Michlovitz's MODALITIES FOR THERAPEUTIC INTERVENTION

Sixth Edition

James W. Bellew
Susan L. Michlovitz
Thomas P. Nolan, Jr.

Contemporary Perspectives in Rehabilitation

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Sixth Edition

Previously titled *Thermal Agents in Rehabilitation*, editions 1, 2, and 3

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This edition is dedicated to my wife, Mary Helen,
and daughters, Kate and Caroline,
who have amazed me with their joy, love, and support
throughout my career and life,
and to all the students past and present who inspire me every day.

— Jim Bellew

I would like to dedicate this edition to the
students, clinicians, and faculty who have
supported and had faith in this textbook since 1986.

— Sue Michlovitz

This edition is dedicated to the physical therapy faculty at
Stockton University and to the many Stockton physical therapy
students who have contributed to this textbook.

— Tom Nolan

Foreword

Pertain: be appropriate, related, or applicable.

synonyms: concern, related to, be connected with, be relevant to, regard, apply to, be pertinent to, refer to have, affect, involve, touch on

Sustain: strengthen or support physically or mentally

synonyms: comfort, help, assist, encourage, succor, support, give strength to, buoy up, carry, cheer up, hearten

The American Physical Therapy Association defines physical therapists as professional health care providers who . . .

". . . will be responsible for evaluating and managing an individual's movement system across the lifespan to promote optimal development; diagnose impairments, activity limitations, and participation restrictions; and provide interventions targeted at preventing or ameliorating activity limitations and participation restrictions. The movement system is the core of physical therapist practice, education, and research." (http://www.apta.org/Vision/)

There is little doubt that embedded within this definition is the recognition that physical therapists are outstanding authorities on movement pathology and, as such, are responsible for the implementation of new procedures and technologies, irrespective of the patient population for which each possesses the greatest treatment skills. While the advent and assimilation of novel manual skills and assistive technologies are undeniable, throughout our distinguished history a common thread has weaved its way through our professional fabric: our use of modalities as either primary sources of treatment or as adjuncts to our manual skills and the concurrent discourse with our patients. One might say that modalities pertain to much of what we do . . . often to relax or excite tissues or structures in preparation for enhanced function. More often than not, such applications bring comfort to our patients and foster compliance with the totality of a therapeutic plan. We could even believe the tools that we call modalities sustain us because so often there is unequivocal evidence of the immediacy to which our patients respond to their physiological impact. Such positive responsiveness infuses confidence in us by our patients and reaffirms that we are on the right path toward improving an existing pathology.

While this perspective appears encouraging and may validate the belief that we are truly helping our patients, we are equally justified in our concern that perhaps we have come to take for granted the myriad of modalities and the conditions that they can positively influence. Without a reference that is continuously updated and to which any clinician can turn with unabated confidence, perhaps we might lose sight of advances in these agents or in our ability to maintain our position as the foremost authorities in their use. *Modalities for Therapeutic Interventions,* originally called *Thermal Agents in Rehabilitation* in its first iteration as the very first volume within the *Contemporary Perspectives in Rehabilitation (CPR)* series exactly 30 years ago, is now experiencing its sixth edition. The fact that this text has truly withstood the test of time is testimony to how well it has evolved and become beloved as the "go to" textbook on modality use in rehabilitation. This edition has been brilliantly conceived by Drs. Bellew, Michlovitz, and Nolan and now—for the first time—is even more vibrant owing to the four-color format and color photos that pervade its content. All chapters have been updated, and the tradition that "binds" all volumes of the CPR series—challenging case histories and clinical decision-making formatting—is pervasive, as is the infusion of Key Points distributed throughout each chapter. These points stand out in blue print as beacons from which students can extract essential information within subject material.

Jim Bellew provides a new and exciting introductory chapter that reminds students and clinicians about the importance and use of modalities. New chapters on ultrasound (Chapter 4, David Lake), mechanical compression (Chapter 8, Robert Marsico), electrical stimulation for pain control (Chapter 11, Richard Liebano), and modalities for improving range of motion (Chapter 12, Andrew Starsky) and new content on laser therapy within the chapter on Therapeutic Modalities for Tissue

Healing (Chapter 15, Ed Mahoney) are contributions that contain information not previously addressed in the fifth edition. Throughout the text, attention is directed not only to evidence supporting the circumstances for optimal use of a modality (a concept gathering greater appreciation as we struggle to support additional treatment for our patients) but also—equally as significant and so often overlooked—the identification of situations and circumstances where evidence is lacking.

In a time when modalities might be less appreciated, we must not lose sight of the fact that our treatment approaches have become far more dynamic and interactive. If we choose a perspective that advocates for modality application as a vehicle to foster functionally based activity either in conjunction with its use or as an immediate consequence, we begin to see these steadfast stalwarts as our faithful partners, who have always been there for our use but whose appeal can be viewed in a more contemporary mode. For over 70 years they have been a part of our armamentarium. Indeed, they do pertain to the totality of our treatment, and their very presence has always been there to sustain us.

Our collective hope is that this philosophical bent will be conveyed to the next generation of students and clinicians, who will view this text as the friend it has become to past generations.

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Atlanta, Georgia
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Preface to the Sixth Edition

Circa 1982, I met Dr. Steve Wolf at a Pan American Rheumatology Meeting in Washington, DC. He had recently published a book on electrotherapy that I was using in my course at Hahnemann University. I told him I was using his book but needed one for my first course, Thermal Agents. I met F. A. Davis acquisitions editor, Bob Martone, shortly thereafter, and bingo, the second book in the Contemporary Perspectives in Rehabilitation was birthed. In this sixth edition, I have turned over the reins to Dr. Jim Bellew. He continues to team with Dr. Tom Nolan and our many authors to produce a high-quality textbook.

Over the decades of my career as a physical therapist, I have seen modalities used or not used in a similar manner as the action potential of a nerve—that is, "all or nothing." On one end of the spectrum we would frown upon "fake and bake" clinics. At the other end of the spectrum there are therapists and documents that profess the lack of need or that discourage use of any modalities for a patient. Somewhere between lies good clinical reasoning.

To instructors, please do not use the material in this book in isolation of other courses you teach. Combine the information into the curriculum related to musculoskeletal, neuromuscular, and integumentary problems. Foster rationale and logical uses of modalities in the patient-centered care model. Teach your students how to appropriately assess the need for a modality within a treatment paradigm and how to appropriately measure the outcome.

Over the last five editions, we have worked and reworked sections and chapters. You can read through the table of contents and peruse the book to appreciate the variety of topics covered by expert clinician authors. Aspects of rational clinical decision-making are threaded throughout the chapters. We want our patients to have the best chance to work toward functional mobility and improve their body structure and function, activities, and participation. The judicious use of modalities is a good place to begin.

To all young faculty and students who aspire to work on projects, be careful what you ask for! I met Steve Wolf in 1982, had a brief discussion, and was on the road to a textbook that is now in its sixth edition.

Enjoy this textbook and please do give us feedback.

Sue Michlovitz

Preface to the First Edition

Thermal agents are used in physical therapy and rehabilitation to reduce pain, to enhance healing, and to improve motion. The physical therapist should have a solid foundation in the normal physiologic control of the cardiovascular and neuromuscular systems prior to using an agent that can alter the function of these structures. In addition, a background in the physiology of healing mechanisms and of pain serves as a basis for the rationale of using thermal agents.

Often, the decision to include a thermal agent in a therapy plan or to have the thermal agent be the sole treatment rendered (as in the case of the frequently used "hot packs and ultrasound combination" for back pain) is based on empirical evidence. The purpose of this book is to provide the reader with the underlying rationale for selection of an agent to be included in a therapy program, based on (1) the known physiologic and physical effects of that agent; (2) the safety and use of the heat/cold agent, given the conditions and limitations of the patient's dysfunction; and (3) the therapeutic goals for that particular patient. The authors have been asked to review critically the literature available that documents the efficacy and effectiveness of each thermal agent. A problem-solving approach to the use of thermal agents is stressed throughout the text.

The primary audience for this text is the physical therapist. The student will gain a solid foundation in thermal agents, the clinician will strengthen his or her perspective of thermal agents, and the researcher is given information that will provide ideas for clinical studies on thermal agents. Athletic trainers and other professionals who use thermal agents in their practice should find this text of value.

The text is in three parts. Part I, Foundations for the Use of Thermal Agents, includes information from basic and medical sciences that can serve as a framework for the choice to include thermal agents in a rehabilitation program. A discussion of the proposed mechanisms by which heat and cold can alter inflammation, healing, and pain is included in these chapters.

