# Physical Rehabilitation for the Management of Canine Hip Dysplasia

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**KEYWORDS**

• Hip dysplasia • Osteoarthritis • Hip laxity • Therapeutic modalities
• Triple pelvic osteotomy • Juvenile pubic symphysiodesis
• Femoral head and neck ostectomy • Total hip replacement

**KEY POINTS**

- The goals of rehabilitation at various stages of canine hip dysplasia vary; initially, clinical signs and discomfort are thought to be due to underlying laxity.
- Laxity results in lateralization of the femoral head during the swing phase of the gait with a "catastrophic reduction" of the femoral head into the acetabulum during foot strike.
- Conservative management is centered around maintaining pain control and comfort while improving hip range of motion in extension and muscle mass.
- Surgical therapy focuses on improving femoral head coverage and reducing the development of osteoarthritis or removing the source of discomfort.
- Each aspect of rehabilitation such as manual, therapeutic, and physical modalities follows a multimodal patient-centered approach.

## INTRODUCTION

Canine hip dysplasia (CHD) causes diffuse joint inflammation and subsequent coxofemoral osteoarthritis (OA).[1,2] Hip dysplasia was identified in more than 40% of golden retrievers and Rottweilers in 1 report.[3] Hip dysplasia was originally described more than 80 years ago, but its exact etiology remains unknown; however, it is

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considered multifactorial with both genetic and environmental cues playing a role in its phenotypic expression.[3] The central theme surrounding CHD is hip laxity, which is thought to play a major role in the development of OA. Hip laxity permits subluxation during growth, which results in abnormal development of the acetabulum and femoral head. The repetitive subluxation and reduction lead to excessive cartilage wear and damage to the dorsal acetabular rim, leading to OA. OA progresses over time.[4] Management of CHD is centered around both conservative and surgical therapies, as well as the age of the onset of clinical signs.[4–6] Physical rehabilitation will play a role in the management of CHD, with either conservative or surgical therapies by providing pain relief through strengthening, maintaining range of motion (ROM), promoting optimal weight, and environmental modifications if needed. The purpose of this article is to present the rehabilitation steps that can be implemented to manage CHD at its various stages.

## PHYSICAL REHABILITATION IN THE CONSERVATIVE MANAGEMENT OF HIP DYSPLASIA

Although CHD has been analyzed in several hundred scientific publications, few publications discuss the conservative management of OA in dogs, and fewer have assessed the long-term clinical signs and progression of OA.[7] The approach should be multimodal, with goals to improve function, reduce clinical signs of pain, improve hip ROM and strength, and thus potentially slow down or minimize the progression of OA. Given that the goal of conservative management of CHD is aimed at trying to improve the coxofemoral joint environment, many of the recommendations for management are similar to the management of OA. Loss of motion in OA patients results from the development of osteophytes and enthesophytes, thickening of the synovium, and from potential changes in muscle fiber elasticity. Motion should be assessed at regular intervals using goniometry as an objective assessment.[8] Loss of limb strength, core strength, and cardiovascular fitness results from a decrease in spontaneous activity, a decrease in owner-supervised exercise, and a reflex inhibition of muscle contractions (secondary to joint pain).[9] Although OA in dogs is most often diagnosed on radiographs, osteophyte size and severity of clinical signs correlate poorly. As a consequence, the management of OA should not be based on radiographic appearance, but rather on the specific physical limitations of the patient. The goals of conservative management of CHD and the associated OA are accomplished by weight reduction, minimizing joint pain, pharmaceuticals, disease-modifying osteoarthritic agents, manual therapy, therapeutic exercises, and physical modalities. Weight reduction, minimizing joint pain, pharmaceutical, and disease-modifying osteoarthritic agents are covered elsewhere in this issue.

### *Manual Therapy to Minimize Joint Pain*

Nonpharmacologic, antiinflammatory options for peripheral pain management include cold therapy (icing) and massage. Icing provides direct pain relief by decreasing nerve conduction velocity. It also provides secondary pain relief by decreasing edema (itself a source of pain) and decreasing the overactivity of catabolic enzymes in osteoarthritic cartilage.[10,11] Icing should be considered in osteoarthritic patients with flare-ups, after a period of exercise, and before bedtime. Ice cubes or frozen vegetables are not recommended because they have large air pockets that decrease cold conduction. Ice bags filled with ice chips or crushed ice or cold packs provide more effective cold delivery. Most cold packs reach therapeutic temperatures after 2 hours in a freezer. For longhaired patients, place and hold an ice bag or cold pack directly on the pet's

arthritic joint or joints and secure it with a self-adhesive band. A towel may be used between the cold pack or bag and the skin in patients with short or no hair. Some cold packs have built-in self-adhesive bands. A neoprene sleeve may also be used to secure a cold pack or bag. Icing should last for 10 to 15 minutes to achieve effective cooling (Fig. 1).[10] Most dogs tolerate the treatment, but should not be left unattended. The person applying the ice should make sure the patient is not uncomfortable and that the skin surface feels cold to the touch after icing.

Additional nonpharmacologic options for central pain management include low-level heating, massage, and possibly acupuncture, acupressure, and electroacupuncture. The short-term and long-term effects of massage in companion animals are not known. Massage may decrease myofascial pain and muscle tension.[12] These methods primarily stimulate Aβ sensory fibers with rapid conduction velocities (30–70 m/s), sparing pain fibers with slower conduction velocities: Aδ (12–30 m/s) and C fibers (0.5–3 m/s). Heat is widely considered to positively impact painful OA patients (Fig. 2).[11] The use of heat is 2-fold. Low-level heat (elevation of tissue temperature by 1–2°C) relieves pain through the stimulation of nonnociceptive Aβ sensory fibers, as well as the vasodilation and normalization of blood flow. This low-level tissue relaxation may be achieved by keeping osteoarthritic patients in relatively dry and warm temperatures throughout the day (eg, sleeping in heated indoor environments or providing heated beds). More intense heat (elevation of tissue temperature by 3–4°C) is used to increase the effectiveness of stretching while minimizing tissue damage. Intense heating is most often applied by a health care professional using a hot pack that is heated by a hydrocollator or microwave oven. Four layers of dry towels are generally placed between a hot pack and the skin, and heat is generally applied for 10 to 20 minutes.[13] Caution must be used when placing a hot pack on a dog because burns can occur. Initially, the packs may not seem to be excessively hot to the touch, but they can induce thermal damage after several minutes of contact. Furthermore, it is not recommended to use heating pads in place of a hot pack. Checking for excessive redness, skin swelling, or blistering every few minutes during intense heat therapy is important.

### *Therapeutic Exercises to Minimize Joint Pain, Maintain or Increase Joint Motion*

To help with minimizing joint pain and increasing joint motion in the hip, active and passive ROM along with stretching exercises are important (Fig. 3). Little is known about the impact of OA on joint motion: dysplastic hips seemingly lose extension but not flexion, dysplastic elbows primarily lose flexion, and arthritic stifles lose


**Fig. 1.** Limb cryotherapy can be done using (*A*) a cold pack wrapped around the hind limb, (*B*) cryotherapy to the stifle, or (*C*) cryotherapy to the carpus. (*From* Millis D, Levine D. Canine rehabilitation and physical therapy. 2nd edition. Philadelphia: Saunders; 2016. p. 318; with permission.)

