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The whole horse approach to equine physical rehabilitation: The biomechanical view

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Abstract

When the biomechanics of movement of the whole horse is evaluated during rehabilitation, the chance of a successful outcome increases. Faulty movement can be caused by conformation, injury and/or imbalanced work. Faulty movement induces pain and pain induces faulty movement. These related issues result in weakness of the tissues associated with the pain and incorrect movement. As weakness is the symptom of the inciting problem, strengthening alone only treats the symptom. Locating and treating the cause, especially the mechanical cause of pain, is an important part of a rehabilitation protocol. Strengthening of muscles, tendons and ligaments is a common goal of a rehabilitation program. However, too much strength can be as detrimental to healing and injury prevention as too little strength, and can disrupt the biomechanical balance of the body. Flexibility is necessary to keep joint movement smooth and to retain range of motion. However, Hypermobility can be a major cause of injury and is a typical outcome when hypomobility has produced limited range of motion in one area of the body. The excessive movement of hypermobility can cause degenerative joint disease leading to compensatory movement and further pain. Diagnostic ultrasound is a quick, safe, economical and effective means of diagnosing a variety of issues in equine medicine and is the optimal method for monitoring the progression of healing in these injuries. Physical rehabilitation takes time, but simply allowing more time for the rehabilitation process is not the answer.

Keywords

Flexibility, muscle, joint, strength, tendon, ultrasound

Introduction

The science of physical rehabilitation takes the basis of knowledge from biomechanics, kinesiology and anatomy, and adds to that a practical clinical application. Physical rehabilitation is not just rest with a gradual increase in work.

Rather, the science of rehabilitation takes into account information that we have learned about the mechanics of movement, how tissues heal, and in what environment they heal the best. The goal of a quality rehabilitation protocol is to apply information from a variety of scientific fields to offer the patient the best opportunity to obtain the highest quality of healing.

Biomechanics is defined as the mechanics of a biological system, using the basis of physics to understand movement. Biomechanics can be helpful in breaking down the complex movement of the body into singular concepts that are more easily evaluated. Physical rehabilitation for the equine athlete is an important means of retaining the value of the horse as well as improving the quality of the horse's life. The purpose of this paper is to look at how the concepts of biomechanics can help us better understand the theories of equine rehabilitation.

What is the WHOLE horse approach to rehabilitation?

Looking at the entire horse to evaluate a physical rehabilitation plan is a realistic goal. However, we tend to concentrate on the areas of the horse that we are the most comfortable in evaluating. For example, a kinesiologist will focus on the muscular components that are causing pain and may overlook the heel bruise that is the primary cause of the lameness. Or the clinical veterinarian will determine that the cause of lameness is the adhesions of the deep digital tendon sheath and miss the muscular shoulder asymmetry producing incorrect loading of the limb. Combining the skills of several experts is an obvious advantage when developing a rehabilitation plan.

Diagnostic ultrasound monitoring of soft tissue injuries, avulsion fractures and bone surface remodeling can enable a more accurate assessment of the injury than can be done with less objective means such as heat, swelling or pain. Using ultrasound, one can evaluate the stage of healing and the level of motion and load that the tissue can withstand without reinjury. Serial ultrasound imaging throughout the rehabilitation period can determine if the work is excessive and may cause reinjury, or if the work is correct and the tissues are healing appropriately (Gillis, 1997). Small changes in ultrasonographic parameters of size, echogenicity, and fiber pattern are associated with a relatively large change in anatomical parameters (Gillis, 2004).

What is the biomechanical focus of the WHOLE horse approach to rehabilitation?

The whole horse body mechanics should always be evaluated weather the diagnosis is overriding dorsal spinal processes or a distal limb pathology. For example, if the diagnosis is an epaxial muscle tear, the loading of the limbs and the swing and stance pattern of the stride should also be thoroughly examined. Even during the hand walking stage of rehabilitation, the horse should be carefully monitored to reduce abnormal limb loading and swing patterns. Conversely, if the diagnosis is a distal limb problem, the epaxial muscles should be evaluated for symmetry, hypertension and atrophy of the musculoskeletal system.

