The Role of Manual Therapies in Equine Pain Management

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KEYWORDS

• Manual therapy • Touch • Stretching • Massage • Mobilization • Manipulation • Pain

Beyond all doubt the use of the human hand, as a method of reducing human suffering, is the oldest remedy known to man; historically no date can be given for its adaptation.

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The use of touch, massage, or manipulation of painful articulations or tense muscles is arguably one of the oldest and most universally accepted forms of therapy to relieve pain and suffering.[1] Firmly grasping an acutely injured thumb after a misdirected hammer blow or rubbing a sore muscle or stiff joint after a long-day's work are simple and often effective methods of providing short-term pain relief in humans. Similarly, animals lick, scratch, or rub wounds or areas of irritation on themselves or their offspring in an apparent attempt to reduce pain and suffering. Horses are known to respond favorably to grooming, to stretch, roll on their backs, and rub up against objects, presumably because these activities provide some sense of comfort. Over time, both lay and licensed practitioners have developed a spectrum of manual methods to provide varying levels of pain relief to both humans and animals. However, most organized medicine often remains skeptical of any purported effects of massage or other forms of manual therapy, and routinely ostracizes practitioners that apply these techniques.[2] In the last few decades, considerable advances have been made in conducting investigations into plausible mechanisms of action and scientific reviews of the clinical efficacy of manual therapy in pain management.

All forms of manual therapy involve the application of the hands to the body, with a diagnostic or therapeutic intent.[3] Abdominal and rectal palpation, soft tissue and bony palpation of musculoskeletal structures, or moving a joint through its expected range of motion are considered essential diagnostic techniques used routinely in veterinary medicine (**Fig. 1**). Touch therapies, massage, physical therapy, osteopathy,

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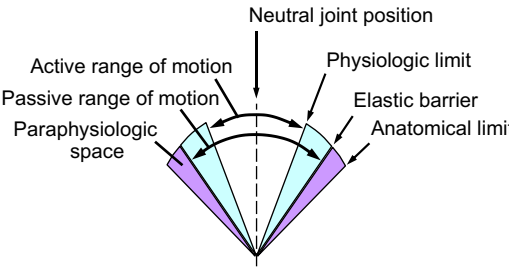

Fig. 1. Joint mechanics as it relates to active and passive joint range of motion. The physiologic limit demarcates active versus passive joint range of motion. The paraphysiologic space is defined by the elastic barrier and the anatomic limit of the articulation. Inducing motion beyond the anatomic limit of the joint induces tissue damage and results in joint subluxation or luxation.

and chiropractic are techniques that have been developed for treatment of musculoskeletal disorders in humans and transferred for use in horses. Each treatment method has a unique origin and different proposed biomechanical or physiologic effects; however, all forms of manual therapy are characterized by applying variable gradations of manual force and degrees of soft tissue or articular displacement (**Fig. 2**).[4] The goal of all manual therapies is to influence reparative or healing processes within the neuromusculoskeletal system, which often includes pain relief.

The therapeutic effects of manual therapies may be generalized to the entire body by inducing relaxation or altering behavior; regional effects may include alterations in pain perception or neuromuscular control; or effects may be localized to specific tissues and cellular responses.[3] The challenge for practitioners is in selecting the most appropriate and effective form of manual therapy to produce the desired physiologic effect within an individual patient, such as increasing joint range of motion, reducing pain, or promoting general body relaxation. Anecdotally, all forms of manual therapy have varying reported levels of effectiveness in humans and horses. Unfortunately, most claims are not supported by high levels of evidence from randomized, controlled trials or systematic reviews of the literature. The purpose of this article is provide a brief description and overview of the scientific literature on the efficacy,

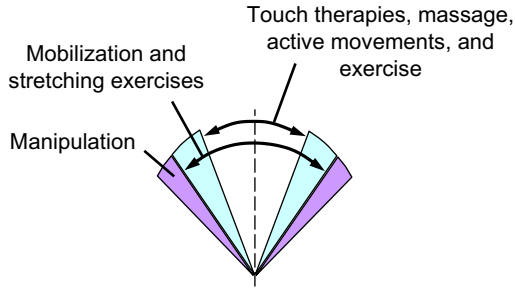

Fig. 2. Joint mechanics as it relates to the site of action of various manual therapies. Touch therapies and massage do not typically induce joint motion, whereas all forms of exercise occur within the active range of joint motion. Passive stretching and joint mobilization occur within the passive range of joint motion. Joint manipulation, characterized by a high-velocity, low-amplitude thrust, occurs outside of the limits of passive joint motion; within the paraphysiologic space.

safety, and mechanisms of action of the different manual therapy techniques commonly applied to horses, with a specific focus on their role in acute and chronic pain management.

ANTINOCICEPTIVE EFFECTS OF MANUAL THERAPIES

Pain represents a series of complex molecular, cellular, physiologic, physical, and behavioral attributes and interactions.[5] Nociception involves the processes of transduction (at the sensory nerve ends), transmission (via peripheral sensory nerves), modulation (within the spinal cord), projection (via ascending pain pathways), and pain perception (within the thalamus and cerebral cortex).[6] The exact mechanisms by which manual therapies relieve pain are unknown; however, the various forms of manual therapy may influence the nociceptive processes at each of these levels. The problem, in part, is in defining and objectively measuring the primary cause of musculoskeletal pain.[1] Transduction may be altered by local biochemical changes induced by massage that modulates local blood flow and oxygenation of tissues.[7] Pinching the skin at the site of an injection is a form of a manually induced counterirritant or afferent stimulation that acts to reduce the perception of pain associated with percutaneous injections. The transmission of nociceptive signals may be altered by mechanical and neurophysiologic mechanisms associated with spinal manipulation, which influence primary afferent neurons from paraspinal tissues, the motor control system, and pain processing.[8,9] Modulations of spinal pathways act to inhibit central sensitization and influence referred pain. Peripheral and central sensitization are characterized by increased sensitivity of local tissues and the spinal cord to noxious and innocuous stimuli, which causes an increase in pain perception. Spinal manipulation is theorized to produce an inhibitory effect mediated by induced stretching of spinal mechanoreceptors that reduce central sensitization of the segmental dorsal horn neurons.[8,10] Neuronal and synaptic plasticity of spinal neurons may also be influenced by manual therapies.[11] The gate-control theory predicts that massaging a particular area stimulates large diameter nerve fibers, which have an inhibitory input within the spinal cord.[7] Projection of nociceptive signals may be altered by descending pain inhibitory systems projecting from the brain to the spinal cord, which can be activated by spinal manipulation via sympathoexcitatory effects.[12] Manual therapies may also increase pain thresholds through the release of endorphins and serotonin and modulate activity within subcortical nuclei that influence mood and pain perception.[7] Pain perception may be influenced through physical and mental relaxation.[7] Placebo or psychological effects also play a role in human pain; however the magnitude of these effects within the veterinarian-client-patient relationship is unknown.[13]

Manual therapy is considered to produce physiologic effects within local tissues, on sensory and motor components of the nervous system, and at a psychological or behavioral level.[3] It is likely that specific manual therapy techniques are inherently more effective than others in addressing each of these local, regional, or systemic components.[14] The challenge is in choosing the most appropriate form of manual therapy or combination of techniques that will be efficacious for an individual patient with specific musculoskeletal disabilities (**Table 1**). If soft tissue restriction and pain are identified as the primary components of a musculoskeletal injury, then massage, stretching, and soft tissue mobilization techniques are indicated for increasing tissue extensibility (**Fig. 3**).[15] However, if the musculoskeletal dysfunction is localized to articular structures, then stretching, joint mobilization, and manipulation are the most indicated manual therapy techniques for restoring joint range of motion and reducing pain.[16]

Table 1
Potential indications for application of various equine manual therapy techniques

Manual Therapy Technique	Indications
Touch therapies	Pain
Massage	Muscle hypertonicity, soft tissue restriction, pain
Stretching	Soft tissue restriction, joint stiffness
Soft tissue mobilization	Soft tissue restriction, pain
Joint mobilization	Joint stiffness, pain
Joint manipulation	Joint stiffness, pain, muscle hypertonicity

