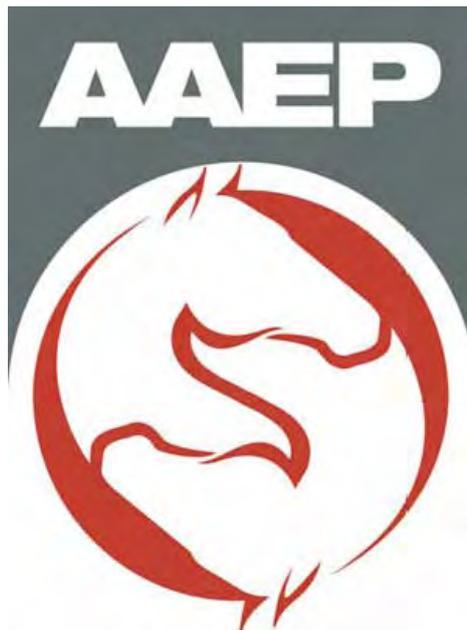


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Physical Therapy Approaches for Strengthening the Stifle and Pelvic Limb

Jennifer H. Brooks, PT, MEd

The physical therapy approach to stifle dysfunction and hindlimb weakness involves client education, increase in the activity level of the horse, and a stretching program followed by a specific ascending therapeutic strengthening exercise progression. A thorough examination by a veterinarian should first clear the horse for physical therapy treatment before initiation of this program. Horses recovering from lameness, surgery, or systemic diseases are appropriate for this program. The complementary use of modalities can be beneficial to this exercise program to decrease pain and inflammation and promote healing of tissues. Numerous training aids and therapeutic devices can contribute to this exercise program progression. This program is intensive for the owner and horse in terms of time and energy for successful outcomes. After the horse is symptom free, a cross-training maintenance program should be used to prevent recurrence. Author's address: Equine Rehabilitation Services, LLC, 23 Dupaw-Gould Road, Brookline, NH 03033; e-mail: jenequinept@charter.net. © 2011 AAEP.

1. Introduction

Background and Literature Review

The stifle is the largest, most complex joint in the horse, and it can be, problematically, the weakest joint.¹ Anatomically, this joint corresponds to the knee joint in humans. Injury specific to the stifle or any structures involving the pelvic limb can result in proximal muscle disuse atrophy, thus contributing to stifle pathomechanics and resulting in impaired limb function. In physical therapy treatment of the human knee, the muscles surrounding the knee play pivotal roles specific to strength, flexibility, structural alignment, and biomechanical integrity of the patella-femoral and tibio-femoral joints for proper knee function. This role is also true regarding the stifle of the horse.

Results can be devastating for the stifle joint when muscles of the pelvic limb decline in strength secondary to limb injury, surgery, lack of activity, or growth spurts. This scenario leads to stifle pathomechanics, contributing to a malady known as upward fixation of the patella (UFP), where the patella becomes lodged on the medial aspect of the femoral condyle, resulting in pain, swelling, and inability of limb flexion and forward locomotion. The horse cannot voluntarily relieve this fixation. The failure in disengagement of the patella is caused by a failure of the quadriceps muscle group to adequately pull the patella up and off the medial trochlear ridge of the femur.² More commonly, in milder cases, there is a partial or intermittent catching of the patella that results from a delayed release of the patella, known as intermittent upward fixation of patella (IUFP).

NOTES

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Several theories postulate that this problem originates from ligaments being too tight or the opposite (being too lax). Research does not substantiate either of these hypotheses well. Many treatments are based on one or the other condition of restriction or laxity. Various invasive surgical procedures and a multitude of suggestions for conditioning exercise have had less than favorable results.³ Until the recent decade, not much has been offered to the equine in the way of standard physical therapy or rehabilitation for the treatment of UFP or IUFP.³ Many factors contribute to UFP/IUFP, such as conformation faults, less than adequate stifle joint angulation, youth, and pregnancy, which may not be easily corrected. Current veterinarian intervention for treatment of UFP/ IUFP consists of medial patellar ligament desmotomy (MPLD),⁴ medial patellar ligament splitting,⁵ injection of caustic agents,⁶ estrogen therapy,² corrective trimming or shoeing (CTS),⁷ and periods of rest with non-steroidal anti-inflammatory drugs (NSAIDs)⁸ along with vague suggestions of exercise conditioning.

Historically, some trainers and veterinarians have instructed clients to “run him up hills and in straight lines” without specific guidelines. Many statements similar to these statements are typical in terms of an exercise protocol when seeking methods to address stifle dysfunction. This statement is common in most current sources when referring to conditioning of stifle weakness and rehabilitation.² A systematic literature review did not reveal any detailed programs to address stifle dysfunction. Asking a horse presenting with stifle pain and hindlimb weakness to perform hills is most likely to result in more pain, inflammation, lameness, and poor performance.

In the human, excessive compressive force or repetitive use stress may contribute to patellofemoral degeneration and pathologies, such as patella chondromalacia and osteoarthritis.⁹ Patellofemoral compressive forces, tibiofemoral compressive forces, and tibiofemoral shear forces all progressively increase as the knee flexes and decrease as the knee extends, reaching peak compressive forces near maximum knee flexion.⁹ Muscle activity generally progressively increases as the knees flex and decreases as the knees extend, which supports athletes performing the parallel squat (0–90°) over the one-half squat (0–50°).⁹ Tibiofemoral compressive forces can equal up to four times one’s body weight.¹⁰ This force occurs at walking gait and 55° of knee flexion. The patellofemoral joint can encounter loads as high as 5.1 times the body weight in midrange flexed positions.¹⁰ Therefore, the task of walking up stairs or hills, requiring up to 80–90° flexion, could involve joint compressive forces approximately 4–5 times one’s body weight. An injured knee with joint effusion, pain, and irritation to underlying articular cartilage with surrounding muscle weakness would have difficulty at carrying out such a demanding task in the acute or subacute

stages of recovery. This therapy would be terms for malpractice if a physical therapist (PT) made a human post-surgical knee patient do this regimen in the acute phase of recovery. Therefore, patients presenting with these symptoms benefit from a much less aggressive protocol of pain reduction modalities and muscle toning isometric exercise in avoidance of pain provocation before asking them to perform activities that require knee flexion and strength, such as hill or stair climbing.

Miller and Swanson² state, referring to the equine, that “altering the conditioning program can be helpful to gain adequate quadriceps function. The conditioning should include long, extended, straight exercises. Uphill work with limited downhill work in good footing is encouraged, but deep soil should be avoided no matter the type of exercise. Work that involves slow tight circles should be avoided.”² Jeffcott and Kold⁸ contribute that “treatment in most of these chronic stifle injuries consisted of a period of rest followed by a gradual return to exercise; in some cases this was combined with a short course of a non-steroidal anti-inflammatory drug,” but they do not comment on a specific outline of suggested conditioning exercises.⁸ There are several specific conditioning programs in the literature aimed at dressage horses¹¹ and those horses recovering from tendon¹² and ligamentous injuries¹³ but not many specific to stifle and pelvic limb weakness post-injury. Denoix and Pailloux¹⁴ gave this statement regarding physiotherapy reeducation of femorpatellar syndrome: “Go out for walks, interspersed with trotting: limit on two tracks as well as figures, which involve raising the legs. Jumps regulated by caveletties, preferable at the trot.” These examples are non-specific exercise progressions with multiple variables in terms of conditioning.

The most common statement of “work him in straight lines and up hills” is vague, leaving many questions for owners and trainers to ponder such as how much, how often, how does one go only in straight lines when confined to ring work, and how does one go uphill and not downhill? What level of incline is enough or too much? If the horse gets sore, how should one proceed: push through or hold off? These are all appropriate questions that have gone unanswered. Many horses and their owners have had to proceed through trial and error because of lack of an existing protocol specific for strengthening the hind end after injury, surgery, or other.

The next few paragraphs will review proposed veterinary treatments for IUFP. Transection of medial patellar ligament has historically been recommended, but it is now more commonly reserved for cases unresponsive to all other treatments and used as a last resort.² MPLD has been purported to result in pathologic changes in the articular cartilage of the patella and adjacent soft tissues.⁴ A variety of undesirable conditions that can result

from MPLD were reported by Gibson and McIlwraith,⁴ such as fragmentation formation at the distal aspect of the patella, bone production at the attachment of the middle patellar ligament on the patella, and articular cartilage fibrillation or detachment. Transection of the MPL results in patellar instability. Without tension from the medial patellar ligament, the patella becomes unstable within the femoropatellar joint, and femoropatellar synovitis and frequently, osteoarthritis result.⁴ Baccarin et al.¹⁵ report an increase in the angle between the proximal articular surface of the patella and the cranial distal surface of the femur along with enthesophyte formation and lateral deviation of the patella determined by radiographs after MPLD, concluding that MPLD leads to patellar instability. Baccarin et al.¹⁵ state that 120 days rest did not prevent the lesions caused by post-surgical patellar instability. Therefore, the use of this surgical procedure should be reserved for the most persistent cases of upward fixation of the patella.⁴

Although the mechanism of action is unknown, it is postulated that systemic estrogen relaxes the peripelvic muscles and ligaments, thus altering the angle of the pelvis.⁴ The alteration in pelvic angle may decrease the stifle joint angulation and thus, enables the patella to release from the femur.² Miller and Swanson² stress the use of exercise in conjunction with estrogen therapy, but they do not specify what is meant by exercise. Many authors state that this approach may be appropriately used short term in the young growing horse or pony, but results are not longstanding.

The use of caustic agents injected into the MPL has been well-researched.⁶ The use of injecting 2% iodine in almond oil (IAO) and ethanolamine oleate (EO) are two common agents.⁶ Histological responses of these agents are thought to cause thickening of the MPL through inflammatory response, fibroplasia, and chondroid metaplasia. Injection of the patellar ligaments with IAO resulted in a greater increase in cross-sectional area on ultrasonography than EO. Both agents resulted in significantly greater fibroplasia relative to control specimens.⁶ It is thought that the mechanism of irritation, through internal blistering to the ligament, will cause the ligament to thicken with scar tissue to reduce hyperlaxity. The downside to this approach is that if agents are poorly administered into the surrounding tissues or joint synovium, impending degenerative changes can be catastrophic to the stifle joint.