Muscle memory patterns have been shown to be an adaptation of the neuromuscular system (Chapman et al, 2009; Wakeling and Horn, 2009). Therefore, the muscle pattern recognition can be very strong, especially when the pattern has been established at an early age, and changing movement patterns takes time and repetition (Halsban and Lange, 2006). Rehabilitation programs that occur over an extended period of time and emphasize quality movement will have a better chance of success.

Ultrasound can identify the size, shape, echogenicity (gray scale that enables the detection of edema, normal tissue, and scar tissue), bone reaction at soft tissue attachments, joint and bursa effusion, synovial proliferation and capsule thickness. Fiber pattern, showing the parallel alignment of tendon and ligament fibers, is an indication of tissue strength (Gigante et al, 2009) and can be monitored via ultrasound throughout the rehabilitation period. Serial imaging facilitates assessment of tissue structure to determine if the rehabilitation work is overloading the injured tissues or is enabling healing for return to function.

Pain

When body movement is not ideal, limitations in movement occur and the body will start to change the biomechanically correct manner in which it functions, resulting in pain and breakdown of the musculoskeletal system (Van Dillen et al, 2007). Late-stage structural faults of the body typically begin as alignment faults and pain does not usually occur until the alignment fault becomes severe (Spitznagel, 2011).

Unfortunately, just removing the pain will not automatically solve the problem if the incorrect mechanics are not addressed. Pain may cause the movement of the horse to change as a consequence of injury (Sterling, 2001), or incorrect biomechanical movement may result in pain (Sahrmann, 2002). In addition, if the pain is due to compensatory issues, dealing with only the site of the initial injury will not heal the horse.

If the pain is removed, the horse can be returned to work, and may do so happily. However, once the pain is removed, continuing to work the horse without correcting the cause of the pain may make future problems worse. It is important to correct the painful movement pattern rather than just treating the painful tissues. For example, if a horse with cervical joint disease is treated with injections and is then put back to full work, the treatment can actually cause a progression of the disease. Due to the joint disease, the muscles supporting the cervical spine are atrophied and/or in hypertension. Asking the horse to return to work after removing the joint pain without providing the correct supportive musculature, worsens the degenerative joint disease. This is due to the fact that the abnormal movement pattern has not been corrected. Therefore, the next injection doesn't work as well or last as long and the degenerative cycle continues until the horse must be retired. If before and after the horse is injected there is a period of careful muscle strengthening, while maintaining alignment, then the horse can return to work without the joint instability that is detrimental to healing. Continuing specific exercises to maintain appropriate muscle function for joint stability and alignment enables the horse to remain in work without, or with minimal, progression in joint degeneration.

Stance phase and swing phase of the limb

Stance-phase lameness and swing-phase lameness differentiation is another means of pinpointing the source of the lameness. In stance-phase lameness, the discomfort occurs during weight bearing, and in swing-phase lameness, the discomfort occurs during the unweighted movement of the limb. In general, swing-phase lameness has a distinct muscular dysfunction as the cause (Piazza and Delp, 1996). Swing phase of the stride has not been studied extensively due to the early impression that this element of the stride was simply a pendulum effect.

The distinction between swing-phase lameness and stance-phase lameness has led to improved diagnostic and treatment regimes in rehabilitation (Lam et al, 2008). A recent study in humans has shown that the hamstrings of sprinters are most susceptible to injury during the late swing phase of the stride (Chumanov et al, 2012). In addition, correction of swing-phase pathology will typically improve the stance phase of the limb.

In biomechanics, the first evaluation of incorrect movement is to examine the way the limb contacts the ground in the stance phase. The structure of the foot, the shoe and the surfaces that the foot is in contact with during stance, are of primary concern. Secondly, the evaluation moves to the swing phase where observation is focused on the movement proximal to the core to determine any defects. Third, evaluations of the swing phase are made in succession moving incrementally distal. Fourth, evaluation of the stance phase continues with observations being made proximal to distal to identify problems. This rehabilitation structure is based on the biomechanical principle that distal structures are most influenced by the type of rotation closest to the center of the structure. Therefore, during rehabilitation influencing the center of rotation influences the distal limb.