Local tissue effects produced by manual therapy techniques relate to direct mechanical stimulation of skin, fascia, muscles, tendons, ligaments, and joint capsules.[17] Direct mechanical loading of tissues can alter tissue healing, the physical properties of tissues (eg, elongation), and local tissue fluid dynamics associated with extracellular or intravascular fluids. Normal tissue repair and remodeling relies on mechanical stimulation of cells and tissues to restore optimal structural and functional properties, such as tensile strength and flexibility. Nonspecific back pain is most likely related to a functional impairment and not a structural disorder; therefore, many back problems may be related to muscle or joint dysfunction with secondary soft tissue irritation and pain generation.[18] Soft tissue contractures and adhesions are unwanted effects associated with musculoskeletal injuries and postsurgical immobilization.[19] Stretching exercises or direct mechanical mobilization of the affected tissue can be used to elongate contracted or fibrotic connective tissues to improve soft tissue extensibility and increase joint range of motion.[15] Tissue viability is highly dependent on its vascular and lymphatic supply, which is often compromised as a result of mechanical disruption or ischemia. Soft tissue or joint mobilization may facilitate flow to and from the affected tissues, help to reduce pain and edema, and decrease joint effusion.[20] Joint manipulation can improve restricted joint mobility and may reduce the harmful effects associated with joint immobilization and joint capsule contractures. Limb and joint mobilization can also have direct mechanical effects on nerve roots and the dura mater, which may have clinical application in the treatment of perineural adhesions and edema.[21]

Fig. 3. Soft tissue mobilization of the skin overlying the trunk. The skin and superficial fascia is mobilized in cranial-caudal and medial-lateral directions to assess or treat any soft tissue restrictions in movement.

Joint mobilization and manipulation are believed to produce different physiologic effects; however, the evidence in humans is mixed. Manipulation has been shown to immediately reduce spontaneous myoelectrical activity and paraspinal muscle spindles, whereas mobilization has not.[22,23] For neck pain in humans, manipulation produces significant reductions in pain and disability, compared with mobilization.[24] However, both joint mobilization and manipulation increase cervical range of motion to a similar degree.[25] Other studies report that neither manipulation nor mobilization are beneficial or significantly different for mechanical neck disorders.[26] For acute low back pain in humans, there is moderate evidence that spinal manipulation provides more short-term pain relief than does mobilization.[16] It has been theorized that spinal manipulation preferentially influences a sensory bed, which, in terms of anatomic location and function, is different from the sensory bed influenced by spinal mobilization techniques.[27] Manipulation may particularly stimulate receptors within deep intervertebral muscles, whereas mobilization techniques most likely affect more superficial axial muscles. In horses, spinal manipulation increased the dorsoventral displacement of the trunk and applied force, which indicate increased spinal flexibility and increased tolerance to pressure in the thoracolumbar region of the equine vertebral column, compared with mobilization alone.[28,29] The literature suggests that any stimulus that activates high-threshold receptors within the periarticular tissues has the potential to initiate unique neurologic reflexes associated with joint manipulation.[30,31]

Tissue manipulation has the additional effect of stimulating regional or systemic changes in neurologic signaling related to pain processing and motor control.[32] Manual therapy can provide effective management of pain and neuromuscular deficits associated with musculoskeletal injuries, alterations in postural control, and locomotory issues related to antalgic or compensatory gait.[3] In response to chronic pain or stiffness, new movement patterns are developed by the nervous system and adopted in an attempt to reduce pain or discomfort. Long after the initial injury has healed, adaptive or secondary movement patterns may continue to persist, which predispose adjacent articulations or muscles to injury.[18] Activation of proprioceptors, nociceptors, and components of the muscle spindles provide afferent stimuli that have direct and widespread influences on components of the peripheral and central nervous systems that directly regulate muscle tone and movement patterns.[18] The various forms of manual therapy are believed to affect different aspects of joint function via diverse mechanical and neurologic mechanisms.[4] Alterations in articular neurophysiology from mechanical or chemical injuries can affect both mechanoreceptor and nociceptor function via increased joint capsule tension and nerve ending hypersensitivity.[33] Mechanoreceptor stimulation induces reflex paraspinal musculature hypertonicity and altered local and systemic neurologic reflexes. Nociceptor stimulation results in a lowered pain threshold, sustained afferent stimulation (ie, facilitation), reflex paraspinal musculature hypertonicity, and abnormal neurologic reflexes. Touch and light massage preferentially stimulate superficial proprioceptors, whereas any technique that involves deep tissue massage, stretching, muscle contraction, or joint movement has the potential to stimulate deep proprioceptors.[3] Massage, stretching, and joint mobilization are also considered to affect more superficial epaxial muscles, such as the longissimus muscle, and to have a multisegmental effect. In contrast, manipulation preferentially stimulates mechanoreceptors within deep multifidi muscles and has a more segmental focus.[27] Joint manipulation can affect mechanoreceptors (ie, Golgi tendon organ and muscle spindles) to induce reflex inhibition of pain and muscle relaxation and to correct abnormal movement patterns.[8] Because of somatovisceral innervation, mobilization and manipulation within the trunk has

possible influences on the autonomic system and visceral functions; however, the clinical significance and repeatability of these effects are largely unknown.[34,35]

The effects of touch or massage on psychological issues such as behavior or emotion are often dismissed as an insignificant component of the overall healing process in patients.[3] Promoting general body relaxation and reducing anxiety may be significant components of pain management protocols.[36] Behaviors related to pain, depression, or fear are associated with patterned somatic responses, which may be manifest as generalized changes in muscle tone, autonomic activity, or altered pain tolerance. Other psychological factors associated with manual therapies include placebo effects and patient satisfaction. Unfortunately, the role of placebo effects in horses and their owners is currently unknown.

THERAPEUTIC TOUCH

The physical act of touching another human being or an animal can induce physiologic responses and is often considered therapeutic.[37] Interacting with animals during animal-assisted therapy sessions has been shown to reduce blood pressure and cholesterol, decrease anxiety, improve a person's sense of well-being, and cause a significant reduction in pain levels in humans.[38,39] Similarly, petting a horse or a dog can cause physiologic changes within the animal itself.[40] In humans, therapeutic touch is used by nurses to nurture premature infants, for supportive care in cancer or terminally ill patients, and for support of the bereaved.[41] Recognized touch therapy techniques in humans include Healing Touch, Therapeutic Touch and Reiki.[42] These techniques are considered a form of energy-based therapy in which practitioners move their hands over the body but do not contact the patient or use a gentle touch over certain areas of the body with the goal of facilitating physical, emotional, mental, and spiritual health. Human patients often use touch therapies for relaxation, stress reduction, and symptom relief. Mechanical devices or squeeze machines have also been developed to induce deep pressure or full-body compression, which induce calming behaviors in both autistic human patients and animals.[43,44] Reviews of controlled studies in humans evaluating effectiveness of touch therapies show promising results for pain relief, but further rigorous studies are needed to define clinical applications and mechanisms of action.[42,45] Trials conducted by more experienced practitioners appeared to yield greater effects in pain reduction.

In horses, touch therapies have been primarily developed and promoted by Linda Tellington-Jones in a collection of techniques named the Tellington Touch Equine Awareness Method (TTEAM) or Tellington TTouch.[46] Anecdotally, therapeutic touch is considered to improve behavior, performance, and well-being of horses and enhance the relationship between horse and rider, but no controlled studies exist to support these claims. Similar touch therapy techniques have been used in foals at birth to assess the effects of touch or imprint training on behavioral reactions during selected handling procedures.[47] Conditioned foals were significantly less resistant to touching the front and hind limbs and picking up the hind feet at 3 months of age. Well-designed and controlled studies are needed to determine the effectiveness of touch theories in managing behavior and musculoskeletal pain in horses.

