissues • tissue near or over eyes • damaged or at-risk skin **Cold therapy that is intense or applied to a large surface sufficient to produce generalized peripheral vasoconstriction should be applied with caution to** • people with hypertension • people with cardiac failure
 This condition/scenario or body location is NOT contraindicated.	**Superficial cold can be used on** • tissues over active epiphysis • intact skin overlying implants containing metal, plastic, or cement • skin overlying electronic devices • regions of known or suspected malignancy • the low back and abdomen of pregnant women • recently radiated tissues • reproductive organs • areas affected by skin diseases • the chest, heart, and head • tissues inflamed as result of recent injury or exacerbation of chronic inflammatory condition

EPA = electrophysical agent; Cryotherapy includes all forms of cold conductive agents.

Table 6 Consensus and Recommendations on Cryotherapy*

	Resources % ($n = 11$)	Can/US % ($n = 8$)	APA	CSP	Adverse Reaction**	Research Evidence**	Recommendation	For Details See
Conditions								
Cold urticaria or hypersensitivity	100	75	N/A	C	Serious	Strong	C	7-1
Raynaud's disease/vasospasm	100	75	N/A	C	Serious	Strong	C	7-2
Cryoglobulinemia	82	75	N/A	C	Serious	Strong	C	7-3
Hemoglobulinemia	64	75	N/A	N/A	Serious	Strong	C	7-4
Impaired circulation	82	75	C	C	Minor	Moderate	C	7-5
Haemorrhagic conditions	S	13	C	C	Moderate	Moderate	C	7-6
Chronic wounds	27	N/A	C	P	Minor	Moderate	C	7-7
Impaired sensation	36	63	P	P	Minor	Moderate	P	7-8
Superficial regenerating nerve	27	N/A	N/A	N/A	Minor	Strong	C	7-9
Impaired cognition or communication	11	38	P	C	Minor	Strong	C	7-10
Hypertension	N/A	N/A	N/A	N/A	Moderate	Strong	C Systemic P Local	7-11
Infection Tuberculosis	9	25	S	P	Moderate	Moderate	C Systemic P Local C TB	7-12
Deep vein thrombosis Thrombophlebitis	S	N/A	C	P	Serious	Absent	C	N/A

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	Resources % ($n = 11$)	Can/US % ($n = 8$)	APA	CSP	Adverse Reaction**	Research Evidence**	Recommendation	For Details See
Implants								
Metal implant	S	25	N/A	N/A	Minor	Absent	S	N/A
Local Areas								
Eyes	S	25	S	C	Moderate	Absent	P	7-13
Anterior neck Carotid sinus	S	N/A	N/A	P	Serious	Absent	C	N/A

APA = Australian Physiotherapy Association guideline; Can/US = results of survey of North American experts; CSP = Chartered Society of Physiotherapy guideline; C = contraindication; C-local = contraindication over the site; NA = not addressed; P = precaution; S = safe; Systemic = cold therapy is applied in a manner that lowers body temperature (causes shivering); Local = cold is applied to a small localized area of the body not likely to produce changes to core body temperature; Cryotherapy includes all forms of cold conductive agents

* This table shows the percent (raw) agreement of commonly cited contraindications for cryotherapy (e.g., ice, cold packs) by North American experts (Can/US; $n \leq 8$) and authors of textbooks (Resources; $n = 11$). An interpretation of the Australian (APA) and Chartered Society of Physiotherapy (CSP) guidelines is shown. A recommendation is given for each condition based on an interpretation of the risk of adverse reactions and the strength of the supporting evidence.

** Readers should consult the Introduction for criteria used to rank adverse reactions, research evidence, and recommendations.

SUPERFICIAL COLD: RECOMMENDATIONS, RATIONALE, AND REFERENCES

7-1 Cold Urticaria/Hypersensitivity

Recommendation C	Avoid applying superficial cold to persons who are known to have this relatively rare condition. Patients who develop an allergic-type reaction (weals, swelling, erythema) after cold therapy should be advised to consult a physician.
Rationale	Affected individuals usually develop local reactions to ice application (weals, swelling, and erythema). In severe cases, the condition causes a systemic histamine response (sneezing, bronchospasm, and dysphasia) that may progress to anaphylaxis. Loss of consciousness can occur due to a large drop in blood pressure as a result of generalized vasodilatation.
Research Evidence STRONG	Cold urticaria produced by ice application has been reported in the literature.[1–9]

7-2 Raynaud's Disease, Raynaud-Like Phenomenon

Recommendation C	Avoid applying cold to hands and feet that show signs of cyanosis and/or pallor or to individuals with a history of vascular hyperactivity to cold (i.e., reversible vasospasm disproportionate to the triggering event in terms of its duration, diffusion, and intensity).
Rationale	In Raynaud's disease, the blood vessels are commonly in a state of vasospasm, which would be exacerbated by applying cold. Prolonged vasoconstriction can lead to thrombus formation, tissue ischemia, and necrosis.
Research Evidence STRONG	Application of cold to distal extremities can trigger vasospasm in digital arteries.[10,11]

7-3 Cryoglobulinemia

Recommendation C	Cryotherapy should not be used on persons who are known to have this condition.
Rationale	Cryoglobulins are serum proteins that precipitate at 4°C (39.2°F) and redissolve after warming to 37°C (98.6°F). The condition may occur in the absence of any other disease but is commonly associated with hepatitis C virus and with collagen-vascular disorders. Mononeuropathy or symmetric polyneuropathy occurs in 7–15% of individuals.
Research Evidence STRONG	Cooling tissues causes aggregation of serum proteins, which can obstruct blood vessels (thrombosis) and cause tissue ischemia and necrosis.[12,13]

7-4 Haemoglobulinemia (Cold Agglutinin Syndrome)

Recommendation C	Cryotherapy should not be used on persons who are known to have this autoimmune haemolytic disease. If a patient experiences a first occurrence of symptoms during or following cryotherapy, he or she should be referred to a physician for assessment.
Rationale	Affected persons are typically middle-aged or elderly. Symptoms include fatigue; shortness of breath and weakness with exertion; dark urine (especially in cold weather); and severe pallor of fingers, toes, ears, and nose when exposed to cold. Individuals may report haematuria (red-purple urine) after cryotherapy treatment.
Research Evidence STRONG	The symptoms are due to chronic haemolytic anaemia. Haemoglobin is released into the urine as a result of cold-induced haemolysis of red blood cells.[14]