**Fig. 2.** A hot pack is applied over a dog's hip region. (*From* Millis D, Levine D. Canine rehabilitation and physical therapy. 2nd edition. Philadelphia: Saunders; 2016: p. 324; with permission.)

extension. In 1 study, Labrador retrievers with hip dysplasia had on average a decrease of 1° hip extension for each year of life.[14] Minor (<10°) loss of joint motion is unlikely to impact limb function, but severe loss of joint motion will likely lead to the dog's inability to gallop, trot, jump up, or climb steps or stairs. It seems to be beneficial, therefore, to assess joint motion in dogs with chronic CHD through the use of goniometric measurements.[9] Because it is much easier to maintain joint motion than to regain it when lost, it seems reasonable to recommend intermittent physical activity that leads to enhanced joint extension (compared with walking on a flat surface) without creating significant clinical signs. Passive ROM, active ROM, and stretching can be incorporated into the early phases of rehabilitation for CHD and continued as part of the daily exercise plan. These activities can help to increase flexibility, prevent adhesions, remodel periarticular fibrosis, and improve extensibility.[15] Passive ROM is completed without muscle contraction by moving the joint through its full ROM. Any additional force applied at the end of the ROM and held for at least a few seconds is defined as stretching. If regaining joint motion is deemed important, a stretching program should be implemented. Stretching is more effective when tissues are heated immediately before and during the stretching session. Passive and active


**Fig. 3.** Passive range of motion to the hip is completed by supporting the femur in 1 hand and the pelvis in the other. (*A*) Hip flexion. (*B*) Hip extension. (*From* Millis D, Levine D. Canine rehabilitation and physical therapy. 2nd edition. Philadelphia: Saunders; 2016. p. 437; with permission.)

ROM in patients with CHD can be beneficial in the early phases of rehabilitation to facilitate appropriate periarticular fibrosis that develops from laxity in younger patients or help to realign fibrous tissue along lines of stress in older patients with clinical OA. Additionally, ROM and stretching can be incorporated into part of the daily exercise program to maintain mobility between soft tissue layers, enhance blood and lymphatic flow, and improve synovial fluid production.[16] Ideally, ROM and stretching are to tissues that are warmed up; therefore, as part of a daily exercise program ROM and stretching can be completed after therapeutic exercises as part of the cool down process. In the early phases of rehabilitation therapy passive ROM and stretching can be performed 2 to 4 times daily for 10 to 20 repetitions. When used as part of the cool down process, ROM and stretching are performed at the end of the exercise program for 15 to 30 repetitions for ROM. For stretching, we empirically recommend performing ten to fifteen 20- to 40-second-long sustained stretches during each session. Sessions may be performed 2 to 3 times per day. With chronic loss of motion, a weekly gain of 3° to 5° of joint motion is anticipated. A thorough explanation of how to perform ROM and stretching exercises is beyond the scope of this article, and can be found elsewhere.[17,18] Joint mobilization may also be incorporated into a rehabilitation program to help increase ROM. Joint mobilization differs from stretching in that when a stretch is applied, a low load is placed on the tissues for a specified amount of time (usually 10–30 seconds) to facilitate elongation. In joint mobilization, the force is applied in an oscillatory manner rather than a sustained manner (**Fig. 4**).

Along with considerations for maintaining and improving joint ROM, proprioception can be affected in patients with OA from chronic CHD. Although little is known about the negative impact of naturally occurring OA on proprioception in dogs, there is clear evidence that OA progresses rapidly in patients with joint injuries that have sensory deficits. In older humans with decreased proprioception, balance exercises readily improve proprioception.[19] In dogs with OA, it is logical to dedicate a small portion of the exercise program to focus on proprioception and balance. In the early phases, this may include weight-shifting exercises (**Fig. 5**) requiring rapid and unpredictable side-to-side weight shifts and, to a lesser extent, front-to-back and back-to-front

**Fig. 4.** Joint mobilization to the hip uses a caudal glide to increase hip flexion. The black arrow indicates the direction of the mobilization. (*From* Millis D, Levine D. Canine rehabilitation and physical therapy. 2nd edition. Philadelphia: Saunders; 2016. p. 437; with permission.)

**Fig. 5.** Weight shifting being applied to the pelvic limbs. This is accomplished by the therapist behind the patient and the hands on either side of the pelvis for support. Pressure is gently applied to 1 side then applied to the other side in a slow, rhythmic fashion. (*From* Millis D, Levine D. Canine rehabilitation and physical therapy. 2nd edition. Philadelphia: Saunders; 2016. p. 487; with permission.)

weight shifts. This is completed by supporting the animal on either side and gently pushing on 1 side, followed by pushing back the other way. The weight-shifting exercises should be done in a slow, rhythmic fashion for 15 to 25 repetitions, 2 to 4 times daily. As balance and proprioception improve, perturbation exercises can be added to the weight shifting with the goal being to disturb the patient's balance just enough for it to recover, but not so much force that the animal falls. Perturbation exercises are performed by gently pushing the animal at the hips without supporting the other side. More complex weight-shifting exercises can be incorporated while the patient is walking to improve dynamic stability. Gently bumping or pushing the animal to 1 side as it is walking to challenge the dog to maintain its balance is 1 way to further improve proprioceptive function.

Additional proprioception and balancing exercises include balance boards, wobble boards, and exercise balls and rolls. A balance board uses a board placed over a fulcrum to rock the dog side to side or forward to backward (Fig. 6). A more challenging aspect to balance and proprioception improvement is using a wobble board (Fig. 7). Exercise balls and rolls that have been developed for human exercises can be used to improve balance, coordination, and strength. For example, the front limbs can be placed on the ball requiring the dog to maintain static balance of the pelvic

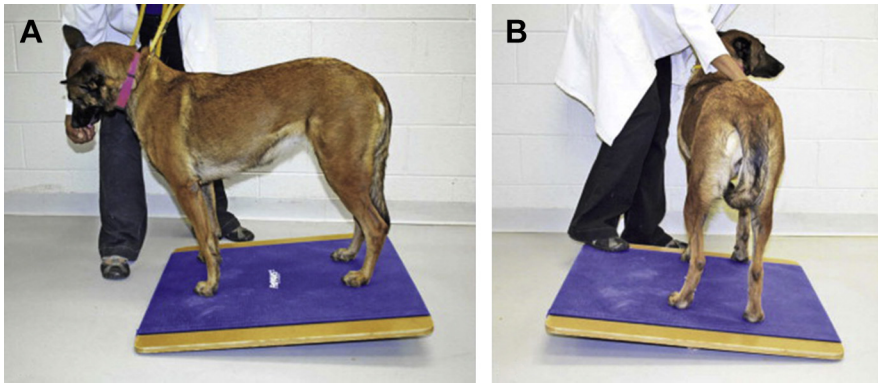


**Fig. 6.** A balance board is used to provide balance and proprioceptive training (*A*) from the front limbs to the hind limbs and (*B*) from side to side. (*From* Millis D, Levine D. Canine rehabilitation and physical therapy. 2nd edition. Philadelphia: Saunders; 2016. p. 491; with permission.)

limbs (Fig. 8). For dynamic challenges, the ball can be rolled forward, backward, and from side to side. This challenges the limbs to maintain balance as movement is occurring. The most challenging use of the exercise balls and rolls is having the patient stand on the therapy ball or roll. This exercise will challenge and engage multiple core stabilizing muscles; therefore, the sessions should be short to avoid fatigue injury.