MPL splitting has shown the most successful long-term results over other surgical approaches. Tnibar⁵ states that the rationale for this surgical procedure is to induce localized desmitis with subsequent ligament thickening. No short- or long-term complications were observed, and no patients had clinical signs of UFP after surgery. This clinical effect was attributed to a two- to three-fold increase in size of the proximal part of the MPL from

an induced localized desmitis, concluding that splitting of the proximal one-third of the MPL is effective for treatment of UFP and allows rapid return to normal activity.⁵

Other conservative approaches to treatment of IUFPP are evaluation and corrective trimming and/or shoeing (CTS), such as those approaches that Dumoulin et al.⁷ present in a 2007 retrospective study. Findings indicated that CTS seemed the most important aspect; only 51.6% of patients were successful, and 20.3% of them improved partially.⁷ In case of no response to conservative treatment or in case of a permanent fixation, medial patellar desmotomy (MPD) was performed in 20 horses, which corrected UFP completely in 17 of 18 followed-up patients. However, gait abnormalities were seen in 7 of those 17 horses post-surgically, but the incidence was lower in horses that had rested for at least 3 mo (25%) compared with horses that had only rested for less than 1 mo (66.6%). Results indicate that conservative treatment, with special attention for CTS, is worth trying before performing more radical procedures to correct UFP and that a longer convalescence period after MPLD is desirable.⁷

Clinical Significance

The clinical significance of stifle dysfunction regarding these conditions of UFP and IUFPP should not be overlooked. Repeated trauma to the underlying articular cartilage of the retro-patella surface can predispose the femoropatellar joint to development of chondromalacia, a predecessor to osteoarthritis, and downward decline in function of the equine. It is possible that this disease is underreported in the literature because of the difficulty in accurately diagnosing the condition.¹⁶ McLellan et al.¹⁶ reported that radiography failed to show chondromalacia pathology, nuclear scintigraphy localized the disease process to the femoropatellar region, and ultrasonography identified pathological changes within the affected joint.¹⁶ Repeated trauma to the fibro-cartilaginous attachment of the MPL on the patella causes additional tissue proliferation, thus causing more surface area to become hung up on the medial femoral condyle along with additional irritation that causes local inflammation and a pain cycle.¹⁶ Horses with this ongoing condition exhibit significant lameness and thus, are often put in box stalls to rest, which often contributes to additional proximal muscle atrophy of the hindlimb.

All of these previous approaches, with the exception of rest and corrective trimming, are invasive procedures, therefore inducing surgical pain, inflammation, and temporary disability with the possibility of infection and low percentages of proven recovery. The purpose of this article is to introduce physical therapy approaches to address the problem of stifle dysfunction of delayed patellar release and pelvic limb weakness that are based on approaches used in human knee treatment. Initially, it is im-

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portant to minimize pain and inflammation with modality use as needed and then slowly progress therapeutic exercise as tolerated to restore proper biomechanics, promoting return to pain-free functional locomotion and strength.

This paper will address five objectives:

1. Compare and contrast equine stifle dysfunction to human knee dysfunction known as patella femoral pain syndrome (PFPS).
2. Determine assessment findings indicative of UFP/IUFP that are, therefore, appropriate for this treatment approach.
3. Introduce appropriate use of modalities to promote healing and decrease pain and inflammation along with training devices and therapeutic products.
4. Provide a systematic progressive exercise protocol of instruction of proper stretching methods of shorted structures followed by a progressive strengthening program initiated by pain-free isometric contractions and a concentric work progression to controlled eccentric contractions.
5. Present the concept of cross-training protocol for prevention of recurrence.

2. Protocol Development

The development of the following therapeutic exercise protocol for treatment of stifle dysfunction (addressing UFP and IUFP symptoms) is based on physical therapy approaches commonly used to treat a similar condition in the human population called PFPS. PFPS affects approximately one in four people.¹⁷ Human patellofemoral biomechanics differ from the equine in that patella tends to misalign over the lateral femoral condyle, causing irritation to the retropatellar articular cartilage, and it can sometimes dislocate lateral to the knee joint. This biomechanical fault has been related to poor muscle strength and length, soft-tissue restrictions, youth, pregnancy, deconditioning, and poor skeletal alignment.

Cleland and McRae¹⁷ purport that biomechanical dysfunction of the patellofemoral joint leads to anterior knee pain and decreased function. The problems of PFPS result from weakened quadriceps, allowing the patella to glide laterally over lateral femoral condyle and causing roughening of the retro-patellar articular cartilage, which leads to inflammation and pain; this problem inhibits quadriceps function and thus, overall lower limb performance. Current rehabilitation of PFPS focuses on restoring normal patellofemoral mechanics by resolving patellofemoral malalignment, promoting tissue extensibility, promoting optimal timing and strength of the vastus medialis obliquus muscle, and normalizing mechanics.¹⁷ Cleland and McRae¹⁷ suggest that the following factors contribute to the cyclic decline of function with equine stifle dysfunction: poor biomechanics for the patellar-

femoral joint secondary to delayed neuromotor response and reflexes of the extensor mechanism of quadriceps, reduced muscle strength, soft-tissue restrictions, resulting in poor joint proprioception and faulty movement.

In both the human and the horse, it is postulated that these scenarios are downward, ongoing cycles that promote the degradation of the articular cartilage with decreased joint and limb function. The process starts with weakening of the quadriceps and proximal limb musculature followed by altered mechanical function of the patella and irritation to the articular cartilage, resulting in pain and inflammation of the joint. The presence of pain with increased joint effusion causes reflex inhibition of the extensor mechanism of the quadriceps musculature. Knee joint effusion results in arthrogenic quadriceps muscle inhibition, which can increase loading about the knee that may potentially increase the risk of future knee joint trauma or degeneration.¹⁸ In human studies, it is accepted that a few milliliters (30 ml)¹⁸ of increased synovial fluid volume will inhibit proper firing of the quadriceps muscles, thus contributing to a downward cycle of muscle atrophy, pain, and degeneration of the joint health and function. Excessive fluid of 60 ml in the knee joint showed negative effects on the performance of the quadriceps muscles by decreased torque of 30% after the injection of fluid.¹⁹

Arthrogenic quadriceps muscle inhibition that accompanies knee joint effusion impedes rehabilitation after knee joint injury.¹⁸ Quadriceps strength and endurance are of vital importance for normal knee joint function, and therefore, restoring normal quadriceps function after knee joint injuries is an essential component of human knee rehabilitation. Persistent post-traumatic quadriceps weakness presents as a difficult clinical dilemma for the treating clinician. An important underlying factor contributing to persistent, perhaps rehabilitation-resistant post-traumatic quadriceps weakness is arthrogenic muscle inhibition (AMI), which remains understudied in current clinical outcomes research in patients with knee joint injury.¹⁹ Quadriceps muscle performance can be altered by exercising the swollen joint.

Consideration of alternative options, specifically a progressive physical therapy intervention method known to resolve PFPS, could be of significant value for treatment of the biomechanical deficits of horses afflicted with IUFP. This approach has specific guidelines for progressive advancement of exercise and activity in avoidance of producing pain. This alternative approach of therapeutic exercise is a viable option to be considered by vets and owners before more invasive procedures that have poor evidence-based results.^{4-7,15} Development of this protocol is based on experimentation in the field, literature review,³ a case study,²⁰ and 12 clinical cases of direct treatment along with reporting of numerous long-distance cases.

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A commonly misunderstood approach of rest as a treatment for a mechanical problem such as IUFP is often used by owners to prevent the horse from experiencing the catching or giving way or lameness induced by IUFP and UFP. This method is opposite of what is appropriate in terms of treatment for this dysfunction. Muscle control is facilitated by neurostimulation of motor units, resulting in contraction of muscle fibers. Therefore, some cases of IUFP may result because of dynamic neuromuscular control deficits. The method to address such dysfunction is to increase the input into the neuromuscular system with dynamic increased exercise. Specific ascending exercise, focusing on specific muscle function and controlling pelvic limb muscles of the hip and stifle flexion and extension patterns of movement is the main focus of this therapeutic intervention.

Quadriceps strength and endurance are of vital importance for normal knee joint function, and therefore, restoring normal quadriceps function after knee joint injuries is an essential component of human knee rehabilitation. Persistent post-traumatic quadriceps weakness presents as a difficult clinical dilemma for the treating clinician. An important underlying factor contributing to persistent, perhaps rehabilitation-resistant post-traumatic quadriceps weakness is AMI, which remains understudied in current clinical outcomes research in patients with knee joint injury.¹⁹ Quadriceps muscle performance can be altered by exercising the swollen joint. Excessive fluid of 60 ml in the knee joint showed negative effects on the performance of the quadriceps muscles by decreased torque of 30% after the injection of fluid.²¹

Rationale

The theory of delayed patellar release of IUFP because of muscular atrophy and altered neuromuscular response lends itself to commonly used human physical therapy methods of addressing knee dysfunction, swelling, and pain. A treatment intervention of stretching tight structures followed by strengthening weak muscles and increasing muscle endurance using neuromuscular facilitation techniques to improve proprioceptive awareness and skill in resumption of specific discipline retraining has a significant role to play in the rehabilitation of horses afflicted with IUFP symptoms. The following method to treating horses with patellar instability is a humane approach that avoids increasing pain by inducing ascending strengthening exercises in a logical progression based on approaches used in human PT to address human knee dysfunction.

3. Methods of Assessment

Before implementation of this program, it is important to have the horse properly evaluated by a veterinarian. Veterinary assessment by palpation, lameness evaluation, sonography, and radiographs can assist in a specific diagnosis. The symptom of

UFP/IUFP may be a primary problem or a secondary fault related to another injury of the pelvic limb. A primary problem can be caused by skeletal growth spurts, conformational faults, poor shoeing/trimming techniques, or muscle weakness because of inactivity. The problem of IUFP can be considered secondary if it arose later in the recovery phase from a systemic disease, limb injury, or surgery intervention, all of which will evoke weakness as a result of muscle inhibition and deconditioning during recovery.

After the horse is determined appropriate for PT intervention, the physical therapist will perform an assessment to determine the horse's baseline status. PT assessment will start with a history from the owner. Owners report their horses to be clumsy, frequently stumbling, exhibiting tripping, or getting a hind leg stuck behind. Sometimes, they report the horse's hindlimb just giving out or collapsing. Often, an audible click or pop, known as crepitus or joint noise, can be heard on weight shifting on and off the involved leg. Observation of the horse's conformation and stifle angulation and muscular symmetry should be noted.

On observation, these horses often present with an overweight body condition score of 6 of 9 points or above, weakness of abdominal musculature, atrophy of top-line muscles, or generalized deconditioning along with atrophy of hind-end musculature. A common finding of muscular asymmetry of the hind end is noted by viewing from the posterior in terms of gluteal height and width. Often, a hollowing of the musculature can be noted laterally below the tuber coxae on the affected side. On palpation of the lateral aspect between the tuber coxae and stifle region, tissue depth is often shallow, allowing the examiner's fingers to sink deeper into soft tissues of tensor fascia latae, quadriceps, and bicep femoris muscles compared with the opposite side. Sometimes, muscle fasciculations of the quadriceps and bicep femoris are exhibited. Sometimes, there is stifle joint edema present with pain responses and exhibited annoyance behaviors noted on palpation of the stifle.

More specific examination of the stifle joint can reveal visible jumping of the patellae when the horse initiates a weight shift of stepping forward. This finding is a pathological movement where the patella is momentarily restricted on the trochlear ridge, causing a jittering movement on its release over the medial femoral condyle. Under normal biomechanical circumstances, this movement is a smooth gliding that should go unnoticed. These pathomechanics inhibit proper forward locomotion, often presenting with a resultant shortened cranial phase of step length at walk and trot.