7-5 Impaired Circulation

Recommendation C	Avoid using cryotherapy on ischemic tissues.
Rationale	Poorly perfused tissues appear cyanotic, mottled or pale, shiny, hairless, and cold to touch. The distal lower extremities are usually the most affected by arterial disease.
Research Evidence MODERATE	Thermoregulation is impaired when circulation is compromised (e.g., in diabetes), and the distal extremities become highly susceptible to temperature extremes. Cold-induced vasoconstriction may compromise tissues already deprived of oxygen and thus increase the risk of tissue damage.[15] Hypoxia may alter the coagulation cascade, which may precipitate a thrombotic event.[16]

7-6 Haemorrhagic Conditions

Recommendation C **Systemic**	Avoid reducing core body temperature (indicated by shivering) via excessive duration or extent of ice application. Cold therapy alone is not sufficient to stop uncontrolled bleeding (e.g., post surgery or trauma, or in patients with coagulopathy or uncontrolled haemophilia) and is always applied in conjunction with other measures. In cases of haemophilia, cold can be applied after the patient has received replacement factor.
Rationale	Hypothermia can interfere with platelet function. Therefore, prolonged cold can have the unintended effect of delaying haemostasis and increasing bleeding. Intermittent cold therapy (e.g., applied for 10–20 minutes and repeated every 2 hours) is not likely to alter core temperature.
Research Evidence MODERATE	Perioperative reduction in core body temperature impairs platelet activation.[16–18]

7-7 Chronic Wounds

Recommendation C	Prolonged ice treatment should be avoided in areas of surgical wounds for all persons immediately post surgery or post injury. Cryotherapy treatments should be avoided in the vicinity of a chronic non-healing wound.
Rationale	Reduction in tissue temperature impairs wound-healing processes, reduces tissue perfusion, and increases susceptibility to infection. Intermittent cryotherapy treatments are advisable post surgery and following acute injuries to help with symptom management while allowing tissue to return to normal physiological temperature between applications. Hypothermia-induced impairment of healing further compromises the closure of chronic non-healing wounds.
Research Evidence **MODERATE**	Cold induces vasoconstriction, decreases collagen synthesis, and compromises wound strength. Healing is arrested during and for 1 to 2 hours following tissue hypothermia induced by wound dressing changes.[17,19,20] Some wound applications have been developed expressly to maintain wound tissues at normal physiological temperature (37°C) in order to promote healing.[21] Hypothermia following surgery reduces resistance to infection by impairing neutrophil function; conversely, maintaining normal physiological temperature after surgery is associated with lower incidence of infection.[18]

7-8 Impaired Sensation

Recommendation P	Use cryotherapy cautiously in patients who have a sensory disturbance (e.g., diabetes, post stroke). Monitor skin very closely when electing to treat in the presence of such conditions. Excessive or prolonged changes in skin colour are a sign of frostbite.
Rationale	In normally innervated skin, cryotherapy slows nerve-conduction velocity and ultimately blocks all sensation. Therefore, intact sensation should not be a prerequisite for cryotherapy. Importantly, patient feedback should not be the only information used to gauge the safe intensity or duration of treatment. Monitor skin changes frequently during treatments; marked skin pallor or blue-black colouring is an adverse sign and may indicate the development of frostbite. In persons with underlying loss of neurogenic control of the vascular system (e.g., diabetes, spinal-cord injury) the response to cold therapy can be highly atypical; the main concern is excessive vasoconstriction.
Research Evidence **STRONG**	Patients who are post stroke or who have diabetes or Complex Regional Pain Syndrome may experience a paradoxical burning sensation (allodynia) from cryotherapy.[22] It has been hypothesized that cold can accelerate the progression of diabetic polyneuropathy by enhancing neuronal ischemia.[23] There are many reported cases of skin injury (frostbite) as a result of cryotherapy.[23–35]

7-9 Regenerating Nerve

Recommendation C	Avoid applying cold directly over regenerating superficial nerves (e.g., peroneal, ulnar).
Rationale	Cold-induced neuronal ischemia may delay regeneration.
Research Evidence **MODERATE**	Cold can cause allodynia (burning sensation) after peripheral nerve injury.[22] Applying cold to superficial nerves reduces nerve-conduction velocity, and excessive cooling has resulted in nerve injury.[24–33]

7-10 Impaired Cognition or Communication

Recommendation C	Ensure that patients understand the appropriate use of cold therapy and the risks of adverse reactions, particularly for patients using cold therapy as a home treatment (see "Safe Practice" below). Self-treatment should be discouraged in patients with an impaired ability to follow instructions.
Rationale	Tissue damage is a latent effect of excessive cooling. The evolving injury is seldom appreciated during treatment because of reduced pain awareness (numbness). Ice is readily accessible and inexpensive, and it may be used with no appreciation of its potential adverse effects.
Research Evidence STRONG	Adverse reactions (frostbite and nerve injuries) appear to be strongly associated with inappropriate techniques and prolonged or excessively cold applications.[34–37] Many instances of cryotherapy-induced injury are associated with self-treatment.

7-11 Hypertension

Recommendation C **Systemic** P **Local**	Monitor vital signs when treating individuals with known cardiovascular disease.
Rationale	Cooling a large surface area may cause widespread peripheral vasoconstriction, leading to increased mean arterial blood pressure. In hypertensive individuals, cryotherapy should be discontinued if blood pressure becomes elevated.
Research Evidence STRONG	Cold increases sympathetic tone and produces peripheral vasoconstriction, which increases blood pressure.[38–40]

7-12 Infection, Tuberculosis

Recommendation C **Systemic** C **TB** P **Local**	Monitor signs of advancing infection when treating individuals with localized infection. Avoid cooling a large body region to the point of lowering core body temperature. Do not apply cold to areas affected by tuberculosis.
Rationale	Although reducing tissue temperature limits bacterial growth, local tissue vasoconstriction reduces tissue oxygenation and polymorphonuclear leukocyte infiltration, which impairs host phagocytic activity against bacteria. Core hypothermia reduces defence against infection.
Research Evidence MODERATE	Cold increases sympathetic tone and produces peripheral vasoconstriction.[38–40] Perioperative hypothermia is associated with greater incidence of postoperative wound infections.[18]

7-13 Eyes

Recommendation P	Application of cold in the vicinity of the eyes should be undertaken with caution.
Rationale	There is no literature to guide practice in this area. Facial skin is normally highly sensitive; therefore, it is likely that potentially damaging cold would cause discomfort, prompting a patient to ask for treatment to be terminated.
Research Evidence ABSENT	No reference found.

