

What Is a Canine Athlete?

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SUMMARY

Canine sports medicine and rehabilitation is one of the newest specialties in veterinary medicine. It encompasses and integrates a variety of fields, including orthopedics, exercise physiology, neurology, cardiology, pulmonology, nutrition, and others. Rehabilitation, which includes regaining and maintaining fitness as well as conditioning targeted with the goal of preventing future injury, is a critical partner with canine sports medicine. Canine athletes include dogs that compete in performance events as varied as agility trials, obedience trials, and disc dog competitions, as well as working dogs such as police/military dogs, search and rescue dogs, and assistance dogs for the disabled. Principles of canine sports medicine and rehabilitation apply to all active dogs, regardless of whether they train or compete; this comprises a large proportion of the canine population. Canine sports medicine and rehabilitation professionals play a pivotal role in helping canine athletes and working dogs recover after injury or illness. They work to prevent reinjury while moving the patient back to a state of muscular ability, endurance, coordination, balance, and flexibility that optimizes their physical abilities. Understanding the physical activities that are involved in different performance events and the jobs that working dogs perform is critical to devising targeted rehabilitation for sports/working dogs after injury or illness and retraining them to perform their specific duties. This is best accomplished by attending athletic/working dog training sessions and competitions. This chapter introduces the performance requirements for sporting and working dogs.

INTRODUCTION TO CANINE SPORTS MEDICINE

Humans and dogs have been partners for at least 33,000 years (Galibert *et al.*, 2011; Ovodov *et al.*, 2011; Thalmann *et al.*, 2013; Shannon *et al.*, 2015; Frantz *et al.*, 2016; Wang *et al.*, 2016). As working companions, dogs have assisted in hunting food, guarding family and property, gathering and moving livestock, patrolling with soldiers, detecting drugs and explosives, and searching for lost humans.

With increases in disposable income and a change in attitudes toward work/life balance, there has been an exponential growth in the number of sporting events devised by people to challenge their abilities to train dogs for competition. The field of canine sports medicine began with veterinarians working with racing Greyhounds and has grown over the decades,

with veterinarians now working with dogs that participate in dozens, if not hundreds, of different canine sports and working roles.

Canine sports medicine is specifically concerned with injuries sustained by canine athletes, including their prevention, diagnosis, and treatment. The field of canine sports medicine comprises many different aspects of traditional and integrative veterinary medicine as well as nonclinical ancillary roles in canine care such as exercise physiology, athletic training, and others (Table 1.1) and encourages significant collaboration between veterinarians and others with expertise in a wide variety of complementary fields. In addition, canine sports medicine is intimately linked to canine rehabilitation, where veterinarians, physical therapists, and veterinary technicians work together to return injured canine athletes and working dogs not only to health but to optimal performance.

Table 1.1 Fields included in canine sports medicine

Canine sports medicine fields of study
• Anatomy and Biomechanics
• Exercise Physiology
• Sports Conditioning
• Rehabilitation
• Orthopedics
• Internal Medicine
• Pulmonology
• Cardiology
• Neurology
• Gerontology
• Nutrition
• Integrative Medicine

There are many advantages for veterinarians and rehabilitation professionals working with canine athletes and working dogs (Table 1.2). The field involves assisting clients who have invested significant time, emotion, effort, and finances into raising, training, and competing/working with their canine partners. These clients want the best care and the best outcomes for their dogs, so there is substantial opportunity to practice state-of-the-art sports and rehabilitation medicine.

Table 1.2 Canine sports medicine and rehabilitation advantages

• Opportunity to practice state-of-the-art rehabilitation medicine
• Highly educated clients with significant financial, time, and emotional investment in their dogs
• High client compliance
• Healthier dogs than in general practice
• Higher success rate due to dogs' better plane of fitness
• Measurable success returning dog to training and competition
• Abundant research opportunities

Human athletes are assisted by teams of health professionals with diverse expertise who work on maintaining and regaining their health and fitness. Canine sports medicine and rehabilitation professionals likewise play a pivotal role in helping the owners/handlers of canine athletes and working dogs keep their dogs in athletic condition, prevent injury, and recover after injury or illness. They help move dogs back to a state of muscular ability, endurance, coordination, balance, and flexibility that allows them to optimize their respective functions.

Clients with canine athletes and working dogs are generally highly compliant. Once given detailed, individualized conditioning programs, clients will work with their dogs to perform those exercises diligently. This is a key to success for the canine sports medicine and rehabilitation professional and brings significant job satisfaction, allowing them to develop relationships with clients that last through generations of dogs.

Canine athletes and working dogs usually enter the rehabilitation program at a higher fitness plane than most inactive pet dogs. This provides the canine sports medicine and rehabilitation professional with the advantage and enjoyment of working with health more than with illness.

There is significant opportunity for research in the field of canine sports medicine and rehabilitation. Opportunities abound for retrospective studies of outcomes as well as prospective studies that formulate specific hypotheses and design test and control groups to address those hypotheses. Owners/handlers of canine athletes and working dogs are generally enthusiastic about participating in studies that will provide information they can use to become more efficient in training and more successful in either competition or their function as working dogs and that will result in greater health and longevity.