Additional assessment involves taking the horse through flexibility testing. Often, the involved pelvic limb is limited in passive mobility compared with the non-involved limb, indicating shortening of soft-tissue structures surrounding the stifle and hip

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joints. Mobility and stability testing can be administered when lifting the non-involved pelvic limb off the ground; one can observe how well and long the horse can remain standing on the involved limb and what kind of muscle recruitment patterns the horse exhibits to remain standing. The examiner can weight shift or sway the horse over his weight-bearing limb to see how well the horse can stabilize and adjust to movement over that limb and thus, compare the results with the opposite limb.

Proprioceptive testing can be carried out by having the horse back in hand and perform turns on the forehand. Often, these horses will be resistant to these maneuvers or exhibit clumsiness at foot placement. Often, at backing, the horse will drag the involved limb, take a shortened step length, and place the limb in a more abducted position, causing the path to deviate to the involved side. Turning on the forehand, the horse may exhibit poor ability to cross midline with the involved limb, and often, the horse will compensate with excessive pelvic obliquity rather than smooth cross over under the belly with the limbs.

Last, for the assessment, gaits are viewed. Horses with stifle dysfunction will show poor hind-end awareness, presenting as if their hind end is not attached to their trunk or seeming to be dragged along by the forehand. Often, these horses do not step up or track up well at the walk or trot. This observation is most noted in the trot. Often, the horses present with a Western jog at the hind end. Their front limbs are exhibiting full strides, but the back limbs have a much shorter stride, without the hind hoof coming up into the front hoof print (mal-tracking). On occasion, some of these horses may exhibit forging from behind in which the hind hoof strikes the fore hoof, but this finding is the lesser occurrence in this author's experience. Forging can be an indicator of hind-end weakness and decreased proprioceptive awareness, of which this pathology would be attributed. These horses often exhibit trouble with cantering, such as running into the canter with poor control, trouble picking up the proper leads, cross-cantering behind, using a four-beat canter, and having poor balance. All of these problems may be resultant of hind-end weakness, poor core strength, and possible joint pain.

The more muscular atrophy and poor neuromuscular response of the extensor patellar release mechanism, the greater potential irritation of the fibrocartilaginous patellar ligamentous extension and degradation of retropatellar articular cartilage, which can lead to chondromalacia. McLellan et al.¹⁶ report that it is possible that chondromalacia in horses goes underreported in the literature because of the difficulty in accurately diagnosing the condition. Radiography fails to show chondromalacia pathology. Nuclear scintigraphy localizes the disease process to the femoropatellar region, requiring ultrasonography to identify the pathological changes within the affected joint.¹⁶ When this pro-

cess is present, the weakened limb will continue to get weaker without intervention. Thus, addressing this downward spiral of events through PT has clinical significance in the prevention of degenerative changes, leading to development of osteoarthritis, avoidance of more invasive procedures, saving of fiscal resources, and promotion of functional restoration to prior level of performance.

Treatment Objectives of Stifle and Pelvic Limb Strengthening Program

1. Educate the owner regarding pathology, treatment approaches, and weight reduction.
2. Decrease pain and swelling of stifle joint.
3. Decrease articular cartilage wear.
4. Strengthen stifle musculature to optimize patella mechanics and neuromuscular reflex.
5. Increase overall conditioning (flexibility, strength, proprioception, and endurance) of the hind end, abdominals, and top-line musculature.
6. Return to function for safe locomotion and riding back to the prior level of functional performance.

Indications

Indications for use of this program would be stifle dysfunction presentation of pain, swelling, mechanical symptoms of UFP/IUFP, proximal pelvic limb muscle atrophy, shortened stride, abduction gait deviation, decreased flexibility, proprioceptive deficits, recovery from pelvic limb injury, pain post-surgery, recovery phase of systemic diseases, and general deconditioned status.

Contraindications

Contraindications are insufficient physical examination or diagnostics to rule out clinically significant medical or surgical conditions that would be better managed with traditional veterinary approaches along with obvious conditions such as hoof abscess, joint integrity problems, presence of loose bodies, osteochondrosis dissecans lesions, subchondral bone cyst, fractures, neoplasm, and excessive pain that prevents weight-bearing on pelvic limb.

4. Objective Measures of Success

Long-Term Goal

Reduce the number of audible clicks or visual jumps of the patella in 10 weight-shift movements within an 8-wk period.

Short-Term Goal

Increase tolerance to lateral tail pull isometric exercises to holding 10 s for 10 repetitions. Establish a baseline of tolerance on first assessment session.

5. Treatment: A Systematic, Progressive Therapeutic Exercise Program

Success of this program is owner-dependent and labor-intensive. This rehab protocol is a high-

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energy expenditure undertaking for the owner. Treatment should be carried out daily for adequate improvement to be noted.

The first method of intervention starts with education of the horse owner. The area of education most needed to owners is the revelation that afflicted horses need more movement rather than less movement, such as stall rest. Stall rest is only warranted if determined necessary by a veterinarian. More movement is necessary in terms of daily mobility outside of a box stall as much as possible. Owners may need to consider moving their horses to more desirable facilities to address the requirements of this program.

Containing horses in box stalls is equivalent to humans remaining on bed rest (BR). Deleterious results are known for humans staying on prolonged BR. Periods of limb unloading, whether produced by BR or spaceflight, have been shown to induce muscle atrophy and loss of force and power. The latter always exceeds in volume loss attributed to a selective decline in myofibrillar protein.²² Kortebein et al.²³ indicated that 10 days of BR results in a substantial loss of lower extremity strength, power, and aerobic capacity and a reduction in physical activity; therefore, the need for interventions to maintain muscle function during hospitalization or periods of BR in humans should be a high priority.²³ Horse owners and veterinarians need to understand the importance of minimizing stall rest and instead, providing the daily ongoing movement necessary to halt the progression of pelvic limb muscle atrophy that often occurs after injury. It is essential that owners understand that IUFP etiology often stems from muscle weakness of inactivity and that atrophy contributes to biomechanical faults of the patella femoral joint.

The following suggestions increase mobility of sedentary horses. Keep horses moving throughout the day. Allow 24-h access from shelter to turnout. Ideal turnout consists of large, expansive pastures involving slight hills. Have a companion animal, horse, or pony to maximize the herd instinct. One horse will always dominate the other to keep them moving and foraging.¹⁶ Provide multiple feed piles long distances from one another to keep horses migrating around the paddock from pile to pile.

Many clients have concerns if their horse has pain when afflicted with IUFP. There is not verification of pain presentation in current literature regarding IUFP. When less than ideal biomechanics occur, it is certainly imaginable that pain could result. Cartilage itself does not have nerve endings. Pain will result on disruption of retropatellar articular cartilage or irritation of the MPL fibrocartilaginous extension lodging on the medial condyle. When structures misalign and malfunction, pain is often the result from tissue irritation, setting off chemical mediator release and resulting in inflammation. The presence of repeated misalignment, inflammation, and pain sets off muscle response of inhibition

and spasm, contributing to additional downward spiraling of pathomechanics. Therefore, it is probable and clinically relevant that pain is an issue with some horses. When pain is present, it is necessary to address pain and inflammation with appropriate medications prescribed by veterinarians.

Neuromuscular alterations, including decreased voluntary quadriceps activation, are commonly associated with knee osteoarthritis.²⁴ AMI is a clinical impairment characterized by reflexive inhibition of the motor neuron pool in uninjured muscle surrounding the injured joint. This occurrence decreases the ability of the muscle to recruit motor neurons during contraction, limiting the potential force that a muscle can generate as a protective mechanism to decreasing excessive force around an injured joint. Prolonged deficits of muscle activation through AMI, along with muscle weakness, may decrease shock absorption attenuation at the knee, leading to the increase of joint surface breakdown.¹⁸

Atrophied muscles can also be a source of pain. Muscle pain is associated with decreased motor unit discharge rate during constant force contractions²⁵ such as isometrics exercises. Motor unit recruitment strategies are altered during pain to maintain force despite reduced discharge rate.²⁵ Because discharge rate is a determinant of force, other adaptations in strategy (possibly modulation in both cortical and spinal reflex mechanisms) must explain force maintenance during pain.²⁵

A variety of PT modalities and interventions can be quite helpful in addition to pharmaceutical intervention. Use of cryotherapy is beneficial at reducing pain perception and inflammation simultaneously. Modalities of heat and ice are significant for the reduction of pain, swelling, and muscle spasm. The use of electrical stimulation known as transcutaneous electrical nerve stimulation (TENS) can help mediate afferent pain impulses. TENS applied to human knee joints with osteoarthritis has been reported to disinhibit AMI of the quadriceps.²⁶ The roles of therapeutic ultrasound, laser, and electrical stimulation are well-supported by research for the potential to increase healing of tissues and decrease pain. Manual techniques such as massage to soft tissues can increase blood flow and decrease spasm. Joint mobilization can also decrease pain and regain accessory joint motion to promote pain-free range of motion. Therapeutic ultrasound, pulsed electromagnetic fields, and low-level laser therapy have been shown to increase collagen synthesis in fibroblasts, thereby increasing tensile strength of tissues.²⁷ Modalities and manual therapies should be considered and used to relieve pain and inflammation while implementing an exercise program to promote faster recovery to function. Decreasing pain will allow the horse to move more freely into the exercise phase of rehab.

6. Therapeutic Stretching Program of Pelvic Limb

After minimizing pain, the first exercise approach of this program is to address flexibility by stretching exercises of the hindlimbs. Tight muscles and soft-tissue structures can cause pain and weakening of tissue and contribute to abnormal biomechanics of surrounding joints.²⁸ Stretching has shown reduction of muscle atrophy and induced hypertrophic effects in muscle.^{29,30} Addressing flexibility of the surrounding hip and stifle muscle is important for gaining full range of motion, promoting proper skeletal alignment, and maintaining correct biomechanics of joints. Stretching before participation in athletic activities is standard protocol for many human sport training sessions,³¹ and it can reduce the risk of injury³² and enhance performance.²⁷ Stretch routines for horses are also becoming more widespread, probably reflecting the positive findings from research on human athletes that indicate potential increases in muscle force, jump height, speed, range of motion (ROM), muscle length, and flexibility.^{31,33}

There are many texts (Porter,³⁴ Bromiley,³⁵ and Denoix and Pailloux¹⁴) written about equine stretching with instruction for stretching of limbs, neck, and trunk. Unfortunately, most texts do not indicate proper hand holds to minimize overstretching of multijoint muscles and tendons. Also, they do not suggest the proper time to hold stretches to allow for physiological lengthening of the muscle tendonous fibers, and they do not address the required frequency for repetition. A study done by Rose et al.³³ addressing hindlimb stretching comprised of hamstring stretch, stifle and hip flexor stretch, and lateral quad stretch; stretches were applied two times, held for 10 s initially, and then, held for 20 s. Bandy et al.³⁶ suggest, "Change in true flexibility (physiological lengthening of the fascicles) is dependent on the duration and frequency of stretching." Therefore, Bandy et al.³⁶ suggest maintaining passive stretches for 30 s or longer as tolerated for optimal relaxation and lengthening. They go on to suggest that each stretch be repeated three times to allow for the most advantageous physiological lengthening.³⁶ Bandy et al.³⁶ suggest that clients repeat these stretches daily to all muscle groups as tolerated for the first 6 wk and then decrease frequency to every other day as necessary.