Part II of the text, Instrumentation: Methods and Application, incorporates concepts of equipment selection, operation and maintenance, and clinical application. The leading chapter in this part is on instrumentation principles and serves to introduce concepts of equipment circuitry and safety as applied to equipment used for thermal therapy. Physical therapists have become responsible for product purchase and making recommendations about products through the expansion of consultation services, private practices, sports medicine clinics, extended care facilities, and home health care. Therefore, we must be prepared to engage in dialogue with manufacturers, product distributors, and other colleagues about the safety and quality of these products. To this end, some practical suggestions are provided in Chapter 3 to assist with purchase decisions.

Chapters 4 through 8 discuss the operation and application of heat and cold agents. Numerous principles of clinical decision-making are included within each chapter. There are certain principles inherent to all agent applications: (1) The patient must be evaluated and treatment goals established; (2) contraindications to treatment must be known; and (3) the safe and effective use of equipment must be understood.

Chapter 9, on low-power laser, deviates somewhat from the overall theme of thermal agents. Low-power laser is not expected to produce an increase in tissue temperature, so its effects could not be attributed to thermal mechanisms. Therefore, this cannot be categorized as a thermal agent. However, I believe this topic is worthy of inclusion in this text because (1) the indications for its use overlap those of thermal agents; (2) laser is a form of non-ionizing radiation, as are diathermy and ultrasound, which are used for pain reduction and tissue healing; and (3) laser would most likely be included in a physical therapy student curriculum in the coursework that includes thermal agents. At the time of this writing (summer 1985), low-power laser is still considered by the U.S. Food and Drug Administration as an investigational device. Only carefully designed clinical studies will help determine the laser's clinical efficacy—perhaps contributing to the body of knowledge needed to change the laser's status from an investigational to an accepted therapeutic product.

Part III, Clinical Decision Making, is designed to assist the student and clinician in integrating basic concepts that have been presented throughout the entire book, emphasizing problem solving and evaluation.

Much information has been published in the medical literature on the effects or clinical results of heat and cold application. Oftentimes, the therapist is called upon to justify the use of a certain modality. A careful review of the research literature may be necessary to provide an explanation for treatment.

There are many areas that require further investigation. For example, contrast baths (alternating heat and cold) are often used in sports medicine clinics. But a careful review of the literature reveals that only scanty information supports the use of contrast baths for any patient population. It is important for the clinician to be able to interpret accurately and to apply the methods and results that are presented in the literature. The inclusion of a chapter (Chapter 10) on techniques for reviewing the literature and establishing a paradigm for clinical studies of thermal agents provides the clinician with such a background on which to build.

Chapters 11 and 12 are devoted to specific patient populations in which thermal agents are commonly used. The chapter on sports medicine is representative of a population with a known cause of injury and predictable course of recovery. The majority of these patients are otherwise healthy. On the other hand, the chapter on rheumatic disease presents a model for a patient population that can be expected to have chronic recurrent—sometimes progressive—dysfunction associated with systemic manifestations.

An appendix is included: temperature conversion scales (this text uses the centigrade scale).

Susan L. Michlovitz, PhD, PT, CHT

Acknowledgments

To continue into this sixth edition would not be possible without the continued support of our loyal users. Thank you to the faculty, students, and clinicians who have continued to use this text throughout its history. Many thanks are due to the special people at F. A. Davis who continue to support this text: Melissa Duffield, George Lang, and Margaret Biblis. A very special thank-you goes to the developmental editor, Susan Williams, of the Williams Company, for all the guidance and experience in completing this edition. Thank you to Jason Torres of J. Torres Photography for the outstanding photography included in this first full-color edition. Thank you to Drs. Joe McCulloch and Ed Mahoney of the School of Allied Health Professions at the Louisiana State University Health Sciences Center–Shreveport for their contribution of several key images throughout this text. Thank you to Dr. Rick Proctor and Dave Walters of DJO Global for supplying equipment for the photo shoot. And finally, but never last, a huge thank-you to the students who participated as models in this edition: Daniel Batteiger, Brooke Versteeg, Allison Colligan, and Austin Biefnes from the University of Indianapolis, and Jamie Umstetter, Brandon Dooley, Kavita Patel, and Matthew Romen from Richard Stockton University.

Biographies

James W. Bellew

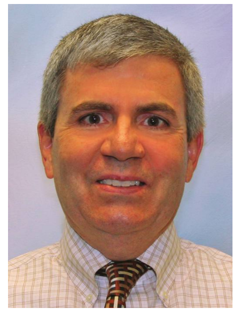
James W. Bellew, PT, EdD, is Professor of Physical Therapy in the Krannert School of Physical Therapy at the University of Indianapolis. Dr. Bellew received his entry-level bachelor of science degree in physical therapy from Marquette University. After several years of clinical practice in Milwaukee, he received a master of science degree in physical therapy and doctor of education degree in exercise physiology from the University of Kentucky. His research encompasses the use of electrotherapeutic waveforms and muscle physiology. Dr. Bellew has published more than 50 peer-reviewed scientific manuscripts and abstracts in the areas of electrotherapy, exercise training, balance, and muscle physiology. He teaches in the areas of clinical medicine, therapeutic modalities, and human physiology. He is a regular presenter and speaker at the American Physical Therapy Association's (APTA) Combined Sections Meetings and is routinely sought nationally and internationally for consultation regarding clinical applications of electrotherapeutic agents. In 2013, he was named conference president for an international meeting on electrophysical agents in Amparo, Brazil. He is a member of APTA and Academy of Clinical Electrophysiology and Wound Management. Dr. Bellew resides with his family in Indianapolis and maintains a regular clinical practice at St. Francis Hospital Rehabilitation Services.

Susan Michlovitz

Susan Michlovitz, PT, PhD, CHT, is a hand therapist and physical therapist. Her clinical interests include arthritis, trauma, and disorders affecting the hand, wrist, and elbow. Dr. Michlovitz is also an adjunct associate professor of rehabilitation medicine at Columbia University, where she teaches in the Doctorate of Physical Therapy Program. In 2005, she was a professor in the Department of Physical Therapy at Temple University, Philadelphia. Her published research has been in determining the effectiveness of therapy interventions and in reliability and validity of examination techniques, mostly related to hand and upper extremity conditions.

Dr. Michlovitz has extensive experience in teaching therapists at the APTA Combined Sections Meetings, the American Society of Hand Therapists (ASHT), the American Association for Hand Surgery (AAHS) Annual Meetings, and the International Federation for Societies of Hand Therapists. She is an associate editor for case reports in the *Journal of Hand Therapy*. Her volunteer outreach work is spent with Guatemala Healing Hands Foundation for teaching and patient care in Guatemala City. She lives in Ithaca, New York, with her husband, Paul Velleman, their basset hound/beagle, Mr. Baxter, their beagle Freddy, and a somewhat calico cat named Shayna. Sue is a wannabe photojournalist.

Thomas P. Nolan Jr.



Thomas Patrick Nolan Jr., PT, MS, DPT, OCS, is associate professor of physical therapy at Stockton University. Dr. Nolan received his bachelor of science in physical therapy from New York University and his master of science and doctor of physical therapy in physical therapy from Temple University. He is a certified orthopedic specialist (OCS) through the American Board of Physical Therapy Specialties. Dr. Nolan teaches physical modalities, electrotherapy, kinesiology of the spine, musculoskeletal physical therapy, and pharmacology at Stockton University, where he is also the coordinator of physical therapy continuing education courses. He is a per diem physical therapist for Virtua in Motion outpatient offices located in southern New Jersey. He is a member of APTA and the APTA New Jersey Chapter, the APTA Academy of Clinical Electrophysiology and Wound Management, and the APTA Orthopaedic Section. Tom lives in Marlton, New Jersey, where he enjoys spending time with his family at home and summers in Ocean City, New Jersey.

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Contents

How to Use This Book

THERAPEUTIC MODALITIES AS A CURRICULAR THREAD

Traditional classroom and lab-based education in the principles and administration of therapeutic modalities has remained a cornerstone in educational programs within the rehabilitation sciences. The history and evolution of the clinical rehabilitation sciences have shown that certain areas of practice, such as electrical stimulation for denervated muscle or ultraviolet treatment for psoriasis, have waned, whereas other areas of clinical practice, such as integumentary or wound care and oncology, have grown immensely over the past few decades. Consequently, curricular content has undergone continual change and updating. This flux of curricular content reflects the advancement of scientific discovery and application and the mounting rise of literature to bolster evidence-based practice. The fact that curricular content given to principles and application of therapeutic modalities has remained pervasive in educational programs within the rehabilitation sciences substantiates the continued contribution of this area of practice to the more encompassing patient management model.