SAFE PRACTICE

Prescribe Safe Treatment Schedules

Recommended temperature of the cooling agent, method of application, and duration of treatment are specific to location and patient and should account for both volume and depth of target tissue. For example, 5 minutes might be appropriate for a hand injury but inadequate for a hamstring injury. Modest cooling may improve outcomes in acute injury; however, excessive cooling may cause greater damage.[7] Generally, longer applications are associated with reports of frostbite and nerve injury. The re-warming period should be at least twice as long as the treatment time (1:2 ratio), although a 1:6 ratio is preferred (20 min on, 120 min off). Too-frequent application of cryotherapy increases the likelihood of frostbite.[41–44] Application of ice should be restricted to 10–15 minutes over areas of minimal subcutaneous fat and over superficial nerves. Decreased nerve-conduction velocity leading to transient and reversible nerve block occurs if nerve temperature is brought within −5°C to 0°C (23–32°F). Cryotherapy-induced nerve injuries are most common when cold is applied in conjunction with compression. For this reason, blood-flow restriction rather than cold-induced effects is believed by some to be the causative factor. Check capillary refill during application of ice combined with compression therapy to ensure that blood flow to the extremity is not limited.[24–33,45–47]

Prescribe Safe Treatment Methods

The hierarchy of cooling, from most to least efficient, is as follows: ice-water immersion, crushed ice, frozen peas, gel pack. If a patient has risk factors for an adverse reaction to cooling (e.g., impaired sensation, advanced age), then the clinician should select a mode with less cooling potential. The rate of skin cooling is reduced by placing a layer of dry towel between the cooling agent and the skin.[47–49] An insulating layer should always be used when applying ice over wound staples or recent surgical wounds.

Prevent Skin Burn When Using Commercial Cold Gel Packs

Cold gel packs stored in a freezer have a surface temperature below 0°C (32°F). An insulating layer should be used between the cold pack and the patient's skin. Commercial gel packs should not be secured against the skin using elastic wraps.[46] Longer application times may be required when a cooling agent is applied over an insulating layer (e.g., dry towel, dressing, or plaster cast).[31]

Monitor for Physiological Signs of General Body Cooling

Shivering and piloerection are signs of generalized cooling and a decrease in core temperature, which may compromise patient safety. The application of therapeutic cryotherapy should produce only local effects. General cooling effects are more likely to occur in elderly patients, who have difficulty regulating body temperature, and in persons with elevated temperature (fever). Adequate draping of patients may be used to offset generalized effects.[47]

Avoid Cooling the Skin Prior to or During Electrical Stimulation Therapy

Cryotherapy induces vasoconstriction and transient nerve block. There is a risk of thermal burn when electrical current, particularly interferential current, is applied in areas of reduced sensation and circulation. Awareness of increasing temperature and pain is a protective mechanism against thermal damage.[50]

Consider the Effect of Cold on Patient Performance

Cryotherapy application slows conduction velocity, affecting sensory, motor, and autonomic nervous systems. As a result, local pain awareness, proprioception, muscle strength, agility, and dexterity are reduced immediately after cold application. Clinicians should use caution in prescribing activity immediately post cryotherapy because of the increased risk of injury or re-injury.[51,52] Sensory loss also counteracts potential effects of pain treatments that depend on intact sensory systems, such as TENS, IFC, and other pain-modulating currents.[53]

Avoid Prolonged Ice or Iced-Water Application after Burn

The immediate application of cool water to a burn provides prompt relief of pain. However, excessive cooling of burned tissue can increase the severity of the injury by increasing tissue hypoxia.[15]

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8. Short-Wave Therapy

SUMMARY OF RECOMMENDATIONS

 Do NOT use the EPA to treat person with this condition or in this body location.	**All forms of short-wave therapy (thermal or non-thermal) should not be applied to** • persons with known or suspected malignancy • pregnant women (anywhere) • persons with electronic implants • persons with active deep vein thrombosis or thrombophlebitis • persons with tuberculosis • recently radiated tissues • heart, anterior neck region, or carotid sinus • actively bleeding tissue or persons with untreated hemorrhagic disorders **Thermal doses of short-wave therapy (including PSW) should not be applied [in addition to those listed above]** • to areas of impaired circulation • to areas of impaired sensation that prevent the patient from giving accurate and timely feedback • to areas with ceramic-, plastic-, or cement-containing implants • to persons with metal implants • to persons with heat-sensitive skin diseases (e.g., eczema) • to persons with a fever • to areas of skin damage or severe edema • to infected tissues • to tissues inflamed as result of recent injury or exacerbation of chronic inflammatory condition • over areas of the body covered with a thick layer of adipose tissue (obesity) • to eyes • to persons with cognition or communication impairments sufficient to prevent them from giving accurate and timely feedback • over lung fields • to reproductive organs • to areas with regenerating nerves
 Experienced clinicians may elect to treat this condition/location with caution (e.g., at lower intensities or with more frequent monitoring).	**Thermal short-wave can be applied with caution to** • persons with cardiac disease or cardiac failure • areas of damaged or at-risk skin or chronic wounds • active epiphysis **Non-thermal short-wave therapy can be applied with caution** • to areas with impaired circulation • to infected tissues • in persons with cognitive or communication impairments sufficient to prevent them from giving accurate and timely feedback • to areas with regenerating nerves • to persons with heat-sensitive skin diseases (e.g., eczema) • to eyes

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S This condition/scenario or body location is NOT contraindicated.	**Non-thermal short-wave therapy can be used on** • areas overlying metal implants • tissues inflamed as result of recent injury or exacerbation of chronic inflammatory condition • areas of damaged or at-risk skin, chronic wounds • areas with a thick layer of adipose tissue (obesity) • areas of impaired sensation that prevent the patient from giving accurate and timely feedback • reproductive organs • lung fields • areas with ceramic-, plastic-, or cement-containing implants

EPA = electrophysical agent; PSW = pulsed short-wave; SWT = short-wave therapy, including all forms of short-wave; Thermal Short-Wave Therapy = SWT producing perceptible skin warming and subcutaneous/deep tissue temperature increases of at least 1°C (using continuous-mode short-wave, pulsed short-wave, or pulsed radiofrequency energy); Non-thermal Short-Wave Therapy = SWT that does NOT produce perceptible skin warming but may slightly increase subcutaneous/deep-tissue temperature (using continuous-mode short-wave, pulsed short-wave, or pulsed radiofrequency energy)

