Chapter 17
Physical Therapy for Pain Management

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Introduction

Physical therapy is considered a cost-effective, evidence-based treatment option for a variety of medical conditions [1]. Physical therapists are specially trained to analyze and address dysfunctions in the movement system. When pain is believed to be precipitated by, perpetuated from, or having a deleterious effect on movement, a physical therapist can provide skilled interventions to alleviate pain and improve physical function. Evidence suggests that early referrals to physical therapy are vital to a patient's enhanced recovery and to the reduction of overall healthcare utilization related to the presenting condition [2, 3]. More specifically, early physical therapy has been associated with reduced long-term opioid use for shoulder, knee, and low back pain [4, 5].

Physical therapy should not be administered via a protocol-driven, onesize- fits all manner. Rather, physical therapists should consider the unique biopsychosocial factors that contribute to each patient's pain when developing a treatment plan. This process begins with a detailed history and examination, which allows therapists to identify potential biological structures (e.g., the spine) or psychosocial beliefs (e.g., fear avoidance) that may contribute to pain and/or movement dysfunction. Based on the findings from the examination, therapists can then prioritize treatment to the primary impairment(s) to movement, whether they be physical, environmental, or psychological. A detailed description of the clinical reasoning process required to adequately identify and discriminate a patient's primary contributing factors to pain is beyond the scope of this chapter. Truly, it is largely this clinical reasoning process that distinguishes expert from novice clinicians and can account for the variability seen in practice patterns and outcomes between therapists. Taking clinical reasoning aside, the aim of this chapter is to provide an overview of the most common,

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evidence-based techniques and approaches used by physical therapists to evaluate and treat patients with pain. The first section on evaluation will include examination techniques, prognosis, and patient diagnosis/classification. The second section on treatment will present management strategies linked to a pain mechanism classification scheme [6–8].

Evaluation

Examination

The physical therapist's examination is primarily concerned with the assessment of movement and its effect on the patient's chief complaint of pain. A distinction is made during the exam between the reproduction of concordant/asterisk sign (related) pain and discordant sign (unrelated) pain. In cases where movement, loading, or sustained postures have no effect on the concordant sign, the role of physical therapy for pain relief is questionable. Physical therapy may in these cases still be appropriate to counteract the deleterious effects of immobilization from pain, such as stiffness, weakness, or functional loss. In cases where the concordant sign is affected by movement, loading, or positioning, the therapist should attempt to differentiate the system(s) involved in the pain and/or movement dysfunction. In the following section, the physical examination will be organized by tests that are performed to uniquely assess the articular, muscular, and nervous systems.

Articular System

Mobility at the spine and extremity joints is fundamental for functional movement to occur. Joint and spinal range of motion (ROM) testing can be performed to assess both osteokinematic and arthrokinematic movements and the effects of pain on each. Osteokinematic movements (e.g., joint flexion) involve active or passive ROM in various planes performed over single or repeated trials. Goniometric measurement is considered a valid and reliable method for the assessment of ROM [9]. Movement that is *limited* actively or passively by pain before the detection of tissue resistance at end range may indicate that *pain* (or *fear* of pain) is the primary impairment to movement. In such cases, care should be taken to avoid vigorous motion testing in the region, so as not to overly exacerbate pain. Active and passive movement that is equally limited, and *accompanied* by pain, suggests that *stiffness* may be a primary impairment to movement, provided that firm tissue resistance is perceptible at the end of the passive ROM. Active movement that is *accompanied* by pain and significantly more limited than passive movement suggests that *weakness* or poor *motor control* may be a primary impairment to movement. In cases where pain accompanies, but does not actually limit motion loss, more vigorous testing is usually tolerable.

When radiating, diffuse pain is present, repeated osteokinematic movements performed in specific planes of motion may be helpful to distinguish the potential source of the pain and to guide treatment. Centralization is a term used to describe a change in the location of pain from a more distal, referred location (away from the joint/spine) to a more proximal, central location (closer to the joint/spine) [10]. Judgments of centralization are considered reliable and may suggest that a spinal structure, possibly the disc, is a likely source of pain [11, 12]. Furthermore, patients exhibiting centralization of extremity pain with spinal ROM have a favorable prognosis for improvement with the ongoing use of repeated movements in the direction of centralization [13].

Palpation is used to determine the contribution of joint/spine tissues to pain nociception and to assess the passive arthrokinematic mobility of these structures. Passive accessory and physiological motion can be tested to determine whether a joint or spinal segment is moving normally, too much, or not enough. This evaluation can form the basis for treatment decisions, utilizing joint mobilization if hypomobility is perceived at a joint or stabilization exercise when hypermobility is detected with pain [14]. A study by Fritz et al. [14] on patients with low back pain found that the likelihood of treatment failure with spinal mobilization was significantly lower when hypomobility was present (26%) than when hypermobility was detected (83%). In contrast, subjects displaying hypermobility were less likely to fail treatment with an exercise program (22%) compared to mobilization (74%). One limitation to the widespread acceptance and use of spinal accessory motion testing and palpation for pain is the wide range of reliability reported, spanning from poor to excellent [15]. Other issues include questionable validity, as poor agreement has been shown between spinal accessory motion testing and MR imaging [16]. While some may dismiss these forms of testing altogether based on conflicting evidence, most therapists continue to utilize manual palpation of tenderness and arthrokinematic assessments of mobility. When combined with other forms of testing, these assessments can provide meaningful clinical value to identify a concordantly painful structure and/or the desired location, direction, and dosage of manual therapy interventions.

Muscular System

Testing for muscular strength and motor control can take on many forms. While manual muscle testing (MMT), handheld dynamometry, and isokinetic testing can all provide valuable information about muscle strength, motor control may be assessed through observation of the quality, timing, and sequencing of movement. MMT using a 6-point (0–5) grading scale is the most common form of strength testing done clinically, where standardized positions are used to test for force production in the direction of the muscle's primary action. MMT is useful because it can be done quickly and requires no equipment to administer; however, reliability is reduced when grading at the 4 or 5 levels, and substitutions must be avoided when testing so as not to over-grade a weak muscle [17]. For the average, nonathletic patient, a muscle grade of 4/5 should be sufficient for activities of daily living. Patients testing below a 4/5 (nonathletic) or 5/5 (athletic) at muscles in the proximity of pain should be provided with a strengthening exercise program. Motor control exercise programs may be useful to apply in advance of strengthening programs to ensure proper muscle activation before loading is applied. Motor control exercise programs may also be useful when pain limits the application of muscle strength testing as a means to gradually load the muscle in preparation for strengthening exercise.

Muscle flexibility is an especially important concept in patients with pain. Testing for lower extremity muscle flexibility has been shown to be reliable and, when limited, may predispose a patient to injury or pain [18]. Muscles that cross more than one joint are especially prone to tightness, which may be defined as increased tone in the muscle that can be rapidly overcome with end-range overpressure. Tightness should not be confused with adaptive shortening of a muscle, which does not change rapidly in response to end-range overpressure. Muscles with limited flexibility may also be tender upon palpation. Palpation of muscles may aid in the identification of tender/trigger points along the origin, insertion, or mid-belly of the muscle. Although the reliability of trigger point identification is debated [19], the mere presence of tightness/trigger points may suggest the need for manual therapy techniques to relax the muscle. Exercise options to address limited flexibility may vary based on whether muscle tightness or shortness is identified. While muscle shortness may be addressed with stretching, muscle tightness may be improved with strengthening of muscles in and around the area of the tight muscle.