MASSAGE THERAPY

Massage therapy is defined as the manipulation of the skin, muscle, or superficial soft tissues either manually (eg, rubbing, kneading, or tapping) or with an instrument or mechanical device (eg, mechanical vibration) for therapeutic purposes (**Fig. 4**). Massage techniques do not typically cause movement or changes in articular

Fig. 4. Mobilization of the skin overlying the lateral scapular region using a skin-rolling technique to assess the quality and quantity of soft tissue mobilization in the region.

positioning and include many named methods such as Swedish massage, Rolfing, myofascial release, trigger point therapy, lymphatic drainage, and acupressure.[7] The manual techniques used in massage include effleurage, pétrissage, friction, kneading, or hacking, and often vary in the depth or speed of the applied pressure and in the specific tissues or regions of interest.[48] Massage is indicated for a wide variety of conditions in which pain relief, reduction of swelling, or mobilization of adhesive tissues are desired.[49] Massage is generally recognized as a safe intervention with minimal adverse effects. However, deep friction, compression, or ischemic compression have been reported to produce temporary postmassage soreness or ecchymosis in humans.[50] Massage is contraindicated for acute injuries, open wounds, and skin infections.[48]

Clinically, massage and soft tissue mobilization are believed to increase blood flow, promote relaxation, reduce muscle hypertonicity, increase tissue extensibility, reduce pain, and speed return to normal function; however, few controlled studies exist to support these claims.[7,51] There are many anecdotal reports of the beneficial effects of massage on human athletic performance; however, strong evidence in the form of controlled studies does not exist for the effects of massage on preventing injuries, recovery from exercise, or enhancing performance.[52] Systematic reviews suggest that massage may be beneficial for patients with subacute and chronic nonspecific low back pain in humans, especially when combined with exercises and education programs.[53,54] There is moderate evidence that acupressure may be more effective than Swedish massage for chronic low back pain.[7] Massage is also a popular adjunct to cancer palliation and systematic reviews suggest that massage can alleviate a wide range of cancer-associated symptoms in humans: pain, nausea, anxiety, depression, anger, stress, and fatigue.[55,56] Unfortunately, the methodological quality of most massage studies is poor, which prevents definitive conclusions and recommendations.[57] More research is needed to determine which type of massage is indicted for similar clinical presentations within patients, such as higher baseline pain scores, muscle spasms, or stress and anxiety.[7]

In horses, massage therapy has been shown to be effective for reducing stress-related behavior[40] and lowering mechanical nociceptive thresholds within the thoracolumbar region.[58] A noncontrolled, clinical trial using 8 horses measured increased stride lengths at the walk and trot before and after massage, but changes were not significant because of the small sample size.[59] Manual lymph drainage has been

described for use in the management of lymphedema in horses; however, no controlled studies exist evaluating its effectiveness.[60] In a clinical trial in dogs, massage was significantly more effective in increasing lymph flow than passive flexion and extension of the forelimb or electrical stimulation of the forelimb musculature.[61] More high-quality, objective, outcome-based evidence is needed to support the use of massage therapy in horses.[62,63]

PASSIVE STRETCHING EXERCISES

Passive stretching consists of applying forces to a limb or body segment to lengthen muscles or connective tissues beyond their normal resting lengths, with the intent of increasing joint range of motion and promoting flexibility.[64] Passive joint range of motion or stretching exercises differ neurophysiologically from active joint motion or exercise, which requires muscle activation, strength, and coordination. Active stretching involves using the patient's own movements to induce a stretch, whereas passive stretches are applied to relaxed muscles or connective tissues during passive soft tissue or joint mobilization. In horses, active stretches of the neck and trunk are often induced with baited (ie, carrot) stretches with the goal in increasing flexion, extension, or lateral bending of the axial skeleton (**Fig. 5**).[65] Asking horses to produce active stretching of specific articulations is often difficult; therefore, passive stretches are most commonly prescribed in horses (**Fig. 6**).[66] Distraction or traction refers to applying manual or mechanical forces to induce separation of adjacent joint surfaces, which causes stretching of the joint capsule, reduced intraarticular pressure, and is often used to reduce joint luxations (**Fig. 7**).

Stretching exercises vary according to the direction, velocity, amplitude, and duration of the applied force or induced movement. However, it is difficult to identify which combination of positions, techniques, and durations of stretching are the most effective

Fig. 5. Induced active cervical range of motion using a baited stretch. Note that the horse is positioned up against a wall to prevent lateral movement of the trunk as the hay is positioned at the girth region to induce left lateral bending of the cervical region. Active range of motion helps to identify left-to-right asymmetries in joint range of motion.

Fig. 6. Induced passive right lateral bending of the lower cervical region. The intervertebral articulation of interest (eg, C5–C6) is stabilized with one hand as the head and neck of the horse is brought into lateral bending. Gentle joint mobilization at the end range of motion helps to localize and lateralize signs of pain, joint stiffness, and muscle hypertonicity to specific cervical intervertebral articulations.

to induce increased joint range of motion and reduced pain within a specified articulation.[67] Stretching should be performed slowly to maximize tissue elongation due to creep and stress relaxation within fibrotic or shortened periarticular soft tissues.[15] Sustained low-load stretching is more effective than rapid high-load stretching for altering viscoelastic properties within soft tissues.[68] Rapid stretching may exceed the tissue's mechanical properties and produce additional trauma within injured tissues.[69] The force applied during stretching exercises should be tailored to specific phases of tissue repair.[15] During the acute inflammatory phase, stretching should be mostly avoided because of the increased risk of tissue injury. During the regenerative and remodeling phases of healing, tissues progressively regain tensile strength and applied manual forces can be gradually increased. The amount of force applied during passive stretching is largely based on the patient's response and signs of pain. Musculoskeletal injuries are often characterized by multiple tissue involvement, each of which has a different

Fig. 7. Passive distraction of the carpus. The distal limb is passively flexed over the doctor's forearm to induce a distractive force to the carpal articulations and associated joint capsules.

healing rate and unique mechanical response to stretching. Therefore, effective stretching programs are best tailored to address specific soft tissue injuries and not only focused on restoring joint motion.

The duration of the applied stretch is dependent on the force applied, affected tissue shape and size, the amount of damage or fibrosis present, and the stage of tissue healing.[15] In humans, the recommended duration for stretching the musculotendinous unit varies from 6 to 60 seconds.[69] Stretching for 30 seconds has been shown to be significantly more effective than 15-second stretches; however, structural and functional differences within each affected tissue makes general recommendations for stretching a particular articulation or limb difficult to establish.[70] The mode of loading during an applied stretch varies from continuous to cyclic. Continuous or static loading can be uncomfortable for some patients and is not recommended.[15] Cyclic or rhythmical stretching is more comfortable and physiologic as it provides periods of tissue loading and unloading, which has biomechanical and neurologic benefits. Cyclic loading also has cumulative effects on soft tissues as a result of incremental elongation and stress relaxation within each stretch cycle; however, these effects are maximized approximately within the first 4 cycles of loading.[69] Therefore, recommendations for optimal passive stretching include applying 4 to 5 repetitions of slow low-load forces held at the end range of motion of the affected tissues, with each stretch applied and released in 30-second cycles, without inducing pain. If performed inappropriately, stretches may cause or aggravate injuries.[71] Therefore, thorough patient evaluation and formulation of a proper stretching program are required before implementing any stretching exercises.

Stretching soft tissues is believed to increase joint range of motion, enhance flexibility, improve coordination and motor control, increase blood flow to muscles, and helps to prevent injuries.[72] Systematic reviews of the human literature suggest that stretching may have beneficial effects on increasing joint range of motion, reducing pain, and preventing work-related musculoskeletal disorders.[71,73] There is strong evidence that stretching and strengthening exercises are effective for reducing pain, improving function, and producing favorable long-term global effects in human patients with subacute and chronic mechanical neck disorders.[74] Randomized studies suggest that regular stretching increases joint range of motion (average of 8°) for more than 1 day after cessation of stretching and that the effects of stretching are possibly greater in muscle groups with limited extensibility.[75] Regular stretching has been shown to improve performance by increasing force, jump height, and speed.[76] Other reviews of the literature report that there is not sufficient evidence to endorse or discontinue routine stretching before or after exercise to prevent injury among competitive or recreational human athletes.[77–79] Because of the relatively low methodological quality of most studies, further research is needed to determine the proper role of stretching in human sports. Stretching combined with strengthening provides the largest improvement in nonspecific chronic neck or low back pain in humans.[80,81]

In horses, passive stretching exercises of the limbs and axial skeleton have anecdotal effects of increasing stride length and joint range of motion and improving overall comfort (**Fig. 8**).[66] In a noncontrolled study, passive thoracic limb stretching lowered wither height as a result of possible relaxation of the fibromuscular thoracic girdle.[82] However, a randomized controlled trial in riding school horses evaluating the effect of 2 different 8-week passive stretching programs reported no significant changes in stride length at the trot but had a detrimental effect of decreasing joint range of motion within the shoulder, stifle, and hock articulations.[83] The investigators concluded that daily stretching may be too intensive in normal horses and may actually cause negative biomechanical effects. Additional studies on the effects of different

Fig. 8. Induced passive thoracic limb protraction. At the end range of motion, the horse is asked to actively extend the thoracic limb into the doctor's hands in an effort to stimulate neuromuscular reflexes and improve active protraction of the limb.

stretching techniques and frequency for specific disease processes using objective outcome measures need to be completed before any further claims of performance enhancement or pain reduction in horses can be made.

