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Hip and Sacroiliac Disease: Selected Disorders and Their Management with Physical Therapy

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Many problems in the hip area show movement dysfunctions of the hip joint in combination with the lumbar spine, sacroiliac joint, neurodynamic structures, and the muscular systems. Muscle strain injuries pertinent to the canine hip have been reported in the iliopsoas, pectineus, gracilis, sartorius, tensor fasciae latae, rectus femoris, and semitendinosus muscles. Physical diagnoses of this type of injury require palpation skills and the ability to specifically stretch the suspected musculotendinous tissue. Treatments shall incorporate modalities, stretches, specific exercises, and advisement on return to normal activity. Canine hip dysplasia (CHD) is a common finding in many large breed dogs. Physical treatments, preventative therapies, and rehabilitation could have a large role to play in the management of nonsurgical CHD patients with the goal to create the best possible musculoskeletal environment for pain-free hip function and to delay or prevent the onset of degenerative joint disease. Osteoarthritic hip joints can benefit from early detection and subsequent treatment. Physical therapists have long utilized manual testing techniques and clinical reasoning to diagnose early-onset joint osteoarthritis and therapeutic treatments consisting of correcting muscle dysfunctions, relieving pain, joint mobilizations, and advisement on lifestyle modifications could be equally beneficial to the canine patient. As well, sacroiliac joint dysfunctions may also afflict the dog. An understanding of the anatomy and biomechanics of the canine sacroiliac joint and application of clinical assessment and treatment techniques from the human field may be substantially beneficial for dogs suffering from lumbopelvic or hindlimb issues.
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It is recognized in humans that many problems in the hip area show movement dysfunctions of the hip joint in combination with the lumbar spine, sacroiliac joint, neurodynamic structures, and the muscular systems.[1] This article attempts to illuminate the clinical picture of pathologies or dysfunctions as they pertain to the hip and sacroiliac joints and presents physical therapeutic options for each of these.

Pathologies of the Hip

Muscle Strains

Muscle strains may be caused by poor flexibility, inadequate warm-up, fatigue, sudden forceful contraction or forced extension/flexion, strength imbalances, intense interval training, insufficient breaks, and overtraining.[2] The potential for certain muscles to be strained or torn is greater for some than others. Multi-joint muscles are those that cross two or more joints and are at greatest risk for strain because they can be stretched by the movement at more than one joint.[2-4] A strain may also occur when high forces are put through tendons and muscles, as occurs during eccentric muscle contractions (where a muscle is contracted during a stretch), or when forces are applied quickly and obliquely, or during an explosive burst of movement.[2-5] Muscle strains most often affect the muscle origin or insertion, typically at the musculotendinous and teno-osseous junctions, but can occur within the muscle belly as well.[2,4] Strain injuries pertinent to the canine hip have been reported in the iliopsoas, pectineus, gracilis, sartorius, tensor fasciae latae, rectus femoris, and semitendinosus muscles.[3,4,6,7]

The assessment for a canine muscle strain relies on evaluation of the history of present injury, gait analysis, palpation of the specific muscle structure, specific muscle stretching, and elimination of differential pathologies or inclusion of concurrent pathologies. Gait analysis may reveal overt lameness with more severe lesions or subtle gait alterations result-

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Table 1 Description of Stretches Designed to Target Specific Muscles

Muscle	Stretch
Iliopsoas	Extend the hip with internal rotation (the stifle should be extended as well)
Pectineus	Abduct the hip (the stifle should be flexed)
Gracilis	Flex the hip with the stifle extended. Add abduction of the hip to focus the stretch
Sartorius	Extend the hip with the stifle flexed
Rectus femoris	Extend the hip with the stifle flexed (Note: During multiple dissections, this author has attempted to stretch the rectus femoris muscle using this method but has found that the tension produced in the sartorius muscle did not permit any stretch of the rectus femoris muscle. It was found that rectus femoris could not be put into tension with any combination of leg movements.)
Semitendinosus	Flex the hip with the stifle extended. A very slight abduction of the hip and/or flexion of the tarsus may accentuate the stretch
Tensor fasciae latae	Adduct the limb with the hip in a slightly extended position

ant from muscle weakness following the strain or active avoidance of strained muscle-tendon use or stretch. A cross-fiber deep palpation over the entire length of the suspected muscle but specifically targeting the musculotendinous and teno-osseous junctions can be utilized to determine tenderness. Cursory conclusions gained from the history, gait analysis, and palpation should be bolstered by individualized stretching of the suspected tissue, utilizing knowledge of the muscle's origin and insertion (Table 1). A painful response to stretching may indicate a strain.

Treatments for any soft-tissue injury need to follow the stages of healing. In the first 24 to 48 hours (the hemorrhagic phase) rest and ice are beneficial to minimize the initial bleeding, control swelling, prevent stress and tension, control inflammation, and reduce pain.[5,8] Over days 3 to 5 the addition of physical therapy modalities such as low-dose pulsed (nonthermal) ultrasound, low-dose LASER, or pulsed electromagnetic field therapy at the lowest setting may assist in removal of traumatic inflammatory exudates so that healing may begin.[5,9,10]