As an example of the investments that clients have in their dogs, an average annual cost to campaign a show dog in conformation shows is in the five- to six-figure range (Dugan & Dugan, 2011). This typically includes the costs of entries, travel to shows, advertising, and fees for professional handlers. Many clients with competitive field trial dogs will spend \$25,000–\$50,000/year to have professional handlers train and compete with their dogs. Most non-conformation competitors spend less than that because they generally train and compete with their own dogs. However, they do have significant costs for lessons, entries, and traveling, and many avid competitors will spend \$10,000–\$25,000/year on their chosen canine sport (Chris Zink, personal communication). This is concrete evidence of the significant temporal, financial, and emotional investment on the part of owners/handlers of canine athletes and working dogs. As a result, these clients are interested in obtaining the best possible care for their canine teammates. They look to canine sports medicine and rehabilitation professionals to help their dogs recover quickly and completely from injuries and to be able to once again compete or work to their fullest potential.

To be most effective, canine sports medicine and rehabilitation professionals must be as familiar as possible with the requirements for canine athletic and working dog activities. It also is important that they are familiar with terminology and training techniques used with these dogs. Training and practice methods can contribute to the types of injuries that performance and working dogs experience, sometimes more than competition itself.

In addition, an understanding of the structure and functions of each dog breed is critical to devising targeted rehabilitation for sports/working dogs after injury or illness and for retraining them to perform their specific roles. This understanding is best achieved by attending athletic/working dog training sessions and competitions. Local competitions can readily be found by searching the Internet. Clients' videos and photos of their dogs working or training often capture evidence of potential tissue stresses that can lead to injury, and a knowledge of the dog's specific activities can assist with diagnosis and return to full function.

The ability to communicate effectively with performance and working dog clients cannot be overemphasized. Often, these clients are as driven as their dogs so that both handler and dog might

ignore a physical problem, attempting to work through it until it becomes a major injury. This can result in critical downtime and even permanent loss of work or performance ability. Clients with canine athletes and working dogs are looking for veterinary and rehabilitation professionals who understand their dogs' activities and communicate with them about that work.

TYPES OF CANINE SPORTING AND WORKING ACTIVITIES

CANINE SPORTING EVENTS

These can be divided into two categories: companion events and performance events. *Companion events* are those in which any breed (usually mixed breeds as well) can participate. These are sports events with rules devised by diverse organizations and are usually meant to be inclusive, with events designed for the participation of as many dogs of different sizes and shapes as possible. Examples include the popular sport of agility, as well as obedience, rally, tracking, Barn Hunt, Fast CAT®, and dock diving.

Performance events are sports designed to recapitulate the original purposes for which various breeds or groups of breeds were bred. Participation is often limited to those breeds. Examples of such sports include herding competitions for breeds such as Border Collies, Shetland Sheepdogs, and Australian Shepherds, and hunt tests and field trials for the retrievers, setters, pointers, and spaniels.

This chapter provides brief information on some of the most popular and most physical canine sporting events. Table 1.3 provides a comprehensive list of popular companion and performance events with websites that provide a wealth of additional information.

Table 1.3 Popular companion and performance events

Sport	Brief Description	Website(s) and Description
Companion Events		
Agility	A popular canine sport in which a handler directs a dog over an obstacle course, running against time.	en.wikipedia.org/wiki/Dog_agility www.akc.org/events/agility www.usdaa.com/ ukagilityinternational.com
Obedience	A sport in which judges instruct handlers to have their dogs perform several exercises on command. Dogs are judged on the precision of their responses and teamwork with their handlers.	www.akc.org/events/ obedience
Rally	A sport in which the dog and handler proceed through a course of 10–20 designated stations, each of which has a sign providing instructions regarding a skill to be performed.	www.akc.org/events/ rally/index.cfm
Conformation	A competition in which purebred dogs are judged on their structure and gait against a written description of the ideal dog of that breed.	www.akc.org/sports/ conformation/
Tracking	A test in which a dog follows the scent of a person over a 400- to 800-yard track aged from 1 to 5 hours.	www.akc.org/ events/tracking
Freestyle	A teamwork sport in which dogs and handlers perform a thematic routine, moving together to music.	www.canine-freestyle.org/ www.worldcaninefreestyle. org/
Flyball	A relay race in which teams of four dogs run over four hurdles 10 ft apart, retrieve a tennis ball that is ejected by pressing a pedal on a box, then return over the hurdles.	www.flyball.org/

Table 1.3 (Continued)