SOFT TISSUE AND JOINT MOBILIZATION

Mobilization is defined as manually or mechanically induced movement of articulations or soft tissues for therapeutic purposes. Soft tissue mobilization focuses on restoring movement to the skin, connective tissue, ligaments, tendons, and muscles with the goal of modulating pain, reducing inflammation, improving tissue repair, increasing extensibility, and improving function.[51] Neural mobilization techniques have been developed to induce movement within specific spinal or peripheral nerves and the dura mater with the intent of reducing neural adhesions and edema.[21,32] Joint mobilization is characterized as nonimpulsive repetitive joint movements induced within the passive range of joint motion with the purpose of restoring normal and symmetric joint range of motion, to stretch connective tissues, and to reduce pain (**Fig. 9**).[84] Biomechanical characteristics of joint mobilization include low velocity movements, low peak forces, and large displacements. Mobilization is typically applied with oscillatory forces within or at the limits of physiologic joint range of motion without imparting a thrust or impulse. Mobilization is also performed within the patient's ability to resist the applied motion and therefore requires cooperation and relaxation of the patient. Joint mobilization is usually applied in a graded manner, with each grade increasing the range of joint movement. Grade 1 and 2 mobilizations are characterized by slow oscillations within the first 25% to 50% of the available joint motion, with the goal of reducing pain. Grade 3 and 4 mobilizations involve slow oscillations at or near the end of available joint motion, which are used to increase joint range of motion. Some soft tissue and joint mobilization techniques may include a hold and stretch at the end range of motion.

Soft tissue and joint mobilization is used to assess the quality and quantity of joint range of motion and as a primary means of treating musculoskeletal disorders. Adjunctive physical therapy techniques include therapeutic exercises and rehabilitation of

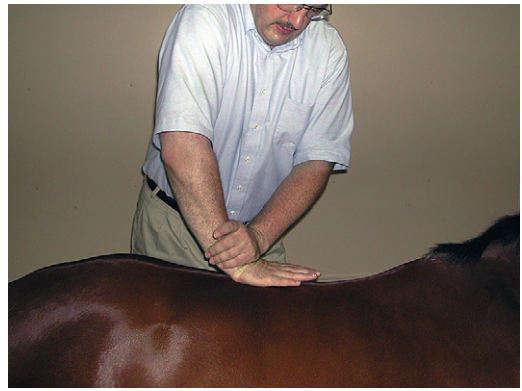

Fig. 9. Spinal mobilization at the thoracolumbar junction. A ventral force is applied rhythmically to assess the quality and quantity of passive joint range of motion and the joint end-feel (ie, anatomic limit of the articulation) in extension at sequential intervertebral levels.

neuromotor control, where manual forces are used to induce passive stretching, weight shifting or activation of spinal reflexes, which help to increase flexibility, stimulate proprioception and strengthen core musculature.[32,65] There is strong evidence that a multimodal approach of cervical mobilization, manipulation, and exercise are effective for reducing pain, improving function, and producing favorable long-term global effects in human patients with subacute and chronic mechanical neck disorders.[74] Active range of motion exercises may be more effective for acute pain reduction in human patients with whiplash-associated disorders.[85] There is mediate evidence in humans that mobilization and manipulation produce similar effects on pain, function, and patient satisfaction at intermediate-term follow-up.[86] Peripheral nerve and nerve root mobilization techniques and exercises are also used for the postoperative rehabilitation of low back pain.[87]

Few formal studies exist to support the use of active soft tissue, joint, or spinal mobilization techniques in horses.[28] Most mobilization studies in horses involve a period of induced joint immobilization by a fixture or cast followed by allowing the horse to spontaneously weight bear and locomote on the affected limb, without evaluation of specific soft tissue or joint mobilization techniques.[19] Spinal mobilization has been shown to be effective at increasing spinal flexibility in ridden horses without clinical signs of back pain.[29] Spinal manipulation, characterized by high-velocity, low-amplitude thrusts, produced immediate and larger increases in displacement within treatment sessions; whereas the effects of spinal mobilization had a delayed effect of increasing displacement, which suggests 2 possibly different mechanisms of action for spinal mobilization and manipulation.[88] Spinal mobilization is generally considered a more conservative or low-force technique applied in acute pain conditions; whereas manipulation is theoretically considered a more specific and forceful type of manual therapy that has shown more beneficial effects for chronic neck or back pain in humans.[16]

MANIPULATION

Joint manipulation is characterized by the application of a high-velocity, low-amplitude thrust or impulse that moves a joint or vertebral segment beyond its physiologic range of motion, without exceeding the anatomic limit of the articulation.[89] Differences in the magnitude and rate of loading associated with mobilization versus manipulation are likely to produce variable therapeutic effects because of the viscoelastic nature of the

soft tissues surrounding the vertebral column.[88,90] Spinal manipulation involves the application of controlled thrust or impulse to articular structures within the axial skeleton with the intent of reducing pain and muscle hypertonicity and increasing joint range of motion.[91]

Both the chiropractic and osteopathic professions use high-velocity, low-amplitude thrusts to induce therapeutic effects in articular structures, muscle function, and neurologic reflexes with the goal of increasing joint range of motion and reducing pain.[4,92] Most human chiropractic patients seek care because of headaches or spinal pain; more than 70% have neck or lower back pain.[93] Human research has demonstrated reductions in pain and muscle hypertonicity and increased joint range of motion after chiropractic treatment.[16,25,94] In humans, osteopathic care significantly reduces low back pain and effects can persist for at least 3 months.[95] Few studies have assessed the efficacy of preventative spinal manipulation for managing chronic low back pain.[96] The therapeutic dose of joint manipulation is varied by the number of vertebrae or articulations treated, the amount of force applied, and the frequency and duration of treatment. Unfortunately, there is not good scientific evidence on which to base optimal dosage recommendations for continued care, therefore therapeutic trials are often used on an individual basis.[97] There is low quality evidence that cervical manipulation alone compared with a control may provide short-term pain relief following 1 to 4 treatment sessions, and that 9 to 12 sessions were superior to 3 treatments for pain and disability in patients with cervicogenic headache.[86] High-dose manipulation is superior to low-dose manipulation for chronic low back pain in the short-term.[98]

In horses, anecdotal evidence and clinical experience suggest that manipulation is an effective adjunctive modality for the conservative treatment of select musculoskeletal-related disorders.[99] However, therapeutic trials of spinal manipulation are often used because there is limited formal research available about the effectiveness of osteopathic or chiropractic techniques in equine practice. Equine osteopathic evaluation and treatment procedures have been described in textbooks and case reports, but no formal hypothesis-driven research exists.[92,100,101] Human osteopathic techniques also include highly controversial methods associated with mobilizing cranial bones and abdominal viscera, which have questionable application to horses.[92,102] The focus of recent equine chiropractic research has been on assessing the clinical effects of spinal manipulation on pain relief, improving flexibility, reducing muscle hypertonicity, and restoring spinal motion symmetry. Obvious criticism has been directed at the physical ability to even induce movement in the horse's back. Pilot work has shown that manually applied forces associated with chiropractic techniques are able to produced substantial segmental spinal motion.[103] Two randomized, controlled clinical trials using pressure algometry to assess mechanical nociceptive thresholds in the thoracolumbar region of horses have shown that both manual and instrument-assisted spinal manipulation can reduce back pain (or increase mechanical nociceptive thresholds).[58,104] Additional studies have assessed the effects of equine chiropractic techniques on increasing passive spinal mobility (ie, flexibility)[28,29] and reducing longissimus muscle tone.[105] The effect of manipulation on asymmetrical spinal movement patterns in horses with documented back pain suggest that chiropractic treatment elicits slight but significant changes in thoracolumbar and pelvic kinematics and that some of these changes are likely to be beneficial.[106,107]

MANUAL-ASSISTED TECHNIQUES

In humans, the application of manual forces can be combined with a wide diversity of therapeutic or medical techniques to produce varying effects. Hand-held

spring-loaded or electromechanical devices can be used to apply single or multiple impulses to articulations or tissues in a series of techniques named manually assisted, mechanical force procedures. It has been reported that approximately 40 N of force is required to activate mechanical and neurologic responses associated with spinal manipulation.[108] Manual impulses applied to the human cervical and lumbar spine range from 40 to 400 N and occur for 30 to 150 milliseconds. Similar amplitudes of force have been measured with instrument-assisted manipulations (ie, 72 N to 230 N); however, the impulse occurs for a much smaller time (ie, 0.1–5.0 milliseconds). It is hypothesized that the velocity of the applied force may be more important than the amplitude of the applied force.[108] Randomized studies have shown similar effectiveness using either manual or instrument-assisted treatment techniques.[109,110] Using a stick and mallet or similar percussive device to apply sharp mechanical forces to dorsal spinous processes has been reported in horses to reduce back pain and increase spinal range of motion, but controlled studies are lacking.[106] Theoretically, there is an increased risk for injury using instrument-assisted techniques or hammers to treat horses because of the possibility of applying excessive forces by inexperienced or lay practitioners with little or no knowledge of spinal or joint biomechanics.

