Therapeutic Exercises for Rehabilitation of Muscle Injury

Melissa R. King, DVM, PhD*, Sandro Colla, DVM, MSc

KEYWORDS

• Muscle • Horse • Therapeutic • Exercises

KEY POINTS

- Muscle recovery is divided into 3 phases: inflammatory, regenerative, and remodeling.
- Early mobilization through controlled walking and isometric exercises supports healing by improving muscle strength and fiber alignment.
- Dynamic mobilization and core strengthening exercises stabilize postural muscles and improve neuromotor control.
- Proprioceptive balance exercises improve postural stability and proprioception, enhancing neuromotor control.
- Aquatic exercises are usually incorporated in the late regenerative to the remodeling phase.

INTRODUCTION

Muscle injuries are frequent and can affect all horses regardless of age or physical activity. A detailed understanding of the mechanisms and phases of muscle injury, including physical modalities and therapeutic exercises utilized during the rehabilitation process, is fundamental for a successful functional muscle recovery. The previous article covered the mechanisms of muscle injury, physical modalities, and injury prevention. This article will focus on therapeutic exercises to rehabilitate muscle injuries. The therapeutic exercises are divided into the 3 phases of muscle recovery: inflammatory, regenerative, and remodeling, but it is important to note that the exercises frequently overlap among the phases.

Department of Clinical Sciences, College of Veterinary Medicine and Biomedical Sciences, Colorado State University, Colorado State University Veterinary Teaching Hospital, Equine Orthopaedic Research Center, 2250 Gillette Drive, Fort Collins, CO 80523, USA
* Corresponding author.
E-mail address: Melissa.king@colostate.edu

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INFLAMMATORY PHASE THERAPEUTIC EXERCISES

Immobilization

Following injury, a short period of immobilization should be considered to avoid repetitive muscle contractions. The duration of relative immobility should be limited to a period of less than 5 days. This allows the newly formed granulation tissue connecting the traumatized myofibril ends to gain the required tensile strength to withstand the forces created by muscle contraction. For equine patients, minimizing activation or, more importantly, avoiding stretching of the injured muscle immediately after injury reduces the likelihood of excessive scar tissue formation and the risk for re-rupture at the injury site.[1] It is paramount that the period of immobility be limited to avoid the adverse effects of atrophy of healthy muscle fibers, excessive deposition of fibrotic tissue, and delayed strength gains associated with prolonged periods of immobilization.[2]

Isometric Exercises

Early mobilization of the injured muscle is strongly recommended and should be tailored to the horse's comfort level and the severity and extent of injury. Various rodent models of experimentally induced muscle injuries demonstrate that beginning active mobilization exercises after the short period of immobilization enhances the ingrowth of muscle fibers through the granulation tissue bed, decreases the amount of persistent fibrotic tissue, orchestrates alignment of the regenerating muscles fibers along the physiologic planes of loading, and assists in regaining the tensile strength of the injured muscle.[2] Early mobilization within 3 to 5 days should begin with controlled walking exercise and gradual increases in isometric training. Isometric exercises involve initiating a muscle contraction in which the length of muscle does not change, but the tension within the muscle increases. Isometric contractions in the early phases of rehabilitation are critical to regaining muscle strength and neuromotor control. Isometric exercises for the horse include wither pulls, lateral tail pulls, and caudal tail pulls.

- *Wither pulls:* With the horse standing square, stand on the left side and place both hands over the withers. Gently pull the withers toward yourself until the right fetlock extends slightly. Hold for 10 seconds, then gently release. Perform 5 times on the left and 5 times on the right. You should appreciate isometric contractions occurring within the forelimb stabilizing muscles and the thoracic sling muscles (**Fig. 1**).
- *Lateral tail pulls:* Have the horse standing square. Stand to the side of the horse at 90°, grasp the top of the tail with both hands and gently pull to encourage the horse to shift its weight onto that hindlimb and hold for 10 seconds. Note the contraction of the pelvic and stifle musculature. Perform 5 repetitions on each side (**Fig. 2**).
- *Caudal tail pulls*: Stand behind the hindquarters, ensuring you stay close to the horse to be in a safer position. Grab hold of the horse's tail, ensuring that you are holding the top of the tail (grasp bone, not just the hair). Gently apply traction on the tail at an angle along the line of the pelvis (approximately a 45° downward angle) by pulling backward, you should see the horse's weight shift back slightly. Hold for 10 seconds and then relax. Perform 5 repetitions. You should appreciate isometric contractions within the gluteal, bicep femoris, thoracolumbar epaxial, and pectoral muscles (**Fig. 3**).