Table 7 Consensus and Recommendations on Thermal and Non-thermal Short-Wave Therapy (SWT)*

	Resources % ($n = 12$)	Can/US % ($n \leq 8$)		APA	CSP	Adverse Reaction**	Research Evidence**	Recommendation		For Details See
	SWT	Thermal SWT	Non-thermal SWT	SWT	SWT	SWT/PSW	SWT/PSW	Thermal SWT	Non-thermal SWT	
Conditions										
Pregnancy	83	100 ($n = 8$)	100 ($n = 7$)	C	C	Serious	Strong	C	C	8-1
Malignancy	67	100 ($n = 8$)	100 ($n = 7$)	C	C-local	Serious	Moderate	C	C	8-3
Acute inflammation	75	100 ($n = 8$)	S ($n = 7$)	C	P	Minor	Moderate	C	S	8-7
Infection Tuberculosis	42	100 ($n = 8$)	100 ($n = 6$)	C	C	Serious	Low	C	P	8-8
Recently radiated tissue	17	88 ($n = 7$)	83 ($n = 6$)	C	P	Serious	Absent	C	C	8-9
Impaired sensation	67	100 ($n = 8$)	29 ($n = 7$)	C	P	Serious	Low	C	S	8-12
Impaired cognition or communication	42	88 ($n = 8$)	14 ($n = 7$)	C	C	Moderate	Absent	C	P	8-13
Superficial regenerating nerve	S	N/A	N/A	N/A	N/A	Minor	Low	C	P	8-14
Deep vein thrombosis Thrombophlebitis	33	100 ($n = 8$)	57 ($n = 7$)	C	N/A	Serious	Low	C	C	8-15
Haemorrhagic conditions	83	100 ($n = 8$)	50 ($n = 6$)	C	C	Serious	Low	C	C	8-16
Impaired circulation	75	100 ($n = 8$)	33 ($n = 6$)	C	C	Serious	Moderate	C	P	8-17
Obesity	P	N/A	N/A	N/A	N/A	Minor	Low	C	S	8-18

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	Resources % ($n = 12$)	Can/US % ($n \leq 8$)		APA	CSP	Adverse Reaction**	Research Evidence**	Recommendation		For Details See
	SWT	Thermal SWT	Non-thermal SWT	SWT	SWT	SWT/PSW	SWT/PSW	Thermal SWT	Non-thermal SWT	
Skin disorders Severe edema	50	88 ($n = 7$)	33 ($n = 6$)	N/A	N/A	Minor	Absent	C	P	8-20 8-7
Chronic wounds	S	N/A	N/A	N/A	N/A	Minor	Low	P	S	8-20
Fever	25	N/A	N/A	C	N/A	Moderate	Absent	C	S	N/A
Active epiphysis	42	N/A	N/A	N/A	C	Moderate	Absent	P	P	N/A
Implants										
Plastic/cement implants Synthetic materials	25	45 ($n = 7$)	S ($n = 6$)	N/A	N/A	Minor	Low	C	S	8-4
Metal implants	83	88 ($n = 8$)	29 ($n = 7$)	C	C	Moderate	Low	C	S	8-5
Electronic implants	92	100 ($n = 8$)	71 ($n = 7$)	C	C	Serious	Strong	C	C	8-6
Local Areas										
Reproductive organs	67	100 ($n = 8$)	67 ($n = 6$)	C	C	Serious	Low	C	S	8-2
Heart Neck region	S	N/A	N/A	N/A	P	Serious	Low	C	C	8-10
Chest Lungs	S	N/A	N/A	N/A	N/A	Moderate	Absent	P	S	8-11
Eyes	58	100 ($n = 8$)	86 ($n = 7$)	C	C	Moderate	Absent	C	P	8-19

APA = Australian Physiotherapy Association guidelines; Can/US = results of survey of North American experts; CSP = Chartered Society of Physiotherapy guidelines; C = contraindication; C-local = contraindication over the site; N/A = not addressed; P = precaution; S = safe; PSW = pulsed short-wave; SWT = short-wave therapy (including all forms of short-wave); Thermal = Thermal SWT (produces perceptible skin warming and tissue temperature increases of at least 1°C); Non-thermal = Non-thermal SWT (does NOT produce perceptible warmth but may increase tissue temperature slightly)

* This table shows the percent (raw) agreement of commonly cited contraindications by North American experts (Can/US; $n \leq 8$) and authors of textbooks (Resources; $n = 12$). An interpretation of the Australian (APA) and Chartered Society of Physiotherapy (CSP) guidelines is shown. A recommendation is given for each condition based on an interpretation of the risk of adverse reactions and the strength of the supporting evidence.

** Readers should consult the Introduction for criteria used to rank adverse reactions, research evidence, and recommendations.

SHORT-WAVE THERAPY (SWT): RECOMMENDATIONS, RATIONALE, AND REFERENCES

8-1 Pregnancy

Recommendation C	Thermal and non-thermal forms of SWT should not be applied to pregnant women.
Rationale	Hyperthermia and electromagnetic fields are known to have negative effects on fetal development.
Research Evidence STRONG	Adverse birth outcomes have occurred in women who received pelvic SWT treatment during early pregnancy. A negative association between exposure to SWT in the workplace and birth outcomes for physiotherapists has been reported but has not been clearly substantiated.[1–4] Embryolethal effects of non-thermal SWT have been reported in animal studies[5] and teratogenic effects have been demonstrated in guinea pigs using SWT at intensities that produced significant maternal hyperthermia.

8-2 Reproductive Organs

Recommendation C **Thermal** S **Non-thermal**	Thermal SWT should not be directed at the testes of men or the pelvic region of menstruating women.
Rationale	It is known that hyperthermia can cause sterility in men; local heat may increase menstrual flow. The APA and CSP guidelines do not differentiate between thermal and other forms of SWT.
Research Evidence LOW	Historically, infections of the female reproductive tract were treated using a minimally perceptible dose of SWT. There are no reports of this treatment's having produced adverse effects.[6] Other gynaecological and obstetric conditions causing lower-abdominal or perineal pain have been treated using non-thermal SWT (7.4 W mean power), and some authors have reported a benefit from this treatment.[7–9]

8-3 Malignancy

Recommendation C	All forms of SWT should be avoided in persons with known or suspected malignancy. Abnormal growth should be regarded as malignant until the diagnosis has been confirmed.
Rationale	Tumour growth can increase as a result of enhanced circulation associated with an increase in tissue temperature and of up-regulation (increase) of cellular activity associated with non-thermal SWT.
Research Evidence LOW	No reference found.