The regeneration phase occurs over days 5 to 21, but may last up to 15 weeks. At this time, the goals are to help new fibers to align in the strongest format possible and reduce adhesion formation, strengthen the structure, promote circulation, and encourage tissue regeneration and metabolism, and last, to restore coordination and body awareness.[5,8,11] To accomplish these, treatment should begin with pain-free activity and range of motion (ROM) up to day 14, but progress to regaining flexibility by stretching into a small amount of discomfort (but not pain) and beginning strengthening of the associated muscle.[5,11] Early strengthening for the hindlimb in the dog could include three-leg standing balancing (lifting the unaffected contralateral limb off the ground) and easy concentric muscle contractions which might be achieved by walking on flat land or stepping over ground-level obstacles. Once pain has diminished, eccentric strengthening should be prescribed as it can be particularly effective in helping to promote the formation of new collagen or reverse chronic degenerative tendon changes.[8,12] Eccentric strengthening work can be accomplished by walking the dog downhill (iliopsoas, sartorius, rectus femoris), side stepping downhill (pectineus, gracilis, semitendinosus), or backing down a hill (gracilis, semitendinosus). Exercising with neuromuscular electrical stimulation (NMES) may also aid in healing and in the dog could be utilized on the affected muscle in combination with three-leg standing balance.[13] Physical therapy modalities could be increased in intensity as they will increase circulation as well as encourage collagen synthesis and metabolism of tenocytes and myocytes.[9,10,13,14] As well, it is a known phenomenon in human rehab that, following an injury or surgery, the body has a diminished sense of proprioception and that this sensory ability must be retrained to avoid re-injury and to return an athletic animal to full performance.[15] Some techniques to be used would include joint compressions, balancing activities, and progress on to coordination training exercises that are not so challenging as to re-injure the area (ie, walking on uneven surfaces, agility training, short sprints, etc).

The remodeling phase commences at approximately 6 weeks but can take up to 1 year.[5] At this stage, treatment targets building up muscular strength, maintaining musculotendinous extensibility, enhancing joint mobility and improvement of the proprioceptive system, and can include prescribed exercises that allow for a gradual return to sport, challenging the injured muscle and continuance of stretching.

Treatment of muscle strains requires individual patient programming and careful monitoring of tissue healing as the animal progresses with its therapy. It is imperative that therapeutic recommendations/extend beyond just the initial painful period so as to allow full recovery with a reduced chance of recurrence.

Canine Hip Dysplasia

Canine hip dysplasia (CHD) can be identified in most dog breeds but may have an incidence as high as 70% in some large-breed dogs.[16,17] The main feature in the pathogenesis of hip dysplasia is joint laxity, and, while affected dogs are genetically predisposed, the clinical development of the disease may be modified by environmental factors such as diet, exercise, early age gonadectomy, recent gonadectomy, and month of birth.[7,16,17] Excessive hip laxity may lead to developmental changes in the shape of the femoral and pelvic components of the joint, which creates joint incongruency, abnormal joint wear, and subsequent osteoarthritis.[18]

Assessment of the Dysplastic Canine Hip

Assessment of the dog suspected of CHD should begin with subjective history taking, which may reveal owner observations such as a reduced exercise tolerance, an inability to go up and down stairs or in and out of a vehicle, a bunny hopping gait, difficulty rising, lameness after strenuous exercise, or a change of disposition leaning toward aggressiveness due to painful hips.[7] On gait analysis, dogs with severe CHD may attempt to lessen the weight on the hind legs by shifting weight forward, and resultant of hip pain or weakness, may sway, waddle, or stagger as it walks.[19,20] Sources differ as to whether an affected animal will demonstrate a wide base of support with their hind legs to increase stability[19] or, as was found in a kinematic analysis study, affected dogs maintain their femurs closer to midline than normal dogs, resulting in a narrow-base stance during gait.[20]

Physical evaluation should take note of pelvic muscle mass. Canine literature reports that greater pelvic muscle mass is associated with a reduced incidence of CHD.[16,21,22] Diminished muscle mass and altered muscle fiber size and composition is a key finding in dysplastic dogs as early as 8 weeks of age.[22] Muscle bulk and tone of the gluteal muscles in particular can be palpated over the rump of the dog and compared with the general muscle bulk and tone in the forelimb muscles. Physical therapists in human practice routinely evaluate hip abductor strength and function in patients with lower limb or low back problems by assessing for a Trendelenburg sign or gait (a hip drop or torso shift during single leg stance).[23-26] This same test can be modified for the canine patient in standing by slowly lifting one hind leg off the ground and watching for a hip drop or body shift with this movement.

Spasm and tension in the pectineus muscle has been documented to occur in conjunction with CHD.[7] However, spastic activity of the pectineus muscle when stretched is not a suitable index of the presence of hip dysplasia as it occurs in both dysplastic dogs and normal dogs and at least one study confirms that a pectineal tenotomy does not prevent CHD and may indeed result in added pathologic changes within the hip.[27,28] In man, the pectineus muscle has connections to the inferior hip capsule.[23] Similar origination has not been reported in the dog; however, this author has found that a pain response on compression palpation of the canine pectineus muscle correlates well with clinical hip pain.

ROM may also be utilized to assess the quantity, quality (ie, crepitation), and/or presence of pain at the hip joint. Pain on manipulation of the hips may be mild or severe and all ranges (flexion, extension, abduction, adductions, and both rotations) should be evaluated.[7] Often dogs with hip pain secondary to CHD will show a pain response to hip extension with a combined limitation of ROM in that direction.[17] The pain may be caused by hip subluxation or microfractures in the acetabulum (usually in immature dogs) or secondary to osteoarthritis (usually in skeletally mature dogs), or a combination.[7,17,18] The enthusiasm to label painful hip extension as a localized hip pathology should be tempered with the reality that other structures (such as the sacroiliac joint, lumbar spine, femoral nerve, iliopsoas, and sartorius muscles) may be stressed with this maneuver as well and that pathology in one of these sites should be introduced into the realm of differential diagnoses if painful hip extension is the main clinical finding.

Manual testing techniques such as the Barlow, Barden, and Ortolani tests are used to detect laxity in the hip joint and are well described in veterinary orthopedic textbooks. It is hypothesized that passive laxity translates to functional laxity in weight-bearing, which exposes the cartilage surfaces to excess stress.[16] However, not all dogs have enough laxity to permit subluxation and hence a positive sign, and not all dogs with hip joint laxity will develop radiographic signs of osteoarthritis.[7,29] Further testing may incorporate radiographic evaluation of the hips with measures such as distraction indexing to quantify coxofemoral laxity or grading systems.[7,30] Passive laxity is not independently sufficient to cause degenerative joint disease (DJD), yet there is a greater probability of developing DJD if greater laxity is present.[16] In hip dysplasia, as with other degenerative arthropathies, there is no direct correlation between the degree of pain and the severity of radiographic changes within the joints.[17] Therefore evaluation of the canine hips for suspected dysplasia must incorporate subjective evaluations, clinical evaluations, diagnostic testing procedures, and deductive reasoning. Once the diagnosis is made, then treatment options can be considered. Surgical and medical interventions are thoroughly described in veterinary literature, but conservative physical therapeutic treatments and rationale have not been well explored for this condition.