Joint mobilization and manipulation can be combined with sedation or general anesthesia, which provides increased relaxation and analgesia for evaluation of subtle joint motion restrictions or treatment of joint contractures and spinal pain, without the influence of conscious pain or protective muscle guarding.[111] Manipulation under anesthesia generally consists of 4 stages: sedation, mobilization/stretching/traction, manipulation, and aftercare of active rehabilitation and additional manual therapy.[112] Indications for manipulation under anesthesia in humans include pain that will not allow conscious manipulation, conditions that do not respond to conscious spinal manipulation within 4 to 8 weeks, chronic joint or soft tissue fibrosis, acute myofascial rigidity and painful inhibition, severe joint dysfunction, refractory contained disc herniation, and multiple recurrences of a condition.[113] The risks of manipulation under sedation or general anesthesia include the inability of patients to provide verbal feedback on pain or to resist overzealous manipulation because intrinsic guarding mechanisms associated with voluntary muscle contraction are absent, which can produce an increased risk of iatrogenic injuries.[113] There is currently insufficient evidence to make any recommendations regarding the use of manipulation under anesthesia for chronic low back pain in humans.[112]

Spinal manipulation under sedation and anesthesia has been used in horses to address reduced joint mobility; however, controlled studies are lacking.[101,114,115] In a case series of 86 horses, 88% of horses maintained improved ranges of pain-free joint motion after cervical mobilization and sustained stretching at the end range of motion while under anesthesia.[114] Similar indications and risks associated with the mobilization or manipulation under anesthesia in humans are expected in horses. No significant adverse effects were reported with cervical mobilization under general anesthesia in horses.[114] Well-designed controlled studies are needed to further investigate the safety and effectiveness of these techniques in equine practice.

Manipulation combined with epidural analgesia or epidural medications consists of segmental anesthesia with simultaneous epidural corticosteroid injection and spinal manipulation.[111] In humans, epidural anesthesia is less costly and is associated with fewer risks than general anesthesia, patients are able to cooperate during treatment, and epidural corticosteroids reduce inflammation and reduce fibrosis and adhesions, compared with manipulation under anesthesia alone. One possible indication for using this technique in horses is severe or compensatory spinal pain or stiffness associated with chronic limb lameness.

Joint mobilization or manipulation combined with intraarticular injection of either local anesthetic or corticosteroids has also been reported to reduce pain and inflammation associated with osteoarthritis and is believed to more effectively restore joint mobility.[111] Indications in humans include recalcitrant joint pain that prevents mobilization or rehabilitation of the affected region. In horses, one possible indication includes cervical facet osteoarthritis, where acute pain and inflammation can be initially controlled with intraarticular facet injections; however, recurrent stiffness and disability are common. Intraarticular injections combined with a series of spinal manipulations, stretching, and strengthening exercises provides the opportunity to increase pain-free cervical mobility and reduce long-term morbidly or recurrence. Controlled clinical trials are needed to assess other possible clinical indications and effectiveness of manipulation combined with intraarticular injections in horses.

INDICATIONS FOR MANUAL THERAPIES

Most of the current knowledge about equine manual therapies has been borrowed from human techniques, theories, and research, and applied to horses. Therapeutic trials are often used because of limited knowledge about the effectiveness for specific disease conditions or the duration of action of select manual therapies in horses. The indications for joint mobilization and manipulation are similar and include restricted joint range of motion, muscle spasms, pain, fibrosis, or contracted soft tissues.[84] The principal indications for spinal manipulation are neck or back pain, localized or regional joint stiffness, poor performance, and altered gait that is not associated with overt lameness. A thorough diagnostic workup is required to identify soft tissue and osseous disorders, neurologic disorders, or other lameness conditions that may not be responsive to manual therapy. Clinical signs that indicate a primary spinal disorder include localized musculoskeletal pain, muscle hypertonicity, and restricted joint motion. This triad of clinical signs can also be found in a variety of lower limb disorders; however, they are most evident in horses with neck or back problems. Clinical signs that indicate chronic or secondary spinal disorders include regional or diffuse pain, generalized stiffness, and widespread muscle hypertonicity. In these cases, further diagnostic evaluation or imaging should be done to identify the primary cause of lameness or poor performance. Manual therapy may help in the management of muscular, articular, and neurologic components of select musculoskeletal injuries in performance horses. Musculoskeletal conditions that are chronic or recurring, not readily diagnosed, or are not responding to conventional veterinary care may be indicators that manual therapy evaluation and treatment is needed. Manual therapy is usually more effective in the early clinical stages of disease processes versus end-stage disease when reparative processes have been exhausted. Joint manipulation is usually contraindicated in the acute stages of soft tissue injury; however, mobilization is safer than manipulation and has been shown to have short-term benefits for acute neck or back pain in humans.[116] Manipulation is probably more effective than mobilization for chronic neck or back pain and has the potential to help restore normal joint motion, thus limiting the risk of reinjury.[18]

Contraindications for mobilization and manipulation are often based on clinical judgment and are related to the technique applied and skill or experience of the practitioner.[84] Few absolute contraindications exist for joint mobilization if techniques are applied appropriately. Manual therapy is not a cure-all for all joint or back problems and is generally contraindicated in the presence of fractures, acute inflammatory or infectious joint disease, osteomyelitis, joint ankylosis, bleeding disorders, progressive neurologic signs, and primary or metastatic tumors.[84] Joint mobilization and

manipulation cannot reverse severe degenerative processes or overt pathology. Acute episodes of osteoarthritis, impinged dorsal spinous processes, and severe articular instability, such as joint subluxation or luxation, are often contraindications for manipulation. Inadequate physical or spinal examinations and poorly developed manipulative skills are also contraindications for applying manual therapy.[113] All horses with neurologic diseases should be evaluated fully to assess the potential risks or benefits of joint mobilization or manipulation. Cervical vertebral myelopathy occurs because of both structural and functional disorders.[117] Static compression caused by vertebral malformation and dynamic lesions caused by vertebral segment hypermobility are contraindications for cervical manipulation; however, adjacent regions of hypomobile vertebrae may benefit from mobilization or manipulation to help restore joint motion and reduce biomechanical stresses in the affected vertebral segments. Life-threatening injuries or diseases requiring immediate medical or surgical care need to be ruled out and treated by conventional veterinary medicine before any routine manual therapy is initiated. However, manual techniques may contribute to the rehabilitation of most postsurgical cases or severe musculoskeletal injuries by helping to restore normal joint motion and function. Horses that have concurrent hock pain (eg, osteoarthritis) and a stiff, painful thoracolumbar or lumbosacral vertebral region are best managed by addressing all areas of musculoskeletal dysfunction. A multidisciplinary approach entails combined medical treatment of the hock osteoarthritis and manual therapy evaluation and treatment of the back problem.

In humans, adverse effects or risks of complications associated with joint mobilization are minimal. Mobilization is considered safer than manipulation.[116] Some investigators suggest that given the higher risk of adverse reactions and lack of demonstrated effectiveness of manipulation over mobilization, then manual therapists should consider conservative mobilization, especially in human patients with severe neck pain.[118] In humans, most adverse events associated with spinal manipulation are benign and self-limiting.[119] Potential mild adverse effects from properly applied manipulations include transient stiffness or worsening of the condition after treatment. Data from prospective studies suggest that minor, transient adverse events occur in approximately half of all patients during a course of spinal manipulative therapy.[120,121] However, these mild adverse effects do not cause patients to stop seeking manipulative care. Mild adverse effects usually last less than 1 to 2 days and resolve without concurrent medical intervention. Severe complications following spinal manipulation are typically uncommon and estimates of the incidence range from 1 in 200,000 to 1 per 100 million manipulations in humans.[116,122,123] The most common serious adverse events in humans are vertebrobasilar accidents, disk herniation, and cauda equina syndrome.[120] However, there is no evidence of increased risk of vertebrobasilar artery stroke associated with chiropractic care compared with primary medical care.[124] Even though the complication rate of spinal manipulation is small, the potential for adverse outcomes must be considered because of the possibility of permanent impairment or death.[116] The benefits of chiropractic care in humans seem to outweigh the potential risks.[125] The risk of adverse effects associated with joint mobilization or spinal manipulation is unknown in horses. The apparent safety of spinal manipulation, especially compared with other medically accepted treatments for neck or low back pain in humans, should stimulate its use in the conservative treatment of spinal-related problems.[123,126] If an exacerbation of musculoskeletal dysfunction or lameness is noted after spinal manipulation, then a thorough re-examination and appropriate medical treatment should be pursued. If the condition does not improve with conservative care, referral for more extensive diagnostic evaluation or more aggressive medical treatment is recommended.