Findings by Rose et al.¹⁴ in 2009 indicated that horses that were stretched 6 days/wk may have experienced delayed onset muscles soreness (DOMS) from the passive stretching, and they may not have had sufficient opportunity to recover (between stretching treatments) and adapt compared with the horses that were stretched only 3 days/wk, thus experiencing decreased stride length. These results suggest that stretching every day may not be appropriate for the horse but that stretching 3 days/wk (3DSR) may provide some benefit in terms of ROM.³³ "The stifle and other joints showed a

significantly lower ROM after the 6 days of stretching (6DSR) than after the 3DSR. The lower ROM results could indicate that the 6DSR induced increased muscle stiffness compared with the 3DSR."³³ The aim of stretching is to lengthen shortened tissues in an attempt to increase ROM, and therefore, the lengthening of the muscle fibers may cause DOMS. The 6DSR group could have been experiencing DOMS from the stretching treatment, and they may not have had sufficient opportunity to recover (between stretching treatments) and adapt compared with the 3DSR group.³³

Rose et al.³³ currently instruct clients to begin a stretching program daily or as close to daily as possible to start making positive gains as quickly as possible if decreased hindlimb flexibility is noted. The results shown by Rose et al.³³ suggest that stretching every day may not be appropriate for the horse but that stretching 3DSR provided some benefit in terms of ROM. These findings merit additional consideration by this author. In this program, clients reduce the stretching regimen down to every other day at around 6 wk because of the introduction of more aggressive strengthening exercises and consideration of time requirements to carry out all activities.

Besides the lengthening effect that stretching has on surrounding tissues, promoting greater freedom of movement and increasing range of motion, there are other advantages of stretching. Sharma and Maffulli²⁷ indicate that stretching increases collagen synthesis and improves collagen fiber alignment, resulting in higher tensile strength of tissues. Therefore, stretching may have positive contributions to restoration of stifle joint biomechanics through tensile strengthening of the surrounding soft-tissue structures.

There are four specific stretching techniques that this author has found advantageous in treatment of horses afflicted with stifle dysfunction. This author has thought that horses with stifle injuries may have learned response to avoid full flexion action at the hip and stifle and therefore, may resist full flexion patterns of the involved limb, resulting in toe drag and a shortened cranial step length. Therefore, in a stretch called high flexion, which is shown in Figure 1, the limb is brought up passively into a fully flexed hip and stifle position and held for 10–30 s, and it may restore full flexion motion. Bringing the affected limb up into a total flexion pattern to end ranges of hip, stifle, hock, and fetlock flexion by holding at the hoof and hock allows the horse to recover joint memory of full flexion sensation, reminding the horse that he can move his leg up into fully flexed positions. This process can also assist with providing synovial lubrication of joint surfaces and abolishing adhesions that may restrict end-range comfort.

The next stretch is in the protracted position by bringing the limb forward under the horse's belly. This stretch is proposed to place tension on the



Fig. 1. Passive high flexion stretch.

hamstring muscles of biceps femoris, semitendinosus, and semimembranosus along with middle gluteal and deep gluteal muscles and possibly take up slack of the sacrosciatic ligament.³⁷ By keeping the stifle and hock in extension, one may also stretch the gastrocnemius, soleus, and Achilles' tendon.³⁷

Bringing the limb into retraction is proposed to stretch the quadriceps complex, tensor fascia latae, sartorius, and gracilis muscles along with possibly the long digital extensor more distally.³⁷ Many therapists hope that the iliopsoas and iliacus may be addressed in this maneuver, but research is not available to indicate if these deep hip flexor muscles are affected in this maneuver.

Some horses that have had long-term stifle injuries can sometimes adopt a circumferential abduction gait. This gait could arise for two reasons: a method in avoidance to flex the stifle and hip joints secondary to pain or reduced range of motion or adapted tissue tightness of the lateral muscles tensor fascia latae and biceps femoris, restricting protraction of the limb. Therefore, stretching the hindlimb into adduction by crossing midline under the horse's belly can stretch out the tight lateral abductors responsible for inducing an abduction gait.

7. Therapeutic Strengthening Exercise Program

If the veterinarian has cleared the horse for physical therapy and assessment determines that there is no deterrent to weight-bearing on the involved limb, then exercise should be considered the first approach to intervention. The most logical approach to strengthen the hind end is to start with the smallest motion method of muscle work, which is isometric contraction. Isometric exercise is a static form of exercise that occurs when a muscle contracts without change in length of muscle or without visible joint motion,²⁸ which results in tensing or tightening of the muscle. For adaptive changes to occur,



Fig. 2. LTP isometric exercise.

such as increase in strength and endurance, contractions need to be held for 6 s. This process allows for peak tension to develop for metabolic changes to occur within the muscle.²⁸ The cognizance of performing an isometric approach at this point over isotonic activities that involve joint movement is paramount in the avoidance of causing joint pain.

The challenge in working with horses is that we cannot ask them to contract their quadriceps volitionally by verbal request, which we can do with the human patient. Often, the horse with stifle problems will opt to rest the involved or atrophied limb frequently. This rest allows or feeds into the commonly known adage in PT that the weak get weaker, further facilitating the problem of non-use of the weaker limb. Asking the horse to do an isometric by weight shifting, the muscles around the hip and stifle will contract, providing joint stabilization. Stability in the stifle joint is controlled by a combination of its mechanical restraints (e.g., ligaments, joint capsule, and bony geometry) and dynamic restraints (muscles) mediated by the sensorimotor system, including proprioceptive feedback of joint position and neuromuscular control.³⁸ Weight-shifting exercises facilitate neuromuscular input to maximize isometric and cocontractions surrounding the stifle joint.

An isometric contraction can be easily initiated by weight shifting the pelvic weight onto the involved or atrophied pelvic limb by an exercise termed a lateral tail pull (LTP) (Fig. 2). Isometric exercises are excellent for recruiting muscle motor units and biasing muscle without imposing pain from joint movement. Joint pain can produce a reflexive inhibitory response to the surrounding muscles.

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Fig. 3. Stand 90° from the horse's involved pelvic limb and pull laterally to displace weight on that limb.

Muscle atrophy can also cause muscle pain. Muscle pain is associated with decreased motor unit discharge rate during contractions. Motor unit recruitment strategies are altered during pain to maintain force, despite reduced discharge rate.²⁵ Therefore, imposing isometric strengthening exercises on the supportive muscles around the hip and stifle will increase strength, aid in shock absorption and general condition, which can minimize additional injuries,²⁴ and halt atrophy. These exercises should be added one at a time to properly monitor feedback and objective measures of swelling, endurance tolerance, and ROM.³⁹

To perform LTPs, stand to the side of the horse at 90°, have the horse in a squared position, grasp the tail at mid-length, and gently pull the horse's pelvis over the involved hindlimb; this process is shown in Figure 3. This process will induce contractions of tensor fascia lata, quadriceps, and bicep femoris. Often, the gluteals and lower abdominal oblique muscles will fire as well. Hold for 10 s for 10 repetitions. It can be helpful to pre-occupy the horse with grain, hay, or grooming if they become agitated with this exercise. This preliminary exercise is initiated on day 1.

Many owners ask if the horse needs to remain in a squared position to perform this exercise. The answer is that they do not. Strength will increase only at the joint angle at which the isometric exercises are performed.²⁸ Therefore, to develop strength of the hindlimb, the aim is to develop

strength functionally in all positions common to the horse. Horses do not always stand square. Therefore, this isometric toning process by LTPs should be done in all positions that the horse stands to develop strength throughout the range of motion.

To progress isometric demands from the LTP, clients are instructed at a single leg standing exercise to promote stability of the involved limb. This exercise is done by picking up the opposite hindlimb as if to pick out the hoof. One must be mindful of not allowing the horse to rest his weight on the handler but rather, to make him maintain his weight on his involved limb for 10–30 s or more as tolerated. This exercise will ask the horse to build his muscle cocontraction tolerance and endurance, promoting stability of the pelvis, hip, and stifle joints. After the horse has been through the previous exercise regimen for about 1 wk, many owners notice improvement of the horse's tolerance to LTP duration and repetitions along with increased tolerance to stretching. The next step in this program is progressing into isotonic (dynamic) exercise. Isotonic exercise involves the concentric (shortening) and eccentric (lengthening) muscular contractions that result in movement of a joint or body part against a constant load. The load²⁸ (resistance) of isotonic exercise is gravity pulling on the horse's body and limbs while in locomotion. Load can be increased by a rider's weight, walking through mediums of water or snow, pulling a carriage, or working against Theraband (TB).^a

Isotonic exercises begin with hand-walking. Many horses walk with as little energy expenditure from behind as possible. This prescribed hand-walking regimen requires significant impulsion. For horses to make strength and endurance gains, they need to learn an improved manner of walking forward with impulsion coming from their hind end so that their hind foot tracks up into their fore hoof print. This walking may require some training with the owner as to how to ask and impose a forward walk with impulsion. A specific distance or time is assigned dependent of what level of exercise to which the horse is currently accustomed. It is ideal to carry out the hand-walking with impulsion before the passive stretching exercises for warming up soft tissues to increase tissue extensibility.

If the horse is tolerating the progression, backing in hand is introduced next, which is seen in Figure 4. Here, focus is again on good stride quality. This focus means that the horse should willingly pick up the involved limb without dragging it or abducting it and place it with an even step length behind him. To start, a specific distance of 10 ft is reasonable for three repetitions. Many horses do not willingly wish to back. Directly behind them is their one blind spot. Therefore, training with the owner in how to ask for and reinforce this method may be needed. Progress to longer lengths of 20 ft on level ground for 5-min intervals as tolerated daily for 1–2

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Fig. 4. Backing in hand exercise.



Fig. 5. Hand-walking up and down inclines.

wk. A small crop or dressage whip can be helpful to have on hand for reinforcement.

The progression in the program continues by hand-walking up and down slight inclines. Gradients are the foundation of equine strength training.⁴⁰ The therapist has to look about the facility grounds to find the adequate hill available. Sometimes, this hill is non-existent or less than desirable. Therefore, specific guidelines are hard to prescribe that are appropriate for each case scenario. It is recommended that this progression start gradually with two or three trips up and down to start at 5-min intervals for up to 15 min daily for hill work as tolerated. Clayton⁴⁰ advocates walking up gradients as ideal strengthening activity in horses that have unilateral hindlimb weakness. Gradually increase to steeper inclines as tolerated. Document inclines, distance, tolerance, and progression.