Sport	Brief Description	Website(s) and Description
Disc Dog	A sport in which dogs retrieve flying discs while performing various movements, such as leaps and flips.	en.wikipedia.org/wiki/Disc_dog usddn.com
Dock Diving	A game in which dogs compete by jumping for distance or height from a dock into a body of water.	northamericadivingdogs.com en.wikipedia.org/wiki/Dock_jumping
Weight Pulling	A competition in which dogs pull a loaded sled across the ground for various distances.	www.iwpa.net
Canine Scenting	A sport in which dogs search rooms, vehicles, outdoor areas, and other sites for specific scents.	www.nacsw.net www.akc.org/sports/akc-scent-work/
Barn Hunt	A sport in which dogs hunt and find rats safely concealed in PVC tubes with air holes that are hidden among bales of straw.	barnhunt.com
Trick Dog	A sport in which dogs demonstrate a variety of skills or tricks.	www.akc.org/sports/trick-dog/
Performance Events		
Lure Coursing	A sport in which sighthounds chase white plastic bags (to imitate prey) that are moved along the ground by a battery-operated string and pulley system.	www.k9web.com/dog-faqs/activities/lurecoursing.html www.akc.org/events/lure_coursing/ www.asfa.org/
Fast CAT®	A timed, 100-yard dash in which dogs run one at a time, chasing a lure.	www.akc.org/sports/coursing/fast-cat/
Greyhound Racing	An ancient sport in which Greyhounds chase a lure on an oval track. In many countries, Greyhound racing is purely amateur and conducted for enjoyment. In the United States, Australia, and some other countries, Greyhound racing is part of pari-mutuel betting.	en.wikipedia.org/wiki/Greyhound_racing
Herding	A competition in which dogs herd sheep, cattle, or ducks over a specified course and move selected animals into a pen.	www.usbcha.com/ www.akc.org/events/herding/
Field Trials/Hunt Tests	Sports in which retrievers, setters, pointers, spaniels, and Poodles retrieve upland game birds on land and in water.	www.akc.org/sports/retrievers/hunting-tests/ www.akc.org/events/hunting-tests/pointing-breeds www.akc.org/sports/spaniels/hunting-tests/
Earth Dog Tests	A test in which terriers and Dachshunds run through underground tunnels to find a caged rat.	www.akc.org/events/earth-dog/
Coon Dog Tests	A competition that has many different facets, including bench shows, field trials, night hunts, and water races, providing owners with the opportunity to demonstrate the beauty and natural abilities of purebred coonhounds.	www.akcoonhounds.org/ www.ukcdogs.com/htx-hunt-tests
Beagle Field Trials	A competition in which pairs of Beagles are turned loose to find their own rabbit and are judged on how well they search.	www.akc.org/sports/field-events-hounds/beagle-field-trials/

(Continued)

Table 1.3 (Continued)

Sport	Brief Description	Website(s) and Description
Fox Hunting	An activity involving the tracking of a fox by trained Foxhounds or other scent hounds, and a group of unarmed followers who follow the hounds on foot or on horseback.	en.wikipedia.org/wiki/Fox_hunting
IGP, French Ring Sport	Competitions that combine obedience, tracking, and protection work.	en.wikipedia.org/wiki/Schutzhund en.wikipedia.org/wiki/French_Ring_Sport
Mushing	An endurance competition in which dogs pull sleds (or land rigs) over a specified course, which may vary from 1 to 1150 miles.	en.wikipedia.org/wiki/Mushing
Skijoring, Skatejoring, Bikejoring, Canicross	Sports in which dogs pull people on skis, skates, bikes, or while running, respectively.	en.wikipedia.org/wiki/Skijoring
Carting	A sport in which a dog pulls a cart filled with supplies, such as farm goods or firewood, and sometimes people over a specified course.	en.wikipedia.org/wiki/Dog_carting www.akc.org/canine-partners/more-sports-for-all-dogs-drafting-carting-2/

Agility

Agility is an international sport in which owners/handlers direct dogs over a course consisting of 15–20 obstacles, including jumps (Figure 1.1), tunnels, weave poles, seesaws, A-frames, dog walks, and sometimes other obstacles, in a race for both time and accuracy. Dogs run off-leash and the handler cannot touch the dog, but instead guides the dog by voice, movement, and various body signals. This requires exceptional training of the dog and coordination of the handler. Dog–handler teams usually run outdoors on grass or indoors on artificial turf, dirt, or other flooring. The handler can walk the course ahead of time to determine strategies for handling their dog through the course. At this time, they will determine how to compensate for differences in their running speed versus that of their dog, and for the different physical and training strengths and weaknesses of both the dog and handler. The height that agility dogs are required to jump is determined using various formulas based on the dog's height at the withers (a point just cranial to the dorsal-most point of the scapula). Depending on the host organization, dogs can compete in agility as early as 15 months of age, and as a result they generally begin training at a much younger age.

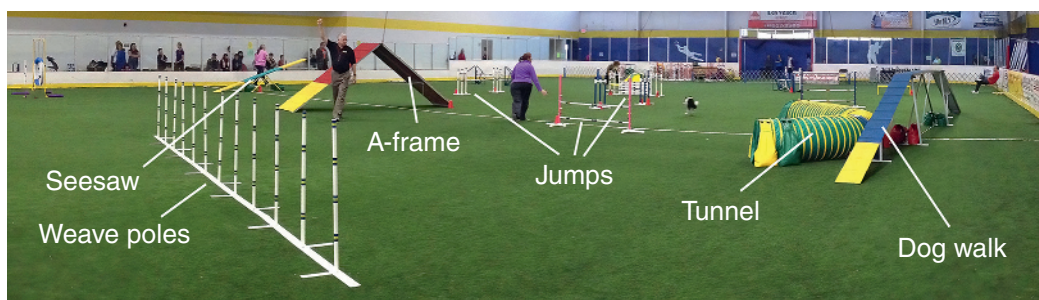


FIGURE 1.1 An agility ring showing different obstacles including a seesaw, weave poles, A-frame, jumps, tunnel, and dog walk.

Agility is a rapidly growing sport worldwide, with over a million entries annually in the last several years in events hosted by the American Kennel Club (AKC) alone (an entry consists of one dog running one course). There are dozens of organizations that host agility events internationally.