Balancing muscle movement

Diagnosis of the specific problem, or problems, is essential, however during the rehabilitation plan, focus is not just placed on the site of the injury. Agonistic and antagonist muscles are of equal importance when trying to improve the faulty movement pattern that is typically present when injury occurs (Scholtes et al, 2010). At times, working the antagonist muscle relative to the injured muscle is more advantageous than working specifically on the site of injury. For example, if the horse has experienced a muscle tear during contraction of the biceps the focus can be on strengthening the triceps to elongate the biceps during healing to help reduce scar tissue and adhesions.

Strength verses flexibility

Strengthening during rehabilitation is emphasized in most protocols, but in many situations over strengthening of one area is the reason the injury occurred initally.

The over strengthened area results in limited mobility in that region which leads to hypermobility in a related region of the body to compensate for this lack of movement (Lotz, et al, 2006). To heal the injury it is sometimes necessary to obtain more flexibility at the primary injury site, while strengthening occurs at an associated area.

To gain joint stability, the balance of flexibility and strength should be emphasized. The major factor in cartilage degeneration appears to be stresses on the synovium due to joint instability rather than inflammation (Lukoschek, et al, 1986). Stabilization of the joint will not occur with rest, rather the opposite will be true (Spitznagle, 2011). In humans, if braces are used early in the stabilization process to protect the site of injury these braces should allow movement of the joint. However, the braces must allow biomechanically correct movement and not just support the incorrect movement patterns that caused the injury in the first place.

Symmetry of movement

One major cause of breakdown is not the number of repetitions of a movement pattern, but rather the number of biomechanically incorrect movements. Asymmetry of movement causes significant biomechanical alignment problems in the body leading to injury (Guilak, et al, 2004). Symmetry of motion is the foundation of quality movement, and quality movement is a very important element of long-term pain-free movement (Gombatto, et al, 2008). Symmetry must be evaluated based on the specific movement, but saggital plane symmetry is a quality to strive for.

Rotation

Torque is sometimes referred to as rotation, but it is actually the force that causes the movement which then results in biomechanically correct or pathological rotation. Pathological rotation quickly deteriorates joints and although it is not always associated with asymmetrical movement, the two issues are distinctly related (Lukoschek, et al, 1986). For example, in humans, pathological rotation of the thorax is a major factor in patients with neck pain (Sahrmann, 2011). In the horse, observation of the rotation in the pelvis can be an important indicator of the pressures placed on the stifle and hock, and vice versa.

Hypermobility and hypomobility

Many times when a horse is palpated, the site of minimal movement is thought to be the main problem area. However as we look at new research, we see that hypermobility can be an important forbearer of injury (Sahrmann, 2011). As hypermobility continues, the joint breaks down and the muscles begin to spasm due to overwork, leading to further complications. The end result is hypomobility where the degenerative process has resulted in the loss of cartilage and exostosis (Adams and Dolan, 1995). An initial reduction in hypermobility, to improve stability, can be necessary before the hypomobility can be addressed. This theory is now widely accepted in human rehabilitation, however when it was first introduced the concept was dismissed (Sahrmann, 2011).

Ground reaction force

Ground reaction force is a major concern during rehabilitation and due to the pressures exerted to the repairing structures, it should be. However, research has shown that the body can handle higher concussionary forces than previously thought, as long as the force is applied in a biomechanically correct manner (Rupp, et al, 2010). If forces are increased gradually, and are within acceptable ranges, adaption can occur which can increase tendon, muscle and bone strength (Woo et al, 1987).

The horse's suspensory ligament can sustain a pound force of about 3500 when landing over a 4-foot jump (Meershoek, 2010). Studies have shown that at high speeds of the gallop the superficial flexor tendons have a small margin of biomechanical safety between tolerance and breakdown (Dowling, 2005) while the extensor tendons have a larger margin of safety (Batson et al. 2003). Problems arise when pathological rotational forces, due to poor alignment, are also present during concussion. Musculoskeletal tissues are not designed to accept the asymmetrical forces, and breakdown quickly occurs.