Although principles and applications of therapeutic modalities remain foundational content in most programs in the rehabilitative sciences, this content is far too often insular or taught apart from other curricular content, such as orthopedics, neurological rehabilitation, integumentary care, patient management, and other areas. This is wholly ironic because therapeutic modalities represent a group of interventions used to augment or supplement interventions taught in these course areas. Many areas of rehabilitative science, such as orthopedics or neurological rehabilitation, are taught with strategic course sequencing with content increasing accordingly in more advanced courses. However, content in therapeutic modalities often exists in a single "how to" course or, worse yet, a smaller part of a single course. Few educational programs sequence curricular content in therapeutic modalities in a progressive manner. Rather, therapeutic modalities are often taught separate from the interventions they complement. For example, orthopedic or musculoskeletal courses include instruction in rehabilitation following surgical repair of the anterior cruciate ligament. Incorporation of therapeutic modalities, such as neuromuscular electrical stimulation, biofeedback, or cryotherapy, reflects the reality of clinical care and better represents the complete patient management model than teaching these elements in a separated or disengaged manner. Because therapeutic modalities are too frequently taught in isolation, students receive a limited "one-time" exposure. It is our intention that this book be used not only in the primary therapeutic modalities course but also in courses where therapeutic modalities supplement or complement the interventions taught in those content-specific course areas, such as orthopedics, neurological rehabilitation, and so on.

At risk is clinical competency when therapeutic modalities are taught in isolation with little to no carry-through in the curriculum to relate or connect therapeutic modalities to those conditions or impairments for which they are advocated. It is our suggestion that the content of this book be used throughout the curriculum where therapeutic modalities offer adjunctive interventions. By maintaining continuity throughout the curriculum between therapeutic modalities and the specific clinical areas of their supported application, a curricular thread is created, thereby improving clinical decision-making skills and competency.

The following table represents specific chapter content in this text and the potential curricular areas where use of therapeutic modalities are part of common clinical practice. It is our belief that the content of this text may be threaded or cross-referenced across the curriculum to reinforce the supplementary role that is offered by therapeutic modalities.

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Chapter Content and Related Curricular Areas

This table shows how therapeutic modalities may be strategically threaded throughout a curriculum to complement the primary content of each section area. Doing so reinforces the role and use of therapeutic modalities as therapies aimed at augmenting or complementing additional areas that are part of the complete patient care plan.

Therapeutic modalities for:	Cross-referenced courses:
Flexibility/ROM Thermotherapy (Chapter 3) Ultrasound (Chapter 4) Hydrotherapy (Chapter 5) Traction (Chapter 7) Electrotherapy (Chapter 12)	Orthopedics, Neurological Rehabilitation, Therapeutic Exercise, Kinesiology, Integumentary for US and Hydrotherapy
Strengthening NMES (Chapters 9, 10, 13, 14) Biofeedback (Chapter 13)	Orthopedics, Therapeutic Exercise, Exercise Science/Physiology, Neurological Rehabilitation
Neuromuscular Reeducation FES (Chapters 9, 10, 14) Biofeedback (Chapters 13, 14)	Neurological Rehabilitation, Orthopedics
Pain Modulation Cryotherapy and Thermotherapy (Chapters 2, 3) Ultrasound (Chapter 4) Hydrotherapy (Chapter 5) LASER and Diathermy (Chapter 6) Traction (Chapter 7) Electrotherapy (Chapters 9, 10, 11) Alternative Modalities (Chapter 16)	Orthopedics, Integumentary
Tissue Healing Electrotherapy (Chapters 10, 15) Hydrotherapy (Chapter 5) Cryotherapy and Thermotherapy (Chapters 2, 3) Ultrasound (Chapter 4) Compression (Chapter 8) Alternative Modalities (Chapter 16)	Orthopedics, Neurological Rehabilitation, Integumentary, Pharmacology
Neurodiagnostics EMG and NCV (Chapter 17)	Orthopedics, Neurological Rehabilitation

SECTION I

Introduction to Therapeutic Modalities

CHAPTER 1

Therapeutic Modalities Past, Present, and Future

Their Role in the Patient Care Management Model

CHAPTER 1

THERAPEUTIC MODALITIES PAST, PRESENT, AND FUTURE

Their Role in the Patient Care Management Model

James W. Bellew, PT, EdD

THERAPEUTIC MODALITIES: ROLES IN REHABILITATION

Therapeutic modalities represent the administration of thermal, mechanical, electromagnetic, and light energies for a specific therapeutic effect; for example, to decrease pain, increase range of motion (ROM), improve tissue healing, or improve muscle activation. The terms *therapeutic modalities* and *physical agents* are often used interchangeably to describe a wide array of treatments and interventions that provide a variety of therapeutic benefits. The term *physical agents* reflects the use of physical energies—such as thermal, mechanical, electromagnetic, or light—but fails to include the purpose or intention of their application. The term *therapeutic modalities,* as used throughout this text, more appropriately reflects the ability of these interventions to provide therapeutic benefits.

Therapeutic modalities have long been, presently are, and will continue to be a part of rehabilitation and are used to complement other elements of the more comprehensive patient care plan, such as therapeutic exercise (e.g., strengthening, stretching, neuromuscular reeducation, balance), manual therapy (e.g., joint and tissue mobilization, manipulation), and patient education (e.g., body mechanics, postural retraining, home exercise program, risk reduction). Cold therapy and compression may be used in the early phases of rehabilitation to limit swelling and pain that a patient may experience following acute injury or surgery. Continuous ultrasound or other heat therapy may be applied to improve elasticity of ligaments or joint capsular structures before beginning ROM activities in a patient who has deficient ROM. Electrical stimulation may be used to increase activation and facilitate volitional recruitment of skeletal muscle until the patient can effectively contract the muscle and begin additional activities. These examples reflect the complementary use of modalities to achieve clinical goals. Because the effectiveness of these treatments may vary from patient to patient, the practitioner is challenged to identify those patients who are more likely to respond to a specific intervention. In this manner, the practitioner must consider or judge the probability or likelihood that a given intervention will help a particular patient. These decisions and others represent the basis of *clinical decision-making*. Competency with clinical decision-making is the basis for effective patient outcomes and attainment of goals.

Therefore, clinical decision-making can be thought of as the process of using information, experience, and judgments to decide which clinical interventions will most likely improve the problems identified in the examination. The bottom line is this: When identifying and establishing an intervention plan, the focus should be on selecting interventions that will most likely achieve positive results or outcomes—both quantitative and qualitative. When judiciously selected and applied, therapeutic modalities may play a significant role in successful patient care.

> ***Key Point!*** In 2014, the American Physical Therapy Association began recommending use of the term "biophysical agents" to collectively refer to physical agents and modalities. We, the editors of this text, support this recommendation and recognize the advancements of our profession in better delineating and understanding the role of biophysical agents in rehabilitation. To maintain consistency with the title of the previous five editions of this text, the term "modalities" will be used interchangeably with biophysical agents throughout this edition. As the transition to the term biophysical agents progresses, future editions of this text will integrate such use.

Clinical decision-making—regarding the best modality to use, when to use it, and which patients are most likely to respond—remains relevant, but more critical and incumbent upon the practitioner is the challenge to use current best evidence to better define the therapeutic dose for a given treatment. This point was well articulated by Meryl Gersh, a professor of therapeutic modalities, who stated, "We would not expect a subclinical dose of antibiotics to successfully treat an infection. So why do we continue to apply TENS at sensory thresholds or a strong, comfortable level of sensation when the evidence suggests that stronger intensities applied for longer durations result in significant analgesia?"

> ***Key Point!*** The current challenge when using therapeutic modalities is to identify and establish consensus for optimal doses and treatment procedures.

As practitioners, we are often challenged by patients who have multiple impairments and dysfunctions. Our role as experts in rehabilitation is to identify and skillfully provide interventions to address these impairments, thus providing optimal recovery of function. Even when facing a seemingly uncomplicated patient case whose therapy plan is clear, the emergence of confounding variables often impacts the execution of the initial plan of care. Imagine this happening during therapy: Your patient, who has decreased ROM and strength, is unable to complete the appropriate therapeutic activities to address ROM and strength because of underlying pain, or your patient has significant swelling of the knee and is unable to effectively contract the quadriceps secondary to effusion inhibition. Although increasing ROM and strength or volitional muscle recruitment are obvious goals in the plan of care, attention may first need to be given to decreasing the pain or reducing the effusion to help the patient continue with the therapy plan.