Other exercises that promote balance and proprioception include standing or walking on foam rubber (Fig. 9), mattresses, air mattresses, or trampolines. Furthermore, patients can be walked on various surfaces such as grass, concrete, sand, mulched paths. Altering the texture and evenness of the surface challenges patients' proprioceptive abilities. To facilitate improving balance and proprioception for daily

**Fig. 7.** A wobble board creates a challenging hind limb exercise for balance and proprioceptive training. (*From* Millis D, Levine D. Canine rehabilitation and physical therapy. 2nd edition. Philadelphia: Saunders; 2016. p. 491; with permission.)

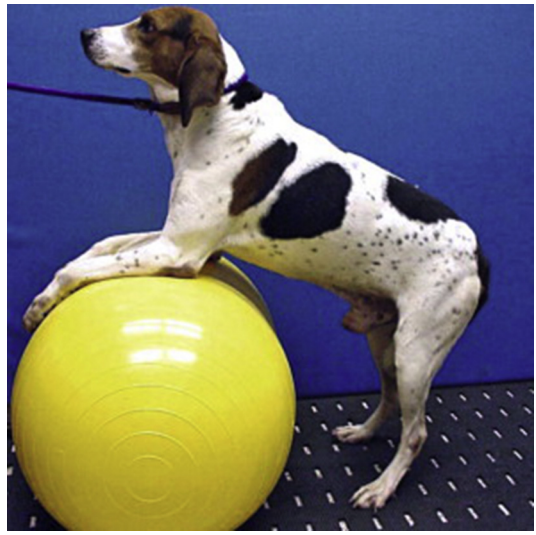

**Fig. 8.** An exercise ball can improve hind limb balance, coordination, and strength. (*From* Millis D, Levine D. Canine rehabilitation and physical therapy. 2nd edition. Philadelphia: Saunders; 2016. p. 491; with permission.)

**Fig. 9.** When walking on foam rubber, the uneven terrain challenges the patient's functional balance and proprioception. (*From* Millis D, Levine D. Canine rehabilitation and physical therapy. 2nd edition. Philadelphia: Saunders; 2016. p. 492; with permission.)

activities, animals should be encouraged to walk over or around obstacles such as low rails, pole weaving, walking on a teeter-totter, and negotiating stairs.

Additional therapeutic exercises that can be incorporated into formal rehabilitation therapy and a home exercise program should be geared toward continued improvement in ROM, specifically in extension of the hip as well as improving weight bearing in a comfortable manner along with building muscle mass and improving muscle fatigue. In structuring a rehabilitation plan for the conservative management of CHD, some basic biomechanics of exercise modification should be understood. Furthermore, the reader is encouraged to learn the biomechanics of physical rehabilitation and kinematics of exercise that can be found elsewhere.[19] The patient should warm up for 5 to 10 minutes before therapeutic exercises.

The simplest of the therapeutic exercises consists of slow, controlled leash walking. Walking can be instituted in the early phases of rehabilitation and can be continued throughout. With regard to the hind limbs, walking will generate approximately 35° of motion in the hip and 40° and 35° of motion in the stifle and hock, respectively.[20,21] Treadmill walking (up to 10° of incline) has been shown to result in the same joint motions as land walking; however, up to 3° of hip extension can be obtained while walking on a inclined (10°) treadmill when compared with walking on land.[19] Although trotting is ideal to increase the speed of muscle contractions and the forces on the limb, it does little to improve ROM in the terms of hip motion compared with walking.[22] Walking up and down stairs or a ramp can facilitate additional flexion and extension to particular joints; however, some consideration has to be placed on the particular exercise for CHD management. For example, incline ramp walking can increase hip flexion by 11%, but does not contribute to improvement in hip extension, which is targeted more commonly in patients with CHD.[23] Walking up stairs is a very good exercise for improving hind limb ROM, such that hip extension can be increased by up to 10° and is greater when compared with walking on level ground (**Fig. 10**).[24] Stair descent results in greater total ROM in the hip (27°) compared with ramp descent (23°).[25]

Having the knowledge of the kinematics of various walking exercises, one is able to create a plan to improve hip ROM as well as improve muscle mass and comfort. For example, in the beginning stages one may use slow controlled leash walking on level ground beginning at 15- to 20-minute intervals 2 to 3 times daily. Once the animal has developed the ability to perform this comfortably, 5 minutes can be added weekly to build up to 30 to 45 minutes. Inclined walking along with stair ascent and descent can be added after several weeks of flat land walking to further improve hip ROM and

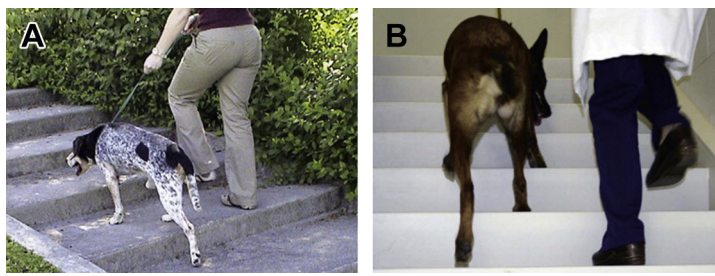


**Fig. 10.** Walking up stairs to improve hip extension more so than walking on level ground. (*A*) Stairs with a gradual rise. (*B*) Steeper stairs can be used as the patient progresses. (*From* Millis D, Levine D. Canine rehabilitation and physical therapy. 2nd edition. Philadelphia: Saunders; 2016. p. 509; with permission.)

muscle mass. It is also beneficial to add in walking down a declined slope and walking over uneven terrain. Walking on uneven terrain (trail walking, walking through high grass, walking or on sand) forces the patient to increase flexion and extension of various joints to navigate the terrain. All walking exercises should be completed in a stepwise manner, only adding more challenging aspects after the patient has successfully completed easier tasks.

Additional therapeutic exercises such as dancing, Cavaletti rail walking, and sit-to-stand exercises can all help with improving ROM in the hip as part of conservative management for CHD. These exercises can be completed as part of a home exercise program or during formal rehabilitation therapy. Dancing exercises (**Fig. 11**) are designed to increase weight bearing on the rear limbs. This is accomplished by raising the forelimbs off the ground and walking the patient either forward or backward. Interestingly, different kinematics are accomplished by walking the dog forward versus backward. Dancing forward will result in less hip flexion and total hip ROM (22°) compared with walking on level ground (total hip ROM, 33°). Alternatively, dancing backward increases hip extension more than walking on level ground. This difference plays an important role in deciding on what direction dancing exercises should be performed. For example, during the early phases of rehabilitation when hip extension is painful, it may be more comfortable to improve gluteal muscle strengthening by walking the patient forward rather than backward. However, in the later phases when hip extension is improved, walking the patient backward will be more challenging and help to further improve hip extension.[26] Total hip ROM is increased by using Cavaletti rail walking (**Fig. 12**). That increase is proportional to the height of the rails. For example, total hip ROM is improved by 2° (38° total ROM) compared with walking (36° total ROM) with a Cavaletti rail in the low position (level of the carpus). By moving the Cavaletti rail to a medium position total hip ROM is improved to 40° total. In a high position (mid antebrachium) total hip ROM is improved to 43° total. It is

**Fig. 11.** Dancing exercises to encourage hip range of motion and strength. Initially, dancing the patient forward is less painful and helps to improve gluteal strength. As the patient becomes stronger, dancing the patient backward is more challenging and leads to improved hip extension. (*From* Millis D, Levine D. Canine rehabilitation and physical therapy. 2nd edition. Philadelphia: Saunders; 2016. p. 510; with permission.)