Figure 1 Three-legs standing exercise with the use of NMES to facilitate properly timed and stronger gluteals contractions.

Treatment of the Dysplastic Canine Hip

Physical treatments, preventative therapies, and rehabilitation could have a large role to play in the management of the nonsurgical CHD patient. The therapeutic goals are to create the best possible musculoskeletal environment for pain-free hip functioning and to slow down the process of DJD. Human literature cites that well-functioning gluteal muscles are needed for walking ability, gait symmetry, prevention of osteoarthritis, and prevention of total hip arthroplasty implant loosening.[31-33] Exercises designed to strengthen the gluteals and other hip musculature should incorporate gross motor strengthening, fine-motor control, and muscle timing, and additional exercises should be targeted toward balance, coordination, and body awareness. Gross muscle strengthening can include leash-walking in a tight "figure 8" pattern, underwater treadmill walking, sit-to-stand exercises, hill walking (up down and diagonal), and destination jumping (onto a platform or over a jump). Fine-motor control and muscle timing exercises can include three-legs standing (lifting one hind leg); this same exercise can be used in combination with tapping, clapping, or NMES on the gluteals of the weight-bearing leg to facilitate a better gluteal contraction (Fig. 1).

Additionally, diagonal leg standing (lifting one hind leg and its opposite front leg) or stepping up onto a pair of blocks with a diagonal pair of legs simultaneously may also provide fine-motor control and muscle timing. Balance, coordination, and body awareness could be accomplished by walking the dog across a raised plank of wood, standing and balancing on a wobble board or mini-trampoline as a displacement force is added, encouraging walking backwards or sideways, and challenging this by placing poles/obstacles for the animal to navigate while doing the same tasks, or last, a tying loose bandage around the chest, torso, and hind legs of the animal, to be worn while it walks so that the front legs can feel when the back legs move and vice versa.

Manual therapies may additionally benefit the dysplastic hip joint. One human physical therapy technique is that of joint approximations/compressions. This is utilized to stimulate joint proprioceptive fibers and activate postural reflexes.[34] In the dog, coxofemoral compressions may be applied dorsally through the shaft of the femur or medially through the greater trochanter and neck of the femur. Additionally, it has been described that puppies between the ages of 6 and 16 weeks with hip joint laxity may benefit from a manipulation technique performed 100 times a day: Laying the puppy on its back, properly positioning the femurs so as to force the femoral heads deep into the acetabulum, and motion them while in an abducted position in and out of flexion.[7] Basic stretching and ROM may additionally aid in maintaining the appropriate soft-tissue flexibility necessary for normal movement and providing nutrition to all areas of the articular cartilage. The hips should be put through all available ranges and key muscles should be stretched; sartorius, iliopsoas, tensor fascia lata, the hamstring muscle group, gracilis, pectineus and adductor. As a maintenance program, key muscles need only be stretched for 15 to 30 seconds for at least once a day or every second day.[35]

Many immature dysplastic dogs will overcome acute hip pain as they mature.[29] This is perhaps due to fibrosis of the joint capsule and acetabular remodeling that increases stability and healing of microfractures.[29] A long-term study followed 68 dogs diagnosed with clinical hip dysplasia that were managed conservatively for 10 years.[36] Seventy-six percent of the animals were evaluated at the end of this time. Sixty-three percent had no discomfort with forced hip extension; 79% had normal ROM, and 72% had normal exercise tolerance. Rationale for conservative management has been proposed that included controlled exercise, prevention of obesity, and use of heat.[37] Several surgical options exist with the intent to prevent DJD; however, mild-to-moderate DJD often causes only mild or no clinical abnormalities in dogs.[16]

Further research needs to be conducted into rehabilitation or physical therapeutic management of dysplastic dogs. However, advisement in preventative exercises or therapies may be useful for all puppies and those with asymptomatic CHD or those with mild-to-moderate symptoms may be an ideal candidate for the implementation of the above treatments.

Osteoarthritis

Osteoarthritis (OA) is characterized by progressive loss of articular cartilage and by reactive changes at the margins of the joints and bones.[38] Human literature reports that the clinical manifestations include pain or an aching discomfort that worsens with activity and is relieved by rest, a restriction of activity level, and limitation in the ability to perform tasks, poorer proprioception, joint stiffness, effusion and enlargement, as well as loss of strength and flexibility.[38-41] Veterinary literature reports that animals with OA demonstrate pain on manipulation of the joint, periarticular swelling, palpable effusion, and crepitus, and specific to the canine hip joint; stiffness in the morning or after exercise, a lower exercise tolerance level possibly with some degree of pain after exercise, atrophy of hip and thigh musculature, often lameness, and signs of pain with hip extension with reduced ROM.[17,42]

In humans, OA has been classified as primary or secondary. Primary hip OA is reported to have no recognizable underlying cause; however, it is likely that many cases of primary hip OA are the result of subtle secondary factors and should be considered secondary OA.[31,43] Factors that alter the normal mechanics of the joint create secondary hip OA and may include congenital and developmental abnormalities (ie, Perthes disease or slipped upper femoral epiphysis), single or repetitive impact loads or overloading, and alterations in the normal gait pattern.[32,44] As discussed earlier in this article, it is well recognized in veterinary medicine that canine hip dysplasia is a significant precursor to the development of hip OA.[7]