A hallmark of management for chronic pain is aerobic exercise. Before engaging in this form of treatment, it is important to identify the patient's aerobic exercise threshold. Various forms of submaximal exercise testing may be used in a clinical setting on patients with pain. The Åstrand test; bicycle ergometry; walk tests of 5, 6, or 10 minutes; shuttle walk test; and the modified Bruce treadmill test have all been reported to be valid and reliable in patients with chronic pain, chronic fatigue, and fibromyalgia [20]. Careful monitoring should be performed during testing using a rating of perceived exertion or a heart rate monitor. Testing should be discontinued if the heart rate becomes too fast or slow or if the patient experiences chest pain or other cardiopulmonary signs of distress.

Nervous System

Neurodynamic mobility can be assessed through a series of nerve tension tests. Reflex testing should be performed before doing this type of testing, as neurodynamic excursion should be limited or avoided when nerve compression signs are present [21]. The neurodynamic test most often referred to is the straight leg raise, assessing sciatic nerve mobility from L4 to S2. Femoral nerve mobility can be tested with Ely's test, which assesses nerve roots from L2 to L4. Various upper limb tension tests exist to bias the median, radial, or ulnar nerves and the nerve roots from C5 to T1. Nerve root pain from foraminal stenosis or a herniated disc may also be elicited or relieved with spinal compression or traction testing, respectively. Patients with positive neurodynamic testing may benefit from neurodynamic exercise to relieve pain, while patients with positive traction testing may benefit from manual or mechanical traction application for pain relief.

Quantitative sensory testing (QST) can be useful for determining a patient's prognosis and to provide evidence of the patient's underlying pain mechanism [22]. Using various mechanical, vibratory, thermal, or temperature stimuli, the threshold of sensory detection or pain is reported by the patient at both the site of pain and remotely. Examples of QST include pressure pain threshold testing to detect regional or local hyperalgesia, temporal summation testing with monofilaments to detect the presence of windup, and conditioned pain modulation testing to detect loss of descending pain inhibition. Although these tests are primarily confined to laboratory studies at the present time, some authors have suggested that greater clinical application of an abbreviated, standardized battery of QST testing could improve prognosis formation and treatment of pain in the future [23].

Prognosis

Multiple factors should be considered when determining a patient's rehabilitation potential. Factors that when present may suggest a more favorable prognosis include high self-efficacy and motivation, maintaining an active lifestyle in spite of pain, adequate nutritional intake, and good sleep habits [24–26]. Unemployment, high degrees of disability/pain intensity, and low self-rated health are all considered negative prognostic signs when present in patients with low back pain [27]. Additionally, a host of psychosocial factors such as anxiety, catastrophizing, depression, and fear avoidance beliefs have also been reported in patients with chronic pain, particularly in those exhibiting peripheral or central neuropathic pain [28, 29]. Of these factors, catastrophizing and depression have been identified as the strongest predictors of pain-related outcomes [30, 31]. Multiple self-report questionnaires may be used to assess for the presence of psychosocial factors, including the Patient Health Questionnaire-2, Pain Catastrophizing Scale, and the Fear-Avoidance Beliefs Questionnaire. These assessments have all been reported to have acceptable reliability and validity in patients with various pain conditions [32–34]. Besides requiring a longer course of therapy, or achieving only a partial improvement in pain with rehabilitation, patients presenting with an increasing number of negative prognostic signs may also benefit from multidisciplinary forms of rehabilitation. The STarT Back tool is one example of an assessment that allows providers to stratify patients into those most likely to benefit from education only, traditional (PT), or nontraditional (psychologically enhanced PT) forms of rehabilitation [35]. The following section will expand on the idea of stratified care using a variety of proposed models.

Patient Classification

Physical therapy assessments are typically not based on the pathoanatomical cause of pain, since many times the exact source of pain is not able to be determined. Rather, movement-based classification schemes provide a logical framework on which physical therapists can base their treatment decisions. The majority of movement-based classification schemes have been developed for the management of spinal pain. These include Mechanical Diagnosis and Treatment (MDT), Treatment-based Classification (TBC), Movement System Impairment (MSI), and O'Sullivan Classification [36]. Movement-based classification schemes allow patients to be placed into homogenous subgroups with the goal of providing treatment to either increase or limit mobility and loading in specific directions. While the reliability for placing patients into homogenous subgroups is generally considered acceptable for all of the aforementioned movement-based classification schemes, the utility of these schemes to improve patient outcomes is debated [37]. No one movement-based classification scheme has been shown to be superior to another, and studies comparing classification-based treatment to traditional/multimodal treatment have yielded mixed results [37–42]. Therefore, new models of classification have been suggested to guide the management of pain.

Pain mechanism-based classification models have evolved along with our rapidly developing understanding of pain science. Physical therapy treatments can be linked to pain mechanisms in much the same way that pharmaceutical treatments are in order to maximize therapeutic benefit. Pain can be classified as nociceptive, neuropathic, or nociplastic (central) according to the preponderance of signs present. Nociceptive pain is localized to the area of injury/dysfunction, proportionate to the aggravating/easing factors, and typically resolves within expected healing timeframes [8]. Neuropathic pain can be described as burning, shooting, or electric, occurring in a dermatomal or cutaneous distribution, accompanied by positive neurodynamic and dysesthesia signs and associated with a history of nerve pathology or compromise [7]. Finally, nociplastic pain is widespread, described as highly irritable and intense, disproportionate to aggravating/easing factors, and associated with diffuse palpation tenderness (allodynia) and psychosocial issues [6]. In addition to sensory discrimination testing with QST, self-report questionnaires may be used to aid in the distinction of a patient's pain mechanism. The painDETECT questionnaire is a reliable and valid tool to identify nociceptive vs. neuropathic mechanisms of pain [43]. Scores below 19 suggest a nociceptive mechanism to pain, while scores at or above this threshold are consistent with neuropathic pain. The Central Sensitization Inventory is a valid and reliable tool that uses a score >40/100 to identify patients with nociplastic pain [44].