Dynamic Mobilization Exercises

Rehabilitation programs should also incorporate core stability and trunk stabilization exercises beginning in the early phases of rehabilitation and progressing through



Fig. 1. Wither pull to the right.



Fig. 2. Lateral tail pull to the right.



Fig. 3. Caudal tail pull.

the entire program. In a randomized prospective study on human athletes with hamstring muscle strains, those individuals that participated in protocols involving trunk stabilization exercises reduced their reinjury rate and had a quicker return-to-sport activity compared to protocols focusing only on stretching and strengthening of the injured hamstring muscle.[3] This demonstrates the need to develop a global whole body rehabilitation protocol and avoid placing all the emphasis on the injured muscle. In horses, core training exercises are intended to activate and strengthen not only the epaxial muscles but also the abdominal and sublumbar muscles that are critical for static and dynamic balance control. The primary focus in the early phases of any rehabilitation program is to restore motor control, improve stability, and regain muscle strength before targeting flexibility. Pursuant to the equine patient, several core strengthening exercises and their role in activating deep epaxial musculature to subsequently improve postural motor control and alter thoracolumbar kinematics have been investigated.[4,5] Institution of dynamic mobilization exercises over a 3 month time period has been shown to increase both size and symmetry of the multifidus muscle as assessed through longitudinal ultrasonographic evaluation. Dynamic spinal mobilization involves having the horse move in a controlled manner that involves rounding and/or bending the neck and back in a manner that recruits both the long mobilizing musculature and the deep stabilizing musculature to round or bend the neck and back. Performing a series of dynamic mobilization exercises with 5 repetitions of each exercise 3 times weekly for 6 weeks is sufficient to stimulate significant hypertrophy of the multifidus muscles. Performing more repetitions or with a higher frequency does not appear to provide greater hypertrophy.[5,6] Each target position (chin to chest, chin to carpi, chin to forelimb fetlocks, chin to girth, chin to hip, chin

to tarsus, and neck extension; Figs. 4 and 5) should be conducted in a set of 5 holding for 10 seconds at each position, 3 times a week. The optimal time to perform dynamic mobilization exercises is immediately before exercise to preactivate the postural control muscles.

Core Strengthening Exercises

Core strengthening exercises are designed so that the axial and appendicular neuromuscular systems can respond appropriately to the numerous destabilizing forces that occur during functional movement, thereby reducing the chances of injury. These exercises are regarded as a progression from the dynamic mobilization exercises. The exercises are based on the horse's response to pressure applied over specific anatomic areas to induce muscular contractions that move the intervertebral joints in a manner that is regarded as being beneficial during locomotion or performance. As with dynamic mobilization exercises, the most effective time to use core strengthening exercises is immediately before exercise to preactivate the muscles that will round and stabilize the spine during athletic activity. Equine electromyographic studies have shown that the longissimus dorsi muscle is activated during stimulated extension or lateral bending of the thoracolumbar spine with activity being greater at T12 than at T16 or L3.[7] Core strengthening exercises combined with dynamic mobilization exercises conducted in horses following colic surgery improves the level of performance and results in an earlier return to training compared to a similar group of horses that had colic surgery but did not have core or dynamic mobilization exercises in the recovery period.[8]

Core strengthening exercises for the horse include

- *Induced thoracic spinal flexion*
  - Upward pressure is applied over the sternum on ventral midline between the pectoral muscles and moving slowly caudally while maintaining steady pressure (Fig. 6).
  - Horse responds by contracting the abdominal muscles and lifting through the cranial to midthoracic region.
  - This exercise increases strength in the abdominal musculature and improves thoracolumbar motion.
  - Conduct a set of 5 holding for 10 seconds, 3 to 4 times a week.
- *Lumbosacral-induced flexion*
  - Pressure is applied on dorsal midline above the tail head or bilaterally in the intermuscular groove between the biceps femoris and semitendinosus muscles (Fig. 7).
  - The lumbosacral joint and caudal lumbar intervertebral joints are flexed primarily by the sublumbar muscles, iliacus, and psoas minor.

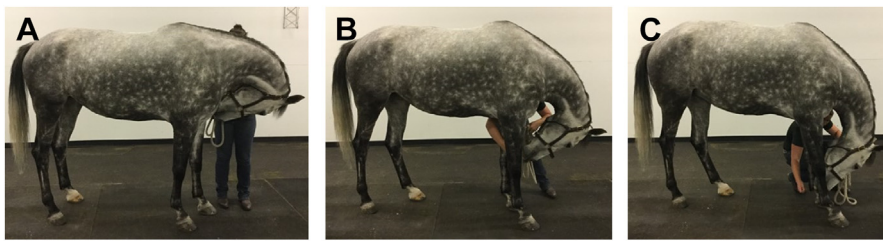


Fig. 4. Dynamic mobilization exercises. (*A*) Demonstrates chin to chest, (*B*) chin to carpi, and (*C*) chin between forelimb fetlocks.