FUTURE STUDIES

Further research is needed to assess the effectiveness of specific manual therapy recommendations or combined treatments for pain management and select lameness conditions. Currently there is no validated equine model for studying the effects of manual therapies that would allow characterization of the anatomic, biomechanical, neurophysiologic, pathophysiologic, cellular, or biochemical changes associated with soft tissue and joint mobilization or high-velocity thrusts. Further understanding of the local and systemic effects of mobilization and manipulation on pain reduction and tissue healing is also needed. Additional studies are needed to determine the duration of the clinical effects of manual therapies and the multimodal use of mobilization or manipulation and analgesics or other pain management strategies. Controlled trials using different forms of spinal manipulation (eg, manual thrusts vs instrument-assisted thrusts vs manipulation under anesthesia) need to be done to determine which method is most effective for addressing specific disease processes. Studies are needed to identify which pain or patient characteristics are likely to benefit from the various forms of manual therapy, either individually or in combination. New methods of objectively measuring musculoskeletal dysfunction and further studies into the pathophysiology of chronic pain syndromes are needed to help assess the effectiveness of manual therapies on reducing morbidity and improving overall performance in equine athletes.

SUMMARY

A thorough knowledge of equine anatomy, soft tissue and joint biomechanics, musculoskeletal pathology, tissue-healing processes, and pain mechanisms is required to understand the basic principles and application of the various forms of manual therapies for pain management. There is a notable lack of evidence for using touch, massage, stretching exercises, and joint mobilization techniques in horses. However, spinal manipulation has been shown in several studies to be effective for reducing pain, improving flexibility, reducing muscle tone, and improving symmetry of spinal kinematics in horses. Because of potential misuse and safety issues, mobilization and manipulative therapies should be provided only by specially trained veterinarians or licensed human manual therapists.

REFERENCES

1. Haldeman S, Hooper PD. Mobilization, manipulation, massage and exercise for the relief of musculoskeletal pain. In: Wall PD, Melzack R, editors. Textbook of pain. 4th edition. New York: Churchill Livingstone; 1999. p. 1399–418.
2. Ramey D, Ernst E. Common misconceptions about alternative medicine. In: Ramey D, editor. Consumer's guide to alternative therapies in the horse. Foster City (CA): Howell Book House; 1999. p. 35–42.
3. Lederman E. Fundamentals of manual therapy: physiology, neurology and psychology. St. Louis (MO): Churchill Livingstone; 1997.
4. Bergmann TF. High-velocity low-amplitude manipulative techniques. In: Haldeman S, editor. Principles and practice of chiropractic. 3rd edition. New York: McGraw-Hill; 2005. p. 755–66.
5. Taylor PM, Pascoe PJ, Mama KR. Diagnosing and treating pain in the horse. Where are we today? Vet Clin North Am Equine Pract 2002;18(1):1–19, v.
6. Muir W. Recognizing and treating pain in horses. In: Reed SM, Bayly WM, Sellon DC, editors. Equine internal medicine. 2nd edition. St. Louis (MO): Saunders; 2004. p. 1529–41.

7. Imamura M, Furlan AD, Dryden T, et al. Evidence-informed management of chronic low back pain with massage. Spine J 2008;8(1):121–33.
8. Pickar JG. Neurophysiological effects of spinal manipulation. Spine J 2002;2(5): 357–71.
9. Colloca CJ, Keller TS, Gunzburg R. Neuromechanical characterization of in vivo lumbar spinal manipulation. Part II. Neurophysiological response. J Manipulative Physiol Ther 2003;26(9):579–91.
10. Vernon H. Qualitative review of studies of manipulation-induced hypoalgesia. J Manipulative Physiol Ther 2000;23(2):134–8.
11. Boal RW, Gillette RG. Central neuronal plasticity, low back pain and spinal manipulative therapy. J Manipulative Physiol Ther 2004;27:314–26.
12. Wright A. Hypoalgesia post-manipulative therapy: a review of a potential neurophysiological mechanism. Man Ther 1995;1(1):11–6.
13. Wall PD. The placebo and the placebo response. In: Wall PD, Melzack R, editors. Textbook of pain. 4th edition. New York: Churchill Livingstone; 1999. p. 1419–30.
14. Triano J. The theoretical basis for spinal manipulation. In: Haldeman S, editor. Principles and practice of chiropractic. 3rd edition. New York: McGraw-Hill; 2005. p. 361–81.
15. Lederman E. The biomechanical response. Fundamentals of manual therapy: physiology, neurology and psychology. St. Louis (MO): Churchill Livingstone; 1997. p. 23–37.
16. Bronfort G, Haas M, Evans RL, et al. Efficacy of spinal manipulation and mobilization for low back pain and neck pain: a systematic review and best evidence synthesis. Spine J 2004;4(3):335–56.
17. Threlkeld AJ. The effects of manual therapy on connective tissue. Phys Ther 1992;72(12):893–902.
18. Liebenson C. Rehabilitation of the spine. 1st edition. Baltimore (MD): Williams & Wilkins; 1996.
19. van Harreveld PD, Lillich JD, Kawcak CE, et al. Clinical evaluation of the effects of immobilization followed by remobilization and exercise on the metacarpophalangeal joint in horses. Am J Vet Res 2002;63(2):282–8.
20. Lederman E. Changes in tissue fluid dynamics. In: Lederman E, editor. Fundamentals of manual therapy: physiology, neurology and psychology. St. Louis (MO): Churchill Livingstone; 1997. p. 39–54.
21. Gruenenfelder FI, Boos A, Mouwen M, et al. Evaluation of the anatomic effect of physical therapy exercises for mobilization of lumbar spinal nerves and the dura mater in dogs. Am J Vet Res 2006;67(10):1773–9.
22. Leach RA. Segmental dysfunction hypothesis. The chiropractic theories: principles and clinical applications. 3rd edition. Baltimore (MD): Williams & Wilkins; 1994. p. 43–54.
23. Pickar JG, Sung PS, Kang YM, et al. Response of lumbar paraspinal muscles spindles is greater to spinal manipulative loading compared with slower loading under length control. Spine J 2007;7(5):583–95.
24. Cleland JA, Glynn P, Whitman JM, et al. Short-term effects of thrust versus nonthrust mobilization/manipulation directed at the thoracic spine in patients with neck pain: a randomized clinical trial. Phys Ther 2007;87(4):431–40.
25. Cassidy JD, Lopes AA, Yong-Hing K. The immediate effect of manipulation versus mobilization on pain and range of motion in the cervical spine: a randomized controlled trial. J Manipulative Physiol Ther 1992;15(9):570–5.
26. Gross AR, Hoving JL, Haines TA, et al. A Cochrane review of manipulation and mobilization for mechanical neck disorders. Spine (Phla Pa 1976) 2004;29(14): 1541–8.