**Fig. 12.** Example of Cavaletti rail walking to help improve active range of motion (flexion). (*From* Millis D, Levine D. Canine rehabilitation and physical therapy. 2nd edition. Philadelphia: Saunders; 2016. p. 513; with permission.)

important to note that Cavaletti rail walking does not improve joint extension.[27] Sit-to-stand exercises are beneficial in improving both quadriceps and hamstring muscle mass, as well as improving total hip active ROM. Hip extension with sit-to-stand exercises is less compared with walking; however, total hip active ROM is greatly improved (66°) when compared with walking (36°).[28] This is beneficial in the early rehabilitation, when hip extension is still painful, to allow a comfortable exercise that improves overall hip active ROM.

Aquatic therapy has become very versatile in veterinary rehabilitation. It allows active muscle contractions with decreased weight bearing on joints and bones. In patients with CHD, aquatic therapy can help with muscle spasm, muscle weakness, and pain associated with OA. The most significant benefit of aquatic therapy is likely buoyancy, which allows the patient to exercise in an upright position and may decrease pain by minimizing the amount of weight bearing on joints. The higher the water level, the more stress that is taken off of the joints. With water at the level of the lateral malleolus of the fibula, dogs support about 91% of their body weight. With water to the lateral condyle of the femur, dogs support 85% of their body weight. With water to the greater trochanter, dogs are supporting only 38% of their body weight (**Fig. 13**).[29] Another feature of aquatic therapy is hydrostatic pressure and its ability to reduce edema and decrease pain during exercise. This technique is thought to decrease a patient's pain perception, which allows the patient to exercise longer and with less pain.[30] An additional feature of aquatic therapy is the resistance needed to move through the water versus air. This resistance can help to strengthen weak muscles and improve endurance. In patients with OA from associated CHD, underwater treadmill therapy can improve ROM and comfort, while increasing muscular fatigue and building endurance, all while unloading painful joints. Initially, many dogs only tolerate 2 to 5 minutes once or twice weekly. The goal is to work up to 10 to 20 minutes with as few breaks as necessary. Because of the different kinematics of underwater treadmill versus swimming and walking on dry land, in patients with CHD underwater treadmill therapy is likely more beneficial than swimming. Compared with walking on ground, joint flexion is increased in both underwater treadmill walking and swimming; however, almost near normal joint extension is noted in underwater treadmill therapy compared with swimming, where

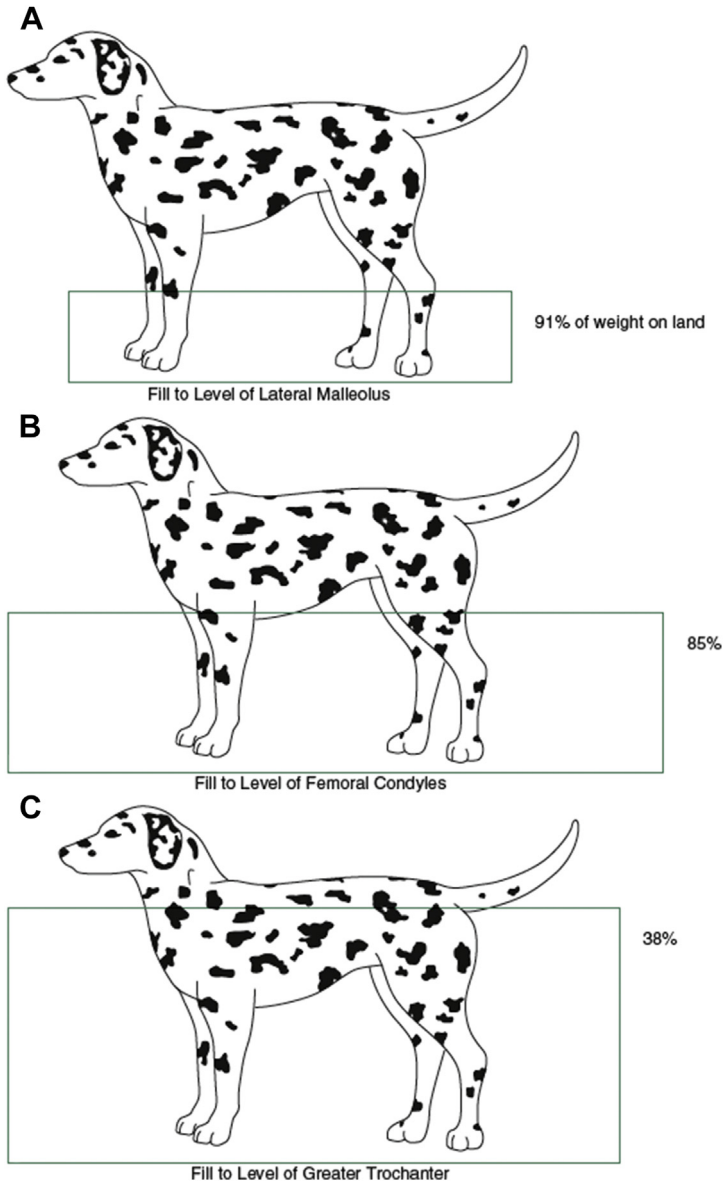


**Fig. 13.** Amount of body weight borne when immersed in water (*A*) at the height of the lateral malleolus of the fibula, (*B*) to the lateral condyle of the femur, (*C*) at the level of the greater trochanter. Therefore, the higher the water level, the more stress that is taken off of the joints. (*From* Millis D, Levine D. Canine rehabilitation and physical therapy. 2nd edition. Philadelphia: Saunders; 2016. p. 528, with permission; and Levine D, Marcellin-Little DJ, Millis DL, et al. Effects of partial immersion in water on vertical ground reaction forces and weight distribution in dogs. Am J Vet Res 2010;71:1413–16.)

hip joint extension is limited.[31] Furthermore, walking or trotting in the underwater treadmill encourages a more normal gait pattern than swimming. For a more in-depth discussion on the indications, contraindications, parameters, settings, and usages for various physical modalities the reader is encouraged to use additional resources.[32–36]

In summary, dancing backward maximally increases hip extension, whereas sit-to-stand, ramp descent, ramp ascent, and stair descent minimize hip extension. Total hip ROM is maximized with sit-to-stand exercises and dancing forward has the least impact on total hip ROM. Aquatic therapy can further be added to improve muscular strength and endurance as well decrease weight bearing on painful bones and joints. Potential therapeutic exercises used to manage canine CHD are listed in **Table 1**. For more in-depth therapeutic exercises to improve joint motion, strengthen, improve endurance and speed, the reader is encouraged to read additional sources.[37]