In an attempt to bridge the gap between the International Classification of Functioning, Disability, and Health (ICF) model of care, a traditional focus on movement-based treatment, and our evolving focus on pain mechanism-based treatment, Tousignant-Laflamme et al. [45] have proposed the Pain and Disability Driver Management Model for low back pain [45]. In this model, movement-based classification schemes are overlapped with nociceptive mechanisms of pain, which follows a more mechanically based approach to rehabilitation using exercise, manual therapy, and modalities. Multidisciplinary approaches to care, such as psychologically enhanced PT or interdisciplinary treatment, are incorporated for the management of peripheral/central neuropathic pain mechanisms and environmental/behavioral-based contributing factors. The Pain and Disability Driver Management

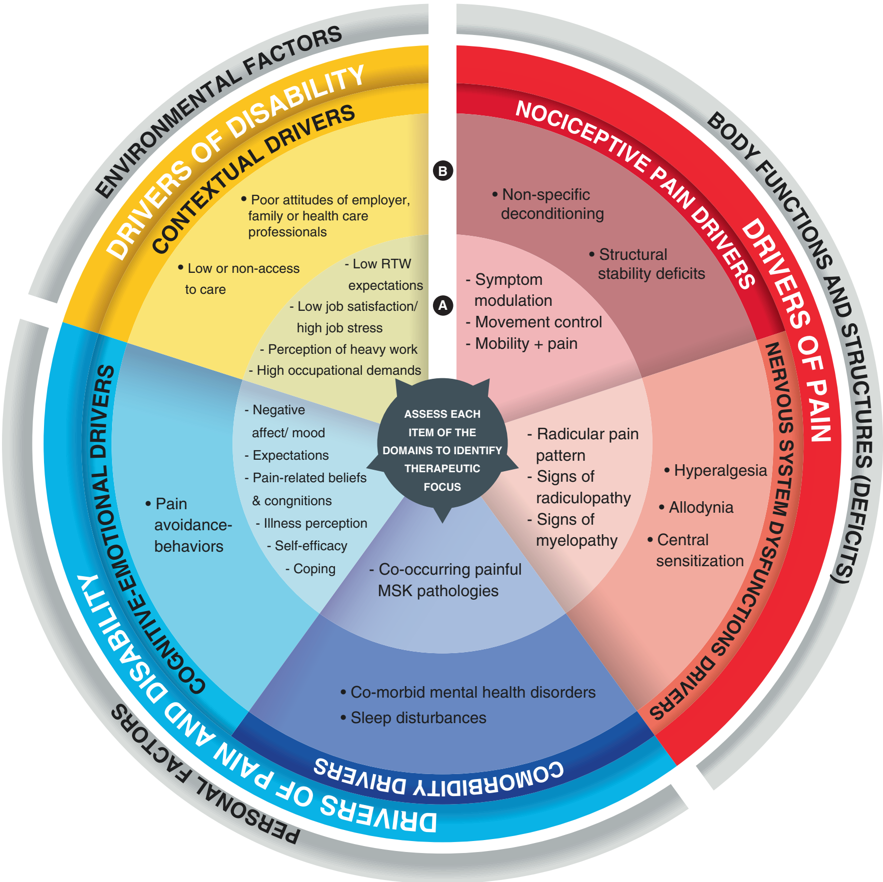

Fig. 17.1 Model for Pain and Disability Driver Management. (From Tousignant-Laflamme et al. [45]. With permission from Dove Medical Press)

Model is among the most comprehensive, biopsychosocial models currently available for the rehabilitation of low back pain (Fig. 17.1). While the current model specifically references treatments for the spine, the principles could be adapted to apply to patients with any type of musculoskeletal pain. The following section will use a pain mechanism model as the basis for discussing physical therapy treatments while also referencing movement/environmental/behavioral-based contributing factors that can be addressed with treatment.

Figure 17.1 shows a model for Pain and Disability Driver Management. Level A includes common elements that are more responsive to individualized treatment. Level B includes complex elements that require an interdisciplinary approach. RTW = Return to work. MSK = Musculoskeletal.

Management

Nociceptive Pain

The majority of published clinical practice guidelines for pain are written to apply to patients who report pain associated with an articular or muscular system impairment. Such is the case for guidelines on the treatment of nonspecific neck or low back pain and lower extremity osteoarthritis [46–63]. While a peripheral nociceptive mechanism is believed to contribute primarily to many of these conditions, a neuropathic or nociplastic mechanism may predominate in some cases [64]. This coexistence of pain mechanisms may explain why some patients with chronic pain do not respond to mechanical, nociceptive-focused treatments which emphasize articular or muscular dysfunction. In cases where nociceptive and non-nociceptive mechanisms are present, a multidisciplinary approach, including treatments described in the neuropathic and nociplastic sections of this chapter, may improve patient outcomes. Multidisciplinary care has been shown to be more effective than standard medical treatment for managing nonmalignant chronic pain conditions such as chronic LBP, fibromyalgia, and mixed chronic pain [65].

Assuming a nociceptive mechanism is predominant, treatments may be selected that address the primary impairment to a patient's movement, regardless of the pathological diagnosis. Using this reasoning strategy, treatment is tied to improving the quality of movement at and around the site of pain, rather than treatment directed at a specific tissue believed to be the source of pain. Regional interdependence is an important concept in this model of treatment, as movement in remote, non-painful areas can influence the degree of pain reported in localized areas [66].

The following section will present a treatment model for nociceptive pain using the core tenants of education, exercise, manual therapy, and modalities to address movement, environmental, and behavioral-based contributing factors. Clinical reasoning is essential to determine which tenant(s) should be emphasized in a particular patient's plan of care, as significant variations can occur in the ordering and grouping of interventions. Supplementary tables are provided detailing the clinical practice guideline recommendations published for spinal pain (Table 17.1) and lower extremity osteoarthritis (Table 17.2).

Education

All patients with nociceptive pain should be educated about their condition and assist in the development of the plan of care for the condition. Education regarding the condition generally includes reassurance about the benign and self-limiting nature of pain from a non-serious pathology. Education about the goals and plan of care should incorporate the patient's preferences where possible. A strong therapeutic alliance is built between the therapist and patient when the patient understands

Table 17.1 Evidence-based recommendations for physical therapy management of acute-chronic neck and low back pain

Treatment for spinal pain	Strength of evidence	Determination
Setting and education		
Inter−/multidisciplinary treatment (chronic)	Low to moderate [46, 48, 49, 52, 82]	Evidence-based treatment
Education, reassurance, and advice to stay active	Low to moderate [48, 49, 51, 53, 82]	
Exercise		
Mindfulness, yoga, tai chi, pilates (chronic)	Low [46, 47, 49, 52]	Evidence-based treatment
Therapeutic exercise: Strengthening, stretching, aerobic, motor control (subacute to chronic)	Low to high [46–49, 51–53, 82]	
Manual therapy		
Manual therapy	Low to high [46–49, 51–53, 82]	Evidence-based treatment
Spinal manipulation (acute)	Low [47, 49, 52, 82]	
Massage	Low to moderate [46, 47, 49, 51, 52, 82]	
Modalities		
Acupuncture	Low to moderate [46, 49, 51, 52, 82]	Evidence-based treatment
Superficial heat or cold (acute)	Moderate [52]	
Low-level laser therapy (chronic)	Low [49, 52]	
Lumbar supports	Low [55]	Accepted but unproven
Kinesiotape	Low [127]	
Therapeutic ultrasound	Low [55]	
Transcutaneous electrical nerve stimulation	Low [55]	
Electrical muscle stimulation	Low [55]	
Traction	Low [47]	Disproven
Pulsed electromagnetic field	Low [131]	Emerging or promising treatments
Cupping	Low [132]	
Whole-body vibration	Low [133]	

their condition and has confidence and trust in the mutually agreed upon plan to address the condition. Evidence suggests that a patient's positive or negative perspectives regarding a specific treatment can positively or negatively affect the outcome of the intervention [67, 68]. Additionally, a strong therapeutic alliance has been associated with improved overall patient outcomes [69].