The chart shown in Table 1 is an example of the flow sheet handout given to clients to track their horse's progress and tolerance.

A variable introduced next is surface variety. There are many reasons for this variable. Introducing a variety of surfaces provides tactile and proprioceptive input into the horse's sensorisystem. Consider how much time most performance horses spend going around and around on the same level surface in the ring. This author believes that horses that do mainly ring work accommodate to the anticipation of the common dependable surface that they do not need to think about for their next footfall. If there is no variability in terms of surfaces, obstacles, and inclines, their sensory feedback system may accommodate to the expectation of constant footing. By introducing the horse to a variety of surfaces, such as asphalt, wood chips, sand, mud,

Table 1. Example of the Flow Sheet Handout Given to Clients to Track Their Horses' Progress and Tolerance

<i>Stifle Protocol Exercise Flow Sheet</i>			
<i>Exercise</i>	<i>date</i>	<i>hold secs</i>	<i>reps</i>
<i>Lateral Tail Pulls</i>			
<i>Opposite Leg Lifts</i>			
<i>Walking in hand</i>			
<i>Backing in hand</i>			
<i>Hills</i>			
<i>Walk/trot transitions</i>			
<i>Long-lining</i>			
<i>Stretching:</i>			
<i>Protraction</i>			
<i>Retraction</i>			
<i>Adduction</i>			
<i>High flexion</i>			

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Fig. 6. LTP on mounting block for contraction of stifle muscles in flexed position.

gravel, and ground poles, he will receive different proprioceptive and kinesthetic feedback at the hoof and phalangeal joints. This input will stimulate the sensory feedback system, facilitating a neuromuscular response to prepare for whatever changes in surface appear.

After about 2 wk of the above program and reassessment, the next progression step is walk to trot transitions in hand. The focus is on quality long strides behind with accelerating transitions up and controlled transitions down from trot to walk. Down transitions emphasize eccentric control of the hip and stifle muscles essential for conditioning⁴⁰ for improved stifle function. Muscles develop the greatest tension when they perform eccentrically.⁴⁰ Eccentric exercise can increase collagen, tensile stiffness, and strength.²⁷ Eccentric contractions have been found to cause minor damage to muscle fibers and may produce DOMS⁴⁰; therefore, some horses may become a little more stiff in this phase. Dependent on the horse's level of fitness, a number of transitions are again decided for use as a baseline and documented on which to build. As the horse tolerates this progression, the owner can increase as tolerated. Good-quality up and down transitions must be demanded from the horse to maximize muscle recruitment and rewrite the previous motor plans of poorly controlled transitions.

The following progression of exercises is purposefully abridged (not explained in full detail) because of the author's effort at reducing the length of this

paper. The exercises are introduced according to the horse's tolerance to the previous activities of the program without showing signs of regression, increased pain, swelling, stiffness, or lameness. These exercises and activities increase demand on the horse in terms of isotonic work, eccentric control, and introduction of coordination and skill. Many of these horses, because of injury, weakness, and deconditioning, lack good motor control of the hindlimbs. Often, they have poor motor planning and faulty foot placement along with poor lumbopelvic control. Therefore, these exercises are selected to also recruit thoracolumbar epaxials, abdominals, and pelvic muscles.

Turn on forehand (TOF) in hand in both directions challenges the horse's flexibility of the lateral pelvic muscles and coordination at crossing midline with hindlimbs. Many horses with stifle dysfunction lack good motor control at this movement. Compare one side to the other side in terms of willingness and fluidity in motion. They improve rapidly with repetition of this activity.

Backing in hand up and down gentle inclines for short distances of 10–20 ft requires gluteal recruitment, weight shifting, flexion, and extension of the lumbopelvic region, thus demanding increased control of the patellar extensor release mechanism. Clayton⁴⁰ advises that alternating between forward movement, halt, and backing on downhill gradients will improve both strength and balance.

Progression to lunging activities can be considered next. Given the option of the horse standing idle or getting exercise, Clayton⁴⁰ advocates: "Movement is better than no movement." Lunging, long lining, and posoa work are all ways to get the horse's cardiovascular and musculoskeletal systems into condition before putting a rider's weight on the horse's back for ridden work.

Lunging by use of a halter and rope is discouraged. Lunging a horse in this tack allows excess freedom of movement and poor control of the horse. Often, the result of this setup encourages improper posturing. The horse often rushes his gaits, using an elevated head looking to the outside of the circle, a hollowed shortened back, poor use of abdominals, off-balanced center of gravity, and increased weight-bearing on the inner fore and hind legs. Increased weight-bearing and probable increased torque forces on the inside hind stifle joint are less than ideal for rehab purposes. Often, lunging a horse with just a halter and rope allows the horse to swing his head away from the handler, work off of the forehand, deprive use of his hind end, have poor tracking-up, and have reduced dynamic balance. This author discourages lunging in this manner.

Preference over lunging with a halter is use of a long line or a posoa with full tack, bit, and bridle. These techniques encourage abdominal muscle recruitment and lengthening of epaxial muscles for development of proper self-carriage, thus facilitating improved movement patterns and better popul-

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sion from the hind end. Using long lines (LL) allows the handler to have aids to the horse's mouth through bit, bridle, and lines, thus allowing increased control over the horse in terms of bending on a circle properly, creating impulsion from behind into the bit, and recruiting better use and development of the top-line and hind-end muscles. LL will encourage the horse to come up under himself and round throughout the top line, thus encouraging proper use of his hind end in a more flexed position through the croup. A step up from LL would be use of a posoa. Posoas are helpful for encouraging the horse's proper carriage by stepping up into the cranial aspect of gaits from behind. Posoas require significant training to use properly. Improper use can lead to fatigue and injury. Large circumference circles are again required to avoid increased torque stress on the stifle.

The use of intermittent ground poles requires increased flexion of the hip, stifle, and hock while in motion. Ground poles can also help improve proprioceptive awareness of limb placement, improving coordination of fluid movement patterns and balance. They can be placed in a variety of methods from well-measured distances haphazardly arranged to encourage the horse to look and place his feet carefully with adaptation to his stride lengths. In a study conducted by Holler et al.⁴¹ of canines traveling over ground rails, they determined that an increasing flexion range of motion of the stifle and hock were evident. For the horse recovering from stifle dysfunction or pelvic weakness, the addition of ground poles or cavelettis can be an excellent activity to promote proprioceptive awareness of limb placement and improve coordination of fluid movement patterns and balance.

Additional advancement in the progression uses any of the above exercises on hills. Hill progression should start with minimal slopes, building to moderate and extreme gradients. Long lining on a hill can maintain the horse's collected frame, while emphasizing eccentric strength and control and addressing many training factors at one time. Careful progression and monitoring of these activities are essential to avoid fatigue, which will cause the horse to use undesirable compensation strategies. Clayton⁴⁰ suggests for horses with asymmetric weakness to work across a slope with the weaker limb positioned on the upper side of the slope so that it works in a more flexed position.

After approximately an 8-wk period of the above exercise regimen, with noted reduction of IUFPP symptoms and no signs of lameness, the horse is appropriate for a riding trial. If the horse is able to withstand the weight of a rider, conditioning under saddle, and slow progression of W-T-C on the flat, work may be progressed. Continuation of the above exercises are done under saddle with transitions up and down at all three gaits, lateral work, TOF, rein backing, up and down hills, and ground pole work, and work is slowly progressed to caveletti

work as tolerated. These activities are all determined in quantity and quality by the therapist and documented for tolerance and progression. Continued variation of ground surfaces will challenge the horse with coordination and foot placement. The addition of rider weight and forward locomotion through water, snow, or sand can act as resistance, increasing the training responses for strengthening. For horses that are trained for cart pulling, the cart is, again, an added resistance that the horse can benefit from for strengthening the hind-end muscles.

Frequently, some riding facilities and certain parts of the country do not have access to hills. Therefore, to replicate strengthening by hill climbing, a creative alternative is to position the horse's hindlimb in a flexed position on the step of a mounting block or sturdy elevated block and impose a weight shift or LTP. Dressage horses often do not work on hills. It has been this author's experience that many dressage horses with stifle dysfunction benefit from this program and the addition of cross-training with use of hills or cavelettis to increase the strength demand on the hind-end musculature.

The use of therapeutic training aids such as fetlock jangles, TBs, and kinesthetic proprioceptive tape^b can be used creatively to affect the horse's sensory feedback system to enhance and correct performance. By tapping into the equine sensory modulation system through mechanoreceptors and proprioceptive systems, the physical therapist can effectively enhance performance in many forms using aids applied directly to the horse's skin or body.⁴²

A TB is a useful strengthening tool in the human clinic as well as the equine training arena. TB use is a resistive exercise system of stretching elastic band material, which provides an inexpensive and easy way to train muscles concentrically and eccentrically. The therapist can design TB exercise programs to provide resistance to a variety of body parts or any phase of motion desired.³⁹ Used properly, TB exercises can successfully achieve sport-specific strength and function of the musculature³⁹ when placed around a weakened limb. For example, use of TB adds sensory awareness and resistance to the horse's hamstrings on retraction of the hindlimb. Based on this author's experience, resistance of the band at the horse's hamstrings encourages the horse to step up and under belly more, flexing at croup to lengthen the hind-end stride into the cranial aspect.

Kinesthetic proprioceptive taping techniques used on humans enhance the sensorimotor system and have been used clinically in horses for similar purposes. The aim of taping is to stimulate mechanoreceptive and proprioceptive activity in the skin, fascia, ligaments, and joints. This taping affects the sensory afferent activity from that region, modulating or altering neuromotor control of locomotion.⁴³ Patellar taping has been shown to improve

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joint control in pain-free humans with poor proprioception of the knee⁴⁴ and individuals with PFPS.^{45,46} Similarly, in human studies, the combined mechanical and proprioceptive benefits of taping for prevention of ankle sprains as well as recurrence of sprains is well-documented.⁴⁷ One study investigated the biomechanical effects of taping the fetlock in the forelimbs of horses.⁴⁸ However, in this model, mechanical rather than sensorimotor effects were investigated, with results suggesting that changes seen might be a reflection of proprioceptive adaptations. Effects on ground reaction forces as well and joint ranges of motion were observed, and additional research is warranted.⁴³ Kinesthetic proprioceptive tape can be used to stimulate and recruit proximal musculature, providing tactile stimulation to facilitate elastic recoil of muscle in the early phase of swing.

Many horses that have stifle dysfunction tend to exhibit a toe drag of the involved limb. A method of using a lightweight bracelet jangle that provides tactile stimulation to the horse's pastern and coronet band can induce a higher flight arc of the hoof, which was determined by Clayton et al.⁴⁹ Tactile stimulation was provided by a lightweight (55 g) device consisting of a strap with seven chains that was attached loosely around the pastern.⁴⁹ Results of their research indicated that peak hind-hoof height increased significantly when wearing hind stimulators. The first trial with stimulators showed the greatest elevation followed by a rapid decrease over the next three trials and then, a more gradual decrease. Their research concluded that, to facilitate a generalized muscular response for increased stifle and hock flexion, a short burst of tactile stimulation is likely to be most effective, whereas longer periods of stimulation will be more effective for strength training.