Fig. 5. Neck extension.

- This exercise encourages lumbosacral flexion, and strengthens and activates the abdominal and sublumbar musculature to lift the lumbar region.
- Useful in all horses, particularly those performing high-level dressage, jumping, reining, and cutting.
- Conduct a set of 5 holding for 10 seconds, 3 to 4 times a week.

- *Axial pelvic rotation*
  - Pressure is applied across midline, 10 to 20 cm lateral from midline, and midway between the tuber coxae and tail head. The therapist applies pressure in a ventromedial direction (Fig. 8).
  - For example, the therapist will stand on the left side and reach across the croup placing a hand 10 to 20 cm off midline and midway between the right tuber coxae and right side of the tail head.
  - The horse responds by lifting the lumbar region and flexing the lumbosacral joint while simultaneously laterally bending toward the therapist.
  - Conduct a set of 5 holding for 10 seconds, 3 to 4 times a week, bilaterally.
- *Advanced thoracic spinal and lumbosacral flexion coupled exercise*
  - This is an advanced coupled exercise that should be conducted once the horse has gained strength conducting the 2 exercises independently.
  - It requires 2 people performing the 2 relevant exercises simultaneously.
  - Conduct a set of 5 holding for 10 seconds, 3 to 4 times a week.

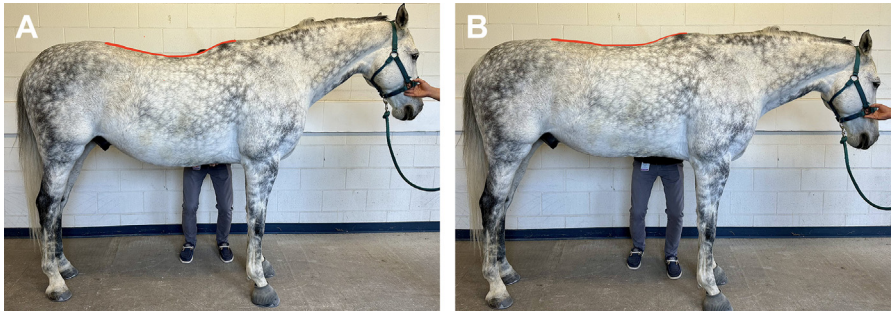


Fig. 6. Induced thoracic spinal flexion. The red line shows the difference before (*A*) and during (*B*) thoracic flexion.

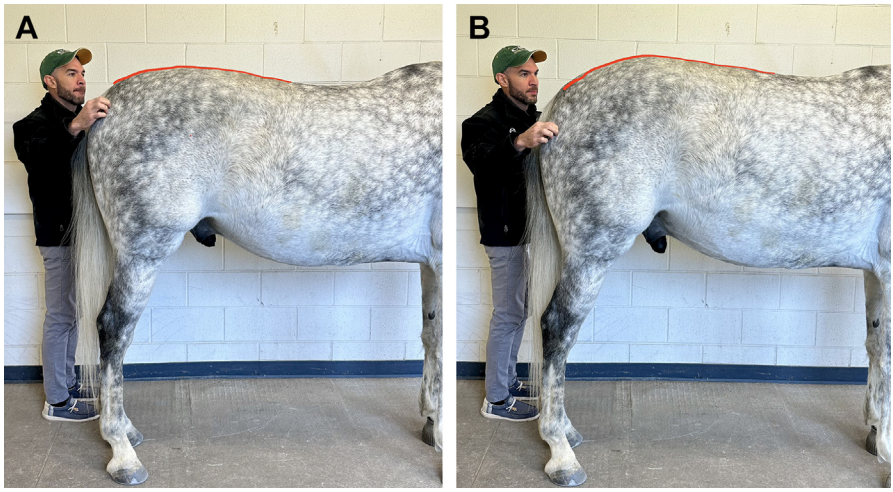


Fig. 7. Lumbosacral-induced flexion. This image demonstrates pressure being applied to the intermuscular groove between the semitendinosus and the biceps femoris muscles to lift the lumbar and lumbosacral regions. The *red line* demonstrates the change in contour of the caudal thoracic and lumbar region as the exercise induces lumbosacral flexion. The movements should occur smoothly and slowly, not in a fast, jerky manner. (*A*) Before and (*B*) during the lumbosacral flexion.