In their assessment of how therapeutic modalities affect muscle inhibition following knee joint effusion, Hopkins et al[1] reported that effusion-induced inhibition of the quadriceps was temporarily suspended with application of cold or transcutaneous electrical nerve stimulation (TENS), noting a near complete reversal of quadriceps inhibition. This finding provides a rationale for using and considering therapeutic modalities as complements to the therapy plan.

Modalities as Part of the Comprehensive Plan

Therapeutic modalities have long been used in rehabilitation, and history of their use is well documented.

Although the use of therapeutic modalities has varied over the years, their application remains pervasive in many areas of clinical practice across several professions. In early 2014, the Centers for Medicare and Medicaid Services (CMS) released data on Medicare payments for services provided in 2012. Electrical stimulation (unattended) and ultrasound ranked sixth and eighth, respectively, among the top 10 procedures in total Medicare payments to providers of physical medicine and rehabilitation services in 2012 (available at www.healthdata.gov). With this sustained usage has come greater clinical interest, more research, and evidence of the effects of modalities, yet much regarding their use remains poorly agreed upon, ill-communicated, and even less accepted by some.

With advancing technology and scientific discovery has come the evolution and emergence of newer modalities that add to the spectrum of interventional strategies and that enhance their role in rehabilitation. Use of therapeutic modalities has been and will remain a cornerstone of rehabilitation for joint and soft tissue injury, acute and chronic pain, and impaired muscle function. Whether used only during specific phases of rehabilitation or throughout the entire rehab program, therapeutic modalities represent a group of interventions that are adjunctive components of a more comprehensive therapy plan. Figure 1-1 depicts the complementary role therapeutic modalities play in the complete intervention plan.

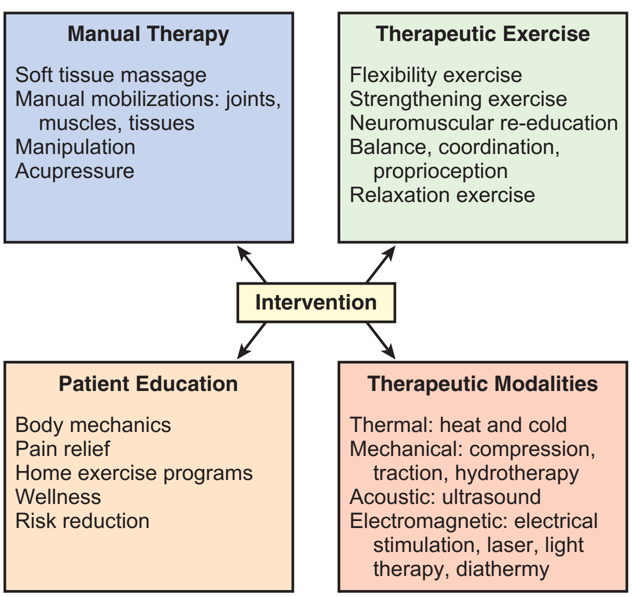

Fig 1 ■ 1 Therapeutic modalities represent a diverse group of interventions that add to and complement other therapies that are part of the comprehensive rehabilitation plan.

Clinicians should review current evidence when therapeutic modalities are considered as adjuncts for an intervention plan. Many techniques in common use have not been studied, which has led to scientific inquiry addressing the efficacy of many therapeutic modalities. However, it should be noted that many studies examining the effectiveness of therapeutic modalities often assess their efficacy when used alone or in isolation—separate from and counter to the supplementary role that the editors of this text and the American Physical Therapy Association (APTA) advocate.

Key Point! In 2014, the APTA Choosing Wisely campaign specifically addressed the use of therapeutic modalities, stating that clinicians should not "employ passive physical agents except when necessary to facilitate participation in an active treatment program." This followed their earlier position statement that "without documentation that justifies the necessity of the exclusive use of physical agents, the use of physical agents, in the absence of other skilled therapeutic or educational intervention, should not be considered physical therapy."[2] These statements reflect the standpoint from which we, the authors of this text, attempt to present the use and administration of and evidence for therapeutic modalities as complementary, not stand-alone, therapies used as part of the complete patient care plan.

TYPES OF THERAPEUTIC MODALITIES

Therapeutic modalities are generally categorized as *thermal* (heat and cold), *electromagnetic* (electrotherapy, diathermy, ultraviolet, and infrared light), or *mechanical* (traction and compression). These modalities are used to increase the probability of a specific therapeutic effect (e.g., decreased pain, increased ROM, tissue healing, or improved muscle recruitment). Therapeutic modalities may be procedural, in-clinic interventions, such as ultrasound, or they may be home-based interventions, such as ice packs or continuous, low-level heat wraps, and even electrical stimulation; these serve to enhance additional therapeutic interventions identified in the more extensive plan of care, such as ROM or muscle strengthening.

> ***Key Point!*** The term *therapeutic modality* can imply a *type* of energy used by the modality, a specific *range* of that energy, or the *method* of application of that modality.

Remember the impairments you found in your evaluation of the patient with a suspected knee injury: decreased ROM, decreased strength, pain, and swelling? These are just a few of the many problems for which therapeutic modalities may be used in conjunction with other interventions. In this manner, therapeutic modalities are used to increase the probability that certain clinical outcomes are realized.

The term *therapeutic modality* can have several meanings that vary based on the context in which it is used. For example, ultrasound represents both a *form* of energy (i.e., sound energy) and a specific *range* of energy (i.e., greater than 20,000 Hz). By convention, ultrasound has come to represent a *method* or means of delivering a therapeutic modality. It is prudent to be as specific as possible regarding the administration of a modality. When applying ultrasound, for example, it is recommended that the specific frequency used (i.e., 1 MHz or 3.3 MHz) be documented in addition to documenting the form of energy applied (i.e., ultrasound). Human hearing can detect sound frequencies ranging from approximately 15,000 to 20,000 Hz. Thus, *ultrasound* is named for the frequency range above human hearing. Ultrasound derives its name because the sound frequency used with therapeutic ultrasound is in the megahertz range, well beyond the 15,000 to 20,000 Hz range the human ear can detect.

Thermal Modalities: Cold and Heat

Cryotherapy

Cryotherapy (i.e., cold therapy) is the use of cold to induce the therapeutic and physiological responses that result from a decrease in tissue temperature. Therapeutic application of cold will result in reduced blood flow and tissue metabolism—physiological responses that decrease bleeding and acute inflammation following injury or tissue disruption. The application of cold also reduces pain, as the threshold for pain perception is elevated, thereby desensitizing peripheral afferent nociceptors.[3] Collectively reducing swelling and pain may permit patients to complete the other components of the therapy plan, again reinforcing the supplementary role of modalities.

Therapeutic cold can be applied using ice, cold water, cold gel-filled packs, or vapocoolant sprays. Cold packs and ice packs are the most common and familiar applications of therapeutic cold (Fig. 1-2). Ice packs can easily be made at home and used as part of the patient's home program. Commercially made cold packs often contain a gel-like substance that allows the cold pack to mold to the affected body part. Cold water may provide therapeutic benefit and may be applied as cool whirlpool, cold water baths, or added to ice packs to create a slushy ice-water mixture that can be molded to the body part. In addition, larger pieces of ice held in the hand may be used to provide an ice massage (Fig. 1-3) or may be used as an "ice pop" (Fig. 1-4). Also used to reduce tissue temperature are topical, or vapocoolant, sprays (such as Spray and Stretch) that result in rapid, superficial, and short-lived tissue cooling by means of evaporation.

Whichever application of therapeutic cold is most appropriate and most effective will depend on several

Fig 1 ■ 2 Cold therapy can be applied by use of gel or ice packs.