The above training aids can be used in the latter parts of this rehab program. They should only be used under a careful eye by a trained therapist for evaluation of their success to address the specific objectives. These devices are used to stimulate proprioceptive and sensory motor responses, and therefore, they have the ability to be abused or overused. Under the wrong conditions of inexperienced handlers, they can be overused dangerously, leading to fatigue and DOMS. Therefore, it is recommended that they only be applied in appropriate conditions by a trained physical therapist and provided for independent use to clients who have a good understanding of their application and conditions.

When they are asymptomatic, horses need to maintain their strength gains and soundness by a vigorous cross-training program. Therapeutic approaches should continue, starting with allowing the horse outdoor roaming as much as possible. These horses should preferably be allowed as much time out of their stalls as possible. Turnout in a field with hills, slopes, and a herd mate is most optimal. A run-in shelter can be ideal, with more housing as

necessary depending on climate and weather. The less that the horse stands idle, the better the outcome. To keep these horses in top condition to prevent regression, they should continue to be worked using a variety of the above exercise regimens three to four times a week. Intensity can and should vary with cross-training; on some days, address ring work on the flat, and on other days, consider trail riding with hills and small jumps. Some days should address ground poles and jumping of a variety of obstacles with variable heights. The stretching program can be carried out post-exercise several times throughout the week. The more demands on the horse isotonicly through ridden work or long lining with hill and ground poles, the less that the owner should have to keep up with LTP exercises. LTP exercises are a start that should not be necessary after the horse has progressed to more skillful activities as outlined above.

The effects of conditioning depend on intensity, duration, and frequency of the regular exercise.⁴⁰ This program attempts to address each of these factors by careful introduction and slow progression of exercises. Conditioning exercises should be tailored to the requirements of the sport to simulate adaptive changes in muscle fibers.⁴⁰ This idea is a widely accepted theory in terms of human physiology, referred to as the specific adaptation to imposed demands (SAID) principle, which emphasizes the importance of specificity of training to a skill.³⁹ In general, endurance exercise enhances the aerobic capacity but compromises the power and speed of muscle contraction. Sprinting activities enhance the horse's power and peak at the expanse of aerobic endurance.⁴⁰ Therefore, in terms of a maintenance program of exercise after rehab, a cross-training approach should be carried out three to four times per week.

8. Discussion

This program has been conducted by in-the-field clinical experimentation. It has been anecdotally successful in that the majority of the clients that have tried this approach with their horses have seen positive improvements. At the time of this writing, this author has treated 12 horses directly in terms of hands-on assessment and treatment. Please refer to Table 2 to understand the signalment, discipline, and outcomes of each horse.

Each of the above-listed horses, two mules, and one miniature horse made improvement in terms of decreased symptoms and return to function. Refer below to "Limitations" to understand the reasons why this author has difficulty in reporting quantitative outcome measures. One horse was started on the program with good tolerance before veterinary evaluation. After veterinary evaluation, radiographic diagnostics indicated that significant OA was present, and the veterinarian advised the client to terminate PT intervention, which was unfortu-

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nate for this horse. The baseline for progression in this program is based on initiation of the preliminary goal of tolerating a 10-s hold at LTP exercise done for 10 repetitions. All equines that reached this point showed a decrease in their IUFP symptoms. On initiation of treatment, some horses could not tolerate a full 10-s hold, and therefore, their baseline would have to start at 5-s holds, with only five repetitions tolerated and progression as tolerated. After a horse can tolerate a 10-s hold done 10 times, the criteria to move them on in the program as outlined was fulfilled.

Each horse presented as a different scenario presenting with different findings for baseline. Many had pre-existing or co-existing conditions of a variety of diagnosis. Therefore, generalized outcomes are difficult to quantify and qualify because of this reason of varied starting conditions of the involved equines (uncontrolled variable) and various client reasons for terminating treatment. Success was based on subjective views of the clients and objective findings listed below. Except in one case, where treatment was terminated by a veterinarian's decision, all other clients felt their equine made objective gains of less frequency of IUFP and decreased jumping of the patella on weight shifting and forward locomotion. Each equine had to achieve the short-term goal (heralding achievement) tolerance to isometric LTP exercises, holding for 10 s for 10 repetitions before progressing with the program.

Because of the nature of individual client economics, each horse had different lengths of treatment. One horse received only 3 wk of direct supervision, whereas another horse progressed through a 2-yr program of supervised progression. It is difficult to provide exact objective measures for each horse. Each horse started at a different baseline, and owners had different outcome goals dependent on their discipline. Often, owners were the decision-makers as to when they felt that they had achieved their personal goals with their horse and thus, would self terminate. Another variable that plays a role as to how quickly horses progress and achieve wellness is very owner-dependent, because it depends on how much time and energy they put into this rehab program. Exercises are generated by facilitation methods taught to the owner by the therapist for them to perform daily. Many owners admit to not being able to do all prescribed exercises based on their physical stamina or time limits.

Of the 12 equines, 8 of them improved, reaching the goals stated for progression, and they continued with the program back into their riding discipline. Two of the equines made no changes because of pre-existing conditions, and two equines made advances in the program and then later relapsed. The most common reasons for relapse or regression were winter in New England, leading to increased time of immobility, and lack of owner continuance with the program.

Attainment of the following criteria indicates a successful recovery outcome:

- Owner understands pathology and has knowledge of IUFP and how to prevent recurrence.
- Reduction of audible clicking of the patella (from established baseline).
- No pain responses on stifle palpation.
- No evidence of lameness with equal stride lengths.
- Noted increase in hind end musculature (hypertrophy).
- Increased flexibility of bilateral hindlimbs.
- Decreased frequency of stumbling and tripping occurrences.
- Decreased occurrence of giving way of locking up (UFP) of stifles.
- Increased endurance to exercise tolerance to perform 50–60 min ridden work.
- Return to function at prior level of performance and discipline.

This author has also had several long-distance clients who attest that their horses, diagnosed with stifle dysfunction and pelvic limb weakness, have recovered by using this program. These clients, treated by consultation and instruction of the program through electronic mail and phone conversations, feel that they have made positive gains based on the criteria listed above.

This author was unable to compare this program with other similar programs because of the lack of published pre-existing stifle programs found by searching PubMed and a variety of other established veterinarian search engines. The common references to strengthening approaches were vague, stated, for example, by Miller and Swanson² as “altering the conditioning program can be helpful ... it should include long, extended, straight exercises. Uphill work with limited downhill work in good footing is encouraged.”² Many other non-exercise approaches have been documented regarding the positive and negative evidence for a variety of treatments of IUFP. In terms of invasive procedures, the following points will compare and contrast the variety of approaches versus the use of this therapeutic exercise program.

Researchers do not seem to agree or have determined if there is a laxity or tightening of the MPL to contribute occurrence of IUFP. Both conditions have been theorized. One approach to the theory of the ligament being too lax is to irritate it with caustic agents. The exact mechanism of irritant action remains unknown; however, it is thought to cause inflammation and thus, tighten the ligament, hindering fixation on the femur.² The use of 2% iodine in almond oil as a caustic agent to the MPL induces severe inflammation and fibroplasia. Maturation of the inflammatory and fibrous response may contribute to resolution or attenuation of upward fixation of the patella by subsequent stiffening of the

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Table 2. Signalment, Discipline, and Outcomes of Each Horse

Horse	Discipline	Age	Breed	Sex	Hx length of involvement	Time in Rx protocol	Sxs at end of Rx	Max # IUFP vs LTFs		Gains	Recurrence	Concurrent factors
								IUFP	IUFP			
Na	pleasure	4	draft x	geld	1.5 yrs	6 mos	none	10 IUFP	10 IUFP	80%	yes	draft in small paddock, med. collateral desmitis and meniscal injury
Be	pleasure	4	fox trotter	mare	2 yrs.	5 mos	yes	10 IUFP	10 IUFP	50%	yes	flat small paddock, family hx
Mar	dressage	7	warmblood	mare	2 yrs.	3 mos	yes	10 IUFP	10 IUFP	50%	yes	EPM, Lymes, injured suspensory 3 mos into program
Mas	dressage	14	warmblood	geld	1 yr	2 yrs	none	10 both	10 both	90%	no	post subcondral bone cyst sx, w/stem cell, EPM, Metabolic disorder large bone cyst, OCD, Exotosis OA
La	endurance	13	fox trotter	mare	4 wks	5 mos	yes	10 both	10 both	50%	yes	immobility in winter
KK	endurance	4	mule	mare	2 yrs.	6 mos	yes	10 both	10 both	50%	yes	vet terminated Rx
BB	pleasure	14	draft x	geld	1 yr +	1 visit	NA	NA both	NA both	NA	NA	chronic condition, stall
1st	pleasure	14	QH	geld	3 mos	8 wks	yes	8 both	8 both	30%	yes	rested great then turn out.
TB	halter show	7	mini	mare	chronic/life	4 mos	yes	8 both	8 both	40%	yes	Front
Le	pleasure	9	QH	mare	2.5 mos	1 month	none	10 IUFP	10 IUFP	100%	no	flattening of femoral heads
Lu	trail	4	mule	geld	3 mos	6 mos	none	10 both	10 both	100%	no	had previous HS and adductor strains, weak topline
Sh	dressage	8	Morgan	geld	3 yrs	3 visits	yes	? IUFP	? IUFP	poor	yes	

ligaments.⁶ Caution should be considered because of concern of infection whenever injecting tissues, ligaments, and joints to injections. Injection of caustic agents mistakenly directed into the synovial stifle joints can cause articular cartilage breakdown, significantly damaging the animal's potential for recovery. If done correctly, irritation to the MPL with the caustic agent will cause inflammation and pain to the stifle region for several days. Often, NSAIDs are not provided after MPL injections to encourage a full inflammatory process to dictate fibrotic enlargement of the ligament.

Along the lines of injections, it is postulated that systemic estrogen relaxes the peripelvic muscles and ligaments, thus altering the angle of the pelvis. Alteration in pelvic angle may decrease the stifle joint angulation and thus, enable the patella to release from the femur.² Miller and Swanson² stress the use of exercise in conjunction with estrogen therapy. They also state that this approach may be appropriate when used short term in the young growing horse or pony but that results are not long-standing.² Applying this stifle strengthening program to a horse that has undergone either of these injection methods may improve their outcomes.

Unfortunately, the approach of MPD commonly used over the past two decades resulted in pathologic changes in the articular cartilage of the patella and adjacent soft tissues.⁴ A controlled study designed to evaluate the effects of MPD, combined with exercise restriction, determined that enthesophyte formation and lateral deviation of the patella were found by radiographic evidence, concluding that MPD leads to patellar instability. Four months of stall rest did not prevent the lesions caused by post-surgical patellar instability.¹⁵ Gibson and McIlwraith⁴ conclude that the use of this surgical procedure should be reserved for only the most persistent and confirmed cases of UFP.⁴

In human orthopedic intervention, ligament resection is rare. To restore proper joint biomechanics, human clients are referred to physical therapy for strengthening of surrounding musculature and stretching of tight soft-tissue structures. Therefore, this stifle rehab program may be a preferred method of treatment to minimize MPD in equines.