The incidence of injury in agility dogs has been reported to be anywhere from 30 to 42% (Levy *et al.*, 2009; Cullen *et al.*, 2013a, 2013b; Evanow *et al.*, 2021; Pechette Markley *et al.*, 2021, 2022, 2023). Factors associated with increased risk of injury include previous injury, competing at national events, older age of the dog, less than or equal to 4 years of agility experience, use of alternative or rehabilitative therapies, Border Collie breed, high frequency of training, young age (3–18 months) when starting jump training, older age when starting course-like training, training for a moderate amount of time per week, performing on dry outdoor surfaces or rubber matting, and jumping 2–4 inches over shoulder height (Levy *et al.*, 2009; Cullen *et al.*, 2013b, Kerr *et al.*, 2014; Sellon *et al.*, 2018; Evanow *et al.*, 2021; Pechette Markley *et al.*, 2021, 2022, 2023; Fry *et al.*, 2022; Inkila *et al.*, 2022a; Jiminez *et al.*, 2022; Sundby *et al.*, 2022). Factors associated with decreased risk for injury include increased handler experience, increased dog experience, older handler age (>65 years old), training for very small or very large amounts of time per week, and moderate competition frequency (Cullen *et al.*, 2013b; Evanow *et al.*, 2021; Inkila *et al.*, 2022b; Sundby *et al.*, 2022; Pechette Markley *et al.*, 2023).

Since the sport of agility involves speed and jumping, agility dogs commonly suffer injuries to soft tissues. These include injuries of the thoracic limb, particularly of the shoulder such as biceps, supraspinatus and subscapularis tendinopathies, medial glenohumeral ligament sprain, and/or shoulder labral tears, and of the pelvic limb such as iliopsoas strain and cranial cruciate ligament (CCL) insufficiency (Levy *et al.*, 2009; Cullen *et al.*, 2013a; Kerr *et al.*, 2014; Inkila *et al.*, 2022b; Pechette Markley *et al.*, 2021; Jiminez *et al.*, 2022; Kieves *et al.*, 2024; Fry *et al.*, 2022).

Injuries to the thoracic limbs, particularly the shoulder, have the highest reported incidence (up to 61%; Levy *et al.*, 2009; Cullen *et al.*, 2013a, Kerr *et al.*, 2014; Pechette Markley *et al.*, 2021; Inkila *et al.*, 2022b; Jiminez *et al.*, 2022). Iliopsoas injury also is commonly found and has a reported incidence of 7.8–19.4% (Pechette Markley *et al.*, 2021; Fry *et al.*, 2022). One retrospective study on iliopsoas injury in agility dogs found that 73.6% of dogs with iliopsoas injury had concurrent pathological changes, with CCL insufficiency being the most common (27.8%) followed closely by lumbosacral disease (23.6%; Sack *et al.*, 2023). Stifle injuries have been documented in agility dogs with heavier dogs, Border Collies, male dogs neutered at less than 10 months of age, female dogs spayed before their first heat cycle, handlers aged 18–24, and teeter contact behavior having a higher risk (Kieves *et al.*, 2024). Specifically, CCL injury also is commonly reported in agility dogs and is associated with younger dog age, being a spayed female, greater body weight, greater weight-to-height ratio, competing at novice and intermediate levels, and competing in fewer than 10 events/year (Sellon & Marcellin-Little, 2022).

Digit injuries also have been reported in agility dogs and are associated with long nails, Border Collie breed, absence of dewclaws, and greater weight-to-height ratio Sellon *et al.*, 2018. Finally, injuries to the spine also have been reported in agility dogs at an incidence of 17–24% of injuries, with lumbosacral disease and intervertebral disc disease being mentioned as specific spinal conditions affecting agility dogs (Levy *et al.*, 2009; Cullen *et al.*, 2013a; Pechette Markley *et al.*, 2021; Sack *et al.*, 2023).

With respect to return to agility training and competition following injury, one survey found that there was no relationship between age, sex, and breed and the likelihood of injured agility dogs to return to competition. That study reported that 67.4% of dogs returned to competition but almost half (47%) of the owners/handlers chose to have their dogs jump a lower height after injury (Tomlinson & Manfredi, 2018).

CASE STUDY 1.1 Subclinical Soft Tissue Shoulder Injury**SIGNALMENT**

9 y.o. F/S (spayed at 5 years of age) Golden Retriever; 26 kg

HISTORY

Patient had been competing in masters level AKC agility one to two weekends per month for the past 6 years. For the past 4 years, despite intensive retraining, patient would refuse to enter weave poles in competition only, not when training at home. If the owner/handler restarted weave poles, patient would complete them. Owner/handler requested complete examination to determine whether any orthopedic problems exist that might result in this performance problem.

CLINICAL FINDINGS

Patient in excellent physical condition, at a correct weight, and age-appropriately well-muscled. Pain elicited on flexion of the right shoulder. Sensitivity on palpation at the insertion of the iliopsoas muscles in the area of the lesser trochanters of both femurs. Musculoskeletal ultrasound showed islands of hypoechoic fibers in the musculotendinous junction of the right supraspinatus tendon and of both iliopsoas tendons at their insertion onto the femurs.

DIAGNOSES

- Grade I/III right supraspinatus tendinopathy
- Grade I/III bilateral iliopsoas strain

TREATMENT

Owner advised to initiate room rest and rehabilitation therapy. Rehabilitation therapy included therapeutic ultrasound for the right supraspinatus and bilateral iliopsoas tendons, laser therapy for all

areas of compensatory discomfort, and therapeutic exercises beginning with gentle stretching, then progressing to isometric, then concentric contraction, then eccentric contraction, twice per week for 4 weeks, and then once per week for 4 weeks. At 4 weeks, underwater treadmill was added to the patient's rehabilitation regimen. At 8 weeks, the patient was gradually reintroduced to agility by working on short sequences of low jumps with minimal turns, gradually increasing sequence lengths, height of jumps, and tightness of turns over an 8-week period. Weave poles not added to retraining program until 8 weeks after agility retraining initiated.