### *Physical Modalities to Improve Range of Motion, Comfort, and Function*

Physical modalities can be used in rehabilitation therapy to augment therapeutic exercises and promote tissue healing. Modalities such as therapeutic ultrasound, electrical stimulation, laser therapy, and extracorporeal shockwave therapy (ESWT) can be used to manage CHD. Therapeutic ultrasound can be beneficial to patients with OA associated with CHD by improving ROM and decreasing pain and muscle spasm. It allows heating of deeper tissues than cannot be reached with hot packing. Therapeutic ultrasound depth penetration changes based on frequency: 1.0 MHz heats to a depth ranging from 2 to 5 cm and 3.3 MHz heats from 0.5 to 3 cm.[38] Hot packing can heat tissue up to 2 cm; however, the greatest temperature change is noted from the skin surface to approximately 1 cm in depth. The thermal effect of therapeutic ultrasound may increase collagen extensibility, blood flow, pain threshold, and enzyme activity. Therapeutic ultrasound can be incorporated into a rehabilitation protocol in the management of CHD to heat the tissues to further improve stretching and ROM for maximal benefit. To achieve this an intensity of 1.0 to 2.0 W/cm$^2$ could be used with either 1.0 or 3.3 MHz frequencies, depending on dog breed and size. Treatment time varies, but is typically 8 to 10 minutes. The thermal effects of therapeutic ultrasound are short lived. Therefore, ROM and stretching exercises should occur while the tissue is heated or immediately afterward.

Electrical stimulation increases muscle strength and ROM, improves muscle tone, improves pain control, and decreases edema and muscle spasm.[39] Neuromuscular electrical stimulation is used for muscle reeducation, prevention of muscle atrophy,

**Table 1**
**Therapeutic exercises potentially included in the management of canine hip dysplasia**

| Purpose | Possible Therapeutic Exercises |
|---|---|
| Increasing limb strength | Daily walk or trot >10 min; tunnel walk, sit to stand, and stand to sit repetitions, swimming |
| Increasing core strength | Daily walk or trot >10 min; swimming |
| Increasing cardiovascular fitness | Daily walk or trot >10 min |
| Stretching pelvic limbs | Climbing up slopes, hills, and stairs; low jumps |
| Increasing proprioception | Daily walk or trot >10 min; walk on soft surfaces: sand, mulch, gravel, leaves, grass; teeter-totter or pole weaving |

and enhanced joint movement, whereas transcutaneous electrical nerve stimulation is commonly used for pain control. In patients with CHD, electrical stimulation can be incorporated into a rehabilitation program to help with long-standing muscle atrophy or selected strengthening of muscle groups (hamstrings, gluteals, or quadriceps) by using neuromuscular electrical stimulation twice weekly for 10 to 20 minutes. In patients with chronic OA pain associated with CHD, transcutaneous electrical nerve stimulation can be used for relief of pain. Treatment can be 2 to 3 times weekly for 30 minutes.

Laser therapy can be used to relieve pain, reduce inflammation, and increase microcirculation through the concept of photobiomodulation. The antiinflammatory and analgesic benefit of laser therapy for patients with OA has been described.[40–42] For patients with OA from CHD, 8 to 10 J/cm$^2$ are used and the entire hip area is treated. Start treatment at the greater trochanter, then direct the probe head around the cranial, medial, and caudal surfaces of the hip in a circumferential pattern. Because of compensatory changes, referred pain from the lumbosacral and epaxial areas can be treated as well. Treatment protocols vary, but initially 6 treatments are applied over 3 weeks, followed by maintenance treatments every 3 to 4 weeks. Regardless of the treatment protocol, the treatment is designed to achieve the appropriate dose, number of treatments, and interval between treatments.

The use of ESWT is centered around the pain-relieving response in patients with OA from chronic CHD. Shock waves are acoustic waves with various frequencies that are delivered and travel through soft tissues to the target area. Once the shockwave reaches the target, energy is then released, which creates a biologic response promoting analgesia and decreasing certain inflammatory mediators. The analgesic effect after ESWT is poorly understood, but thought to be due to the release of cytokines and growth factors centered around decreasing inflammation and swelling. In dogs with hip OA, ESWT improved ground reaction forces after 4 weeks of treatment, and benefits lasted as long as 3 months.[43] In a human study of arthritic chondrocytes, inflammatory factors (tumor necrosis factor-alpha and interleukin-10) were found to be decreased in patients treated with ESWT when compared with the pretreated chondrocytes.[44] The effects of ESWT on articular cartilage is an area of concern that warrants additional investigation because preliminary research suggests that high-energy ESWT applied directly to cartilage may cause degenerative changes.[45,46] Patients are sedated or anesthetized before ESWT. Typically, 500 to 1000 shocks are applied with an energy level of 0.15 mJ/mm$^2$ and 180 pulses/min to the hip region for 2 treatments spaced 3 to 4 weeks apart. Improvement may be noted for days to several months after treatment.

### *Selecting a Treatment Program for a Conservative Approach to Canine Hip Dysplasia*

Arthritic dogs with minor locomotion problems will have a treatment program focused on decreasing pain, maintaining optimal weight, maintaining limb and core strength, stretching affected joints, and stimulating proprioception. Pain management is generally achieved with simple pharmacologic steps, rest, and exercise supervision and customization. Pharmacologic and other forms of pain relief may be intermittent as long as dogs adhere to a long-term exercise program. Because OA screening is not done routinely in dogs, OA is most often discovered in its later stages. Losing mobility because of severe OA is common in large breed dogs. For patients with severe OA, it is important to implement all possible support strategies to decrease the impact of the disease on the dogs' well-being and mobility. These may include multimodal pharmacologic management, ice, heat, massage,

acupuncture, acupressure, electroacupuncture, transcutaneous electrical nerve stimulation, and rest. Once pain is managed, it is important to initiate an initially conservative and subsequently progressive exercise program. Patients with severe OA may need temporary or permanent ambulation assistance. Slings are the most common and cost-effective ambulation assistance devices. Severely impaired dogs may benefit from an ambulation cart. Underwater treadmills significantly reduce pelvic limb peak vertical force[30] and are useful in building muscle in a weight-minimized environment. Overall, a management program for companion animals with OA should be simple and logical. Managing pain is the first priority for all patients. The program must then address the most critical aspects of each patient's unique situation and, over time, improve the patient's mobility, strength, proprioception and, above all, quality of life.

## PHYSICAL REHABILITATION AFTER SURGICAL MANAGEMENT OF HIP DYSPLASIA

Surgical intervention is recommended in older patients with debilitating OA that have failed medical, conservative, and rehabilitative therapies or in younger patients to provide a good, pain-free quality of life. The type of surgical intervention is dictated by the clinical signs present, age, and if the clinical signs of CHD are owing to underlying laxity in the early phases or secondary OA in the later phases. Rehabilitation therapy is paramount and in the authors' opinion considered the standard of care after surgery for CHD. Rehabilitation therapy will improve overall comfort, ROM, early usage of the postoperative limb, and facilitate healing.