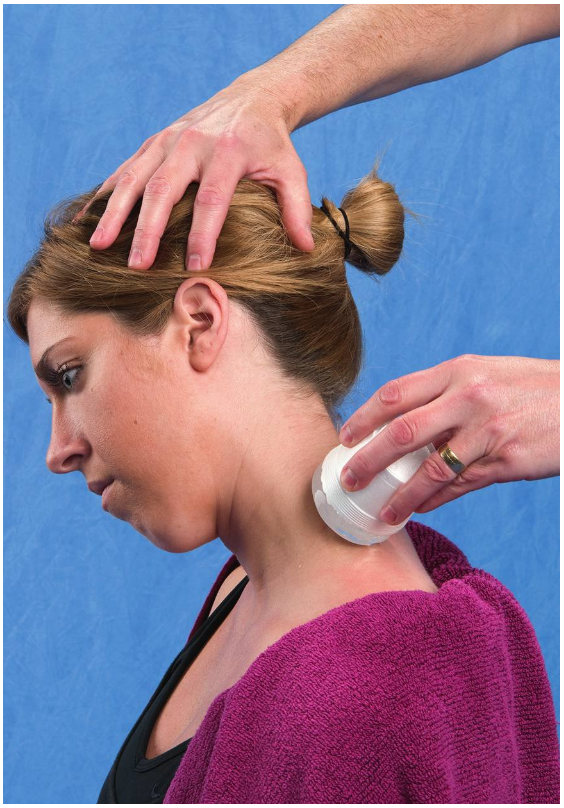

Fig 1 ■ 3 Handheld ice cups provide cold therapy during an ice massage.

factors, including the size of the affected area, the depth of the tissues to be treated, the patient's tolerance to cold, and whether the application will occur in the clinic or at home. More extensive descriptions of cryotherapy and therapeutic use of cold are found in Chapter 2.

Thermotherapy

The therapeutic application of heat provides a variety of benefits that augment the comprehensive therapy plan. Heat may facilitate tissue healing, relax skeletal muscles and decrease spasms, decrease pain, promote an increase in blood flow, and prepare joints, capsular structures, muscles, and other soft tissues for stretching, mobilization, and exercise.[4–7]

Heat can be applied in many forms and through various mediums. Warm water as used in a bath or whirlpool has long been used in rehabilitation and can easily be used at home. Use of heat packs, both in-clinic and at home, have led to the commercial production of single-use heat wraps that can be placed on various body regions (Fig. 1-5). Heat may also be delivered through the use of light, sound, and electromagnetic energies.

Fig 1 ■ 4 Use of handheld "ice pops" offers quick and efficient cold therapy to many areas where cold packs may be less effective.

Fig 1 ■ 5 Heat wraps are an easy and convenient source of heat therapy.

The warmth of the sun's rays is a well-known example of heat transfer via ultraviolet energy. Shortwave diathermy (SWD) can provide therapeutic heat through the use of electromagnetic energy, and acoustical or sound energy from ultrasound can be used to increase tissue temperature. Warm water and hot packs are used to raise tissue temperature in the skin and the superficial subcutaneous tissues, whereas continuous-wave ultrasound and SWD are better suited to raising temperature in deeper tissues (up to 5 cm). Selection of the appropriate form of therapeutic heat will depend on several factors, including the area to be treated, the depth of the tissues to be heated, the patient's tolerance to heat, the patient's medical history, and the interventions to be used that are complemented by therapeutic heat. More extensive detail on therapeutic heat and its application are presented in Chapter 3.

Electromagnetic Modalities

Electrotherapy

Electrical currents are used for a wide variety of therapeutic benefits and for an equally wide variety of needs. General therapeutic benefits of electrotherapy may include strengthening and relaxing skeletal muscle, decreasing pain, facilitating neuromuscular reeducation, augmenting ROM, attenuating disuse atrophy, promoting tissue and wound healing, reducing edema, increasing local blood flow, and delivering medicinal ions transdermally. The robust and wide-ranging therapeutic benefits of electrotherapy are derived from the selection of specific parameters of electrical currents such as amplitude, duration, and frequency.

Fundamental to most applications of electrical stimulation is the depolarization, or activation, of peripheral nerves. Use of TENS to decrease perception of pain is one of the most widely recognized applications of electrotherapy, and its clinical effects have been extensively researched.[8–10] Activation of skeletal muscle is used for increasing strength (known as *neuromuscular electrical stimulation,* or NMES) or for restoring or improving use of skeletal muscle during functional activities such as walking (known as *functional electrical stimulation,* or FES; Fig. 1-6). Research continues to delineate the benefits of electrotherapy for actuation of skeletal muscle.[11,12]

Use of certain electrotherapeutic currents have also demonstrated specific and unique effects on cell populations found in wounds and healing tissues.[13–16] Iontophoresis is the use of electrical current to facilitate the delivery of specific drugs and ions to reduce tissue inflammation, decrease local pain, reduce calcium deposits, and reduce scar restrictions. More extensive descriptions of the principles and applications of electrotherapy are presented in Chapters 9 and 10.

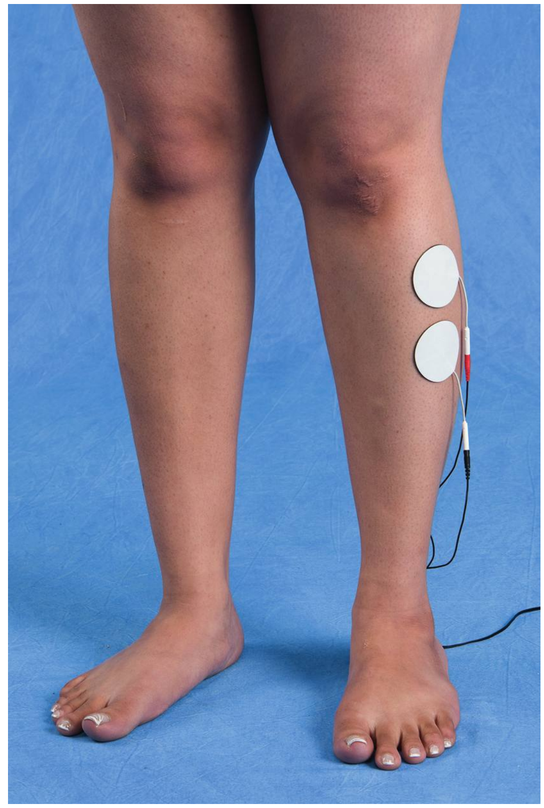

Fig 1 ▪ 6 Electrical stimulation can be used to facilitate functional activities. Stimulation of the anterior tibialis in patients with impaired activation can assist in dorsiflexion of the ankle during gait.

Electromagnetic radiation is used for a variety of therapeutic benefits, both thermal and nonthermal. Classified according to the specific frequency of the electromagnetic wave, therapeutic electromagnetic radiation includes SWD, infrared radiation (IR), and ultraviolet (UVA and UVB) radiation. Continuous SWD and infrared are used to increase tissue temperature. IR increases temperature more in superficial tissues; SWD heats both superficial and deep tissues (Fig. 1-7). The therapeutic benefits of tissue heating complement soft tissue and joint mobilization,[17,18] muscle activation,[19] flexibility,[17] tissue healing,[20] and pain modulation.[19,21]

SWD has primarily been used as a thermal modality. Nonthermal benefits of therapeutic electromagnetic

Fig 1 ■ 7 Diathermy provides heating of deep tissues and may precede stretching or other range of motion activities.

radiation (e.g., UVA and UVB and pulsed diathermy) remain somewhat unclear but are thought to affect activity at the cellular level, perhaps by altering permeability of the semipermeable phospholipid bilayer, enhancing metabolic activity of the cell and production of adenosine triphosphate (ATP), or altering the activity of membrane-bound cell proteins.[20] More detailed descriptions of the therapeutic benefits and applications of electromagnetic energy are provided in Chapter 6.

Mechanical Modalities

Compression

Force, either of a compressive or distractive nature, may be used for therapeutic benefit during rehabilitation. Compressive force may come from application of wraps, stockings, or garments. It may also come from compression pumps and even from water via the hydrostatic pressure created when a body part is submerged in water. Compression techniques are applied to prevent, attenuate, or reverse swelling that may follow soft tissue injury or compromise the circulatory system, or they may be applied to alter formation of scar tissue during the proliferation and maturation phase of scarring.

The principal mechanism underlying the use of compression to manage edema is applying external compression on the body or body part to increase hydrostatic pressure in the interstitial space. This directs counterpressure at the outflow of fluid from the compromised vessels, thereby reducing the accumulation of fluid in the interstitial space. Compression may also be used during the formation and modeling of scar tissue (e.g., following burn injury) to minimize scar formation and reduce hypertrophic scarring. Unlike collagen synthesis, which requires oxygen, collagen lysis does not require oxygen; therefore, compression can be used to limit scar formation while not affecting scar lysis[22] (Fig. 1-8).

Traction

Mechanical or manual traction is the application of distractive forces to lessen or reduce compression on a structure and is most commonly associated with spinal traction (Fig. 1-9). By separating or reducing compression of adjacent segments, such as joints, or reducing pressure on anatomical structures, such as nerves, blood vessels, and joint capsules, traction may be used to decrease pain, increase ROM, improve functional ability, increase blood flow, and reduce muscle guarding. Manual therapy, exercises for muscle strengthening and

Fig 1 ■ 8 Compression can be used to limit or reduce swelling that often follows soft tissue damage.