OUTCOME

Patient competed successfully in agility 6 months after the diagnosis and continued to compete without injury until 12 years of age.

COMMENTS

This case is typical of agility dogs in several ways:

1. The presenting complaint frequently involves a decline in performance of an obstacle, particularly the weave poles and/or a reduction in the yards per second during competition. Knowing the requirement for changes in lead legs while performing the weave poles helped direct the veterinarian toward a front limb injury. This dog likely had problems only during competition because she competed on relatively slippery surfaces (noted on video) but was trained on grass at home.
2. Agility dogs frequently have subclinical abnormalities that do not present as overt lameness.
3. Agility dogs frequently have more than one musculoskeletal injury.

Obedience

The sport of obedience started in the 1930s, arising as an adaptation of the work of military dogs. Formal obedience competitions were originally designed to showcase a dog's ability to work with their owner/handler and follow specific commands so that together they could go for a walk in a park, have good manners in public, or take a pleasant ride in the car. Obedience

competitions are sponsored predominantly by the American Kennel Club in the United States and by many other organizations nationally and internationally. While obedience trials have competed with agility trials for participants over the last two decades, they still retain a stalwart following.

Basic obedience skills include walking on the handler's left side and staying in place when the handler turns or changes speed (Figure 1.2), sitting when stopped, coming when called, lying down when asked, and staying in position when the handler leaves. Higher levels of obedience competition include competency in retrieving, jumping various styles of jumps, and scenting.

Obedience dogs that are campaigned heavily in the sport most commonly experience chronic strain injuries to the shoulders, such as biceps and/or supraspinatus tendinopathy. This particularly affects the left shoulder since more of the dog's weight is borne on the left shoulder when the dog is heeling with its head looking up and to the right toward the handler. Heeling is a major component of obedience at all levels.

Rally

Rally is a sport based on the obedience practice of active warm-up and freestyle exercises. It requires teamwork between dog and handler along with performance skills similar to obedience. However, unlike obedience, instead of responding to a judge's instructions, the competitor proceeds around a course of 10–20 designated stations with the dog in heel position. At each station, a sign provides instructions regarding the specific movements required of the dog. In contrast to obedience competition, rally owners/handlers are allowed to verbally encourage their dogs while on course. Due to the minimally concussive nature of this sport, injuries are uncommon.



FIGURE 1.2 Dog heeling during obedience competition. Note the position of the dog's head as it stays in heel position at the handler's left side. This causes the dog to bear more weight on the left thoracic limb.

Conformation

Conformation is a competition in which a judge subjectively evaluates individual purebred dogs for how closely they conform to the established standards for the breed. A conformation judge does not compare one dog to the others, but rather assesses the extent to which each dog meets the written and illustrated standard for its breed. The judge evaluates dogs both in a standing position and while moving at a trot. The number of entries annually in conformation is in the millions, although this number has been declining over the last decade.

Flyball

In the sport of flyball, two teams of four dogs race against each other from a start/finish line, over four jumps placed 10 ft apart to a box that releases a tennis ball to be caught when the dog presses a spring-loaded pad, then back over the jumps to their handlers while carrying the ball (Figure 1.3). Two teams run in a heat against each other, with the fastest team proceeding to the next heat. The height of the jumps for all dogs is determined by the height at the shoulder of the smallest dog on each team.

Flyball competition involves very high speeds. The world record speed for all four dogs performing a flyball run as of this writing was 14.16 seconds. Thus, each dog ran the 102-ft course in an average of 3.54 seconds, indicating that the dogs were running at well over 30 mph when they hit the box. In a typical tournament, dogs might participate in more than 25 heats/day.

The injuries that flyball dogs typically experience are associated with chronic repetitive stress and most often occur in the shoulder opposite to and in the coxofemoral joint toward which the dog turns at the flyball box. Typical injuries include carpal desmitis, biceps, supraspinatus and/or subscapularis tendinopathy, medial glenohumeral ligament sprain, shoulder labral tears, coxofemoral arthritis, and iliopsoas strain. An internet survey of dogs participating in flyball showed that 39% of dogs incurred at least one injury in their career, with injuries to the limbs being most common (30.8% affecting the thoracic limbs and 25.6% affecting the pelvic limbs; Montalbano *et al.*, 2019). Interestingly, more injuries were reported in younger dogs, and the use of carpal wraps was positively associated with increased injury risk. Breed, dog size, age of neuter, having a tail, and jump height were not associated with an increased risk of injury.