8-4 Plastic Implants

Recommendation C **Thermal** S **Non-thermal**	Do not apply thermal SWT over implants fixed with acrylic bone cement. Do not apply thermal SWT over metal–plastic implants until further research is performed. Non-thermal SWT can safely be applied in the vicinity of metal–plastic implants.
Rationale	Plastic is an inert substance. However, plastic implants (e.g., stents, joint replacements) are commonly constructed of plastic polymers with added conductive materials (e.g., carbon-fibre-reinforced plastic), and such implants are affected by electromagnetic fields (e.g., development of radiofrequency eddy currents; distortion, depending on the shape of the implant and whether it is tubular). Until more information is available, thermal effects should be avoided. Plastic (non-conductive) materials and materials used to fix plastic prostheses are affected by high temperatures. Although SWT sufficient to produce these effects would not likely be tolerated by conscious individuals, safe practice suggests not using thermal SWT around these materials.
Research Evidence LOW	Electromagnetic field effects have been shown for some metal–plastic materials.[10] Water-saturated acrylic bone cement becomes rubbery and soft at temperatures of 60–70°C.[11] Some thermoplastic material (e.g., materials used in oral surgery) must be heated to 63°C to attain moldability.[12]

8-5 Metal Implants

Recommendation C **Thermal** S **Non-thermal**	Thermal SWT should not be used in the vicinity of implanted metal until further research is performed. Non-thermal SWT can safely be applied in the vicinity of implanted metal. Thermal and non-thermal SWT are likely safe in women fitted with copper-bearing intrauterine devices (IUDs).
Rationale	Metal is readily polarized in an electromagnetic field and, therefore, distorts the electrical field. Although the metal itself does not heat, a soft-tissue burn could potentially occur at each end of an implanted metal rod as a result of intensification of the electrical field. The CSP guidelines suggest that SWT can be applied over metal provided that mean power output does not exceed 5 W. However, there is not 100% consensus on this issue.
Research Evidence MODERATE	Pulsed SWT using mean power of 48 W has been used with benefit and without adverse effects over implanted metal involving elbow and ankle joints in a few patients; placement of the implants was examined radiographically in each patient to determine safety.[2,13–15] The effects of SWT directed at the uterus appear very similar in the presence of copper-bearing versus non-copper-bearing IUDs: intrauterine temperature increased less than 1°C following a 20-minute application.[16,17]

8-6 Electronic Devices

Recommendation C	No form of SWT should be used in any circumstance within 3 m of a person wearing an electronic implant. This contraindication applies regardless of the body site or the type of implanted device. Hearing aids and any externally worn medical device should be removed prior to treatments involving SWT.
Rationale	Some types of pacemaker are not affected by operating SWT units. However, because of the diversity of pacemaker and cardiac defibrillator devices, it is safest that persons with any type of pacemaker never be treated with or permitted within 3 m of an operating SWT unit.
Research Evidence STRONG	Not all types of pacemakers are affected by short-wave treatments.[18] The FDA Centre for Devices and Radiological Health reported that brain damage occurred in two patients with implanted deep brain stimulators who were directly exposed to SWT.[19–23]

8-7 Acute Injury, Inflammation, Edema

Recommendation C **Thermal** S **Non-thermal**	Avoid thermal SWT in cases of acute swelling. PSW treatment is safe in acute inflammation (e.g., sprains, strains, tendonitis). In cases of severe swelling, treatment should be started using low mean power output, approximately 24 W, and increased gradually up to 32 W at follow-up treatments as the condition improves.
Rationale	Adding heat to already inflamed tissue (indicated by redness, swelling, heat, and pain) may further increase the inflammatory response and exacerbate pain. Excessive swelling can cause ischemia and tissue necrosis. Tissues of high water content heat relatively more than drier tissues; heating may therefore be atypically high in the presence of gross edema.
Research Evidence **MODERATE**	PSW applied at intensities below 32 W has been used safely to treat acute injuries.[24,25]

8-8 Infection, Tuberculosis

Recommendation C **Thermal** C **TB** P **Non-thermal**	Thermal SWT should not be used on persons with a body temperature above the physiological norm (37°C) or directly targeted at infected tissue. Non-thermal SWT can be applied to treat low-grade chronic infection (e.g., salpingitis). Patients should be monitored closely to check for exacerbation of symptoms. Thermal and non-thermal SWT should not be used on persons with tuberculosis.
Rationale	Bacterial growth increases with a modest rise in host tissue temperature. The CSP guidelines specifically recommend avoiding thermal SWT for persons with TB.
Research Evidence **LOW**	Historically, infections of the female reproductive tract were treated using a minimally perceptible dose of SWT. There are no reports of this treatment's having produced adverse effects.[6] The specific effects of SWT on TB have not been studied.

8-9 Recently Radiated Tissue

Recommendation C	Avoid all forms of SWT over recently radiated tissue.
Rationale	There may be a risk of stimulating growth of any remaining malignant cells. Recently radiated tissue may respond atypically because of the presence of radiation-induced inflammation, scar tissue, and the cellular or circulatory effects of radiation therapy. The APA recommends avoiding treatment for 3 to 6 months after radiation.
Research Evidence **ABSENT**	No reference found.

8-10 Heart, Anterior Neck

Recommendation C	Thermal SWT should not be directed at the heart or major blood vessels in the anterior neck region.
Rationale	There is a risk of increasing blood volume to the head.
Research Evidence **ABSENT**	The effects of SWT directed at the heart and major blood vessels in the neck have not been studied.