### *Rehabilitation Therapy After Juvenile Pubic Symphysiodesis*

The fusion of the medial growth plates of the pubis, referred to as juvenile pubic symphysiodesis (JPS) is sometimes performed in dogs around the age of 16 weeks with the intent to alter pelvic growth to increase dorsal coverage of the femoral head. Dogs undergo JPS to control hip subluxation.[47] Subluxation persists after surgery, but altered growth of the pubis increases the dorsal coverage of the femoral head by the dorsal acetabular rim. Tissue trauma after a JPS is relatively minor and does not warrant specific rehabilitation strategies to accelerate the resorption of edema or decrease focal pain. Also, the strength of the pelvis is not compromised after a JPS, unlike after a double or triple pelvic osteotomy, where the ilium is osteotomized and stabilized with a bone plate. The key aim of rehabilitation after JPS is to minimize the impact of hip subluxation during skeletal development. Dogs with hip subluxation will benefit from having strong muscles around the hip (gluteal muscles, pectineus, adductor, rectus femoris, etc). Growth optimization is also critical: large breed puppies should not be eating ad libitum (as much as they want to eat), they should not overeat carbohydrates, and they should not receive calcium or phosphorus supplementation. The primary focus of rehabilitation is to promote muscular development of the hind limbs with low-impact exercises.

### *Rehabilitation Therapy After Triple or Double Pelvic Osteotomy*

Triple or double pelvic osteotomies are performed on dogs that have early clinical signs of CHD but have not progressed to the point of having significant radiographic evidence of OA. Most dogs that fit these criteria are between 4 and 10 months of age.[5] When performed, the triple pelvic osteotomy or double pelvic osteotomy, much like a JPS will improve dorsal femoral head coverage. The technique involves making 2 or 3 osteotomies: one in the pubis, one in the ischium (only in triple pelvic osteotomy), and

one in the ilium. The caudal ileal segment is variably rotated, based on the amount of subluxation; rotation is commonly 20°. A bone plate is applied to stabilize the ileal osteotomy.[5]

Rehabilitation initially includes specific activity supervision for 4 to 6 weeks to allow bone healing. During this time, nonsteroidal antiinflammatory drugs, cryotherapy, and passive ROM are used to maintain and normalize hip motion. Controlled, low-impact therapeutic exercises, such as sit-to-stand exercises, and aquatic walking may be useful to attenuate muscle atrophy while avoiding excessive stress on the repair. Muscle strengthening can be achieved using controlled walking, aquatic walking, and low-impact exercises. The duration of these activities is increased gradually during the first 3 months. Dogs are restricted to leash walking, with no running or jumping for the first 3 months to reduce the chances of implant loosening or hip luxation.

### *Rehabilitation Therapy After Femoral Head and Neck Ostectomy*

Rehabilitation after femoral head and neck ostectomy emphasizes gaining hip extension, muscle mass, and active use of the pelvic limb. In the authors' opinion, rehabilitation should imperatively begin within 48 hours after femoral head and neck ostectomy and continue until normal weight bearing is achieved on the surgical limb. A sample rehabilitation protocol is included in Appendix A.

After surgery, nonsteroidal antiinflammatory drugs, cryotherapy, and hip passive ROM (especially for hip extension) should be performed daily. In addition to passive ROM for hip extension, ambulation on land, a ground treadmill, or an underwater treadmill can be used to promote active hip extension and weight bearing. Walking up inclines will emphasize strengthening of the hip extensor muscle groups. Dancing exercises encourage muscle strengthening and improve hip ROM, especially in extension. Most dogs will toe touch consistently within 1 to 2 weeks, bear partial weight in 3 weeks, and be actively using the leg by 4 weeks. Deep heating (up to 5 cm) may be accomplished by the use of therapeutic ultrasound,[48] and may be performed before stretching. The animal should regain near-normal walking and trotting gaits, but full ROM is rarely achieved, with hip extension being the most limited. Prognosis for return to daily function is good, but varies with the chronicity of the preexisting lameness and the presence of comorbidities. The dog's overall athletic ability will likely be decreased. Large dogs tend to have more difficulty with recovery than small dogs, and unfit and obese dogs tend to have more difficulty than fit and athletic dogs.

### *Rehabilitation Therapy After Total Hip Arthroplasty/Replacement*

Total hip replacement (THR) is a well-established management option for dogs with severe CHD. THR is generally delayed until CHD can no longer be managed by the use of medical therapy and exercise.

Rehabilitation after THR can be divided into conventional rehabilitation, performed in uncomplicated patients, and targeted rehabilitation, performed to address specific situations relating to THR.

#### *General rehabilitation after total hip replacement*

The goal of rehabilitation after THR is to restore the long-term, pain-free use of the operated limb.[49] Several retrospective and a few prospective studies of canine THR have been published.[50–52] These studies included little information regarding postoperative rehabilitation beyond initial supportive care and progressive leash

walks. In a long-term prospective clinical trial in which physical rehabilitation was limited to walking dogs on a leash to void during the first 2 months after surgery and increasing the length of leash walks during weeks 9 to 12, hip passive ROM was normal in 29 of 31 dogs (94%) that were free of complications 5 years after surgery.[52] Hip extension was decreased in 3 dogs with long-term implant luxation and in 1 dog with a femoral osteosarcoma. In the same study, thigh girth was equal to or greater than the opposite thigh in all dogs that were complication free. To our knowledge, there are no published reports describing dogs that did not achieve proper limb function after THR, provided that the hips were free of implant malposition, infection, fracture, or failure of fracture fixation. Functionally, dogs undergoing routine THR have normal limb use 3 months after surgery.[51] This suggests that specific rehabilitation programs or long hospitalization periods are probably not necessary for the success of uncomplicated THRs, but they may be considered in patients with limited hip motion because of tissue tightness. For example, some patients with dorsal femoral displacement for extended periods before surgery have tight periarticular muscles and other soft tissues after joint replacement.

Rehabilitation includes acute, subacute, and chronic phases. Acutely, the rehabilitation after THR is focused on providing pain relief, and avoiding catastrophic complications, including implant luxation or femoral, fracture. Subacute rehabilitation after THR is focused on completing the recovery of joint motion and strengthening of the operated and contralateral limbs. Because healing is still progressing, exercises that would place excessive stress on the joint capsule and bone–implant interfaces are avoided. Excessive stress on the joint capsule could result from external rotation, from excessive adduction, or from excessive abduction of the operated limb. Walking exercises are generally performed in a straight line. Slippery and unsteady surfaces are avoided.

Chronic rehabilitation after THR is focused on strengthening the operated and contralateral limbs. A wider range of therapeutic exercises is introduced and the intensity of these exercises increases over time (**Fig. 14**).

***Targeted rehabilitation after total hip replacement***

**Tissue tension** Dogs with limited hip extension will benefit from a stretching program. When the loss of hip extension is severe, moist heat and manual stretching techniques are used. Extension uses a spinning motion of the femoral head on the acetabulum and thus tightens the joint capsule at end ranges. This is a safe direction for stretching with regard to limiting the possibility for luxating the hip with overzealous motion, but care must be exercised to not cause the patient pain with this stretch. After the stretching session, active hip extension exercises should be performed to retrain the patient to use increased ROM. Manual stretching is not critical when the loss of hip extension is modest and the patient's limb use is acceptable. Some patients are not receptive to stretching techniques and owners may not be able to safely perform stretching at home. In these situations, targeted therapeutic exercises alone can be used instead to gain hip extension for a more normal gait pattern and better function. Walking up a gentle incline, stepping up a single step or a series of steps with adequate traction, and stepping over objects all place the trailing limb in increased hip extension.