Assessment of the OA Hip

Early detection and subsequent treatment of hip OA will yield the most favorable outcomes. Radiographs are usually helpful in the diagnosis of severe hip OA but are not always beneficial in the diagnosis of mild or moderate disease; as well, there is no direct correlation between degree of pain and the severity of radiographic changes within the joint.[17,45] Physical therapists have long used manual testing techniques and clinical reasoning to diagnose early-onset joint OA.[45] Diminished hip motion can be used to diagnose early OA of the hip, with the diagnostic value of reduced ROM being best when present in two or three planes.[45] If a lesion is of the joint capsule or a total joint reaction is present, as in OA lesions, then a characteristic pattern of restriction in the passive ROM will occur.[24,45] This is called a capsular pattern, and in humans, the common capsular patterns for all joints are documented.[24] The same is not true for canine joints; however, expression of pain and limitation of ROM is reportedly found on extension of the hip in arthritic dogs.[7,17] This author has experienced similar clinical findings with hip rotations in dogs as well. It is important to realize that full hip extension range incorporates not only hip extension but also sacroiliac rotation and extension of the lumbar spine, which can often make differential diagnosis difficult.[25] To gain specificity for pathology within the hip joint with ROM testing, compression of the joint surfaces (either longitudinally through the shaft of the femur or medially through the neck of the femur) may be used to provoke or exacerbate the expression of pain.[46] As well, quadrant testing (combined movements in the ends of range) are also useful in assessing joint pathology, as they bring into articulation different areas of the joint surface and stretch different portions of the hip capsule.[24] Pain, discomfort, crepitus, and quality of movement are noted with these tests. The inner quadrants for the hip are

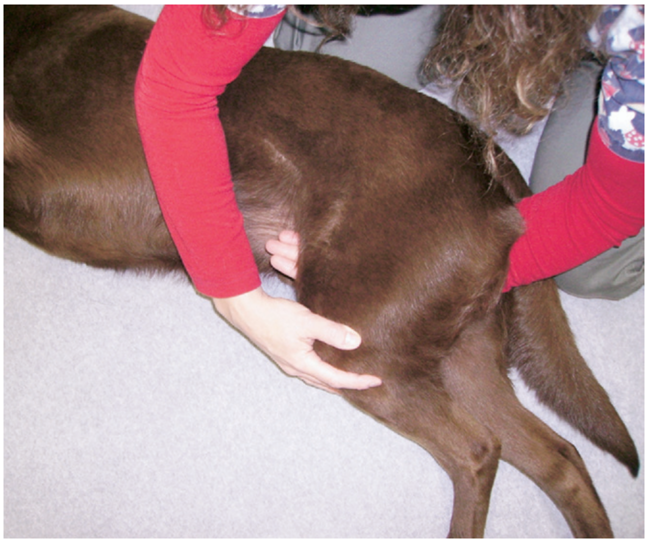

Figure 2 Lateral distraction of the hip. Place the animal in lateral recumbency. The examiner should place one hand, with the palm up, under the proximal thigh, so as to be able to lift the entire limb laterally. The other hand should press downwards (medially) on the side of the stifle and distal femur. Distract the hip laterally, alternating your distractions with a period of rest. The distractions can be attempted in varying ranges of hip flexion/extension.

flexion plus internal rotation and adduction or flexion plus external rotation and abduction. The outer quadrants for the hip are extension plus internal rotation and adduction or extension plus external rotation and abduction.

Human literature describes well the relationship between hip OA and muscle dysfunction, that being an imbalance of muscle length, strength, fine-motor control, and joint proprioception/ability to react to stresses for forces at the joint.[1,32,33] Thus, assessment of soft-tissue structure extensibility (stretches as described in Table 1) and evaluation of neuromuscular control of the hip abductors (Trendelenburg sign as described in the hip dysplasia section earlier in this article) should be included in the physical workup of the animal.

Treatment of the OA Hip

The goals for the treatment of the arthritic canine hip joint are to relieve pain and associated muscle spasm, to improve muscular control (strengthening and fine-motor control/proprioception), normalization of gait patterns, and aerobic conditioning, to maintain and regain joint mobility, and to advise on lifestyle modifications necessary for home management of the condition.[1,33,47]

Pain relief may be accomplished by use of modalities such as ultrasound, LASER, pulsed electromagnetic field, NMES, and transcutaneous neuromuscular stimulation.[9,10,48-50] However, the structure of the hip joint is such that direct penetration to the cartilaginous surface with some modalities (LASER and ultrasound) is questionable. Massage has been shown to reduce pain, increase pain tolerance, and stimulate a release of endorphins so long as regular massage sessions were administered.[50,51] For this reason, owners could be instructed in how to properly perform massage techniques as a regular home-based intervention. Thermal agents such as heat or cold are both reported to have pain-relieving effects and application of each should be taught to owners and/or utilized as part of a therapy session.[9,52]

Human studies have found that isokinetic muscle-strengthening exercises, aerobic conditioning, endurance training, and stretching programs are also capable of significantly reducing pain.[46,47,53-55] Many therapeutic exercises to address these goals are described previously in the section on CHD. Low-impact exercise is often prescribed for patients with OA and both human and dog studies have reported benefits with the use of water exercising or underwater treadmill walking, respectively.[56,57] A combination of transcutaneous neuromuscular stimulation, weight loss, and underwater treadmill as been shown to improve the health status of dogs.[57] Exercise therapy is intended to both strengthen musculature and maintain joint mobility while minimizing additional joint destruction or pain. It has been suggested that owners with animals that show evidence of discomfort from OA should back off on the animal's allowed activity until significant improvement is noted, after which point, activity can then be gradually increased in an effort to find a level that does not exacerbate the signs.[42] Additionally, play time, exercise bouts, or work activities may be divided into more numerous episodes of shorter duration or lower intensity.[42]

Manual physiotherapy techniques such as joint mobilizations, stretching, and joint traction/distraction have been found to be effective in improving quality of life, functioning, and walking tolerance in humans and ROM in dogs.[58,59] Manual therapy as an adjunct to exercise therapy has been shown to have a greater effect than exercise therapy alone on osteoarthritis of the human hip.[58,60] Manual therapy causes a physical loading and unloading of joint cartilage, which facilitates the flow of synovial fluid within the joint, ensuring adequate nutrition to the articular cartilage.[25] Joint mobilizations with compression may also be very effective for stimulating synovial fluid flow and so, in early OA, simply improving cartilage nutrition may be a very important rationale behind the use of manual therapy techniques.[1,25] Transfer-

Figure 3 Longitudinal distraction: place the animal in lateral recumbency. The practitioner should stabilize the ventral aspect of the pelvis (with a thumb and index fingers bracing the iliac crest and ischial tuberosity). The other hand will hold the distal aspect of the femur just proximal to the femoral epicondyles and, from this leverage point, push away from the hip along the line of the femur to create a ventral distraction force at the hip joint. Alternate your distractions with periods of rest. The distractions can be performed in varying degrees of hip flexion/extension.