Education regarding treatment expectations should include advice to remain active and specific recommendations for self-care. Patients reporting increased pain during sustained postures should be asked about external support, including but not limited to footwear (if pain is provoked with sustained standing), chair surfaces (if pain is provoked with sustained sitting), or pillow/bed surfaces (if pain is provoked with sustained lying). Foot orthoses have been shown to provide medium-term pain relief in patients with plantar heel pain [70], while sitting and

Table 17.2 Evidence-based recommendations for physical therapy management of hip and knee osteoarthritis

Treatment for lower extremity osteoarthritis	Strength of evidence	Determination
Education		
Education on activity modification, weight reduction unloading of arthritic joints	Moderate [50]	Evidence-based treatment
Exercise		
Therapeutic exercise for flexibility, strengthening, and endurance	Low to high [50, 54, 57, 58, 60, 61]	Evidence-based treatment
Aquatic exercise for those unable to tolerate land-based treatment	Low [56]	
Functional, gait, and balance training	Low [50, 56]	
Yoga (knee)	Moderate [59]	
Manual therapy		
Joint mobilization (hip)	Moderate to high [50, 54]	Evidence-based treatment
Manual therapy (knee)	Low [57]	Accepted but unproven
Modalities		
Pulsed electromagnetic field (knee)	Low [54]	Evidence-based treatment
Therapeutic ultrasound	Low to moderate [50, 54]	
Superficial heat (hip)	Moderate [50]	
Kinesiotape	Low [128]	Accepted but unproven
Medial compartment unloader brace	Low [57]	
Low-level laser therapy	Low [123]	
Acupuncture	Low [54, 56, 57]	
Transcutaneous electrical nerve stimulation (knee)	Low [54]	Disproven
Lateral wedge insoles (knee)	Low [57]	

sleeping postures have been shown to impact spinal pain [71, 72]. Self-care may also include specific recommendations on a home exercise program (HEP). The HEP should focus on the primary impairment(s) to movement and generally progress from exercises for stretching/mobilization to exercises for strengthening/conditioning. Patients should be reminded about the signs of overload when performing exercises. Since it is common for patients with chronic pain to experience some degree of discomfort during exercise, clear expectations should be communicated about what would be considered an appropriate amount of pain. Pain that is increased during exercise should not be unbearable, should not outweigh the feeling of "work" achieved during exercise, and should begin to decrease within a few hours of completing an exercise (assuming no delayed onset muscle soreness is present). If any of these criteria are violated, the amount of loading for the exercise may be excessive, thus leading to a nonproductive exacerbation of the patient's pain.

Exercise

Exercise is considered the foundation of physical therapy management for multiple painful conditions [46–63]. Exercise has been shown to reduce nociceptor excitability, increase expression of neurotrophins in the muscle, and increase production of anti-inflammatory cytokines [73–75]. Exercise can consist of many forms, including but not limited to ROM/stretching, strengthening, neuromuscular reeducation, aerobic conditioning, and functional training. Additionally, exercise forms can be packaged within different approaches, such as gym/resisted training, spinal stabilization, yoga, pilates, or tai chi. Evidence generally suggests that one exercise approach is not superior to others for the management of chronic spine pain [76, 77]. However, some preference may be given to prescribing a specific form of exercise to specific patient subgroups.

Patients with extremity pain that is being referred from a specific spinal region may benefit from the use of repeated ROM/stretching exercise more than other forms of exercise such as spinal stabilization [78]. Additionally, the direction of the ROM exercise appears to influence the response, as exercise given in the opposite direction to the movement preference did not improve pain as much as exercise matched to the movement preference [79]. The notion of directional preference treatment is well established in the spine and is also now being studied in the extremities [80, 81]. ROM exercises are typically repeated in sets of ten multiple times a day until maximal pain relief has been achieved.

Motor control/stabilization and general exercise programs are each recommended for the rehabilitation of spinal pain [52, 82]. Stabilization programs traditionally include an emphasis on focused, isometric training of core muscles such as the deep neck flexors, transversus abdominis, and multifidus, whereas general exercise programs typically emphasize a mixture of nonspecific muscular stretching and strengthening. While a stabilization program seeks to improve muscular control and coordination, a general exercise program seeks to improve muscular flexibility, endurance, or hypertrophy. In a heterogeneous population of patients with low back pain, evidence suggests that motor control/stabilization and general exercise yield similar benefits in terms of pain and functional improvements. In patients with low back pain and signs of radiographic instability, aberrant movements, or segmental hypermobility, a stabilization/motor control program may be preferred to a general exercise program or to manual therapy [14, 83, 84].

When deciding which form of exercise to select for their patients with either spine or extremity pain, clinicians may consider several factors. In cases where pain is predominant, isometric exercise may be better tolerated than isotonic strengthening exercise for addressing both pain and muscle inhibition [85]. Isometrics can be progressed from low to high intensity, with dosing of hold times being inversely related to the intensity (i.e., submaximal intensity with ≥10-second hold vs maximal intensity with <7-second hold). In patients with predominant movement coordination impairments, an exercise program generally focusing on the correction of aberrant movements and postures, with or without the inclusion of a specific motor control emphasis, may be utilized [86, 87]. Exercise programs for movement coordination impairments typically involve using body weight as resistance, with very high (≥30) repetition dosing and an emphasis on quality of movement. When weakness is predominant, either in areas local or remote to the painful area, a traditional strengthening program emphasizing muscle loading may be beneficial. Physical therapists commonly apply a regional interdependence model to strengthening programs, where thoracic/scapular strengthening is incorporated into cervical and shoulder rehabilitation programs [88] and where hip strengthening is incorporated into low back and knee rehabilitation programs [89]. Using an external load to create muscle fatigue, typical dosing for a strengthening program is to aim for 6–12 repetitions for muscular hypertrophy and >12 repetitions for muscular endurance.

Aerobic conditioning should be recommended as a means of pain modulation, relaxation and stress relief, and cardiovascular/fitness training for all patients with chronic pain [90]. This form of exercise may be most beneficial for patients with deconditioning or fatigue as an accompanying chief complaint to pain [91]. Aerobic conditioning can be effectively performed using a variety of exercise approaches, some of which may include the use of low-impact equipment, low-load environments such as a pool, or the ability to limit movement to non-painful areas. Regardless of the approach, the key element to achieving pain relief is to reach a workout intensity of *at least* 50–60% of one's maximum heart rate [92]. An intensity of 70% of the maximum aerobic capacity has been shown to stimulate endorphin release and activation of descending pain inhibition for up to 30 minutes after exercising [93, 94]. When performed for a duration of 20–30 minutes on at least 2–3 days in a week, patients with a variety of painful conditions can achieve exercise-induced analgesia and improved physical and psychological function [95, 96].