Field Trials/Hunt Tests

Field trials and hunt tests require dogs to retrieve upland game birds such as ducks and pheasants on land and sometimes water, simulating hunting situations where dogs locate and retrieve shot

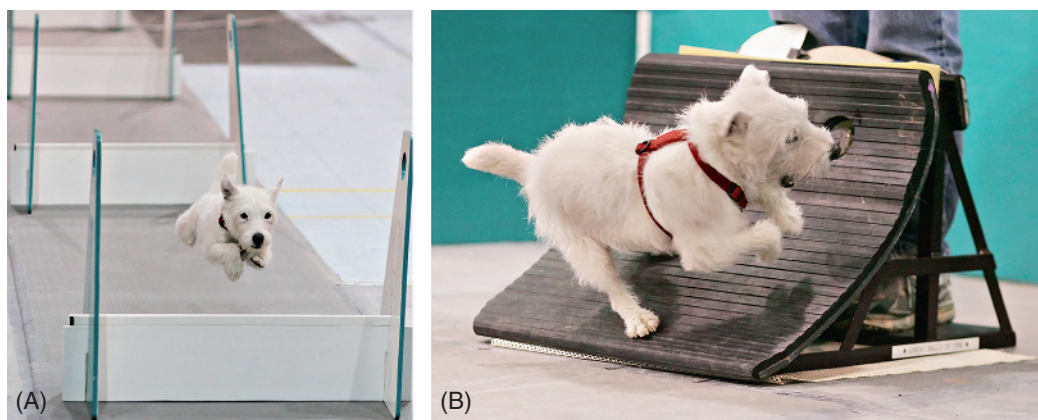


FIGURE 1.3 (A) Dog heading over the row of flyball jumps to the box. (B) Dog leaving the box with the ball and heading for the jumps. (Source: Photo by Steve Surfman.)



FIGURE 1.4 Golden Retriever returning to handler after retrieving a duck during a hunt test. (Source: Photo by Steve Surfman.)

birds for hunters (Figure 1.4). Field trials is competitive in that only the dogs placing first through fourth are awarded points, and a certain number of points are required for a championship title. Hunt tests use more typical hunting scenarios and are graded as pass/fail. There are different rules and regulations for field trials and hunt tests for the three different styles of hunting dogs: retrievers, pointing dogs (pointers and setters), and flushing dogs (spaniels).

In the authors' experience, dogs that compete in field trials and hunt tests are predisposed to injuries of the feet, carpus, and shoulders, including sesamoiditis, carpal hyperextension/arthritis, and biceps and/or supraspinatus tendinopathy as well as lumbosacral disease and calcaneal tendinopathy.

Herding Sports (Herding Trials, Treibball)

Herding sports are designed for dogs of herding breeds to display their innate ability to gather, herd, and protect livestock. Herding trials most often use sheep but sometimes other species such as ducks or cattle. Herding trial judges subjectively score dogs on their versatility, control, and movement of the livestock over a preset course, which requires extensive teamwork between the dog and handler.

Treibball was first introduced in Germany in the early 2000s and is a rapidly growing sport. This sport is not necessarily exclusive to herding breeds, but to be successful dogs often require herding drive and intense focus on balls. In treibball, a dog drives eight oversized, inflatable balls into a goal within a 7-minute timeframe. This sport requires both instinct and training as the handler directs the dog to select the balls in a particular order. As the team becomes more proficient, the distance the dog drives the balls increases and the time allotted to complete the task decreases to add additional layers of challenge.

Due to the nature of movements that dogs participating in herding sports undergo, dogs participating in these sports are predisposed to injuries of the feet, carpal hyperextension, biceps, supraspinatus and subscapularis tendinopathy, medial glenohumeral ligament sprain, and iliopsoas tendinopathy.

Water Sports (Dock Diving, Water Work, Water Rescue)

Water sports for dogs have been designed to showcase a dog's athletic ability in the water. Dock diving is a sport in which dogs run the length of a dock and leap as far out into the water as possible to compete for height or distance. Dogs are often enticed to jump with a toy, which is thrown just out of reach to encourage them to build momentum and power when launching off the dock.

Water work and water rescue sports were created to reflect the working background of various dog breeds (such as the Portuguese Water Dog and the Newfoundland) while displaying the dog's inherent and instinctive working abilities and further developing the working relationship between

a dog and their handler. Dog breed clubs frequently sponsor water work events specifically for their breed. Dogs may be asked to retrieve objects from the water or shore, carry objects from boat to shore, complete timed swims with the handler, and participate in water rescue activities such as delivering a rope to or rescuing a swimming steward in distress. Due to the nature of movements that dogs participating in water sports undergo, they are predisposed to iliopsoas tendinopathy and biceps and/or supraspinatus tendinopathy.

Disc Dog

This sport evolved due to the popularity of Frisbee™ sports. In disc dog, dogs and their handlers compete in a variety of events such as distance catching, freestyle catching, and choreographed routines to music. With distance catching, typically the longest catch wins, but other events may be judged on creativity, originality, and accuracy. Dogs of any breed and size are welcome to compete. Based on the movements that dogs participating in disc dog undergo, they may incur various injuries including iliopsoas tendinopathy, CCL injury, injuries of the feet, carpal hyperextension, biceps, supraspinatus and/or subscapularis tendinopathy, and medial glenohumeral ligament sprain.

Pulling Sports (Mushing, Skijoring, Skatejoring, Bikejoring, Canicross, Carting)

Multiple facets of dog pulling sports have been around since the domestication of dogs thousands of years ago. As the name suggests, dog pulling sports involve a dog pulling weight with the aid of a harness and trace, which is what connects the dog's harness to the sled or cart they are pulling, or to a human in the case of skijoring and other similar sports. Mushing is a sport in which dogs pull a sled containing a human and supplies over the snow, with the fastest team over a given distance winning the competition. Skijoring, skatejoring, and bikejoring require dogs to pull people on skis, skates, and bikes, respectively. In canicross, the dog pulls a person who is running over a course. In carting, dogs are attached to a cart and tasked to transport items and complete various obedience routines or maneuvering exercises, which range in difficulty. By the nature of these pulling sports, these dogs are most susceptible to injuries of digits and the shoulders, including biceps and supraspinatus tendinopathy, as well as lumbosacral disease.