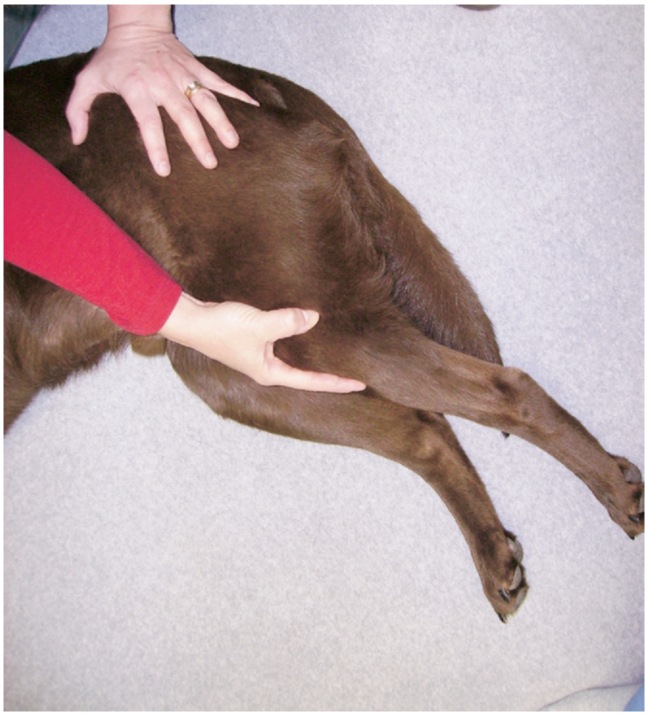

Figure 4 Joint compressions/scouring: utilizing the restricted ranges of hip motion observed in your examination. Put the hip into these ranges just shy of the onset of discomfort (one at a time). From this static position, the practitioner can now perform oscillatory compressions (with both medial compression or longitudinal compression/dorsal compression). This technique can be modified to incorporate scouring of the joint (compression of the joint with the addition of small circulatory motions simultaneously). Joint compressions and scouring can be alternated with distraction techniques.

ence of human mobilization techniques to the canine patient must be adapted due to the orientation of the canine hip. They include lateral and longitudinal distractions and joint compressions/scouring (Figs. 2-4).

Mobilizations can be used in two specific sets of circumstances: (1) the treatment of stiffness or (2) the treatment of pain in the absence of stiffness. The method of mobilizations will differ depending on its objective and can be graded according to Maitland's mobilization scale (Fig. 5).[1] [Note: This author does not feel that grade 5 mobilizations are appropriate at the hip joint. Additionally the mobilization techniques can be further refined in their application in pertaining to the vigor in which the mobilization oscillations are performed: (1) Minimal symptoms: use a staccato technique similar to staccato notes played when plucking violin strings. (2) Moderate symptoms: use a staccato technique similar to staccato notes played with the bow on the violin. (3) Severe symptoms: use oscillatory movements of a smooth and even nature such that a change in direction of movement is unperceivable.[1]]

Last to address is lifestyle modification. Reducing the weight load on joints via weight loss is a well-recognized therapy for OA in both dog and man.[42,47,57,62] Evaluation of the diet and advisement of calorie restriction may be required but is beyond the scope of this article. Of general importance is to educate the dog owners on the need for the animal to have an active lifestyle, avoidance of high-impact activities, and the continuance of regular stretching and strengthening exercises.[23] Nutraceutical supplementation and nonsteroidal anti-inflammatories may be of value as well and can be researched elsewhere in the veterinary literature.

The Sacroiliac Joint

Dysfunctions or lesions of the canine sacroiliac joint has received little attention in veterinary literature or clinical practice. Human literature however recognizes sacroiliac joint dysfunctions as pain in or around the region of the sacroiliac joint (SIJ), which is presumed to be due to misalignment, abnormal movement, or insufficient stabilization of the SIJs.[63] The sacroiliac joint in the dog and possibly in other small animals is similar enough to that of man to argue that sacroiliac joint lesions and dysfunctions may well be a potential source of back, pelvic, and/or hindlimb pain. Subse-