Manual Therapy

Manual therapy may be beneficial to any patient with pain and mobility deficits. Manual therapy can be performed to the joints or soft tissues, delivered using the hands or instruments, via thrust or non-thrust forms of manipulation. Manual therapy has been shown to act through mechanical, neurophysiological, and psychological mechanisms; however, neurophysiological mechanisms have received the most support in the literature [95]. A host of neurophysiological effects have been reported from joint manipulation, including activation of cannabinoid and adenosine analgesic systems, sympathoexcitation, reduced temporal summation, and alteration of muscle tone [97–101]. Additionally, reduced inflammation via altered gene or cytokine expression has been shown with stretching or massage [102]. Short-term improvements in pain have been shown in a majority of randomized controlled trials investigating the use of manual or instrumented massage for treating patients with spinal pain [103].

Regardless of the form used, evidence widely suggests that manipulation is effective for relieving pain and improving function in a number of pain conditions [46–63]. Significant debate still exists, however, regarding the superiority of thrust vs. non-thrust forms of manipulation, particularly related to outcomes for patients with spinal pain [104, 105]. Clinical prediction rules (CPRs) have been developed to identify patients with neck or low back pain who may benefit more from a thrust form of manipulation [106, 107]. The rules generally suggest that acute-subacute patients with localized pain and segmental hypomobility are likely to benefit from a thrust technique. However, these recommendations should be implemented with caution, as the rules have not been successfully subjected to broad-based validation. Multiple randomized controlled trials have attempted to further clarify the question of thrust vs non-thrust superiority, often with mixed results. Evidence from pragmatic trials generally suggests that thrust and non-thrust techniques yield similar results, while evidence from prescriptive trials more often shows that thrust techniques are superior [108]. For the clinician deciding between these techniques, careful screening must first be performed regarding contraindications to manipulation, particularly at the cervical spine, where adverse events such as arterial dissection can result in permanent disability or death. Manipulation should not be performed in cases of poor or questionable bony or ligamentous integrity, cervical arterial dysfunction, severe or progressive neurological involvement, or cases of non-mechanical pain [109]. Adherence to the contraindications for manipulation, in combination with screening of blood pressure and cranial nerve integrity, can significantly reduce the incidence of a serious adverse event with manipulation [109].

A growing body of evidence suggests that regional interdependence may also be at work in manual therapy, which gives the clinician another option regarding the location of applied manipulation techniques [66]. CPRs have been produced for the use of thoracic spine manipulation for both neck and shoulder pain, lumbopelvic manipulation for patellofemoral pain, and hip manipulation for knee osteoarthritis [110–113]. Based on the results of a validation study for the thoracic manipulation CPR for neck pain, the authors concluded that *all* patients with neck pain may benefit from a thoracic manipulation, not just those fitting the rule [110]. Validation studies have otherwise not been performed for the aforementioned CPRs, but with a low risk and minimal time investment to intervention, an implementation trial of regional manual therapy would seem warranted in many cases. In general, patients with shoulder pain who may benefit from cervicothoracic manipulation include those who are acute-subacute, with limited shoulder flexion and internal rotation ROM, and a negative Neer test [113]. Patients with patellofemoral pain who may benefit from lumbopelvic manipulation include those with increased amounts of foot pronation and ankle dorsiflexion ROM, asymmetry in hip internal rotation, and pain with squatting [112]. Patients with knee OA who may benefit from hip manipulation include those with limited hip flexion and internal rotation ROM and hip/anterior thigh pain that is increased with hip distraction [111].

Since manual techniques are often done passively, they should be considered as a means to an end (with the end being active exercise), and not the end. Multiple high-quality trials suggest that outcomes are improved for neck, back, and shoulder pain if manual therapy and exercise are paired together versus applied as a standalone treatment [114–116]. Non-thrust manipulation techniques are typically performed for up to 30 seconds at a time and repeated until a change in pain or mobility has been achieved. A within-session change in pain or mobility can be expected after a single application of manual therapy and when present, is considered a good indicator of future prognosis with treatment [117].

Modalities

Modalities can serve as a valuable adjunct treatment for pain, whether administered in a home or clinical setting. Home-based treatments such as superficial heat or cold are affordable, accessible, and easy for patients to apply. Cold is generally recommended in the first 48–72 hours after an acute injury to reduce visible signs of swelling and inflammation and for pain control [118]. Beyond 72 hours, patients can use either heat or cold for pain relief, although heating is associated with improved blood flow to an injured area which may aid in tissue repair [118]. Cold application is typically limited to 10 minutes at a time, while heat application can be prolonged if the intensity remains low [119]. Evidence generally supports the use of thermal modalities for pain relief in patients with spine pain and lower extremity osteoarthritis.

Electro-physical modalities such as transcutaneous electrical nerve stimulation (TENS), low-level laser therapy, and therapeutic ultrasound may be administered in a clinical setting to relieve pain and facilitate healing. Significant variability exists in the recommended dosages used for these modalities, which may explain the variability seen in results from clinical outcome trials. While it is beyond the scope of this text to discuss the specific parameters for applying these modalities, a general overview of the physiological mechanisms and clinical outcomes is provided. TENS works at a peripheral level to reduce excitation of the sympathetic nervous system via noradrenergic receptor stimulation and to modulate peripheral sensitization via simultaneous activation of μ-opioid receptors and blocking of substance P production [120, 121]. Despite this reported ability to alter pain physiology, clinical trials do not support the use of TENS for improving pain and function in patients with nonspecific spinal pain or lower extremity arthritis [54, 55]. Low-level laser therapy targets the mitochondria to convert light energy into chemical energy used for DNA/RNA synthesis, mitosis, and cell proliferation [122]. Evidence supports the use of low-level laser therapy for chronic spine pain, but is conflicting for its use in lower extremity arthritis [49, 52, 123]. Finally, therapeutic ultrasound targets the superficial soft tissues to improve metabolism, blood flow, and extensibility [124]. While evidence is conflicting for its effectiveness in patients with spinal pain, support is found for using ultrasound in patients with lower extremity osteoarthritis and calcific tendonitis of the shoulder [50, 54, 125].

Two pain-relieving modalities that have gained popularity among physical therapists over the last two decades include kinesiotaping and dry needling. Kinesiotaping is commonly used among athletes, with a proposed list of benefits including improved circulation/lymphatic flow, normalized muscle function, remodeling of fascial tissue, and improved joint balance [126]. Despite its widespread use, evidence on the effects of taping is conflicting overall, but may show promise for functional improvement in patients with back and knee pain [127, 128]. Dry needling is primarily used to target myofascial pain at various sites throughout the body and can be administered with or without electrotherapy. Dry needling is not synonymous with acupuncture due to differences in the theories, techniques, and training provided. However, some overlap between these modalities can be found in two areas. Both the acupuncture and dry needling literature underscore the importance of neurophysiological mechanisms such as endogenous opioid release and improved descending pain inhibition to explain the immediate and lasting improvements in pain relief achieved with treatment [129, 130]. Additionally, close relationships have been found between trigger points, tender points, and acupuncture points, suggesting that a common mechanism such as sensitized nociceptors may be present. Evidence generally supports the use of acupuncture/electro-acupuncture for chronic spine pain, but is conflicting for its use in lower extremity arthritis [52, 57].