8-11 Chest/Lungs

Recommendation C **Thermal** S **Non-thermal**	Experienced clinicians may elect to apply mild thermal SWT or PSW to lung fields; however, further research is needed to substantiate the safety of this treatment.
Rationale	The effects of applying strong warmth through the chest and lungs are unknown.
Research Evidence LOW	Clinical application of mild thermal SWT accelerated resolution of small spontaneous pneumothoraces; no adverse effects were reported.[26]

8-12 Impaired Sensation

Recommendation C **Thermal** S **Non-thermal**	Thermal SWT should not be used on patients who cannot detect changes in skin temperature. Non-thermal SWT can be safely applied at a mean power that does not produce visible skin erythema during treatment.
Rationale	Because subjective skin warmth is used as a guide for treatment intensity, accurate patient feedback is necessary to prevent tissue burn. In the absence of intact skin sensation, PSW should be restricted to applications using mean power <32 W.
Research Evidence LOW	In one study, healthy subjects on average reported perceptible skin warmth at mid-thigh using a drum electrode and PSW at a mean power of approximately 21 W. It is not clear why this low-power treatment produced perceptible warmth; the skin–electrode distance was not described.[27] Non-thermal PSW has been used in persons with spinal-cord injury, with no adverse effects reported.[28,29]

8-13 Impaired Cognition or Communication

Recommendation C **Thermal** P **Non-thermal**	Avoid thermal SWT when a person cannot reliably follow instructions or give appropriate feedback. Experienced clinicians may elect to apply non-thermal PSW to patients who cannot communicate or follow instructions; continuous close monitoring of the patient is advised.
Rationale	Safety and efficacy may be compromised by applying heat to a patient who cannot report his or her perception of heat. Monitoring is necessary when using PSW to ensure that there is no tampering with equipment or moving of a body part in relation to electrodes.
Research Evidence ABSENT	PSW has been used to treat pressure ulcers in elderly institutionalized persons, some of whom were confused and unaware of the treatment; no adverse effects were reported.[28]

8-14 Regenerating Nerves

Recommendation C **Thermal** P **Non-thermal**	Thermal SWT should be avoided over regenerating nerves. Non-thermal PSW can be applied with caution.
Rationale	There appears to be no literature on the effects of thermal SWT on peripheral nerve injury, and only pre-clinical research supporting non-thermal PSW treatment of peripheral nerves.
Research Evidence ABSENT	In an animal model, PSW accelerated regeneration following a crush injury to peripheral nerve; there was no effect on healthy nerves.[30,31]

8-15 Active Deep Vein Thrombosis, Thrombophlebitis

Recommendation C	All forms of SWT should be avoided over the area of an active or suspected DVT. The area overlying a previous DVT that was treated using anti-coagulant therapy can be treated with caution.
Rationale	Thermal SWT can change regional blood flow, which in turn may dislodge or cause disintegration of a thrombus and potentially restrict circulation to vital organs. Possible effects of non-thermal PSW on platelet function and thrombus formation, or on absorption of a dissolving thrombus, have not been established.
Research Evidence LOW	Heat-induced changes in local blood flow have been demonstrated using other thermal agents.[32]

8-16 Haemorrhagic Conditions

Recommendation C	All forms of SWT should be avoided over actively bleeding tissue. Application of non-thermal SWT should be delayed until haemostasis is established. SWT can be applied in persons with haemophilia after replacement factor has been administered.
Rationale	Heat causes local vasodilatation and increased blood flow, which can delay haemostasis and prolong bleeding. Possible effects of PSW on platelet function and blood clots have not been established.
Research Evidence LOW	Heat-induced changes in local blood flow have been demonstrated using other thermal agents.[32]

8-17 Impaired Circulation

Recommendation C **Thermal** P **Non-thermal**	Thermal SWT should not be applied over areas where arterial supply is poor. Non-thermal SWT at low mean power can be applied with caution.
Rationale	There is an increased risk of skin burn when blood flow is compromised, because the vascular system is unable to dissipate the mounting heat. Distal extremities are most affected by arterial disease; therefore, it is important to check hands and feet for signs of arterial disease (thin, shiny, pale skin; cold to touch; thickened brittle nails). There is no literature on the use of PSW in persons with diabetic or venous ulcers; however, PSW has been used safely on pressure ulcers associated with spinal-cord injury. Although relief of pressure may reduce or eliminate the ischemic factor, applied heat will not be dissipated efficiently because of impaired vasodilator response.
Research Evidence MODERATE	PSW using average powers in the 6 W to 38 W range has been used with benefit on chronic Stage II and III pressure ulcers. Although tissue temperature would likely have increased slightly at average powers around 30 W, no adverse effects were reported.[28,33]

8-18 Obesity

Recommendation C **Thermal** S **Non-thermal**	In obese individuals, avoid applying thermal SWT to body regions with high fat content. Distal joints, such as foot/ankle and hand/wrist, can be treated safely. Non-thermal PSW is safe over regions with high fat content, but a thick layer of fat reduces the depth of the short-wave field.
Rationale	Adipose tissue retains heat. The intensity of an electric field is strongest closer to the source; thus, the field will be more intense in the subcutaneous fat layer than in underlying muscle.
Research Evidence LOW	The risk of burn is greater when thermal SWT is applied using capacitor- rather than inductive-type electrodes.[2]

8-19 Eyes

Recommendation C **Thermal** P **Non-thermal**	Avoid thermal SWT near the eyes.
Rationale	Theoretically, heat could accumulate in the fluid-filled chamber of the eye, causing injury.
Research Evidence ABSENT	Barely perceptible thermal SWT was a popular treatment for sinusitis in the past; however, this practice was based on anecdotal evidence. Applications to treat frontal and nasal sinuses included the eye in the field. There appear to be no reports in the literature of adverse effects using this dated but purportedly effective treatment.

8-20 Skin Disease, Damaged or At-Risk Skin, Open Wounds

Recommendation C **Thermal** S **Non-thermal**	Avoid thermal SWT in the presence of heat-sensitive skin lesions (e.g., eczema). PSW can safely be used to treat damaged skin or open wounds.
Rationale	Heat may exacerbate the intensity and extent of skin lesions in cases of eczema and dermatitis.
Research Evidence LOW	PSW using average powers in the 6 W to 38 W range has been used with benefit to treat chronic Stage II and III pressure ulcers.[28,33]

SAFE PRACTICE

Prepare the Patient Prior to Treatment

Undress the body part to be treated. When undressing is not suitable, the patient can wear dry, lightweight, all-cotton clothing. Avoid synthetic fibres, which trap sweat against the skin. Dry the skin of perspiration in the area of application. Remove jewellery, watches, body rings, and so on from the body part to be treated or from areas within the field. Remove hearing aids. Contact lenses should be removed whenever the eye region is within a short-wave field. Historically, barely perceptible thermal SWT was used to treat sinusitis, and treatment included the orbital region; there are no reports of adverse effects of this treatment.