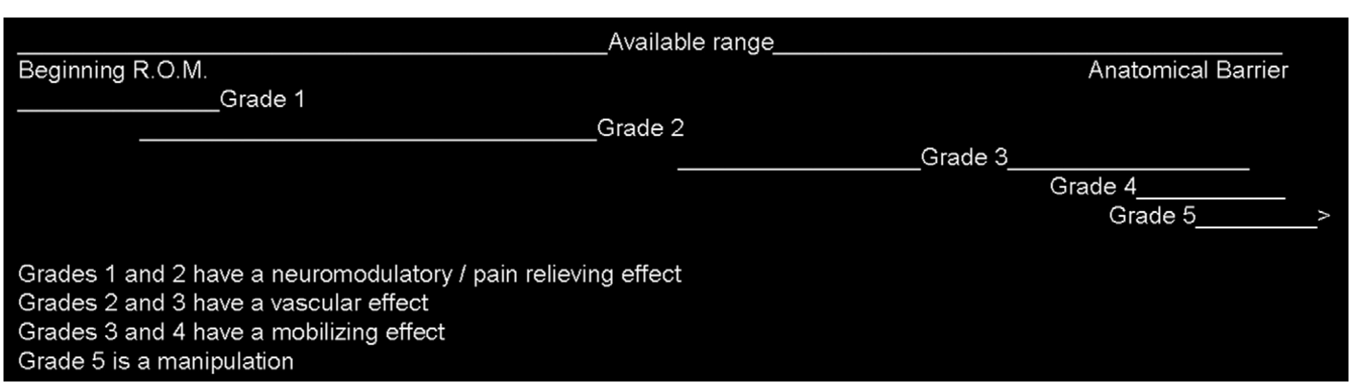

Figure 5 Maitland's mobilization scale: Grade 1: Gentlest. Performed with pressures so light and amplitudes so tiny as may be considered ineffective. Used when pain and more particularly muscle spasms are easily evoked by very gentle passive movement. Grade 2: Large amplitude in painless part of joint's range. Where in the range is guided by pain and spasm so as to avoid both. Grade 3: Big amplitude movement and done to "knock" at the limit of range. Used when pain is felt and the limit of range is moderate and is not associated with spasm. Grade 4: Tiny amplitude: Performed with joint at minimal stretch and used only when the examination reveals near full range no muscle spasm and very little pain. Grade 5: Manipulation: Extension of grade 4 joint suddenly moved through very small amplitude but at high velocity before patient is aware of it.[61]

quently, similar diagnostics and treatment techniques or therapies to those used in humans may be applied to dogs.

Anatomy and Biomechanics of the Canine Sacroiliac Joint

Both synovial and cartilaginous elements comprise the SIJ in dogs and stabilization is gained via the dorsal and ventral sacroiliac ligaments as well as the sacrotuberous ligament.[64] It is capable of an average of 7° of rotation.[65] No other motions (shears or translations) have been tested, but based on the anatomy, one could speculate that some cranial-caudal and dorsoventral movements may also be possible. Orientation and shape of the canine SIJs are often asymmetric with varying angles of dorsoventral slope, medial-lateral slope, and concavity between and within breeds.[66] The SIJs in horses are almost horizontal and allow transmission of biomechanical forces because of low joint flexibility; however, the SIJs in dogs are aligned almost sagittally and may be more vulnerable to loading forces.[67] Of the breeds tested, the lowest inclination angle occurred in German Shepherd dogs, whereas the most oblique alignment of the sacral wings was found in Rottweilers. Additionally, the SIJ articular surface and the ligamentous attachment sites are proportionately smaller in large-breed dogs.[66] Speculation could be made therefore that higher forces may be exerted on the SIJs in larger breed dogs. Calcification has been reportedly observed in more than 50% of dogs by the age of 1.0 to 1.5 years and 100% by age 6, with adult large- or giant-breed dogs being most affected.[68] The calcification lesions appeared most commonly in the interosseous ligaments, less often in the dorsal and/or ventral sacroiliac ligaments, and least frequent at the synovial area of the joint.[68] Chronic overuse, microtrauma from daily repetitive activities, or hormonal relaxation in females might precipitate calcification and are proposed etiologic factors precipitating this finding.[68,69] Potentially, canine SIJ dysfunctions and/or secondary inflammation may also give rise to calcification. However, Vleeming and coworkers reported that, with standard X-rays, the cartilage-covered ridges and depressions in humans can easily be misinterpreted as pathologic because of the well-known over-projections in SIJs, but these cartilage covered ridges are not pathologic.[70] The same might be true in dogs.

Innervation to the SIJ arises from the dorsal rami of the first, second, and third or fourth sacral nerves (S1 to S3 or S4) and has sensory input from the dorsal root ganglia of the first lumbar (L1) to the third sacral (S3).[71,72] Thus sacroiliac joint dysfunctions may also cause pain beyond the pelvic or back region. Human studies have found sacroiliac joint pain referral patterns that range from the upper lumbar spine to anywhere in the lower limb.[73,74]

Sciatica may ensue secondary to compression as a result of piriformis tension (known as piriformis syndrome) in humans.[75] It is possible that a lesion of the sacroiliac joint may cause an inflammatory reaction of the piriformis muscle and its fascia since their origin lies near the capsule of the sacroiliac joint.[76] This phenomenon has been classified as secondary piriformis syndrome or pelvic outlet syndrome in cases where there is buttock pain with or without radiation down the leg (as this depends on the location of the pathology in relation to structures adjacent to the sciatic notch) provided that spinal pathology is excluded.[77] Speculation exists that piriformis syndrome may be as common as herniated discs in the case of sciatica.[78] In dogs, the origin of the piriformis muscle is reported to be the lateral surface of the third sacral (S3) and first coccygeal vertebrae (Cxy1) and/or the border and ventral surface of the sacrum and sacrotuberous ligament.[64,79] The phenomenon of piriformis spasm and tension has been hypothesized to occur in association with sacroiliac joint dysfunctions in the dog.[80]

Clinical Diagnostic Tests for the Sacroiliac Joint

Sacroiliac joint dysfunction in humans is commonly tested by kinematic (movement) tests, pain provocation stress tests, and land-marking evaluation.[26,81-83] A "gold standard" test for the SIJ does not yet appear to exist and hence is impossible to compare against when advocating clinical tests for SIJ dysfunctions. Computed tomography scan, magnetic resonance imaging, nuclear scintigraphy, infrared thermography, ultrasonography, and analgesic injections are all too nonspecific to be considered definitive.[83,84] Color Doppler imaging that detects SIJ asymmetric laxity shows promise but has not been utilized for this purpose in dogs.[85] Human studies have validated a multi-test regimen of five different pain provocation tests as a reliable diagnostic method if three of five of the different tests produce a positive pain response.[81-86]

Pelvis Alignment

Utilizing bilateral, simultaneous palpation of each the ischial tuberosities and iliac crests, respectively, while the animal is positioned in a "square" and equally balanced stance position. Ischial tuberosities can be identified by running the examiners thumbnails up against the undersurface of the most caudal portion of the ischial tuberosities and may give indication of a ventral or dorsal rotation of the ilia. The iliac crests are located by running the examiners fingers down the sides of the back until coming in contact with the wings of the ilia and may give indication of a cranial or caudal slip (Figs. 6 and 7).