27. Bolton PS, Budgell BS. Spinal manipulation and spinal mobilization influence different axial sensory beds. Med Hypotheses 2006;66(2):258–62.
28. Haussler KK, Hill AE, Puttlitz CM, et al. Effects of vertebral mobilization and manipulation on kinematics of the thoracolumbar region. Am J Vet Res 2007; 68(5):508–16.
29. Haussler KK, Martin CE, Hill AE. Efficacy of spinal manipulation and mobilization on trunk flexibility and stiffness in horses: a randomized clinical trial. Equine Vet J Suppl, in press.
30. Triano JJ. Studies on the biomechanical effect of a spinal adjustment. J Manipulative Physiol Ther 1992;15(1):71–5.
31. Dishman JD, Burke J. Spinal reflex excitability changes after cervical and lumbar spinal manipulation: a comparative study. Spine J 2003;3(3):204–12.
32. Goff LM. Manual therapy of the horse – a contemporary perspective. J Equine Vet Sci 2009;29(11):799–808.
33. Cameron MH. Physical agents in rehabilitation. Philadelphia: WB Saunders; 1999.
34. Schmid A, Brunner F, Wright A, et al. Paradigm shift in manual therapy? Evidence for a central nervous system component in the response to passive cervical joint mobilisation. Man Ther 2008;13(5):387–96.
35. Nansel D, Szlazak M. Somatic dysfunction and the phenomenon of visceral disease simulation: a probable explanation for the apparent effectiveness of somatic therapy in patients presumed to be suffering from true visceral disease. J Manipulative Physiol Ther 1995;18(6):379–97.
36. Moyer CA, Rounds J, Hannum JW. A meta-analysis of massage therapy research. Psychol Bull 2004;130(1):3–18.
37. Coppa D. The internal process of therapeutic touch. J Holist Nurs 2008;26(1): 17–24.
38. Friedmann E, Son H. The human-companion animal bond: how humans benefit. Vet Clin North Am Small Anim Pract 2009;39(2):293–326.
39. Braun C, Stangler T, Narveson J, et al. Animal-assisted therapy as a pain relief intervention for children. Complement Ther Clin Pract 2009;15(2):105–9.
40. McBride SD, Hemmings A, Robinson K. A preliminary study on the effect of massage to reduce stress in the horse. J Equine Vet Sci 2004;24(2):76–82.
41. Monroe CM. The effects of therapeutic touch on pain. J Holist Nurs 2009;27(2): 85–92.
42. So PS, Jiang Y, Qin Y. Touch therapies for pain relief in adults. Cochrane Database Syst Rev 2008;(4):CD006535.
43. Edelson SM, Edelson MG, Kerr DC, et al. Behavioral and physiological effects of deep pressure on children with autism: a pilot study evaluating the efficacy of Grandin's Hug Machine. Am J Occup Ther 1999;53(2):145–52.
44. Grandin T. Calming effects of deep touch pressure in patients with autistic disorder, college students, and animals. J Child Adolesc Psychopharmacol 1992;2(1):63–72.
45. Bardia A, Barton DL, Prokop LJ, et al. Efficacy of complementary and alternative medicine therapies in relieving cancer pain: a systematic review. J Clin Oncol 2006;24(34):5457–64.
46. Tellington-Jones L, Lieberman B. The ultimate horse behavior and training book. North Pomfret (VT): Trafalgar Square Books; 2006.
47. Spier SJ, Berger Pusterla J, Villarroel A, et al. Outcome of tactile conditioning of neonates, or "imprint training" on selected handling measures in foals. Vet J 2004;168(3):252–8.

48. Scott M, Swenson LA. Evaluating the benefits of equine massage therapy: a review of the evidence and current practices. J Equine Vet Sci 2009;29(9): 687–97.
49. Frey Law LA, Evans S, Knudtson J, et al. Massage reduces pain perception and hyperalgesia in experimental muscle pain: a randomized, controlled trial. J Pain 2008;9(8):714–21.
50. Cherkin DC, Eisenberg D, Sherman KJ, et al. Randomized trial comparing traditional Chinese medical acupuncture, therapeutic massage, and self-care education for chronic low back pain. Arch Intern Med 2001;161(8):1081–8.
51. Bromiley MW. Massage techniques for horse and rider. Wiltshire (UK): The Crowood Press; 2002.
52. Hemmings BJ. Physiological, psychological and performance effects of massage in sport: a review of the literature. Phys Ther Sport 2001;2:165–70.
53. Furlan AD, Imamura M, Dryden T, et al. Massage for low-back pain. Cochrane Database Syst Rev 2008;(4):CD001929.
54. Ernst E. Massage therapy for low back pain: a systematic review. J Pain Symptom Manage 1999;17(1):65–9.
55. Ernst E. Massage therapy for cancer palliation and supportive care: a systematic review of randomised clinical trials. Support Care Cancer 2009;17(4):333–7.
56. Wilkinson S, Barnes K, Storey L. Massage for symptom relief in patients with cancer: systematic review. J Adv Nurs 2008;63(5):430–9.
57. Ernst E. Manual therapies for pain control: chiropractic and massage. Clin J Pain 2004;20(1):8–12.
58. Sullivan KA, Hill AE, Haussler KK. The effects of chiropractic, massage and phenylbutazone on spinal mechanical nociceptive thresholds in horses without clinical signs. Equine Vet J 2008;40(1):14–20.
59. Wilson J. The effects of sports massage on athletic performance and general function. Massage Therapy J 2002;90–100, Summer.
60. Fedele C, Berens von Rautenfeld D. Manual lymph drainage for equine lymphoedema-treatment strategy and therapist training. Equine Vet Educ 2007; 19(1):26–31, February.
61. Ladd MP, Kottke FJ, Blanchard RS. Studies of the effect of massage on the flow of lymph from the foreleg of the dog. Arch Phys Med 1952;604–12, October.
62. Ramey DW, Tiidus PM. Massage therapy in horses: assessing its effectiveness from empirical data in humans and animals. Compendium 2002;24(5):418–23.
63. Buchner HH, Schildboeck U. Physiotherapy applied to the horse: a review. Equine Vet J 2006;38(6):574–80.
64. Blignault K. Stretch exercises for your horse. London: JA Allen; 2003.
65. Stubbs NC, Clayton HM. Activate your horse's core: unmounted exercises for dynamic mobility, strength and balance. Mason (MI): Sport Horse Publications; 2008.
66. Frick A. Fitness in motion: keeping your equine's zone at peak performance. Guilford (CT): The Lyons Press; 2007.
67. Decoster LC, Cleland J, Altieri C, et al. The effects of hamstring stretching on range of motion: a systematic literature review. J Orthop Sports Phys Ther 2005;35(6):377–87.
68. Light KE, Nuzik S, Personius W, et al. Low-load prolonged stretch vs. high-load brief stretch in treating knee contractures. Phys Ther 1984;64(3):330–3.
69. Taylor DC, Dalton JD Jr, Seaber AV, et al. Viscoelastic properties of muscle-tendon units. The biomechanical effects of stretching. Am J Sports Med 1990; 18(3):300–9.

70. Bandy WD, Irion JM. The effect of time on static stretch on the flexibility of the hamstring muscles. Phys Ther 1994;74(9):845–50.
71. da Costa BR, Vieira ER. Stretching to reduce work-related musculoskeletal disorders: a systematic review. J Rehabil Med 2008;40(5):321–8.
72. Frick A. Stretching exercises for horses: are they effective? J Equine Vet Sci 2010;30(1):50–9.
73. Radford JA, Burns J, Buchbinder R, et al. Does stretching increase ankle dorsiflexion range of motion? A systematic review. Br J Sports Med 2006;40(10): 870–5 [discussion: 875].
74. Gross AR, Goldsmith C, Hoving JL, et al. Conservative management of mechanical neck disorders: a systematic review. J Rheumatol 2007;34(5):1083–102.
75. Harvey L, Herbert R, Crosbie J. Does stretching induce lasting increases in joint ROM? A systematic review. Physiother Res Int 2002;7(1):1–13.
76. Shrier I. Does stretching improve performance? A systematic and critical review of the literature. Clin J Sport Med 2004;14(5):267–73.
77. Thacker SB, Gilchrist J, Stroup DF, et al. The impact of stretching on sports injury risk: a systematic review of the literature. Med Sci Sports Exerc 2004; 36(3):371–8.
78. Herbert RD, Gabriel M. Effects of stretching before and after exercising on muscle soreness and risk of injury: systematic review. Br Med J 2002; 325(7362):468.
79. Small K, Mc Naughton L, Matthews M. A systematic review into the efficacy of static stretching as part of a warm-up for the prevention of exercise-related injury. Res Sports Med 2008;16(3):213–31.
80. Hayden JA, van Tulder MW, Tomlinson G. Systematic review: strategies for using exercise therapy to improve outcomes in chronic low back pain. Ann Intern Med 2005;142(9):776–85.
81. Kay TM, Gross A, Goldsmith C, et al. Exercises for mechanical neck disorders. Cochrane Database Syst Rev 2005;(3):CD004250.
82. Giovagnoli G, Plebani G, Daubon JC. Withers height variations after muscle stretching. Proceedings Conference on Equine Sports Medicine and Science. Oslo, Norway, CESMAS, 2004. p. 172–6.
83. Rose NS, Northrop AJ, Brigden CV, et al. Effects of a stretching regime on stride length and range of motion in equine trot. Vet J 2009;181(1):53–5.
84. Scaringe J, Kawaoka C. Mobilization techniques. In: Haldeman S, editor. Principles and practice of chiropractic. 3rd edition. New York: McGraw-Hill; 2005. p. 767–85.
85. McKinney LA. Early mobilisation and outcome in acute sprains of the neck. Br Med J 1989;299(6706):1006–8.
86. Gross A, Miller J, D'Sylva J, et al. Manipulation or mobilisation for neck pain. Cochrane Database Syst Rev 2010;(1):CD004249.
87. Ellis RF, Hing WA. Neural mobilization: a systematic review of randomized controlled trials with an analysis of therapeutic efficacy. J Man Manip Ther 2008;16(1):8–22.
88. Keller TS, Colloca CJ, Gunzburg R. Neuromechanical characterization of in vivo lumbar spinal manipulation. Part I. Vertebral motion. J Manipulative Physiol Ther 2003;26(9):567–78.
89. Gatterman MI. What's in a word. In: Gatterman MI, editor. Foundations of chiropractic. St. Louis (MO): Mosby-Year Book; 1995. p. 5–17.
90. Harms MC, Bader DL. Variability of forces applied by experienced therapists during spinal mobilization. Clin Biomech (Bristol, Avon) 1997;12(6):393–9.