Neuropathic Pain

Patients presenting primarily with a neuropathic mechanism of pain have unique treatment needs compared to patients with nociceptive pain. In particular, evaluation and management of the nervous system is critical for patients with neuropathic pain, whereas a focus on the articular and muscular systems often dominates in cases of nociceptive pain. The following section will discuss a treatment model for neuropathic pain using the same four core tenants previously described and emphasizing interventions that are nervous system-based. One should recognize, however, that patients with neuropathic pain will also likely present with muscular and articular system impairments which may necessitate the use of treatment approaches described in the previous section. Supplementary tables are provided detailing the clinical practice guideline recommendations published for spinal radiculopathy (Table 17.3) and carpal tunnel syndrome (Table 17.4).

Education

Pain neuroscience education (PNE) is the practice of teaching patients how pain processing occurs in the nervous system [134]. Patients gain a practical understanding of such concepts as nociception, spinal inhibition/facilitation, peripheral and central sensitization, and nervous system plasticity. A number of methods can be used to teach PNE, including booklets, videos, and drawings/examples provided by the clinician. A typical example used in PNE is the idea of pain as an alarm system. In a normally functioning nervous system, use of the alarm (pain) is reserved for situations where physical or emotional harm is realized. However, in cases where the nervous system has been sensitized, the threshold for sounding the alarm is lowered. This can make movements or emotions that are well below the threshold of harm be perceived as painful, which can greatly reduce the patient's activity tol-

Table 17.3 Evidence-based recommendations for physical therapy management of cervical or lumbar radiculopathy

Treatment for radiculopathy	Strength of evidence	Determination
Education		
Education on pathology, pain mechanisms, and coping with activity modification	Moderate [51, 53]	Evidence-based treatment
Exercise		
Therapeutic exercise for motor control, graded strengthening, and directional movements	Low [49, 51, 53, 82]	Evidence-based treatment
Manual therapy		
Manual therapy including spinal manipulation	Low [49, 51, 53, 82]	Evidence-based treatment
Massage	Low [49, 82]	Accepted but unproven
Modalities		
Traction	Low [51]	Evidence-based treatment
Transcutaneous electrical nerve stimulation	Low [49]	Accepted but unproven
Acupuncture	Low [49, 82]	
Ultrasound	Low [82]	
Low-level laser therapy	Low [82]	

Table 17.4 Evidence-based recommendations for physical therapy management of carpal tunnel syndrome

Treatment for carpal tunnel syndrome	Strength of evidence	Determination
Education		
Education on immobilization at night with wrist splints	High [155, 156]	Evidence-based treatment
Exercise		
Therapeutic exercise (nerve gliding, tendon gliding, generalized stretching/yoga)	Low [156]	Evidence-based treatment
Manual therapy		
Manual therapy (carpal and soft tissue mobilization)	Low [157]	Evidence-based treatment
Modalities		
Therapeutic ultrasound and ketoprofen phonophoresis	Low [155]	Evidence-based treatment
Low-level laser therapy with transcutaneous electrical nerve stimulation	Low [155]	
Acupuncture	Low [157]	Accepted but unproven
Iontophoresis	Low [156]	Disproven
Magnet therapy (carpal and soft tissue mobilization)	Low [155]	
Polarized polychromatic noncoherent light (Bioptron) therapy	Low [158]	
Cupping	Low [159]	Emerging or promising treatments
Interferential current	Low [160]	
Local microwave hyperthermia	Low [158]	
Continuous shortwave diathermy	Low [158]	

erance. PNE is primarily indicated for patients who are experiencing chronic pain, particularly associated with a neuropathic or nociplastic mechanism. Current evidence supports the use of PNE in chronic musculoskeletal disorders to reduce pain and improve knowledge of pain, improve function and lower disability, reduce psychosocial factors, enhance movement, and minimize healthcare utilization [135].

Exercise

Neurodynamic exercise should be considered in the treatment of patients with neuropathic pain [136]. The potential benefits of this form of exercise may include reduction of nerve adherence, increased neural vascularity, and improvement of axoplasmic flow [21]. Neurodynamic exercise should be based on the results of neurodynamic testing, with expected findings of symptom reproduction and reduced ROM compared to the uninvolved side. A key component of neurodynamic testing is the concept of structural differentiation, whereby movement of a remote area (e.g., neck flexion) alters pain in a primary area (e.g., increased posterior thigh pain) during nerve tension testing (e.g., the straight leg raise test) [21]. When structural differentiation is present, the nervous system (as opposed to the musculoskeletal system) is implicated. Using this concept to inform treatment, tension can also be *reduced* at a remote area while it is being increased across the primary area (e.g., neck extension during a straight leg raise). This type of movement is referred to as a sliding maneuver and is often used as treatment in patients with acute or irritable pain conditions [21]. Neurodynamic exercise should begin with sliding maneuvers on the side of pain or tension maneuvers on the *contralateral* side of pain to reduce forces in the nervous system. Exercises should progressively increase forces in the nervous system through the use of tension maneuvers on the side of pain and through altering the order of applied limb movements so that more painful areas are moved earlier in the neurodynamic sequence [21]. Exercises are generally performed for three to five sets of five to ten repetitions and repeated throughout the day.

Neurodynamic exercise has received support in two recent systematic reviews. Low-level evidence was found for the effect of neurodynamic exercise on reducing intraneural edema in patients with carpal tunnel syndrome [137]. Evidence from randomized controlled trials supports the use of neurodynamic exercise for reducing pain intensity in neck and low back pain and for improving disability in low back pain. The greatest improvements have been found in low back pain, where large effect sizes have been reported for changes in both pain and disability [138]. Lower extremity neurodynamic exercise typically begins with the use of the straight leg raise and progresses to the use of the slump position for maximum loading.

Manual Therapy

Mobilization of the mechanical interface points along a nerve can be an important adjunct intervention to ensure normal neurodynamics. Interface points such as the intervertebral foramen, ligaments, and muscles can become limited in their mobility, which can in turn limit neural mobility. In patients with radiculopathy, mobilization should begin with positioning or manual techniques to open the neural foramen, including spinal flexion and contralateral sidebending [21]. This form of treatment should continue until the patient can tolerate tension maneuvers on the side of pain, at which time closing techniques into extension, ipsilateral sidebending, or contralateral lateral glide may be implemented [21]. A closing technique referred to as the cervical lateral glide has been studied repeatedly as a treatment for cervical radiculopathy [139–141]. During this technique, patients are supine with the ipsilateral upper extremity placed in some degree of neural tension, while the neck is glided laterally away from the side of pain. Immediate to short-term improvements in pain and disability have been reported for the cervical lateral glide technique in patients with arm pain compared to ultrasound, wait list, and placebo [139–141]. Similarly, a lateral glide technique may be performed at the lumbar spine by placing the patient in sidelying with the involved leg in some degree of neural tension and applying a translatoric force to the spinous process away from the side of pain. A randomized controlled trial comparing the lumbar lateral glide technique with exercise to a program of exercise-only demonstrated significant improvements in pain and disability at short and long term for the group receiving the combined interventions [142].