Dumoulin et al.⁷ suggest that an approach of CTS was fully successful in 51.6% of the horses afflicted with IUFP and that a longer convalescence period of 3 mo after MPD is desirable. Results indicate that conservative treatment, with special attention for CTS, is worth trying before performing more radical procedures to correct UFP.⁷ Another surgical but less invasive approach to desmotomy is pre-cutaneous splitting of the proximal one-third of the MPL, and it has been found to be a very effective treatment for UFP and allow for rapid return to normal activity.⁵ Tnibar⁵ proposes that imposing isometric strengthening, hindlimb stretching, and hand-walking during this time of convalescence may

provide improved outcomes over stall rest alone for all post-surgical situations listed previously.

Stall rest confinement is discouraged because of potential loss of muscle tone.² Lack of exercise, in the form of stall rest, generally delays the development of equine musculoskeletal tissues. In a study done by Xie et al.¹³ regarding horses afflicted with distal suspensory ligament desmitis (DSL), exercise did not exacerbate but rather, may have improved signs of DSL in mild to moderate cases.

Sometimes, rest is necessary for structures to heal. For mild cases of ligamentous and/or meniscal damage without gross tearing or rupture of the structures, Jeffcott and Kold⁸ reported that horses responded satisfactorily to rest. Knowing that exercise is an important factor in the biomechanical strength of tissues, it is a potentially powerful tool for the enhancement of injury recovery.⁵⁰ Isometric exercises can retard muscle atrophy in early stages of rehabilitation when immobilization is necessary to protect healing structures.²⁸ Therefore, during periods of stall rest, this author advocates that veterinarians and owners consider the benefits of isometric LTPs to avoid proximal muscle atrophy and stretching to increase tensile strength of surrounding tissues.

Stability of the stifle joint is controlled by a combination of its mechanical restraints (e.g., ligaments, joint capsule, and bony geometry) and dynamic muscle restraint mediated by the sensorimotor system, including proprioceptive feedback of joint position and neuromuscular control.³⁸ To maximize performance and minimize injury, it is important to understand and apply the principles of functional adaptation of skeletal tissues (bone, cartilage, tendons, and ligaments), which differ in their responses to changes in mechanical environment. To keep the equine musculoskeletal system primed during periods of recuperation, it is essential to keep some tension on tissues to avoid decline. This tension can be imposed during the equine's recovery by isometric strengthening and stretching protocols to minimize downward decline to development of IUFP symptoms while horses are on stall rest, are recovering from disease, or during long winters. With appropriate monitoring of exercise programs, owners, trainers, therapists, and veterinarians can apply the science of functional adaptation to the training demand for equine athletes to improve equine health and improve outcomes.

The use of therapeutic aids such as TB, kinesiotherapeutic proprioceptive tape, and a variety of fetlock stimulators or lightweights should be considered for their therapeutic input into the horse's sensory system. These products can be used during the middle to later part of this program to ask more from the horse during isotonic training, whether it be in hand, on long lines, or under saddle, for increased muscle facilitation. Often, horses that have been lame for a long period may need additional input to facilitate increased stride length or heightened flex-

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ion pattern that they have forgotten to use. Clayton et al.⁴⁹ recommend application of the stimulators for short periods (e.g., trotting 50–100 m) when the goal of rehabilitation is to maximize muscle facilitation.⁴⁹ If rehabilitation is being used to mobilize the joints or improve strength or endurance of atrophied flexor muscles, longer periods of treatment (e.g., trotting 200–300 m) are more appropriate.⁴⁹

Many horses with IUPF present with asymmetries that can lead to circumduction gaits and a shortened stride length. Tight structures can also alter biomechanical stresses around joints, such as the patellar femoral complex. This program advocates a regimen of stretching of the horse's pelvic limbs daily. As proposed by Rose et al.,³³ stretching daily may be too intensive and cause delayed onset of muscle soreness. This author will consider these findings in additional development of this program. Additional examination of stretch frequency may establish its potential to enhance performance and welfare.³³ A theory proposed by Schuurman et al.⁵¹ in 2003 is that an overactive vastus medialis muscle may be a culprit of IUPF. Through their research in vivo, they claim that, during weight-bearing, only the vastus medialis but no other muscle was active, providing the necessary traction to stabilize the stifle.⁵¹ The required tension was estimated to be less than 2% of the force that would be needed in absence of a lock mechanism.⁵¹ They conclude that diagnosis and treatment of patellar fixation should include the possibility of an overactive vastus medialis muscle as a possible cause of the disorder.⁵¹

In human PT, treatment of a post-surgical or recently sprained knee or PFPS involves treatment initiated with pain and inflammation reduction methods and modalities along with attempts to prevent additional atrophy of the quadriceps by starting the patient on isometric quadriceps setting exercises. Isometric setting exercise of the quadriceps is performed by positioning the knee in extension; then, the patient actively tightens the quadriceps muscles for a 10-s hold. Patients are started with the least pain-producing exercise of isometrics, then slowly progressed into range of motion and stretching exercises, and later, progressed into weight-bearing closed kinetic chain exercises. Last, skill-related activities, such as kicking a ball, are introduced using proprioceptive feedback strategies to regain coordinated movement.

There is a specific progression to imposing exercise in avoidance of pain, such as starting a strengthening regimen with isometric contractions, then moving into isotonic, and last, focusing on eccentric control and skilled coordination. A patient with an acute knee condition, accompanied by inflammation, atrophy, and pain, would not be expected to fully weight-bear, climb stairs, or run up a hill. It would be considered malpractice to have a knee-injured patient begin PT with a regimen of

stair- and hill-climbing activities under these conditions. Excessive patellofemoral compressive forces can lead to additional patellofemoral pathologies, such as chondromalacia or osteoarthritis.⁹ Therefore, this author proposes that horses with stifle dysfunction should not be asked to initiate rehab by climbing hills when they may have a painful stifle joint surrounded by weakened and inhibited pelvic muscles.

PTs have much to offer in the realm of rehabilitation strategies, with expertise in the practice for the treatments of injury for promoting the best recovery of animals after catastrophic injuries. Education of the animal's owner is the first and foremost significant objective to achieve. This program scenario presented a common human error to want to stall rest an injured horse in prevention of them hurting themselves further. This rest is a widespread misconception, especially in the realm of IUPF. Owners need to understand the relationship between inactivity and muscle atrophy. IUPF pathology can be linked to the horse's poor condition of muscle atrophy. Therefore, engaging owners in this aggressive and demanding approach is vital for their horses' recovery from symptoms and prevention of relapse by use of a cross-training approach after rehab.

Horses represented in the chart did not warrant the role of modality use. They were struggling with IUPF because of primarily deconditioning, post-systemic diseases such as EPM, or post-surgical chronicity of poor motor patterns of gait. None of them were in acute phases of healing or pain. One modality that could play a significant role in aiding in pain and edema reduction of acute-phase horses with IUPF would be that of electrical stimulation (E-stim). The use of E-stim can be very versatile for IUPF. During the acute phase, E-stim can assist with edema reduction around the stifle joint. TENS applied to knee joints has been reported to not inhibit the quadriceps' arthrogenic muscle inhibition.²⁴ In desire of muscle contraction, such as isometrics, E-stim can be used to recruit a larger number of motor units for stronger contractions. This modality, versatile and well-supported in the research,²⁴ can be very advantageous in the multifold treatment of IUPF.

The role of proprioceptive training plays a significant role when treating the equine. The feed-forward and feedback loops of facilitated neuromuscular control apply to strengthening and motor-relearning progression. Deficits in neuromuscular reflex pathways as a result of decreased proprioception have been shown to have a detrimental effect on joints. Proprioceptive rehabilitation to facilitate dynamic joint stabilization is thought to improve the neuromuscular control mechanism.⁵¹ The area of proprioceptive neuromuscular facilitation (PNF) by PT expertise compares with no other equine practitioners, because PTs are experts in the study of and application of movement science with

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use of skilled manual cueing. Application of kinesiotherapeutic proprioceptive tape can be used in conjunction with PNF to aid sensory afferent activity, thus modulating or altering neuromotor control of locomotion. This clearly appropriate area for equine research is limited to date.⁴³

In consideration that some horses may not be prescribed the proper rehabilitation treatments to address IUFP or may not respond favorably, there will be some horses subject to more invasive procedures such as sclerosing injections or MPL surgery. With the stifle joint of a horse's hindlimb being analogous to the human knee, it can be extrapolated that stifle surgeries may induce reflex inhibition of the quadriceps and surrounding muscles. Reflex inhibition of the human quadriceps occurs secondary to edema of the knee joint and joint capsule stretch receptor responses, therefore making the muscles unresponsive to the neuromuscular efferent message to contract and furthering the disuse atrophy. Cutting or fenestration of the medial patellar ligament of the horse of which sartorius, gracilis, and quadriceps muscles tendons attach would certainly propose the possibility that reflex inhibition may follow in the horse post-surgically and therefore, could provide some delay of the horses return to optimal functional outcomes.

If a horse were to be stall-rested after MPD or fenestration, it would benefit from receiving the regimen outlined above to improve the outcome and prevent reflex inhibition and muscle disuse atrophy commonly associated with post-surgical prescribed stall rest. PT intervention with modalities and motor-relearning exercises is ideal for promoting a faster return of functional mobility after caustic injections or surgery of MLD.

Limitations

My practice is not research-based; therefore, when I treated these horses, I did not purposely set out to collect data. Thus, much of what I have to report and compare is based on assessment findings and treatment outcomes of each horse's scenario. Outcome measure varied for each subject. Many external variables limit the findings reported in this case review. The most significant limitations in this study are lack of objective measures and control of variables. In retrospect, when writing up this case report, my sentiments follow the declaration by Rose et al.³³: "Assessments that are conducted 'in-field' can be limited by external variables and are difficult to perform with an appropriate level of repeatability."³³ The following two areas (lack of objective measures and uncontrolled variable) followed by a list of areas to improve could benefit future methods of data collection and better organization for a clinical trial of this program in the future.

Lack of Objective Measures

Strength is difficult to assess on a horse. Horses are not applicable to perform manual muscle test-

ing. No strength assessment methods have been developed regarding the horse. Circumferential measures around the proximal pelvic limb or hind end have not been developed. Additionally, standards of measures with specific landmark locations and tools for measuring have not been established. The best method that one can postulate is to compare before and after photos, with controlled variables of camera distance placement from horse, documented positions and distance lengths, and possible width grid on background wall, to help assess muscle hypertrophy. Because of the nature of the clients, their facilities, availability, and equipment restrictions, photo comparisons were not always available. The most functional indicator of strength gains made by the horses that have undergone this protocol is their ability to return to their prior performance level (return to function). Other indicators of improvement were decreased incidence of IUFP symptoms reported by their owners. Stability gains were determined by increased tolerance to carry out 10- to 20-s holds repeated 10–12 times at LTP exercise.