Piriformis Pain Tolerance and Sacrotuberous Ligament Palpation

This author has found that manually strumming over each of the piriformis muscles (caudal to cranial), one at a time, is often painful in animals with an asymmetric pelvis and suspected sacroiliac joint dysfunction. As well, asymmetry of tone of the sacrotuberous ligaments on palpation from side to side may signify a unilateral dysfunction at the SIJ depending on relative position of the ilium and sacrum. In some instances a very taut sacrotuberous ligament may be painful on palpation as compared with the contralateral side.

Pain Provocation Stress Tests

A thigh thrust technique (modified from human use) may be conducted with the animal in lateral recumbency. A slow, deliberate dorsal displacement force is applied through the dog's thigh (via the examiner's hand at the stifle) with the hip in midrange and slightly abducted (to avoid replication of the Barlow test for dysplastic dogs). The examiner's other hand should be on the sacrum to stabilize. The dog's reaction is

Figure 6 Evaluation of the ischial tuberosities for symmetry.

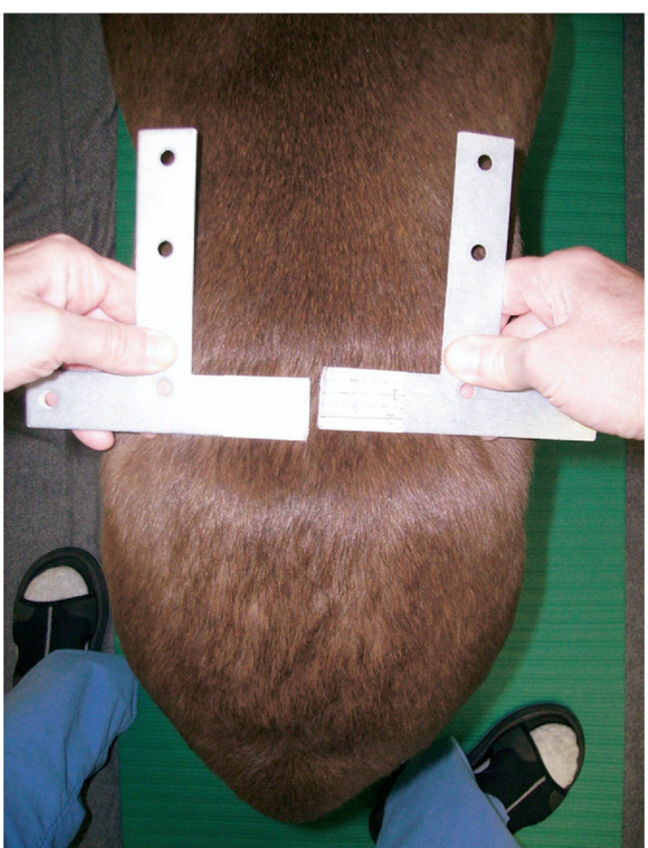

Figure 7 Evaluation of the iliac crests for symmetry.

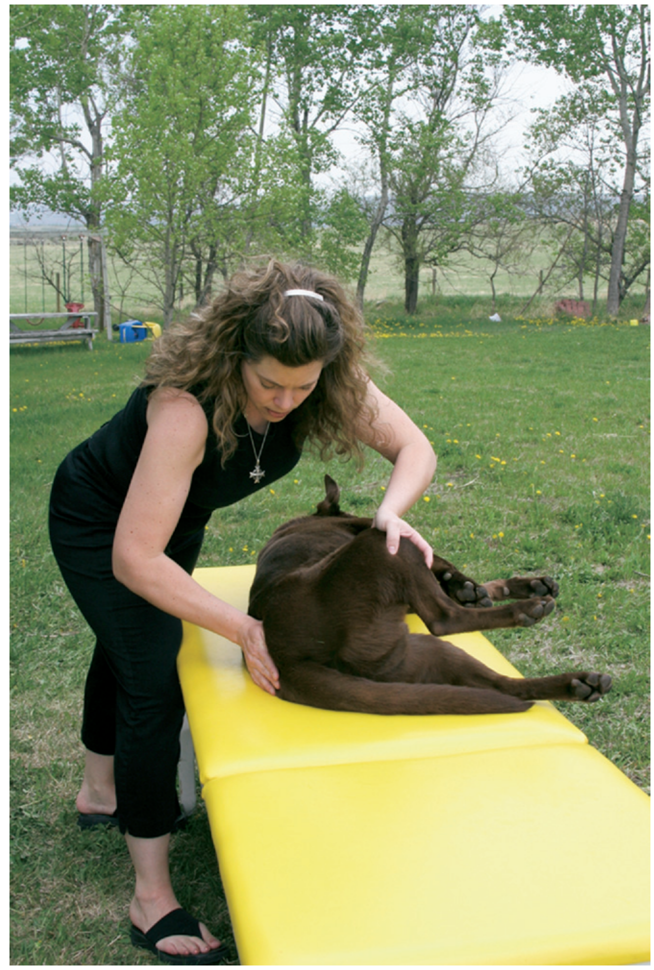

Figure 8 The thigh thrust technique. With the animal in lateral recumbency, a slow, deliberate dorsal displacement force is applied through the dog's thigh (via the examiner's hand at the stifle) with the hip in midrange and slightly abducted to create a modification of the human thigh thrust technique. The examiners other hand supports and stabilizes the sacrum.

noted. This test is hypothesized to stress the dorsal sacroiliac ligaments (Fig. 8).

Kinematic Testing

This testing in humans requires a volitional flexion of the limb or flexion of the trunk while the examiner palpates anatomical landmarks of the pelvis and compares the amount and quality of the movement. In the dog, passive flexion and extension of the hip with the examiner palpating the quantity and quality of movement of the iliac spines can detect differences from side to side.

Motor Control/Coordination Testing

Assessment for a Trendelenburg sign is as described in the hip dysplasia section. While performing this maneuver, the examiner can simultaneously palpate individual muscles/muscle groups to evaluate muscle contractions (required for pelvis stabilization); the contralateral gluteal muscle, the ipsilateral latissimus dorsi, the deep fibers of multifidus bilaterally (just adjacent to the spinous processes), the abdominals, and/or the epaxial muscles. Tapping/clapping each muscle independently and simultaneously retesting may correct the Trendelenburg sign and will point to which muscle/muscle group to strengthen.