Fig. 8. Axial pelvic rotation to the left. The red line shows the apex of the sacrum deviated to the right and the green arrow shows the direction of the pelvic rotation.

Proprioceptive Balance Exercises

Human athletes that incorporate proprioceptive balance exercises into their rehabilitation programs are significantly less likely to suffer reinjury during a 12 month period following injury, compared to those individuals with similar injuries that did not emphasize core strength (7% reinjury rate in the balance training group vs 29% reinjury rate in the control group).[9] Strengthening and improving proprioception and balance control following injury remains a central focus of human physical therapy programs, and while standardized investigations have yet to focus on equine applications, there are several mechanisms through which neuromotor control can be recruited. Proprioceptive balance pads can be used to stimulate isometric contractions and engage the postural control musculature (**Fig. 9**). Following a 3 month rehabilitation program, horses that incorporated standing daily on balance foam pads demonstrated a significant strong correlation between multifidus muscle hypertrophy and functional improvements in postural stability.[10] This suggests that with improved postural stability, there is enhanced proprioception and neuromotor control critical to protecting the axial and appendicular skeleton. When incorporating proprioceptive balance pads, initially start with 1 to 3 minutes, once to twice daily, progressing to 5 minutes twice daily. Begin with firm pads and progress to less firm material. Initially place the targeted paired limbs on pads and progress to all 4 limbs on pads. Similar to the above modalities and exercises the utilization of proprioceptive balance pads should continue into the regenerative and remodeling phases of muscle injury utilizing a stepwise progressive approach.

REGENERATIVE PHASE THERAPEUTIC EXERCISES

Therapeutic exercises during this phase are designed to progressively improve proprioception, neuromotor control, and to gradually load and strengthen musculoskeletal tissues.

Physiotherapeutic exercises aimed at stimulating motor control, flexibility, and stability can be designed to build upon and advance what was established in the inflammatory phase of rehabilitation. The application of various proprioceptive techniques is frequently utilized to increase joint range of motion, re-establish appropriate



Fig. 9. A horse standing on proprioceptive balance pads in order to increase core stability. In this image, the horse is standing on firm (*green*) pads in front and softer (*purple*) pads behind to increase the level of difficulty of the exercise.

neuromuscular firing patterns, and improve the strength of targeted muscles that function to move and stabilize the joints.

Tactile Stimulators

The use of tactile stimulators applied around the hind limb pastern joints demonstrated a significantly higher hoof flight arc, with increased flexion of the fetlock, hock, and stifle joints.[11] Additional application of ankle weights (700 g) plus hind pastern tactile devices provided added increases in hip flexion and increased positive work performed by the hip, stifle, and tarsal musculature.[11] Long-term application of a hind limb bell boot (82 g) every 3 days for 6 weeks significantly improved superficial gluteal muscle imbalances detected via acoustic myography.[12] There is often habituation to the proprioceptive devices and limb weights, whereby they induce the greatest effects initially, followed by a rapid decrease in altered limb kinematics.[13] The use of these proprioceptive techniques supports the facilitation of enhanced afferent input to indirectly produce and modulate a targeted efferent response for the purpose of reestablishing motor control and improving joint range of motion. While further studies are needed to establish specific recommendations regarding use, initial biomechanic effects for targeted rehabilitation are encouraging.

Resistance Bands and Training Lines

Resistance band training is successfully used in human physical therapy programs to improve core strength and stability.[14,15] The use of resistance bands as a therapeutic technique for equine rehabilitation has been purported to provide a proprioceptive stimuli, whose sensory input drives a targeted motor output. Commonly referred to as a Theraband,[16] the 2 piece equine elastic band system is thought to stimulate core abdominal muscles with the abdominal band and engage hind limb musculature with the hindquarter band. Its use in horses at a trot was recently investigated and found to reduce mediolateral and rotational movement throughout the thoracolumbar region.[16] Optical motion capture analysis at the walk and trot during application of the hindquarter band demonstrates significant stabilization of the lumbar region, improving working posture and core stability.[17] Similarly, surface electromyography studies demonstrate increased rectus abdominus muscle activity at a trot in the presence of both abdominal and hindquarter resistance bands.[18] Further studies investigating long-term use and potential mechanistic pathways will help refine its use in the rehabilitation setting. Also pertinent to rehabilitation is the use of training lines. Pessoa training aids were demonstrated to increase both lumbosacral angles and thoracolumbar dorsoventral excursion when used in horses trotting on a lunge line.[19] While further studies are needed to establish specific recommendations regarding use, initial biomechanic effects for targeted rehabilitation are encouraging.