Patients with carpal tunnel syndrome may also benefit from various manual therapy interventions applied along nerve interface points. A group receiving carpal joint mobilization achieved superior results in pain relief compared to controls, but similar improvements compared to a group receiving neurodynamic exercise of the median nerve [143]. Specific, interface-based massage yielded greater improvements in grip strength compared to the application of general massage at the neck, back, and upper extremity [144]. And finally, similar improvements in nerve conduction velocity, hand function, and symptom severity were reported in a group of patients receiving instrumented, Graston soft tissue mobilization and exercise compared to manual soft tissue and joint mobilization with exercise [145].

Modalities

Modalities for the treatment of neuropathic pain can be grouped into those that are directed at the nerves or their mechanical interfaces. Traction may provide unique benefits for the patient with radiculopathy due to its ability to influence multiple mechanical interface points which impact foraminal opening and intervertebral disc dynamics. While traction is generally not recommended for patients with nonspecific spinal pain, multiple studies have supported the use of traction in patients with radiculopathy, particularly in the cervical spine [146–148]. A clinical prediction rule for the use of cervical traction suggests that patients >55 years old with positive neurodynamic testing, relief of symptoms with traction and shoulder abduction testing, and radiation of symptoms with cervical mobility testing may have the greatest likelihood of achieving a clinical benefit [149]. While this CPR has only been partially validated in a subsequent study [150], a more recent systematic review supported the widespread application of traction and physical therapy in patients with cervical radiculopathy [148].

Modalities that are directed at the nerve for the management of carpal tunnel syndrome may include ultrasound/phonophoresis, laser/TENS, and splinting. Night splinting is typically recommended as superior to no treatment, although no preference has been found for different splinting styles or wearing regimens [151]. The use of ultrasound with or without phonophoresis provides greater benefits than sham treatment [152]; however, ketoprofen phonophoresis may provide superior benefits over ultrasound alone [153]. Finally, a combination treatment of laser and TENS yielded significant improvements in pain, sensory/motor latency, and provocation tests compared to a sham treatment in patients with carpal tunnel syndrome [154].

Nociplastic pain

The final treatment category is reserved for patients with chronic, complex pain that requires a multifaceted approach to care. Whether physical therapy treatment is administered within an interdisciplinary pain program or not, it should be psychologically enhanced to better influence the cognitive-emotional needs of the patient with nociplastic pain [35, 45]. Interventions may be selected from any of the aforementioned sections, but should also uniquely address the issues of sensory integration and behavioral modification. The following section will emphasize these unique treatment approaches in the context of the four core tenants to physical therapy management. Supplementary tables are provided detailing the clinical practice guideline recommendations published for fibromyalgia (Table 17.5) and complex regional pain syndrome (CRPS), type 1 (Table 17.6).

Education

PNE is considered fundamental in the education provided to patients with nociplastic pain. In addition to learning about pain neurophysiology, patients with nociplastic pain should be informed about brain body maps and the disassociation between pain and a tissue pathology [161]. An image of the brain's homunculus is useful to help explain the concepts of neuroplasticity and cortical smudging. Patients are educated that the internal picture of our body can become warped very quickly when pain is present and that ongoing distortions of this image can result in abnormal movement patterns, decreased coordination, poor body awareness, and heightened nerve sensitivity [162]. The patient is reassured that the body map can be reimaged rapidly and that physical therapy can successfully test for and treat distortions in brain mapping. Additionally, patients are educated that as pain becomes chronic, the timeframe for normal tissue healing has passed away, suggesting that pain is more

Table 17.5 Evidence-based recommendations for physical therapy management of fibromyalgia

Treatment for fibromyalgia	Strength of evidence	Determination
Setting and education		
Multicomponent treatment (≥1 educational or psychological therapy with ≥1 exercise therapy)	Low [54, 181]	Evidence-based treatment
Education to pursue a normal lifestyle using pacing and/or graded activity	Low [181, 185]	
Exercise		
Graduated exercise (aerobic, strengthening, aquatics)	Low to moderate [181, 185, 186]	Evidence-based treatment
Tai chi, yoga, qigong, or Body awareness therapy	Low [54, 181]	
Whole-body vibration exercise training	Low [187]	Emerging or promising treatments
Guided imagery	Low [181]	
Manual therapy		
Myofascial release massage	Moderate [54, 181]	Evidence-based treatment
Chiropractic (massage, stretching, spinal manipulation, education, and resistance training)	Low [181]	Accepted but unproven
Modalities		
Acupuncture	Moderate [54, 181]	Evidence-based treatment
Hydrotherapy	Low [181]	
Low-level laser therapy	Low [188]	Accepted but unproven
Transcutaneous electrical nerve stimulation	Low [189]	
Transcranial magnetic and direct current stimulation	Low [190, 191]	Emerging or promising treatments

a product of a dysfunctional nervous system than it is a dysfunctional tissue [161]. This type of information can be liberating for a patient who has otherwise been told that there is nothing wrong with them or that it is all in their head. In addition to the previously cited outcomes of PNE for improving pain and function, physiological changes have also been observed using FMRI. A single case report found evidence of deactivation at the periaqueductal gray and cerebellum, coupled with activation of the motor cortex, indicating alterations in central pain processing that are critical for the patient with nociplastic pain [163].

Exercise

The term graded motor imagery (GMI) is used to refer to a collection of exercises including left/right discrimination, motor imagery, and mirror therapy to address sensory integration impairments in patients with nociplastic pain [164]. It is critical that any GMI program begins with PNE, as the patient must have a basic under-

Table 17.6 Evidence-based recommendations for physical therapy management of complex regional pain syndrome, type 1