**Sciatic neurapraxia** Patients with sciatic neurapraxia typically present with knuckling and weakness of the muscles in the sciatic distribution, including the hamstrings and crus musculature. Dogs exhibiting deficits owing to sciatic neurapraxia after

**Fig. 14.** Example of a patient walking on a land treadmill after a total hip replacement for severe canine hip dysplasia. This patient had previously had a contralateral mid-femoral amputation. Note the sling being used to support the pelvic limb so the patient cannot slip or fall during the exercise session. (*From* Marcellin-Little DJ, Doyle ND, Pyke JF. Physical rehabilitation after total joint arthroplasty in companion animals. Vet Clin North Am Small Anim Pract 2015;45(1):151; with permission.)

THR need rehabilitation for days to months, depending on the severity of the deficits.[53] Rehabilitation focuses on minimizing hip complications owing to decreased active muscular stabilization and protection (such as luxation), avoiding skin abrasions resulting from scuffing or knuckling, decreasing the loss of muscle mass in muscles innervated by branches of the sciatic nerve, and strengthening the affected muscle groups. Neuromuscular electrical stimulation can be used to elicit muscle contractions of the affected muscles to attenuate atrophy,[33] but is not universally well-accepted by patients. If active hock extension is absent for weight bearing, the hock can be stabilized by an orthosis during therapeutic exercises (**Fig. 15**). Once hock extension improves, the dog can exercise without an orthosis.[54] To avoid abrasions, affected dogs should avoid walking on abrasive surfaces and metacarpals and toes should be protected by a thin bootie or bandage. If the patient frequently knuckles, bootie systems with support straps that pull the hock into flexion and the digits into extension (TheraPaw, Lebanon, NJ) can be used during ambulation and therapeutic exercise sessions to create a more normal posture for functional limb use while simultaneously protecting the skin from abrasions. In dogs with weak hock flexion, an exercise band or rubber traction band (Anti-

**Fig. 15.** A patient with sciatic neurapraxia after a total hip replacement. In the upper image, the patient is wearing a tarsal orthotic, which will allow the patient to exercise without scuffing or knuckling while walking. Use of underwater treadmill therapy allows the patient to exercise without scuffing or knuckling. (*From* Marcellin-Little DJ, Doyle ND, Pyke JF. Physical rehabilitation after total joint arthroplasty in companion animals. Vet Clin North Am Small Anim Pract 2015;45(1):159; with permission.)

Knuckling Device; Canine Mobility, Seattle, WA; or Biko Mobility, Raleigh, NC) can be used to facilitate more normal flexion ROM during exercises. Exercises to strengthen hock flexion include stepping over progressively taller objects, such as segments of PVC pipe, walking in water at the height of the hock, and elicitation of a flexor withdraw reflex by pinching the digits. Most dogs fully recover from sciatic neurapraxia.[53]

**Implant luxation (dorsal/ventral)** After the acute management of a luxation, either traumatic or after a THR (with reduction/hobbles and/or surgical revision), targeted strengthening of the appropriate muscle groups provides improved dynamic joint support to help prevent a recurrence. Dogs that experienced a dorsal luxation need additional strengthening of the muscles lying on the dorsal aspect of the hip. Suggested exercises include 3-legged standing (lifting the unaffected pelvic limb and cuing the dog to shift weight onto the operative limb while maintaining a level pelvis), balancing on a soft or unsteady surface (commercial balance discs or an air mattress), walking perpendicular to an incline with the operative limb "downhill," and the previously mentioned hip extension exercises. Dogs experiencing a ventral luxation require strengthening of the adductors. Suggested exercises include resisted TheraBand exercises (TheraBand, Akron, OH) while walking on a treadmill

or alongside the handler (pull the hip into abduction with the band wrapped around the thigh to stimulate a contraction of the adductors), walking sideways, or walking perpendicular to an incline with the operative limb "uphill." Underwater treadmill walking also can effectively and safely target the desired muscle group in both situations,[58] particularly in the earlier phases of recovery. Proprioceptive retraining should also be used to improve body awareness and coordination for decreased risk of future falls.

## SUMMARY

The goals of rehabilitation therapy at various stages of CHD vary. Initially, clinical signs and discomfort are thought to be owing to the underlying laxity. This laxity results in lateralization of the femoral head during the swing phase of the gait with a "catastrophic reduction" of the femoral head into the acetabulum during foot strike. Rehabilitation therapy as part of conservative management in patients with laxity or in older patients with OA is centered around maintaining pain control and comfort while improving hip ROM in extension and maintenance of muscle mass. This is accomplished with weight reduction and fitness, minimizing joint pain, pharmaceuticals, disease-modifying osteoarthritic agents, manual therapies, therapeutic exercises, and physical modalities. Surgical therapy for patients with CHD is focused at improving femoral head coverage and reducing the development of OA (JPS, triple pelvic osteotomy/double pelvic osteotomy) or removing the source of discomfort (femoral head and neck ostectomy or THR). Initially, rehabilitation therapy is designed to improve overall postoperative comfort, ROM, early use of the postoperative limb, and facilitate healing. The later stages of rehabilitation therapy are continuation of improvement in ROM and muscle mass to facilitate return to function once surgical healing is satisfactory. Each aspect of rehabilitation such as manual, therapeutic, and physical modalities follows a multimodal patient centered approach.

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## APPENDIX A: SAMPLE PROTOCOL FOR FEMORAL HEAD AND NECK OSTECTOMY

| Phase | Expected Timeframe[a] | Rehabilitation Clinic Program | Home Program | Outcome Assessment Measures | Criteria for Movement to Next Phase |
|---|---|---|---|---|---|
| Non–weight bearing to toe-touching | Immediate to 48–72 h postoperative | Therapeutic exercises<br>Slow, gentle hip pROM for operated limb focusing on extension (10 reps TID-QID beginning immediately postoperative while recovering from anesthesia)<br>Slow leash walking with sling support available, only to go outside (up to 5 min, TID-QID)<br>Balance exercises on a soft foam pad or bidirectional balance board for weight bearing<br>Modalities<br>Gentle massage around the surgery site, thigh and lumbosacral regions<br>Transcutaneous electrical stimulation for pain relief (15–20 min SID-TID)<br>Cryotherapy (15–20 min TID after activities) – *first session immediately postoperative in combination with slow pROM while recovering from anesthesia*<br>Therapeutic laser therapy SID | Inpatient status preferred during this phase<br>If home:<br>Therapeutic exercises<br>Slow, gentle hip pROM for operated limb focusing on extension (10 reps TID-QID beginning immediately postoperative)<br>Slow leash walking with sling support available, only to go outside (up to 5 min, TID-QID)<br>Balance exercises on a semifirm surface for weight bearing<br>Modalities<br>Gentle massage around the surgery site, thigh and lumbosacral regions<br>Cryotherapy (15–20 min TID after activities) – *first session immediately postoperative* | Postoperative bilateral "hip" pROM and other joints as applicable via goniometry<br>Postoperative bilateral thigh circumference<br>Response to activity and subjective pain level<br>Lameness score at a stance and walk<br>Weight | Early toe-touching<br>Adequate resting analgesia<br>Decreased perioperative swelling and lack of incisional drainage. |