Ground Poles

Ground poles when arranged at various distances, heights, and configurations can encourage increases in range of motion, spinal flexibility, and core abdominal muscle activation. Walking over ground poles increases the activation of the rectus abdominus and longissimus dorsi muscles, while trotting over ground poles increases the activation of the thoracolumbar multifidi and rectus abdominus muscles.[18,20] The increases in active joint range of motion required for the horse to successfully complete the task subsequently activates and strengthens the corresponding musculature. Unlike the use of tactile devices, the effect of exercising over ground poles does not appear to diminish during an exercise session, as the number of repetitions and height of the poles will determine the intensity.

Dry Treadmills and Inclination Effects

Dry treadmills can be beneficial during this phase of rehabilitation due to the ability to control the speed, surface, direction (working in a straight line) and incorporation of an incline. A number of electromyographic studies have demonstrated that the use of inclines and changes in speed progressively recruit the muscles responsible for hind limb propulsion and back mobility.[21] However, it should also be noted that working on an incline increases the force distribution on the hind limbs and that increases in speed increase the ground reaction forces within each limb.[21] Therefore, careful consideration is important when developing rehabilitation protocols utilizing changes in treadmill speed and incline. Similarly to inclined treadmills, hill work and incorporating backing exercises into hill work can also be used to simultaneously improve muscular strength and challenge proprioceptive acuity.

Aquatic Modalities

Aquatic modalities are often used to optimize the treatment of sensory and motor disturbances associated with muscular injuries. Aquatic therapies, including underwater treadmills and swimming, have been reported in humans to improve muscle strength and timing, increase cardiovascular endurance, decrease limb edema, improve range of motion, decrease pain, and reduce mechanical stresses applied to the limb.[22–26] Humans with lower extremity injuries demonstrated a significant increase in limb-loading parameters, improved joint range of motion and a significant reduction in the severity of balance deficits following aquatic exercise.[22–26] Following a 3 month rehabilitation program, horses that had regimens incorporating underwater treadmill exercises significantly improved muscle strength, joint range of motion, neuromotor control, balance, and proprioception.[10]

Underwater treadmill exercise may provide a mechanism to control mechanical loading by decreasing axial loading on the limb depending on the depth of the water. The attenuation of distal limb forces generated by walking in water at increased depths must be balanced against the resistance of the water at higher water depths. The increase in water depth results in a higher coefficient of drag, which enhances muscle recruitment, activation, and strength. The prescription of underwater treadmill exercise must consider the stage of muscle healing and consider if the healing tissue is strong enough to undergo active contractions against resistance depending on the depth of water. The changes in water depth can produce both kinetic and kinematic effects that are directly applicable to the clinical management of musculoskeletal morbidities in horses.

REMODELING PHASE REHABILITATION

Frequently overlapping the regenerative phase, exercises during the remodeling phase aim to continue improving proprioception, range of motion, muscular strength, and cardiovascular fitness.

The diverse physical characteristics of aquatic exercise discussed earlier provide unique approaches to individualized rehabilitation for musculoskeletal issues in horses. Swim training programs have demonstrated an improvement in cardiovascular function, a reduction in locomotor disease, and an increase in the development of fast-twitch, high-oxidative muscle fibers, reflecting improved aerobic capacity.[27,28] Fine-wire electromyography has also been used to measure increases in muscle activation of the thoracic limb musculature during pool swimming exercise, compared to overground walking.[29]

Kinematic analysis of the pelvic limbs during equine swimming exercise demonstrated that horses spend more time (~60%) in protraction (limb flexion) compared

to retraction (limb extension).[30,31] The horse adopts this difference in phase duration as a mechanism to increase thrust and decrease drag during swimming.[30,31] Consequently, along with the vertical orientation of the limbs the forces required to overcome the drag are primarily generated by the pelvic limbs. The stifle and tarsal joints undergo the greatest angular velocities throughout the swimming cycle with the largest difference appreciated during the retraction phase. Careful consideration should be applied to swimming protocols as exercising in water is profoundly different in terms of physiologic responses and changes in locomotion patterns compared to overground exercise.

CLINICS CARE POINTS

- Limit immobilization to less than 5 days after injury where possible, to prevent muscle atrophy and excessive scar tissue formation.
- Therapeutic exercises and modalities can be utilized in different phases of the rehabilitation program to aid recovery from and prevention of future muscle injuries.
- The progression of the therapeutic exercises should be adjusted based on the horse's functional reassessment.

DISCLOSURE

The authors have nothing to disclose.

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