Perform a Sensory Discrimination Test

Test sensory integrity by asking patients to differentiate between hot and cold stimuli *or* between light touch and painful stimuli. Temperature discrimination and pain (a sharp pricking quality) are conveyed by spinothalamic tracts, whereas light touch is conveyed mainly by dorsal columns; thus, it is not sufficient to test light touch only. This sensory test should always be performed when using thermal SWT.

Temperature change in an electromagnetic field depends on mean power of the treatment rather than on the use of continuous or pulsed mode.[27,34,35] In the event of poor sensory discrimination in the treatment area, the short-wave output should be restricted to a maximum of approximately 38 W mean power.[14] PSW (mean power 38 W) has been used under close observation in confused or unconscious patients without complications.[28]

Avoid Surface Moisture

Thermal SWT must not be applied over damp or wet skin surfaces; there is a risk of burn due to field concentration on the moist surface relative to surrounding dry areas. Wet wound dressings must be removed for thermal treatments. PSW using low mean power (not greater than 30 W) can be applied without removal of wet dressings.

Ensure a Safe Treatment Environment

Items of furniture used for the patient (beds, chairs, tables, etc.) should have no metal parts, and metal furniture (cabinets, beds, etc.) should be at least 2 m away from the SWT unit. Other types of electrical equipment should be at least 3 m away from operating SWT units. Secure electrode cables a

safe distance from the patient's body and keep paired cables apart along their full length (equal to the distance between the cable sockets).[2,3,36]

Give Clear and Complete Patient Instructions

Patients need to understand that they should not touch electrode leads while the unit is active because the body part in contact with the leads becomes part of the electromagnetic field and could heat to the point of a burn. Glass or plastic covers over disc electrodes are inert and will not hurt the patient if accidentally touched; however, shifting closer to one electrode during treatment concentrates the field at that surface and may result in overheating and a potential burn. Patients should remain awake and alert during treatment, regardless of the mode of SWT.[3,36–39]

Monitor Patients during Treatment

Check periodically that the patient has not shifted position and that electrode arrangement remains optimal for the body part being treated. Check periodically for skin erythema and reduce intensity accordingly, or discontinue SWT if adequate reduction in intensity cannot be achieved.

Monitor Proximity of Staff and General Public to Operating Short-Wave Equipment

After setting up patients on SWT and adjusting output, personnel should remain at least 2 m away from the unit, electrodes, and cables of short-wave devices operating with capacitor-type electrodes, and 1 m away from short-wave devices operating with inductive-type electrodes (drum or cable), to avoid unnecessary exposure to electromagnetic energy. Members of the general public should be kept an additional 0.5–1.0 m away from operating short-wave units. Studies on pregnancy outcomes for physiotherapists exposed to electromagnetic energy on numerous occasions *prior to* becoming pregnant appear to show no evidence of adverse effects, with the exception of one study that found evidence of low birth weight. It is not advisable for *pregnant* clinicians to work in close proximity to active short-wave devices, despite the inconclusive evidence of fetal harm.[2,4,38,40,41]

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9. Safe Practice Procedures for All Electrophysical Agent Treatments

This section offers suggestions for best practice in the clinical application of all types of electrophysical agents (EPAs). The emphasis is on procedures to ensure safe practice. These procedures should be used in conjunction with those mandated by local physiotherapy regulatory bodies.

Following the normal introduction and patient interview process, your decision to use an EPA as part of patient management will depend on the results of detailed assessment findings, including

- the patient's physical and functional impairment (e.g., pain, swelling, mobility, function, disability), determined using valid outcome measures
- the desired physiologic response (e.g., to stretch soft tissue, reduce muscle spasm, improve blood flow, produce analgesia, facilitate muscle action) and treatment goal
- the type, location, depth, and volume of the target tissue (e.g., muscle, nerve, tendon, ligament, capsule, subcutaneous tissue)

Based on your preliminary decision regarding use of an EPA,

- *Select the most appropriate EPA* to achieve the treatment goals, taking into account both indications and possible contraindications. Screen the patient to ensure that there are no contraindications to the selected treatment.
- *Choose an application technique* that is optimal for the clinical scenario (including dose parameters, electrode type and placement, treatment time, and patient position).
- *Explain to the patient* what is involved in the treatment, including why you chose the EPA, what sensation(s) to expect, the expected treatment duration, and when benefit can be expected.
- *Outline the benefits* of the intended treatment.
- *Explain the short- and long-term risks* of the treatment. There are some risks that can never be entirely eliminated, even in healthy persons and when there are no contraindications (e.g., equipment malfunction, atypical patient response). Therefore, clinicians using EPAs must always inform the patient of the severity and likelihood of relevant risks prior to starting the treatment. Safe practice should be directed at applying EPAs in a manner that reduces the risk of adverse reactions and reduces the severity of an adverse reaction should one occur. Communication with the patient throughout the treatment will also help to prevent any unwanted effects.
- *Confirm that the patient understands* the treatment and respond to any questions or concerns he or she may have.
- *Obtain consent to proceed* from the patient or substitute decision maker.

Once you have obtained consent,

- *Position the patient* comfortably and with optimal access to the target tissue. Advise the patient whether or not it is necessary to remain still during the treatment.
- *Examine integrity and condition of the skin* at the intended treatment site; test sensation.
- *Prepare the treatment area* according to best practice for application of the selected energy form (e.g., clean the skin of products that might reduce transmission of light energy).
- *Start the EPA device*; confirm that it is working properly (check power metres, thermometers, etc.) and that output is at zero. Set parameters.
- *Apply the EPA* while talking to the patient and describing what he or she should feel. Apply the modality in a manner that uses good body mechanics, preserves patient comfort and safety, and optimizes delivery of the sound, thermal, light, or electrical energy.
- *Monitor patient's response* every 5 minutes during treatment (ask, look, or feel) and adjust parameters appropriately.

Note: If you plan to move away during the treatment, advise what is not desirable and how you can be summoned (bell, etc.).

When treatment terminates (use a timer),

- Turn dose controls to zero and switch off the device.
- *Examine the treated area* and explain any reactions to the patient. Document whether treatment was well tolerated or whether adverse reactions were observed or reported. Explain to the patient whether after-effects should be expected (stiffness, erythema, return of pain, etc.).
- *Reassess impairment* using valid outcome measures. Document both subjective and objective findings, the possible resolution of impairments, and attainment of patient goals.
- *Record all treatment parameters* in sufficient detail to enable another individual to apply the treatment.
- *Sign and print your name on the record* to permit clarification of treatment if required and for medico-legal purposes.