Goniometric measurements of the stifle joint while standing in square would have been a beneficial objective measure for information regarding conformational significance. Also, measuring the stifle in the extreme of full flexion position would have been helpful to prove flexibility gains. Measuring step lengths of hindlimbs before and after application of this program could have provided information regarding hamstring length changes. Rose et al.³³ indicates that measuring stride length and ROM enables the findings to be directly applied to equine performance.

Each horse presented as a different scenario with positive but different findings for baseline establishment of IUFP. There is no established method of rating the degree of severity for IUFP. Therefore, each horse's starting and ending conditions are based on subjective interpretation of symptom occurrence. All horses had common symptoms of IUFP with jumping patella, but some were more affected than others, with actual delayed release in which they would have to lift the limb up and out to the side or sometimes kick out behind to loosen their stifle from extension. All had history findings of stumbling, tripping, getting caught in gaits, or giving way of limbs.

Each client had their own objectives of what they were looking for with their horses. Therefore, termination of program may have occurred regarding what each individual owner wished to establish rather than achievement of a standard baseline criteria that this therapist would have preferred. A standard baseline for discharge criteria has not been established to date.

Uncontrolled Variables

Each horse presented as a different scenario presenting with different findings for baseline initiation

to the program. Many had pre-existing conditions and a variety of diagnoses. Generalized outcomes are difficult to quantify and qualify because of this reason of varied starting conditions of the involved equines (uncontrolled variable) and various client decisions to terminate treatment.

Owners were a significant variable in the success of this program based on how much money they cared to spend, what their goals of success were, how much they pursued direct PT input, and how willing they were to spend the required time to carry out this labor-intensive program. Some owners were dedicated to this program and made great gains with their horses. Others were not as dedicated for a variety of reasons and thus, got lesser responses from their horse. Often, after owners got comfortable with the program and the horse started to show positive gains, owners stopped requesting the PT to be present. Direct treatment durations varied between horses. Owners were instructed to continue with rehab regimen in anticipation of regaining all musculature return within 6 mo. Optimally, it would have been ideal to have continued contact with each horse's progress for a 6-mo period to view regained symmetry of muscle mass resolution of all IUFP symptoms. Often, economics were stated as a reason for discontinuing direct PT treatment.

Winter in New England is its own challenge. Du-moulin et al.⁷ noted that young horses and ponies were mostly affected during winter months.⁷ The same is true in this author's experience. Many horse owners have their horses stabled in their backyards without the advantage of indoor riding arenas to keep horses in work. Therefore, many New England horses have the winter off. Many may have access to large paddocks, but without grass pasture to entice them and large accumulations of snow height, many horses opt to just stand at run-in sheds or close to the food source of the barn. Even horses that are housed at indoor arena facilities are reduced in their turnout and exercise time in winter. Significant cold temperatures and poor weather decrease owner's frequency of barn visits and riding time. Hill accessibility use is reduced second to all these reasons.

This author's experience with problematic stifle horses has involved primarily pleasure or dressage disciplines but only one jumper. At this preliminary time of this author's experience, it could be just coincidence. Hypothetically, these findings could be based on the fact that strength requirement for jumping heightens demands on the hind-end muscle system to keep stifle musculature in prime condition, and therefore, fewer jumpers are afflicted with IUFP. Jumpers work their hind-end engines harder at power production by frequently putting their pelvic limbs into a flexed (shortened) pre-jump position, exerting isotonic and plyometric³⁹ muscle propulsion, and requiring significant strength of hind-end musculature. This kind of activity may maintain adequate neuromuscular input to keep pa-

tella-femoral biomechanics intact, which is what the activity of squatting exercises does for the human knee.

9. Where to Go From Here?

There is still much to determine regarding the therapeutic benefits of this stifle and pelvic limb-strengthening protocol. Ideally, this author would like the opportunity to run a controlled study of this program on a large group of horses under controlled circumstances to test the validity of this approach. The idea of chondromalacia not being readily identified in the horse¹⁶ and the theory that an overactive vastus medialis obliquus⁵¹ may contribute to the problem of IUFP are areas that warrant more research. Several baseline scales need to be developed, such as IUFP severity and strength-rating scale, and establishing a discharge criteria could contribute positively in the clarification of establishing baselines for quantitative measures of improvement of IUFP.

For example, the measuring of muscle bulk deficit should be developed for better determination if this program increases muscle bulk in correlation of strength. The stifle is a difficult joint to measure for circumference because of deep landmarks submerged within heavy surrounding muscles, making it difficult to palpate on the horse. Therefore, muscle atrophy was judged on a subjective visible observation rather than an objectively measured circumference, which would have been indicative of muscle hypertrophy. Another way to measure this atrophy would have been by total circumferential measurement around the horse's entire hind end in the horizontal plane at the level of the stifle joint, coursing the areas of quadriceps and bicep femoris muscles and encompassing the entire width of the back end. This measurement would have to be done very specifically to keep measuring consistent. Lack of established protruding landmarks promotes greater intra- and interrater error. Therefore, currently, muscle strength can only be assessed in terms of muscle bulk, endurance, and functional biomechanical performance, such as how many times the patella fixates within a set distance.

Based on the above research evidence, there are three areas for improvement in terms of therapeutic interventions to this program. First is the addition of use of electrotherapy modalities of TENS and E-stim. Use of electrical stimulation has been well-supported for pain and edema reduction, disinhibition of arthrogenic muscle inhibition,²⁴ and recruitment of a greater number of motor units during contractions to build strength. Second, consider changing the frequency of the current stretching protocol. The 2009 study by Rose et al.³³ of stretching suggests that stretching every day may not be appropriate for the horse but that stretching 3 days/wk may provide some benefit in terms of range of movement.³³ Third, incorporate joint mobilizations to pelvic limb joints for pain reduction.

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The use of joint mobilization is shown to decrease pain⁵² in the human literature. Although not easy to visualize, the development of stifle joint and patellar mobilizations may be beneficial to the horse with stifle dysfunction treatment. Additional development of manual intervention and application of stifle joint mobilization may be worthy considerations in equine study.

There is a significant deficit in the public awareness of PT interventions and approaches that can compliment veterinary practices in treatment of horses with not only stifle dysfunction but also, other problems such as back pain and delayed soft-tissue healing. Increasing public education awareness to veterinarians and horse owners regarding PT availability has merit in the resolution of stifle dysfunction and pelvic limb weakness in this current equine environment. In small-animal veterinary practices, many PTs are employed directly in the clinical setting alongside the veterinary surgeons and veterinary technicians. In the human practice, orthopedic surgeons work with PTs collaboratively for better patient outcomes and reduction of economic expenditure. Surgeons prescribe PT to surgical candidates before and as mandatory after many musculoskeletal surgeries. PT can often improve many ailments that stem from muscle weakness and poor flexibility that result in biomechanical faults, such as in the case of some IUFP situations, that may prevent horses from more invasive surgeries. Post-surgically, PT can stimulate healing for faster recoveries.

10. Conclusion

Many horses struggle with stifle dysfunction. There is a wide variety of reasons for these problems. The most common of these reasons is muscle weakness because of injury, surgery, immobility, or disease. The best approach for addressing this debilitating condition of muscle weakness of the pelvic leg is to use an interdisciplinary team of equine practitioners. The PT plays a pivotal role within the team as a rehabilitation expert, providing the optimal treatment of therapeutic strengthening exercise program for a horse's recovery from biomechanical stifle dysfunction. The most rewarding aspect of PT is helping clients to help their horses regain their pre-injury health status and return to function. In the case of the equine, this result means that both the owner and practitioners involved feel confident in the horse's wellbeing in the absence of distress, pain, or dysfunction, allowing the owner to confidently ride/work the horse for pleasure or competition.

Strengthening programs for stifle dysfunction such as this program should start slowly with isometric exercises, similar to a human knee patient's start in rehab, to avoid pain and additional joint trauma. Stifle problems require an aggressive cross-training approach of progressive strengthening and stretching exercises, inclusive of hill work,

up and down, ground poles, long lining, and caveleties, etc. Progression of the stifle program is demanding on the horse as well as the owner, because daily intervention is needed for successful outcomes.

PT has much to offer the creatures of the animal kingdom. There is a need for more evidence-based practice in the world of animal PT. By developing the field of animal rehabilitation, presentation of increasing research should support the approaches used for healing humans to be applied to animals, such as the approach in this stifle program. PTs need to incorporate the translation of evidence into the clinical practice of animal patient management. Crusading PTs that are practicing on animals need to continue to follow the human clinicians in the realm of developing clinical practice guidelines for management of all common animal pathologies to make the profession of PT a substantial contribution to the world of animal health and rehabilitation. Animals get hurt and have the potential to heal as well as humans. Treating them to promote their optimal recovery free of recurrence, chronic pain, disability, and possible demise is the goal. There is much to offer horses with stifle dysfunction in terms of non-invasive PT, such as this therapeutic strengthening program.

11. Summary: Take Home Message

Horses with stifle dysfunction symptoms of IUFP can be treated with PT approaches similar to the approach by which humans are treated for recovery of PFPS. Humans and horses with these maladies share faulty patellar-femoral biomechanics often stemming from muscle atrophy, decreased flexibility, and poor neuromuscular responses. Treatment of both IUFP and PFPS involves client education, increase in activity level, a stretching program, and an ascending therapeutic strengthening exercise progression.

A thorough veterinary examination should first clear the horse for PT treatment referral. Horses recovering from injuries, surgery, or systemic diseases are appropriate for this program. This program is owner- and horse-intensive in terms of time and energy for successful outcomes. The use of modalities can be advantageous to promote healing, decrease pain, and decrease swelling response throughout the program. A variety of training aids and therapeutic devices can contribute to exercise program success. After the equine is symptom-free, a cross-training maintenance program should be used to prevent recurrence.

Stifle dysfunction is a serious problem that, if left untreated, can lead to additional joint degradation. Professional intervention should start with veterinarian evaluation and diagnosis. Provision of a PT intervention such as this program can now offer veterinarians and horse owners a specific protocol to follow to avoid use of the common unspecified instruction of work in straight lines and hill climbing. A more humane method of starting the horse on

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pain-free exercises such as isometrics can be initiated for preliminary muscle strengthening followed by specific ascending exercises introduced in this program. Variables of surface variety, hill inclination, and jumping obstacles are recommended for cross-training and maintenance purposes. Consider equine PT in conjunction with veterinary medicine approaches for optimal outcomes after injury or during recovery from systemic diseases and surgeries.

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^aTheraband, Pro Therapy Supplies, Norcross, GA 30071.

^bKinesio-Tape, Pro Therapy Supplies, Norcross, GA 30071.