91. Haussler KK. Chiropractic evaluation and management. Vet Clin North Am Equine Pract 1999;15(1):195–209.
92. Verschooten F. Osteopathy in locomotion problems of the horse: a critical evaluation. Vlaams Diergeneeskd Tijdschr 1992;61:116–20.
93. Coulter ID, Hurwitz EL, Adams AH, et al. Patients using chiropractors in North America: who are they, and why are they in chiropractic care? Spine (Phila Pa 1976) 2002;27(3):291–6 [discussion: 297–8].
94. Nansel DD, Waldorf T, Cooperstein R. Effect of cervical spinal adjustments on lumbar paraspinal muscle tone: evidence for facilitation of intersegmental tonic neck reflexes. J Manipulative Physiol Ther 1993;16(2):91–5.
95. Licciardone JC, Brimhall AK, King LN. Osteopathic manipulative treatment for low back pain: a systematic review and meta-analysis of randomized controlled trials. BMC Musculoskelet Disord 2005;6:43.
96. Descarreaux M, Blouin JS, Drolet M, et al. Efficacy of preventive spinal manipulation for chronic low-back pain and related disabilities: a preliminary study. J Manipulative Physiol Ther 2004;27(8):509–14.
97. Bronfort G, Haas M, Evans R. The clinical effectiveness of spinal manipulation for musculoskeletal conditions. In: Haldeman S, editor. Principles and practice of chiropractic. 3rd edition. New York: McGraw-Hill; 2005. p. 147–66.
98. Haas M, Groupp E, Kraemer DF. Dose-response for chiropractic care of chronic low back pain. Spine J 2004;4(5):574–83.
99. Herrod-Taylor EE. A technique for manipulation of the spine in horses. Vet Rec 1967;81:437–9.
100. Evrard P. Introduction aux techniques ostéopathiques struturelles appliquées au cheval. Thy-Le-Château: Olivier éditeur; 2002.
101. Pusey A, Colles C, Brooks J. Osteopathic treatment of horses – a retrospective study. Br Osteo J 1995;16:30–2.
102. Parsons J, Marcer N. Osteopathy: models for diagnosis, treatment and practice. Philadelphia: Churchill Livingstone; 2006.
103. Haussler KK, Bertram JEA, Gellman K. *In-vivo* segmental kinematics of the thoracolumbar spinal region in horses and effects of chiropractic manipulations. Proc Am Assoc Equine Practitioners 1999;45:327–9.
104. Haussler KK, Erb HN. Pressure algometry: objective assessment of back pain and effects of chiropractic treatment. Proc Am Assoc Equine Practitioners 2003;49:66–70.
105. Wakeling JM, Barnett K, Price S, et al. Effects of manipulative therapy on the longissimus dorsi in the equine back. Equine Comp Exerc Physiol 2006;3(3): 153–60.
106. Faber MJ, van Weeren PR, Schepers M, et al. Long-term follow-up of manipulative treatment in a horse with back problems. J Vet Med A Physiol Pathol Clin Med 2003;50(5):241–5.
107. Gómez Alvarez CB, L'Ami JJ, Moffat D, et al. Effect of chiropractic manipulations on the kinematics of back and limbs in horses with clinically diagnosed back problems. Equine Vet J 2008;40(2):153–9.
108. Fuhr AW, Menke JM. Status of activator methods chiropractic technique, theory, and practice. J Manipulative Physiol Ther 2005;28(2):e1–20.
109. Shearar KA, Colloca CJ, White HL. A randomized clinical trial of manual versus mechanical force manipulation in the treatment of sacroiliac joint syndrome. J Manipulative Physiol Ther 2005;28(7):493–501.
110. Wood TG, Colloca CJ, Matthews R. A pilot randomized clinical trial on the relative effect of instrumental (MFMA) versus manual (HVLA) manipulation in the

treatment of cervical spine dysfunction. J Manipulative Physiol Ther 2001;24(4): 260–71.
111. Kohlbeck FJ, Haldeman S. Medication-assisted spinal manipulation. Spine J 2002;2(4):288–302.
112. Dagenais S, Mayer J, Wooley JR, et al. Evidence-informed management of chronic low back pain with medicine-assisted manipulation. Spine J 2008; 8(1):142–9.
113. West DT, Mathews RS, Miller MR, et al. Effective management of spinal pain in one hundred seventy-seven patients evaluated for manipulation under anesthesia. J Manipulative Physiol Ther 1999;22(5):299–308.
114. Ahern TJ. Cervical vertebral mobilization under anesthetic (CVMUA): a physical therapy for the treatment of cervico-spinal pain and stiffness. J Equine Vet Sci 1994;14(10):540–5.
115. Brooks J, Colles C, Pusey A. The role of osteopathy in the treatment of the horse. In: Rossdale P, Green R, editors. Guardians of the horse II. Newmarket (UK): Romney Publications; 2001. p. 40–9.
116. Hurwitz EL, Aker PD, Adams AH, et al. Manipulation and mobilization of the cervical spine. A systematic review of the literature. Spine (Phila Pa 1976) 1996;21(15):1746–59 [discussion: 1759–60].
117. Levine JM, Adam E, MacKay RJ, et al. Confirmed and presumptive cervical vertebral compressive myelopathy in older horses: a retrospective study (1992–2004). J Vet Intern Med 2007;21(4):812–9.
118. Hurwitz EL, Morgenstern H, Vassilaki M, et al. Frequency and clinical predictors of adverse reactions to chiropractic care in the UCLA neck pain study. Spine (Phila Pa 1976) 2005;30(13):1477–84.
119. Rubinstein SM. Adverse events following chiropractic care for subjects with neck or low-back pain: do the benefits outweigh the risks? J Manipulative Physiol Ther 2008;31(6):461–4.
120. Stevinson C, Ernst E. Risks associated with spinal manipulation. Am J Med 2002;112(7):566–71.
121. Senstad O, Leboeuf-Yde C, Borchgrevink C. Frequency and characteristics of side effects of spinal manipulative therapy. Spine (Phila Pa 1976) 1997;22(4): 435–40 [discussion: 440–1].
122. Thiel HW, Bolton JE, Docherty S, et al. Safety of chiropractic manipulation of the cervical spine: a prospective national survey. Spine (Phila Pa 1976) 2007; 32(21):2375–8 [discussion: 2379].
123. Oliphant D. Safety of spinal manipulation in the treatment of lumbar disk herniations: a systematic review and risk assessment. J Manipulative Physiol Ther 2004;27(3):197–210.
124. Cassidy JD, Boyle E, Cote P, et al. Risk of vertebrobasilar stroke and chiropractic care: results of a population-based case-control and case-crossover study. Spine (Phila Pa 1976) 2008;33(Suppl 4):S176–83.
125. Rubinstein SM, Leboeuf-Yde C, Knol DL, et al. The benefits outweigh the risks for patients undergoing chiropractic care for neck pain: a prospective, multicenter, cohort study. J Manipulative Physiol Ther 2007;30(6):408–18.
126. Dabbs V, Lauretti WJ. A risk assessment of cervical manipulation vs. NSAIDs for the treatment of neck pain. J Manipulative Physiol Ther 1995;18(8):530–6.