Figure 9 Cranial translation requires stabilization of the sacrum with one hand and a graded cranial force imparted onto the ischial tuberosity on the appropriate side with the dog's abdomen stabilized.

Figure 11 Ventral translation must be done with the animal in lateral recumbency. One hand stabilizes the sacrum by pushing on the sides of the sacral spines while the other hand pulls the ilium ventrally.

Flexibility Testing

Several different muscles can affect the motion, mobility, and pull on the pelvis. Evaluation of the passive elongation capacity of the hamstrings, piriformis (flexion and external rotation at the hip), sartorius, iliopsoas, adductors, epaxial muscles (flexing the head under the chest in standing), tensor fasciae, latae, latissimus dorsi (shoulder extension/forelimb protraction), and oblique abdominals (torso rotations in side lying) should be conducted. Compare from side to side, assessing quality and quantity of the movements.

Shear Tests

In a clinical setting, human physiotherapists utilize translatory movement assessment to detect hypermobility and hypomobility dysfunctions. This requires good palpation skills, an ability to detect movement end feels, and positioning and hand placement to perform the shear tests without causing excessive discomfort over the bony structures being used to push through. An abridged list of shears to be evaluated should include the following: cranial and caudal translations; dorsal translation (this is done using the modified thigh thrust technique shown in Fig. 11); ventral translation; dorsal rotation (posterior); ventral rotation (anterior) (Figs. 9-13).

Treatment

Treatment of the sacroiliac joint should encompass "Form Closure" (aimed at restoring mobility and correction of osseous alignment),"'Force Closure" (addressing muscular strengthening or lengthening to stabilize the joint or reduce abnormal forces or pulls on the pelvis), and Retraining of Motor Control within the region (to reestablish normal patterns of movement required for locomotion as well as stabilization).[35]

Form Closure

The shear tests are also utilized as treatment techniques in the dog (see above). The tests are then turned into mobilizations and can be graded according to Maitland's mobilization scale as previously described in the hip osteoarthritis section. Theoretically, the side that is more painful on pain provocation testing or dysfunctional on kinematic testing is the side to mobilize. However, both sides may need some degree of correction.

Figure 10 Caudal translation requires stabilization of the sacrum with one hand and a graded caudal force imparted onto the iliac crest on the appropriate side with the dog's abdomen stabilized.

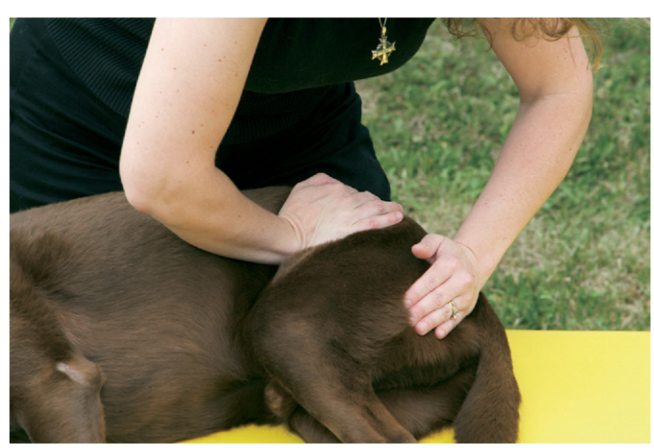

Figure 12 Dorsal rotation is accomplished by pushing down ventrally on the ischial tuberosity and lifting up on the ventral side of the ilium or flexing the hip to its maximum.

Figure 13 Ventral rotation is accomplished by pushing down ventrally on the top of the ilial wing and lifting up on the ventral side of the ischial tuberosity or extending the hip in conjunction with the movement.

Force Closure

Strengthening of the gluteal muscles specifically may be accomplished by using the exercises described in the hip dysplasia section. Flexibility should include daily stretching of the tight muscles detected on evaluation at least once a day for 15 to 30 seconds.

Motor Control and Timing

Motor control and timing can be accomplished with static three-leg standing or diagonal standing, making the animal balance for 15 seconds or up to 2 minutes. Incorporation of muscle facilitation techniques can be used (ie, tapping on the muscles, neuromuscular electrical stimulation, hand positioning, or manual cues) to problematic muscles (ie, gluteals, latissimus dorsi, transverse abdominus, lumbar multifidus, and/or the pelvic floor, ie, using the pudendal reflex). Stationary standing while imparting a rotational hold or small rotational oscillation on the thorax, lumbar, or pelvic regions may stimulate multifidus contraction.

Additional Therapeutics

Advanced proprioceptive retraining could utilize the three-legs standing or diagonal standing techniques but is done on an unstable surface (ie, mini trampoline, large wobble board, or camping foam). *Endurance retraining* is best accomplished by performing repetitions. *Ballistic movement retraining* might include slow retraining of a fast recall from a sit, short bursts of fetching, small jumps, or use of agility equipment and training. *Global hypertonicity or rigidity* can be addressed by stretches, myofascial holds, trigger point releases, or dry-needling intramuscular stimulation. The latter of these techniques are beyond the scope of this article to discuss in detail. Complete SIJ retraining in a human would also sometimes incorporate breath retraining, self muscle-releasing techniques, and self monitoring, all of which are not particularly trainable in a dog.

The creation of a clinical profile and series of tests that point toward the diagnosis of SIJ lesions or dysfunctions as the source of back and/or hindlimb problems and/or pain in dogs could have a large impact on the clinical practice of veterinarians and animal health care practitioners. The sacroiliac joint should be included in any physical assessment of a neuromusculoskeletal problem in a dog. Treatment should be comprehensive and include both joint repositioning (mobilizations) as well as targeted exercise programming to attain joint stability and proper lumbopelvic functioning. More clinical and scientific research needs to be conducted in the area of the canine SIJ.

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