Treatment for complex regional pain syndrome, type 1	Strength of evidence	Determination
Setting and education		
Interdisciplinary treatment with a functional restoration emphasis	Low [169, 184]	Evidence-based treatment
Exercise		
GMI and mirror therapy	Low to moderate [184, 192]	Evidence-based treatment
Tactile discrimination	Low [193]	
Graded exercise and exposure	Low [192]	
Stress loading program	Low [169, 192]	Accepted but unproven
Manual therapy		
Massage and electroacupuncture	Low [184]	Emerging or promising treatments
Manual lymphatic drainage	Low [184, 192]	Disproven
Modalities		
Transcutaneous electrical nerve stimulation	Low [192, 193]	Accepted but unproven
Therapeutic ultrasound of stellate ganglion	Low [184]	Disproven
Low-level laser therapy	Low [184]	Emerging or promising treatments
CO_2 bath therapy	Low [184]	
Pulsed electromagnetic field	Low [192]	

standing of pain neurophysiology to fully buy into this nontraditional "brain" exercise approach. Exercises are introduced on a continuum, where interventions that avoid movement or touch are introduced first. The program begins with exercises on left/right discrimination that are meant to sharpen the mind body maps. Pictures of the affected body part from magazines or mobile apps are shown to the patient, with the goal of having the patient identify whether the image is from a left or right side. Normative data suggests that patients should be able to achieve ≥80% accuracy at an average response rate of ≤2 seconds/image [165]. Patients with extremity pain are more likely to exhibit impairments in left/right discrimination testing than patients with axial pain [166]. The next level of progression is imagery of movements that are considered threatening to the patient. By imaging the movements in a non-limited, non-painful manner, the patient is able to decrease the threat level associated with the activity, which can have rapid effects on pain reduction [167]. Next, patients are ready for gradual exposure to touch and movement. Sensory discrimination training at or around the painful area can take place in many forms, including graphesthesia, localization, desensitization, or two-point discrimination. Regardless of the form selected, tactile stimuli (e.g., shapes drawn on the skin) should be used that will be difficult but not impossible for the patient to accurately identify. Finally, exercise is initiated with the use of mirrors to provide the patient with a non-limited, non-painful image of the affected area moving, when in actuality it is the patient's *opposite* side moving. This form of treatment has been primarily studied in patients with CRPS, with moderate-level evidence suggesting improvements in pain and ROM as a result of mirror therapy [168]. As with any form of exercise, repetition is key for improved performance and outcomes. The recommended dose for imagery and laterality training is 1–2 hours/day which is performed in multiple, short sessions of about 20 images/session. Sensory discrimination and mirror therapy is dosed more similarly to traditional exercise, with two to three sets of ten repetitions performed within a session lasting about 3–5 minutes. Exercise within the GMI framework does not need to be completed in a lockstep fashion, as certain components can be omitted or introduced simultaneously depending on the unique impairments and irritability level of the patient.

Where GMI training may be considered as the means to the end, functional restoration training should be considered as the end goal for patients with nociplastic pain [169]. Functional restoration training utilizes a quota system to encourage improvements in strength, flexibility, and conditioning as the metric for success in an exercise program. With patients focused on improving these physical metrics, as opposed to a focus on their pain response, progressive loading is achieved that results in significant changes in functional capacity. In a graded exercise approach to treatment, quotas are set at the time of baseline testing. Patients who meet their quota receive positive reinforcement and an increase in the quota, while those not meeting their quota are encouraged to meet it during the next exercise session. Examples of graded exercises typically include strength and endurance training, lifting, walking, and cycling. Patients may receive up to 2.5 hours of quota-based activity in a daylong treatment session, which may be repeated on consecutive days within the framework of an interdisciplinary program. Evidence in patients with fibromyalgia suggests that a multimodal program of strengthening and stretching combined with aerobic exercise is superior to a unimodal program of aerobic exercise at improving pain and function, with moderate-large effect sizes reported [170]. Exercise in the moderate- to high-intensity range has been found to be both safe and effective for improving pain, function, and strength in patients with fibromyalgia [171]. Yet, therapists should be aware that patients with central pain processing dysfunction may initially find exercise to be quite irritating due to a loss of descending pain inhibition. In such cases, aerobic exercise may initially be better tolerated than isometric or eccentric exercise, since the latter may elevate nervous system excitability [172]. Furthermore, aerobic exercise may initially be performed at nonpainful body regions or, in the case of fibromyalgia, at an intensity below 70% VO_{2max} [173]. Patience, persistence, and adequate recovery between exercise bouts are the key to overcoming these temporary barriers, as the patient's pain response is expected to improve with continued exercise over the course of several weeks [90].

Finally, graded exposure approaches to exercise may be utilized for patients with fear (vs. pain) as a primary impairment to movement. The Fear of Daily Activities Questionnaire is used to identify a patient's level of fear for a particularly limited activity at baseline [174]. Patients are asked to perform the particular activity at a specified intensity and time and then rate their level of fear post-activity. The time or intensity of the activity is subsequently increased if fear is reduced post-activity, while the exercise is left unchanged and repeated if fear is increased or stays the same. Examples of graded exposure activities include walking, sitting, standing, lifting, and carrying. In a group of patients presenting primarily with work-related chronic low back pain, graded exercise compared similarly to graded exposure for improvements in pain and disability [175].

Manual Therapy

Manual therapy may be beneficial in a subset of patients with nociplastic pain. Joint or soft tissue-based techniques may first be applied locally or regionally to the area of pain as described in the section on nociceptive mechanisms. However, when symptoms are relatively widespread, or when pain limits the application of treatment to the primary area(s), a different perspective may be utilized. In such cases, treating dysfunctions in spinal mobility, even when they are remote to the area of pain, may positively impact neural sensitivity on a systemic level. Spinal manipulation has been performed in a number of conditions associated with a nociplastic mechanism, including fibromyalgia, CRPS, whiplash associated disorder, lateral epicondylitis, and temporomandibular disorder [176]. Additionally, massage has been reported as beneficial for pain relief and functional improvements across a number of pain conditions [177]. Since massage and thrust manipulation have each been shown to work via central mechanisms, these interventions may have greater potential to modulate centrally mediated pain compared to other forms of manual therapy, particularly in patients with fibromyalgia [178–180].

Modalities

A limited number of modalities have been recommended in the management of patients with nociplastic pain. Balneotherapy, which is the therapeutic use of baths, is supported in clinical practice guidelines for fibromyalgia [181]. This hydrotherapy may be delivered at a spa or in the home, via water or mud baths, at a temperature range of 36–45 °C and an average exposure time of 240 minutes over several weeks [181]. Additionally, both acupuncture and dry needling may be beneficial in the treatment of myofascial pain and fibromyalgia [182, 183]. After four weekly sessions of dry needling to the neck and shoulder girdle, patients with fibromyalgia reported significant improvements in a wide range of outcomes, including pain, function, fatigue, anxiety, depression, and sleep quality [183]. Electroacupuncture coupled with massage has also received preliminary support in the literature, making it a promising treatment for patients with CRPS [184].

Conclusion

This chapter provides an evidence-based framework for the evaluation and management of pain by a physical therapist. Using a biomechanical focus to the examination, the therapist should first consider the relative contributions of the articular, muscular, and nervous systems to impaired movement. Using a biopsychosocial focus to the overall assessment, the therapist should then consider how pain mechanisms and environmental/behavioral-based factors contribute to activity limitations and participation restrictions. Formation of a treatment plan may be viewed like the layers of an onion, with treatments becoming increasingly complex, or layered, as you move further away from the center. Patients with a nociceptive mechanism and fewer environmental/behavioral-based factors are found closest to the center of the onion, making up the "core" of traditional articular- and muscular-based physical therapy treatments. Patients with neuropathic and nociplastic pain are found beyond the core and will require a multilayered approach to management. In addition to traditional treatments, these patients should also receive interventions focused on neurodynamics, sensory integration, and behavioral modification. Regardless of the underlying pathology, the skillful application of layered physical therapy treatment is essential for the successful management of chronic pain.

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