| | | | | | |
|---|---|---|---|---|---|
| Early weight bearing | 72 h to 2 weeks postoperative | Therapeutic exercises<br>pROM and flexion/extension hip stretches of operated limb (10–15 reps BID-TID). Bicycling and flexor reflex exercises<br>Slow, controlled walking on a land treadmill, 5–10 min including mild incline settings to encourage hip extension and target gluteal muscles<br>Balance exercises on a soft foam pad or bidirectional balance board for weight bearing BID-TID<br>Modalities<br>Heat therapy before activity (10–15 min BID-TID, not within 72 h after surgery or if S/S of acute inflammation are still present)<br>Therapeutic ultrasound SID<br>Massage<br>Therapeutic laser therapy PRN<br>Cryotherapy (15–20 min BID) after exercises | Therapeutic exercises<br>pROM and flexion/ extension hip stretches of operated limb (10–15 reps BID-TID)<br>Slow, controlled leash walking, 5–20 min including mild inclines to encourage hip extension and target gluteal muscles<br>Balance exercises on a soft foam pad for weight bearing BID-TID<br>Modalities<br>Heat therapy (10–15 min BID-TID, before exercises, Not within 72 h after surgery or if clinical signs of acute inflammation are still present)<br>Cryotherapy (15–20 min BID) after exercises | Goniometry - hip ROM and other joints if applicable<br>Response to activity and subjective pain level<br>Lameness score at a stance and walk<br>Weight | Consistent partial weight bearing on operated limb on all strides at a walk<br>Minimal pain with light activities<br>Incisional healing without complications |

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(*continued*)

| Phase | Expected Timeframe[a] | Rehabilitation Clinic Program | Home Program | Outcome Assessment Measures | Criteria for Movement to Next Phase |
|---|---|---|---|---|---|
| Consistent weight bearing at walk | 2–4 wk postoperative | Therapeutic exercises<br>pROM and flexion/extension hip stretches of operated limb (10–15 reps SID-BID<br>Controlled walking on a land treadmill, 10–15 min with increased incline angle and speed SID<br>Balance exercises on an inflatable disk or 360° wobble board for weight bearing 5 min BID-TID<br>Encourage increased weight bearing on operated limb (examples: initiating dancing exercises as tolerated 5 min BID-TID, applying weight on operated limb at 3%–5% body weight or syringe cap under contralateral foot)<br>Sit-to-stand exercises 5–10 reps BID<br>Aquatic therapy: UWTM walking 5–10 min once incision is sealed SID-BID<br>Swimming 3–5 d per week<br>Cavaletti Rails 5–10 reps BID<br>Modalities<br>Heat therapy before activity<br>Therapeutic ultrasound PRN<br>Massage PRN<br>Therapeutic laser therapy PRN<br>Cryotherapy (15–20 min BID) after exercises | Therapeutic exercises<br>pROM and flexion/extension hip stretches of operated limb (10–15 reps BID-TID)<br>Leash walks 15–20 min including 5–10 min of inclines<br>Balance exercises on an inflatable disk for weight bearing BID-TID<br>Sit-to-stand exercises 5–10 reps BID<br>Light jogging 3–5 min per day<br>Stairs: 1 flight SID-BID<br>Modalities<br>Heat therapy (10 min) before activity<br>Cryotherapy (15–20 min) after exercises | Goniometry - hip ROM and other joints if applicable<br>Reevaluate thigh muscle girth at 3–4 wk postoperative<br>Response to activity and subjective pain level<br>Lameness score at a stance, walk and trot<br>Weight | Consistent weight bearing on operated limb on all strides at a walk, consistent partial weight bearing at a trot<br>Minimal pain with light activities |

| | | | | | |
|---|---|---|---|---|---|
| Consistent weight bearing at a trot | 5–8 wk postoperative | Therapeutic exercises<br>pROM and flexion/extension hip stretches of operated limb PRN<br>Controlled walking or light jogging on a land treadmill, 15–20 min with increased incline angle and speed SID<br>Balance exercises on an inflatable disk or 360° wobble board for weight bearing 10 min BID-TID<br>Sit-to-stand exercises 10–20 reps BID<br>Aquatic therapy: UWTM walking 15–30 min SID-BID<br>Swimming 2–5 d per week<br>Modalities<br>Heat therapy PRN before activity<br>Cryotherapy PRN after exercises | Therapeutic exercises<br>pROM and flexion/extension hip stretches of operated limb PRN<br>Leash walks 20–30 min including up to 10–15 min of inclines, may use weights on affected limb or pulled with a harness as tolerated/required<br>Incorporate challenging surfaces to walks that is, snow, sand, when possible<br>Controlled ball-playing with gradually increasing times and distances<br>Sit-to-stand exercises 10–20 reps BID<br>Light jogging 3–5 min/d<br>Stairs: 2–4 flights SID-BID<br>Modalities<br>Heat therapy PRN before activity<br>Cryotherapy PRN after exercises | Goniometry - hip ROM and other joints if applicable<br>Reevaluate thigh muscle girth at 7–8 wk postoperative<br>Response to activity and subjective pain level<br>Lameness score at a stance, walk and trot<br>Weight | Consistent weight bearing on operated limb at a trot<br>Minimal to no pain with moderate to extensive activities |

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(*continued*)

| Phase | Expected Timeframe[a] | Rehabilitation Clinic Program | Home Program | Outcome Assessment Measures | Criteria for Movement to Next Phase |
|---|---|---|---|---|---|
| Trotting at speed with minimal to no lameness | Nine wk postoperative and beyond | Aquatic therapy as desired; otherwise exercises may be continued as part of a home exercise program | Therapeutic exercises<br>pROM for operated limb PRN<br>Leash walks at times and distances tolerated, including fast walks up inclined surfaces<br>Sit-to-stand exercises 20–30 reps as needed<br>Jogging: working up from 10-15 min per day<br>Stairs: walking and trotting, increasing number of flights as tolerated<br>Swimming or walking in mid-to-upper-thigh-level water<br>Ball playing with gradually increasing times and distances, becoming more vigorous over time | Goniometry every 3–4 wk if needed<br>Reevaluate thigh muscle girth every 3–4 wk PRN<br>Response to activity and subjective pain level<br>Lameness score at a stance, walk and trot<br>Weight | Consistent weight bearing on operated limb at a trot; permanent mild gait deficits may persist<br>Minimal to no pain with extensive activities |

*Abbreviations:* PRN, as needed; pROM, passive range of motion; QID, 4 times a day; reps, repetitions; S/S, signs/symptoms; SID, 1 time a day; TID, 3 times a day; UWTM, underwater treadmill.

[a] This protocol is for use by licensed veterinary professionals. It is intended as a guideline, and may be influenced by many factors affecting individualized patient care.