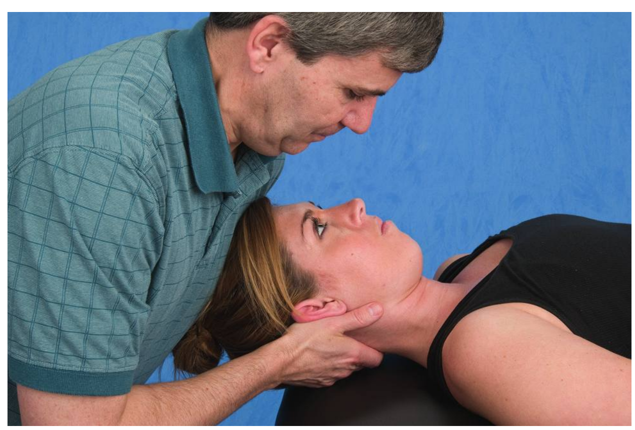

Fig 1 ■ 9 Manual or mechanical traction is used to reduce the compression on a structure such as a joint, nerve, or tissue. Both clinical and home-based forms of traction are used for therapeutic benefit.

retraining, and neural mobilization are often incorporated in conjunction with traction as part of a patient's care plan.[23–26] Devices are available that allow the patient to perform traction at home as part of a comprehensive rehabilitation program. Chapter 7 details the therapeutic benefits and clinical application of traction, along with the controversies of proposed effects of these techniques.

CLINICAL APPLICATIONS OF THERAPEUTIC MODALITIES

Modulation of Pain

Pain may be the most common symptom that leads patients to seek medical intervention. The unique experiences of pain among individuals make this a challenging alteration in body function to manage. The neurobiophysiology of pain generation, transmission, and perception is well described in other sources, and all academic programs in rehabilitation sciences contain curricular content that describes pain.[27,28]

Early discussions of pain modulation were centered on interrupting the ascending pathways of pain (i.e., blocking the transmission of pain along the nerve pathways to more central centers). Widely recognized as the "gate control" theory of pain, this theory described a relationship between painful sensory input carried by small myelinated A-delta and unmyelinated C fibers versus larger diameter and myelinated A-beta nerve fibers.[29] Noxious stimuli carried by A-delta and C fibers are blocked by sensory input along A-beta fibers. Logically, then, efforts to treat pain are often directed at stimulating the large A-beta fibers through various means. Electrical stimulation targeting large afferent nerve fibers is common in rehabilitation, as is the use of ultrasound, cold, heat, diathermy, and other treatments to decrease or modulate noxious sensory input.

Understanding the neurobiophysiology of pain generation, transmission, and perception has grown immensely since the origination of the gate control theory. Chapter 11 addresses the use of electrical stimulation for pain modulation. For a more detailed description of the neurobiophysiology of pain, the reader is directed to other resources.[28] Attention given to the gate control theory of pain in the late 1960s and early 1970s spurred tremendous growth and development of handheld electrical stimulators designed to provide electrical stimuli to A-beta fibers. This period is considered the birth of TENS and other devices to deliver such currents.

Modulating pain is undoubtedly a central focus of rehabilitation, both in the initial stages and throughout the therapy plan. Because pain may limit or even preclude rehabilitative efforts to restore or increase function, attempts to decrease pain often coincide with or even precede efforts toward restoring function. Following the initial injury, for example, soft tissue insult may result in a cascade of inflammatory and reparative physiological events manifesting in pain. Swelling secondary to vascular damage may compress nearby structures, and chemical irritants associated with injury (e.g., bradykinin, PGE1, PGE2) may be released; both of these result in the generation and transmission of pain. Use of therapeutic modalities, such as cold and compression in the initial stages following injury, can reduce swelling and limit production and accumulation of pain-associated chemicals, thereby reducing the patient's perception of pain. This initial reduction of pain can then allow the patient to initiate activities as part of the larger therapy plan (Fig. 1-10).

In the later stages of rehabilitation, therapeutic modalities such as ultrasound may be used to facilitate formation and organization of collagen when administered right before soft tissue mobilization and flexibility exercises. Likewise, muscle weakness and lack of neuromuscular coordination have been associated with dysfunctional movement patterns, and practitioners commonly acknowledge that pain may result from these dysfunctional movement patterns. Electrical stimulation and

Fig 1 ■ 10 Cold therapy is often used during the initial stages of injury to decrease swelling and pain. The reduction of pain and swelling may allow the completion of other activities of the rehab plan.

electromyographic biofeedback can be used to increase muscular strength and coordination, thus addressing the underlying factors related to the movement dysfunction.

To reduce pain, therapeutic modalities may act locally at the site of injury and inflammation to limit the local chemical irritants; this positively impacts the perception of pain by reducing or attenuating the initial creation and generation of pain. (The local effects of therapeutic modalities on tissue's response to injury are addressed in chapters throughout this text and are a strong focus of Chapter 11.) The activity and direction of the migration of specific cells associated with the healing response of tissues, such as neutrophils and macrophages, can be influenced by applying therapeutic modalities such as electrical stimulation. This is further evidence of the enhanced effect on healing that can be harnessed with the use of therapeutic modalities.[15,16,30]

Key Point! Modalities are used to improve or ameliorate alterations in body function such as loss of ROM, pain, and tissue damage.

Alteration of Skeletal Muscle Performance: Facilitation and Inhibition

Therapeutic modalities can be used both directly and indirectly to influence the activity and performance of skeletal muscle to increase or decrease levels of muscle activation for therapeutic benefit. Direct applications of therapeutic modalities to facilitate skeletal muscle performance may occur, for example, by using electrical stimulation to depolarize peripheral nerves to recruit more motor units. A patient with decreased ability to contract the quadriceps after knee surgery may demonstrate increased muscle recruitment following application of electrical stimulation.

NMES and FES are used to increase strength, endurance, and functional use of skeletal muscle for a variety of therapeutic purposes. More recent evidence shows that NMES directly increases the volume or total number of motor units recruited and the duration those motor units are activated; these are both fundamental to the positive adaptations underlying gains in strength seen with NMES.[31] Facilitation of skeletal muscle in patients with compromised ability to activate specific muscles or muscle groups can be used to assist in functional activities such as retraining gait, increasing function of the upper extremity and hand, improving ROM, decreasing spasticity, and exercising to prevent muscle atrophy, cardiorespiratory decline, and bone degradation[32–34] (Fig. 1-11).

Modalities such as heat, cold, or electrical stimulation may also be used to directly inhibit or decrease skeletal muscle activity. By decreasing motor nerve conduction velocity and sympathetic activity in the injured muscles, modalities can play a large role in rehabilitating skeletal muscle. For example, a patient with hyperactivity of skeletal muscle following acute trauma from a whiplash injury may benefit from application of electrical stimulation to decrease muscular activity in the involved muscles, thus permitting ROM activities (Fig. 1-12).

By decreasing pain, therapeutic modalities may act indirectly on muscle and result in increased muscle performance. For example, a patient with subacute lumbar radiculopathy (e.g., low back injury with radiating pain

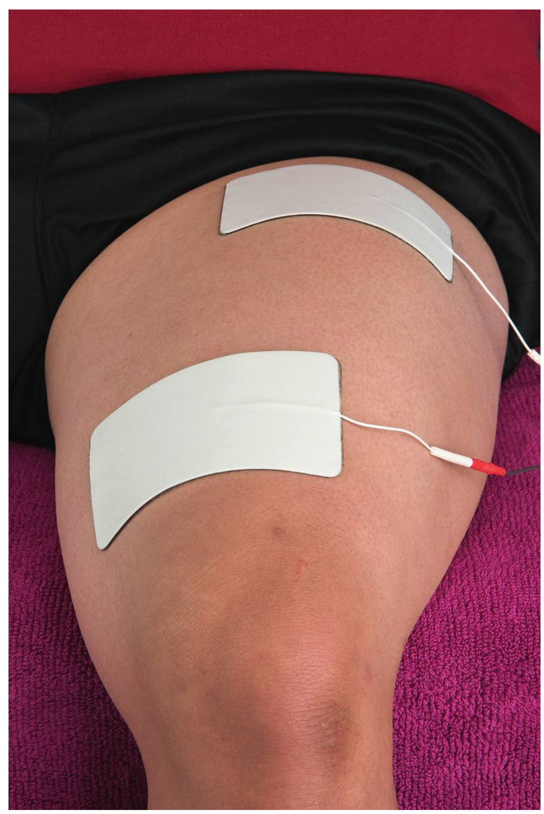

Fig 1 ■ 11 Neuromuscular electrical stimulation is used to increase strength, prevent or limit atrophy, and reeducate muscles. Electrical stimulation alters the manner in which muscle is activated, providing a stimulus for positive adaptation.