Appendix 1: Summary Table of Consensus by Experts

Table A1 Percent (raw) agreement on commonly cited contraindications for selected electrophysical agents (EPAs) by North American experts ($n = 8$, unless otherwise specified). A higher percentage indicates greater consensus that the EPA should *not* be used for the given condition.

	US Cont	US Pulsed	E-stim	LLLT Light	Heat	Cold	SWT Therm	SWT Non
Conditions								
Active deep vein thrombosis, thrombophlebitis	100	100	100 ($n = 7$)	43 ($n = 7$)	100	25	100	57 ($n = 7$)
Acute injury, inflammation	100	P	14	14 ($n = 7$)	88	S	100	S
Haemorrhagic conditions	75	63	100 ($n = 7$)	33 ($n = 6$)	100	13	100	50 ($n = 6$)
Impaired circulation	88	P	43 ($n = 7$)	14 ($n = 7$)	63	75	100	33 ($n = 6$)
Impaired cognition/ communication	63	P	57 ($n = 7$)	P	50	38	88	14 ($n = 7$)
Impaired sensation	63	P	57 ($n = 7$)	S	88	63	100	29 ($n = 7$)
Infection (osteomyelitis, tuberculosis)	100	75	86 ($n = 7$)	71 ($n = 7$)	100	25	100	100 ($n = 6$)
Malignancy	100	88	100 ($n = 7$)	100 ($n = 7$)	100	13	100	100 ($n = 7$)
Pregnancy	100	100	86 ($n = 7$)	86 ($n = 7$)	13	13	100	100 ($n = 7$)
Recently radiated tissue	88	75	86 ($n = 7$)	86 ($n = 6$)	75	13	88 ($n = 7$)	83 ($n = 6$)
Severe edema	25	13	29 ($n = 7$)	S	75	S	88	25
Skin diseases, damaged/ at-risk skin	86 ($n = 7$)	57 ($n = 7$)	71 ($n = 7$)	S	100	38	88	33 ($n = 6$)
Implants								
Metal	P	S	29 ($n = 7$)	S	S	25	88	29 ($n = 7$)
Pacemaker, electronic device	88	88	86 ($n = 7$)	14 ($n = 7$)	13	13	100	71 ($n = 7$)
Plastic, cement	50	38	S	S	13	S	45 ($n = 7$)	S
Local Areas								
Eyes	100	100	86 ($n = 7$)	100 ($n = 7$)	50	25	100	86 ($n = 6$)
Reproductive organs	75	63	50 ($n = 7$)	29	38	13	100	67 ($n = 6$)

P = precaution (majority of experts considered the condition/body location a precaution); S = safe (none of the experts considered the condition/body location a precaution); US Cont = continuous-mode ultrasound (has 100% duty cycle and may produce perceptible skin warming); US Pulsed = pulsed-mode ultrasound (has duty cycle less than 50% and usually does not produce perceptible skin warming); E-stim = all forms of electrical stimulation including TENS, NMES, HVPC, and IFC; LLLT/Light = low-level laser therapy (includes all Class II and III lasers and non-coherent light sources); Heat = hot packs, wax, and other superficial conductive heating agents that heat tissues within 3 cm of the skin surface; Cold = all forms of cryotherapy (cold packs, ice bags, ice bath, ice massage, etc.); SWT = short-wave therapy; Therm = Thermal SWT (produces perceptible skin warming and tissue temperature increases at least 1°C); Non = Non-thermal SWT (does *not* produce perceptible warmth but may increase tissue temperature slightly)

Appendix 2: Textbook Resources Considered

Table A2 Texts reviewed for contraindications and precautions when using EPAs

Author(s)	Title	Publisher	ISBN
Baxter GD	*Therapeutic Lasers: Theory and Practice*	Churchill Livingstone	0-443-04393-0
Behrens BJ, Michlovitz SL, editors	*Physical Agents: Theory and Practice* (2nd ed.)	F.A. Davis	0-8036-1134-X
Belanger AY	*Evidence-Based Guide to Therapeutic Physical Agents*	Lippincott Williams & Wilkins	0-7817-2108-3
Cameron MH	*Physical Agents in Rehabilitation* (2nd ed.)	W.B. Saunders	0-7216-9378-4
Denegar CR	*Therapeutic Modalities for Athletic Injuries*	Human Kinetics	0-88011-838-5
Hecox B, Mehreteab TA, Weisberg MJ, editors	*Physical Agents: A Comprehensive Text for Physical Therapists*	Appleton & Lange	0-0385-8040-8
Kahn J	*Principles and Practice of Electrotherapy* (4th ed.)	Churchill Livingstone	0-443-06553-5
Kitchen S, Bazin S, editors	*Clayton's Electrotherapy* (10th ed.)	Churchill Livingstone	0-443-07216-7
Kitchen S, editor	*Electrotherapy: Evidence-Based Practice* (11th ed.)	Churchill Livingstone	0-443-07216-7
Michlovitz SL, Nolan T, editors	*Modalities for Therapeutic Intervention* (4th ed.)	F.A. Davis	0-8036-1138-2
Nalty T	*Electrotherapy: Clinical Procedures Manual*	McGraw-Hill	0-07-134317-2
Nelson RM, Hayes KW, Currier DP	*Clinical Electrotherapy* (3rd ed.)	Appleton & Lange	0-8385-1491-X
Prentice WE	*Therapeutic Modalities in Rehabilitation* (3rd ed.)	McGraw-Hill	0-07-144123-9
Robertson V, Ward A, Low J, Reed A	*Electrotherapy Explained: Principles and Practice* (4th ed.)	Butterworth Heinemann	0-7506-8843-2
Robinson A, Snyder-Mackler L, editors	*Clinical Electrophysiology*	Lippincott Williams & Wilkins	0-683-07817-8
Shankar K, Randall KD, editors	*Therapeutic Physical Modalities*	Hanley & Belfus	1-56053-434-6
Starkey C	*Therapeutic Modalities for the Physical Therapist Assistant* (2nd ed.)	F.A. Davis	0-8036-0354-1

Index of Recommendations, Rationales, and References