Scenting Sports (Tracking, Nosework/Scent Work, Earth Dog, Barn Hunt)

Scenting sports have been developed to test a dog's innate scenting ability and engage their prey drive. Tracking involves dogs following a track laid by a person over several hundred yards of ground and finding various articles dropped by the track layer. Nosework and scent work mimic the work of detection dogs that are trained to find explosives, drugs, cash, etc. In these competitions, dogs must locate in a specific amount of time cotton swabs saturated with essential oils such as birch, anise, clove, and cypress that are hidden out of sight and sometimes out of reach. Earth dog trials were designed to assess the ability of smaller terriers to hunt prey underground. Dogs are judged on their speed and ability to navigate narrow tunnels and obstacles underground to locate a rat. In Barn Hunt competitions, dogs are given a specific amount of time to locate between one and eight rats that are placed in ventilated tubes and hidden among bales of hay. These are relatively low-impact sports with minimal risk of injury.

Coursing Tests, Fast CAT (Coursing Ability Test)®

Coursing sports were developed to challenge a dog's focus, prey drive, and athletic ability. In these competitions, dogs chase a mechanized, white plastic lure around a course that is designed to simulate the unpredictability of chasing live prey. Coursing sports are physically challenging as they

require a high output of energy and multiple changes of direction as the dog sprints after the lure. Dogs who participate in coursing sports may be predisposed to injuries of the feet, biceps and supraspinatus tendinopathy, and iliopsoas tendinopathy.

Protection Dog Sports (IGP [Internationale Gebrauchshund Pruefung]/French Ring Sport/Mondioring)

Protection sports test dogs' ability to mimic tasks performed in a working dog capacity. They test the temperament and trainability of the dog in the contexts of obedience, tracking, and protection work. Dogs participating in these sports may incur injuries including iliopsoas tendinopathy, injuries to the feet, carpal hyperextension, biceps and supraspinatus tendinopathy, and lumbosacral region.

WORKING DOG ACTIVITIES

A vital aspect of canine sports medicine and rehabilitation is improving the health and performance of dogs that perform critical functions for society including police/military dogs, detection dogs, search and rescue dogs, and service dogs (Table 1.4). The work these dogs do is critical for the security of national and local communities, the safety of agriculture, and the health and safety of individuals with disabilities. Maintaining the health and full capabilities of these dogs can be a matter of life or death to their owners/handlers.

Table 1.4 Working dog activities

Category	Type of work
Search and Rescue	Wildland Urban Cadaver Avalanche
Detection	Drugs Cash Explosives Agricultural threats Cancer Petroleum leaks Mold Insects (termites/bed bugs) Vapor wake (body-worn explosives)
Police, Patrol, Protection	Police and military patrols Police apprehension Protection and security (secure installations/public gatherings)
Farm Dogs	Herding sheep, cattle, ducks, chickens Predator protection Geese police (golf courses)
Service Dogs	Dog guides for the blind Hearing dogs Mobility assistance dogs General assistance dogs Seizure/diabetes alert dogs Psychiatric service dogs
Canine Actors	Movies Television Print advertisements

When dealing with a working/assistance dog, it is important for the canine sports medicine and rehabilitation professional to determine the specific tasks that the dog must perform as a part of its daily work, since these dogs' duties vary tremendously. For example, police dogs may be trained in detection (drugs, weapons, cash, etc.), in suspect apprehension, or both. The canine sports medicine and rehabilitation professional working with these dogs should consider the ergonomics of the equipment the dog wears while at work and whether it might contribute to injuries. For example, some dogs wear only a collar, while others wear specialized harnesses that might include additional weight from supplementary equipment. Many harnesses are designed with little consideration of ergonomics for the dog's body (Vanek, 2010).

Working dogs often experience injuries and disorders related to overuse (repetitive stress) or trauma because of the intense activities required for their jobs. They also can suffer from conditions more commonly seen in working dog breeds, such as fibrotic myopathy, which is seen most often in German Shepherd Dogs (Steiss, 2002). For detailed information on working dogs and their injuries, see Chapter 23.

NONCOMPETITION ATHLETES

Thousands, if not millions, of dogs in North America perform athletic activities that do not involve competition. Dogs that run with their owners, romp freely on beaches or on hiking trails, or catch a thrown ball or disc in the yard are all active and athletic and may, in fact, be doing more physical work than some competitive or working canine athletes. Many of them rest all week and are unprepared for the level of exercise they experience on weekends, making them more susceptible to overuse injuries. These injuries often go unrecognized and untreated for long periods of time. It is easy to see that most dogs can benefit from the expert problem-solving abilities and skilled care of a canine sports medicine and rehabilitation professional. The training that the canine sports medicine and rehabilitation professional experiences raises the bar for diagnosis, treatment, and prevention of musculoskeletal injuries for all dogs.

CANINE STRUCTURE AND ITS EFFECTS ON PERFORMANCE

With each performance and working task comes specialized training and activities that create unique physical demands on the canine body. The detailed anatomy of the bones, muscles, tendons, ligaments, innervation, and vasculature of the injured area can be obtained from textbooks (Hermanson *et al.*, 1979). While all dogs have the same anatomical components, how those components are combined constitutes structure, which is widely varied between breeds. In fact, dogs are the most varied species on earth. Variation in structure has developed through selective breeding for specific functions, and it is critical for the sports medicine and rehabilitation professional to be familiar with structure–function relationships. Of equal importance is an understanding of the ways in which each individual dog uses its body to perform specific tasks. Further, it is important to always consider other anatomical structures that might be affected as the dog compensates for a primary injury.