Fig 1 ▪ 12 Electrical stimulation can be used to decrease the excitability or hyperactivity of skeletal muscle following injury.

due to nerve irritation) resulting from a lifting injury may report decreased pain after administration of cold. This may allow the completion of stabilization exercises that the patient was otherwise unable to perform because of pain. Cold application may also act indirectly on muscle activity by decreasing the synaptic activity of peripheral sensory nerves. This, in turn, may elevate the pain threshold, potentially allowing improved skeletal muscle activation secondary to decreased pain. Likewise, altering either blood flow to the muscle or cell membrane transport in muscle tissues via ultrasound, diathermy, or cold or heat modalities may indirectly facilitate improved performance of skeletal muscle.

Key Point! If you cannot explain the physiological and clinical reasoning for using the therapeutic modality you select, then perhaps you should not be using the technique!

Decreasing Inflammation and Facilitating Tissue Healing

Use of therapeutic modalities often is recommended following acute injury and tissue damage. The primary goals at this point are to minimize inflammation and promote the most expedient and effective healing process. Although it is critical to keep in mind that the *inflammatory stage* is the beginning of the process of tissue healing, use of therapeutic modalities can facilitate and augment progression through the stages of healing so as to provide expedient yet effective healing (Table 1-1).

TABLE 1–1. Normal Stages, Phases, and Events of Inflammation and Repair

Stage	Phase	Physiological Events
I	Inflammatory	• Vasoconstriction • Vasodilation • Hemostasis/clot formation • Cell-mediated phagocytosis
II	Proliferative	• Epithelialization • Collagen production • Closure/contraction • Revascularization
III	Maturation	• Collagen balance: synthesis/lysis • Collagen remodeling

Cold therapy has long been a standard treatment for the inflammation that occurs in the first several days following acute injury. This can decrease local blood flow and metabolic activity in the involved tissues, which provides support for using cold modalities in the period following injury when vascular increases in permeability and the resultant swelling are likely. The analgesic effect of cold also offers palliative benefit to the patient after injury. Use of electrical stimulation or compression to minimize leakage of large blood proteins from damaged vessels and to limit agglutination of proteins in the interstitial space can minimize duration and residual effects of the inflammatory phase.

The *proliferation stage* follows the onset of the acute inflammatory stage and is characterized by the production, organization, and infiltration of collagen at the site of tissue damage. Collagen serves to repair damaged tissue and represents the first stages in the formation of new tissue. Cells involved in the healing process, such as macrophages and neutrophils, demonstrate unique and specific behaviors as they migrate to the site of tissue repair.[13,16] Blood-borne proteins, such as fibrinogen and fibronectin, aggregate in the involved area, acting to reinforce collagen in the injured tissue. Modalities, such as superficial heat, ultrasound, and diathermy, can facilitate and enhance local blood flow and cellular activity, thereby promoting the proliferation or repair of the damaged tissue.

The third and final stage of tissue healing is the *maturation stage*. This stage is characterized by the modeling, remodeling, organization, and maturation of collagen into new tissue and may last from several days to years. Therapeutic modalities, such as ultrasound, are commonly used to influence the maturation and organization of collagen. Heating collagen tissue by applying ultrasound complements stretching and mobilization of newly formed, maturing collagen. This heat-and-stretch aids in restoring functional integrity to the newly formed and repaired tissue.

Increasing Tissue Extensibility: Flexibility and Range of Motion

Efficiency of functional movement depends on flexibility, and because disuse, immobilization, and detraining can negatively impact flexibility, rehabilitation often focuses on maintaining and restoring flexibility. Flexibility in tissue is largely related to the amount, organization, and extensibility of collagen—the primary protein imparting integrity to connective tissue.[35] Decreased extensibility and organization of collagen can lead to decreased flexibility and can therefore impair function. This decreased extensibility may persist and perhaps worsen unless the tissues can be exercised through full ROM activities.

Intervention aimed at improving or increasing flexibility must address the viscoelastic and remodeling properties of collagen. These properties are enhanced by elevating tissue temperature; therefore, heating of collagen facilitates elongation and deformation of collagen fibers to result in sustained or lasting gains in flexibility. These changes support the rationale for heat as an effective and appropriate modality. Heating delivered to connective tissues by modalities such as hot packs, continuous wave ultrasound, and continuous SWD complement stretching, mobilization, and other techniques and remodel connective tissue (Fig. 1-13). Further description of the use and effect of heat is presented in Chapter 3. Interventions for loss of motion are presented in Chapter 12.

The reparative processes of tissue healing are dependent on the production, organization, and maturation of collagen. Collagen is the most abundant protein in the body and has a tensile strength approaching that of steel. It is collagen that imparts strength to the newly formed tissue.[36,37]

Fig 1 ■ 13 Continuous wave ultrasound and other heat modalities can be used to increase tissue temperature. Decreased pain, increased tissue extensibility, and increased blood flow follow tissue heating and provide therapeutic benefit.

ASSESSING CLINICAL EFFECTIVENESS OF MODALITIES

Use of therapeutic modalities augments other interventions, increasing the probability that the collective effect of the therapies will result in the desired outcomes. Consequently, use of therapeutic modalities has remained a key element of rehabilitation.[38] Of late, however, therapeutic modalities have been scrutinized in regard to outcome measures, the most common being modulation or alleviation of pain.[10,20,39] Although scrutiny and examination of efficacy are warranted for all elements of the intervention plan, much of the scrutiny applied to therapeutic modalities has failed to assess them in their role as complementary interventions. This point is reflected in a 2009 Cochrane Review by Walsh et al[39] that examined and ultimately criticized the efficacy of TENS for treating acute pain. Randomized controlled trials of adults with acute pain (injuries that were less than 12 weeks old) were included only if they examined TENS given as the sole treatment. To assess therapeutic modalities separate from the other interventions they complement is contrary to the position of the American Physical Therapy Association and these authors.

Studies, data, and recent statements have also imposed a negative viewpoint regarding the efficacy of TENS in alleviating pain. These studies and statements have often assessed effectiveness using more quantitative methods, such as pain scales, and have overlooked qualitative measures of improvement in quality of life and functional ability, reduction in the use of pharmacological agents, or simply patient satisfaction. Examining or assessing the efficacy of therapeutic modalities outside the context of their complementary role assumes that they have the inherent ability to induce the desired effect when used in isolation, which is inconsistent with the fundamental use of therapeutic modalities.

Recent Cochrane Reviews have concluded that studies examining the effectiveness of TENS are often plagued by heterogeneity in design, outcomes, chronic pain conditions, and methodological quality. Reporting of methods and results for analgesic outcomes were largely inconsistent across studies and were generally poor, making meta-analysis infeasible.[9,10]

Examinations of this nature have not demonstrated so much that therapeutic modalities are ineffective but more that research examining the effects may be ineffective and problematic. Effectiveness of therapeutic modalities must be considered in the context of their intended use—as adjuncts to other elements of the therapy plan of care. To examine the efficacy of modalities when used separately from the interventions they supplement is unfair. It also trivializes the adjunctive skill of application and coordination with other therapeutic interventions that skilled practitioners use when selecting and applying therapeutic modalities. Use of therapeutic modalities in unskilled, inexperienced hands and, more importantly, in isolation from other elements of rehabilitation can be compared with placing a scalpel in the hands of a novice versus the hands of a skilled surgeon—the probability of a successful outcome is inherently reduced.

Study of the efficacy of therapeutic modalities has not so much shown lack of efficacy for therapeutic modalities as much as it has shown a lack of quality research performed on therapeutic modalities.

USING THE RIGHT OUTCOME MEASURES

So what can we use as appropriate measures to assess the effectiveness of therapeutic modalities? This can greatly determine the attitudes and beliefs associated with clinical use of these therapies. If we use inappropriate measurements or match techniques with the wrong diagnoses or stages of healing, we are more likely to conclude that the modality is ineffective. If we do use appropriate measures, we are more apt to expand our understanding of when and for whom the modality is most appropriate.