The type of surface used in a rehabilitation program is important when evaluating how to obtain the desired ground reaction forces. In human studies, the firm surface of clay produced fewer injuries, compared to grass and asphalt, when injuries were evaluated in tennis players (Bastholt, 2000). In addition, studies in horses have shown that a soft surface, which deforms considerably, can increase physical demands of work and induce an earlier onset of fatigue (Sloet van Oldruitenborgh-Oosterbaan et al., 1991).

Proprioception

Proprioception is the nueromuscular response that causes muscles to react appropriately without conscious effort. Proprioception is one of the first reactions of the body to diminish with immobilization (Hewitt, 2002). With proprioception retraining after injury, the horse has a reduced chance of reinjury when the footing becomes uneven, or they loose their balance, especially at speed. Challenging the balance of the horse by reasonably working the horse in uneven footing, in lateral exercises, over a variety of surfaces and up and down hills, as a few examples, will assist in improving the horse's proprioception during rehabilitation.

Summary

Shirley Sahrmann, a leader in physical rehabilitation theory and techniques for people, has summarized how motor control is related to movement asymmetries, which is related to pain syndromes. She states that 'the critical factor is not what you do as much as how you do it' (Sahrmann and Bloom, 2011)

When the biomechanics of movement of the whole horse is evaluated during rehabilitation, the chance of a successful outcome increases. For example, if the distinct asymmetry in the scapula is not addressed, the prognosis of the front suspensory tear will be guarded. This is due to the fact that the pathological loading of the limb caused by the asymmetrical body biomechanics has not been corrected.

Faulty movement can be caused by conformation, injury and/or imbalanced work. Faulty movement induces pain and pain induces faulty movement. These related issues result in weakness of the tissues associated with the pain and incorrect movement. As weakness is the symptom of the inciting problem, strengthening alone only treats the symptom. Locating and treating the cause, especially the mechanical cause of pain, is an important part of a rehabilitation protocol.

The causes of swing- and stance-phase lameness are distinctly different when viewed biomechanically. Swing-phase lameness is the most easily overlooked and typically has a muscular component, which can be the primary or secondary cause of movement dysfunction. If swing-phase corrections are made, a difference in loading will also be seen. Therefore, if only stance phase corrections are made, the cause of the lameness may not be completely addressed.

Asymmetrical movement and pathological rotations are two of the primary reasons for injury. Strengthening of muscles, tendons and ligaments is a common goal of a rehabilitation program. However, too much strength can be as detrimental to healing and injury prevention as too little strength, and can disrupt the biomechanical balance of the body. When strengthening does not improve the symmetry of the body, the effect of the strengthening exercises can result in uneven loading and stress on the musculoskeletal system.

Flexibility is necessary to keep joint movement smooth and to retain range of motion. However, hypermobility can be a major cause of injury. Hypermobility is a typical outcome when hypomobility has produced limited range of motion in one area of the body. To compensate for this inhibition of joint movement, the associated joints have excessive movement. The excessive movement causes degenerative joint disease leading to compensatory movement and further pain.

Ground reaction forces are important issues to consider, however studies have shown that the body can handle higher concussionary forces than previously thought. Both hard and soft surfaces are responsible for injuries although the types of injuries vary based on the surface. For soft tissue injuries, firm surfaces are being viewed as producing fewer injuries when compared to softer or harder surfaces.

Diagnostic ultrasound is a quick, safe, economical and effective means of diagnosing a variety of issues in equine medicine. The majority of equine injuries include soft tissue damage and ultrasound is the optimal method for diagnosing and monitoring the progression of healing in these injuries. Ultrasound can identify many of the upper body issues, such as spinal and muscle problems that cannot be imaged with any other modality due to the size of the horse. Ultrasound is effective at identifying subtle bone surface changes such as osteophytes, enthesiopathies, avulsion fractures, periosteal reaction, callous formation, and stress fractures. In addition, through sequential ultrasounds structural changes can be monitored throughout the healing process.

Physical rehabilitation takes time, but simply allowing more time for the rehabilitation process is not the answer. The science of physical rehabilitation is complex and constantly evolving and requires knowledgeable evaluation and application. Many caregivers through trial and error have learned valuable techniques and protocols that should be evaluated as we bring together clinical and research concepts.

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