There must also be consideration of whether a specific measure of effectiveness is appropriate for all patients or whether the effectiveness of a modality be measured differently for different patients based on the specific clinical presentation. For example, consider the following two patients: The first patient has cervical pain while sitting at work and the second has pain in the knee following surgery. As noted previously, the amount of pain and the location is often measured and used to assess efficacy of therapeutic modalities. But pain may be the sole dysfunction for one patient whereas for another patient it may be an anticipated consequence of some additional factor such as surgery. For these examples, it must be considered whether measurement of pain in and of itself is the best indicator of effectiveness for a given therapeutic modality. Perhaps the answer is yes for the first patient, where pain is the primary clinical complaint, and no for the second patient, where pain is an expected consequence and part of the rehabilitation process. In other words, the measure used to assess a modality should consider the role, relevance, or significance of the variable to be evaluated.

Academic preparation and experience are fundamental factors related to successful patient management. However, individuality and differences between patients will always influence the probability that a specific intervention will yield effective outcomes. This simply reflects nature and the natural differences among people. The extent to which patient individuality can influence our clinical decision-making is questionable but must be recognized.

The enigmatic nature of pain makes measurement precarious. The effectiveness of interventions to address pain is equally precarious. Pain assessment scales and other pain rating tools are used, and each practitioner likely has a preferred method of assessing pain. However, pain is often assessed in a quantitative manner, such as a 1-to-10 scale or a 10-cm line, and while necessary, these fail to consider qualitative matters such as functional ability with pain and quality of life.

Perhaps then, assessment of clinical effectiveness of therapeutic modalities should be considered in the larger picture of the patient's overall outcome. For example, pain is an expected part of the clinical course for many patients. Simply assessing the effectiveness of modalities for pain during periods when pain is expected to be present or elevated (i.e., in the acute stages of injury) may yield less favorable attitudes toward modalities than if pain is assessed in terms of the functional improvements that were made when pain was attenuated or decreased, permitting other aspects of the therapy plan.

Practitioners are encouraged to assess the efficacy of therapeutic modalities when used with other components of the more comprehensive therapy plan. Many variables or methods of assessing effectiveness of therapeutic modalities are available. The astute practitioner will select measures that clearly reflect the expected or anticipated physiological effect of a therapeutic modality. Table 1-2 presents a variety of outcome measures associated with the use of modalities and the physiological rationale for their use.

OVERVIEW OF CONTRAINDICATIONS AND PRECAUTIONS

If a technique can have a positive effect, there is also potential for it to cause harm. For example, the correct dosage of aspirin may relieve a headache, but too much may cause gastric bleeding. The same principles of dosage and treatment selection apply to modalities. The practitioner must judge and determine whether to use specific techniques and must consider the probability that the modality will result in a favorable response. In addition, the practitioner must decide if the patient's history or current status presents any factors or risks that may render a specific

TABLE 1–2. Measures Used to Assess Effectiveness of Therapeutic Modalities

Measurement	Clinical Presentation	Therapeutic Modality	Rationale
Girth, circumference, and volumetrics	Swelling	Cryotherapy	Cold can reduce swelling and inflammation.
		Compression	Compression can decrease edema and swelling.
Goniometric measures	Decreased ROM, flexibility	Thermotherapy	Superficial heating of tissue before stretching can increase ROM.
		Diathermy	Continuous wave diathermy can increase tissue temperature to allow for increased elasticity of tissue.
		Ultrasound	Thermal ultrasound can increase tissue temperature to allow for increased elasticity of tissue.
Strength tests (manual muscle testing, dynamometry)	Decreased strength	Neuromuscular electrical stimulation	Electrical stimulation can enhance volitional muscle activation.
		Biofeedback	Biofeedback can augment volitional activation of muscle.
Tests of function (balance, jump height)	Decreased functional ability	Variable	Therapeutic modalities can help increase function.
Tissue healing (closure time, wound depth)	Compromised integumentary	Electrical stimulation	Monophasic current can increase rate of healing.
Pain (visual analog scale)	Pain	Cryotherapy	Application of cold can reduce pain.
		Thermotherapy	Application of heat can reduce pain.
		Ultrasound	Acoustic energy can decrease pain.
		Electrotherapy	Electrical stimulation can attenuate pain.

therapeutic modality harmful or disadvantageous to the patient's well-being.

Contraindications are specific situations in which a drug, procedure, or surgery should not be used because it may be harmful to the patient.[40] More specific to therapeutic modalities, contraindications have been defined as conditions or factors in which application of a modality over a specific location or region of the body could be harmful and thus the modality should not be used at this location/region.[40] Contraindications are against (or *contra-*) the usual indication to use a specific therapeutic modality. This may be due to an increased risk of an adverse effect or undesired outcome such as use of mechanical traction to the cervical spine in a patient with spinal instability or the use of cryotherapy in a patient with compromised circulation in the area to be treated.

Precautions present a somewhat different aspect to clinical decision-making. Although not outright contraindications, precautions reflect situations in which a patient is at some risk of experiencing an adverse event. In this case, treatment may proceed with caution and proactive measures should be taken to mitigate the risk of potential harm. This may include adjustment of treatment parameters such as intensity or frequency of treatment and closer monitoring of patient response to the treatment.[40]

The following list details the most common contraindications or precautions that practitioners are likely to encounter:

- *Active deep vein thrombosis or thrombophlebitis:* Physical energies applied to local areas of thrombosis or thrombophlebitis may dislodge or disrupt a thrombus, leading to blockage or occlusion to vital tissues; thus, most therapeutic modalities are considered a contraindication.
- *Hemorrhagic conditions:* Application of physical energies may result in disruption of platelet plug formation and uncontrolled bleeding; thus, hemorrhagic conditions are considered a contraindication.
- *Compromised, impaired, or diminished sensation:* Safe administration of most therapeutic modalities requires that the patient have the ability to feel the treatment so that proper adjustments in temperature, intensity, time, position, and so on, may be made to allow for optimal therapeutic benefit while minimizing risk for tissue injury. In most cases, compromised or impaired sensation presents a precaution but may become a contraindication in certain patients.
- *Compromised, impaired, or diminished cognition or communication:* Proper and safe administration of therapeutic modalities requires communication and feedback between the patient and the practitioner. An impaired ability to recognize or communicate the associated sensation of many modalities makes diminished cognition or impaired communication a precaution.
- *Electronic implants—pacemakers, cardioverter defibrillators, phrenic nerve stimulators, and pain pumps:* Administration of therapeutic modalities that deliver electrical or electromagnetic energy (i.e., ultrasound, electrical stimulation, and diathermy) near implanted or external electrical devices worn by the patient requires special consideration. The presence of these devices is typically considered a contraindication by most practitioners. This is mainly due to the potential for the energy emitted by the modality to interfere with the functioning of the electronic device. Application of other modalities, such as hot and cold packs, compression, and traction, may be used in patients with electronic implants but should at least be considered precautions.
- *Pregnancy:* Pregnancy is widely considered a contraindication to the use of modalities if the energies delivered may reach the low back, abdominal, and pelvic areas. This is largely due to the potential and unknown effect on fetal development.
- *Presence of malignancy:* Malignancy in the local area of modality application is considered a contraindication primarily if the therapeutic energy delivered has the potential to alter metabolic activity or blood flow in or around the area of the malignant tissue. These factors are associated with accelerated cell growth and are to be avoided because of the risk of proliferating the malignant cells. Although electrical stimulation has been used to manage cancer-related pain, it has generally been used during palliative care in late-stage cancer and evidence is equivocal.[8,40–42]

Clinical Controversy

There continues to be a lack of consensus as to whether a history of cancer versus the presence of cancer (i.e., active malignancy) remains a contraindication for some modality applications. Malignant tissues can metastasize and go undetected for periods of time, so there is no clear answer. Application within the local area remains a contraindication. Thus, there is no point at which a history of cancer should not be considered at least a precaution, if not a contraindication.

CLOSING COMMENTS

This text is written for and directed at those practitioners who recognize the proper role of therapeutic modalities and understand and embrace their role in the larger continuum of the intervention plan. The authors of this text encourage the use and application of therapeutic modalities within the context of their biophysical properties. In this textbook, we address each modality in this manner. It is imperative and mandatory that clinicians recognize how therapeutic modalities can complement their skills in the interventions used in comprehensive patient management. Scrutiny and further examination of therapeutic applications are warranted and encouraged but only when done so in a manner that is consistent with actual clinical use and in a way that considers and incorporates qualitative measures of improvement or effectiveness.

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SECTION II

Types of Modalities

Continued