This prospect is made much more complex by the extreme variation in the structure of different breeds of dogs. Canine sports medicine and rehabilitation professionals can provide a significant service to their clients by helping them understand their individual dog's structural strengths and weaknesses for their chosen activities, how those structural components might comprise an advantage or disadvantage for the dog's activities, and what can be done to mitigate the potential for injuries (Zink & Schlehr, 2020).

For example, a Corgi and a Toy Poodle must navigate the same obstacles on an agility course—jumping the same height jumps and making the same turns, all with the same maximum allowed time—yet the Toy Poodle has a significant biomechanical advantage over the Corgi simply



FIGURE 1.5 A Corgi (A) and a Toy Poodle (B) have very different body weights and structures, yet both breeds have the same requirements in agility and obedience. (Source: Photos by Steve Surfman.)

because it weighs one-fifth as much (Figure 1.5). This does not mean that Corgis cannot be successful agility dogs—they are very successful—but it does mean that the client who plans to run a Corgi in agility should maintain his or her dog at peak fitness (particularly the core and pelvic limb muscles) and plan to train and compete intelligently, with the dog's heavyset structure in mind.

One way to evaluate the stresses on the musculoskeletal system of a dog is to calculate a dog's weight-to-height ratio using the following simple formula:

$$\text{Weight:Height (W:H) ratio} = \frac{\text{body weight (kg)}}{\text{height at the withers (cm)}}$$

This is a useful determinant of the amount of stress on a dog's body during running, jumping, and turning. For example, a typical male Golden Retriever's W:H ratio is $31.8/60 = 0.53$, while a male Corgi's W:H ratio is $13.6/27.5 = 0.49$. This suggests that, despite the obvious size differences in these two breeds, their musculoskeletal systems experience similar stresses. Clients with performance dogs that have a W:H ratio above 0.45 should be advised to train and compete as much as possible on surfaces that are nonslip and highly compressible to reduce the effects of repetitive strain on the musculoskeletal system.

STANDARDIZED POSITIONING

Evaluation of canine structure is best assessed by having the dog stand in a standardized position. Ideally, the dog should be placed in a standing position with the radius and ulna perpendicular to the ground, the metatarsals perpendicular to the ground, and the head held up with the muzzle pointing forward (Figure 1.6). This positioning provides a consistent picture with which to evaluate a dog's structure, either to compare the dog's structural features to the breed standard or to identify changes in structure over time. Changes in the dog's topline, such as lordosis or kyphosis, might indicate core muscle weakness or a spinal injury. Changes in limb angulation, asymmetries between thoracic or pelvic limbs, and off-loading of one limb can be more easily identified when dogs are positioned in a consistent way for evaluation.



FIGURE 1.6 Evaluation of canine structure is best assessed by having the dog stand in a standardized position (often referred to as being *stacked*). The dog should be standing with the radius and ulna perpendicular to the ground, metatarsals perpendicular to the ground, and the head held up with the muzzle pointing forward.

PELVIC LIMB STRUCTURE

Pelvic Limb Structure, Lateral View

Different breeds of dogs and individuals within those breeds can have substantial variation in the structure of the pelvic limbs. The most obvious differences in the pelvic limb structure of dogs are the angles at which the long bones meet one another when the dog is standing, a characteristic that is termed *pelvic limb angulation* or *rear angulation* by those who study and evaluate canine structure (Brown, 1986, pp. 36–39; Elliott, 2009, pp. 25–29; Zink & Schlehr, 2020). Pelvic limb angulation can readily be assessed by drawing an imaginary line perpendicular to the ground touching the ischiatic tuberosity. If the dog's rear toenails are within a half of the dog's foot length of touching that line, the dog has moderate pelvic limb angulation, which is ideal (Figure 1.7). If the dog's toenails are more than a half of its foot length caudal to that line, we consider the dog to have abundant rear angulation. Figure 1.8 illustrates two dogs of the same breed with substantially different pelvic limb angulation.

Dogs with abundant pelvic limb angulation can take longer strides with the pelvic limbs and thus expend less energy moving over a given distance because they take fewer steps. If they have sufficient strength of the pelvic limb musculature, abundant angulation can provide more power from the rear. However, excessive angulation often causes instability of the pelvic limbs, which saps power and drive from the rear (Figure 1.9).

If the dog's toenails are more than a half of its foot length cranial to that line, we consider the dog to have minimal rear angulation. Dogs with straighter pelvic limb angulation tend to be more accurate when placing their rear feet and tend to be able to turn more sharply than dogs with very angulated pelvic limbs. However, they also tend to have less power from the rear than dogs with moderate pelvic limb angulation and are more susceptible to CCL injury when torque is placed on the stifle.

For most performance dogs, moderate pelvic limb angulation is an ideal compromise. Regardless, appropriate pelvic limb muscle strength is needed to optimize each dog's genetically determined angulation because strong muscles are required to support the limbs in their angled positions. Dogs with weak pelvic limb musculature tend to have straighter pelvic limb angulation so that they can use the bones of the pelvic limb to support their weight.

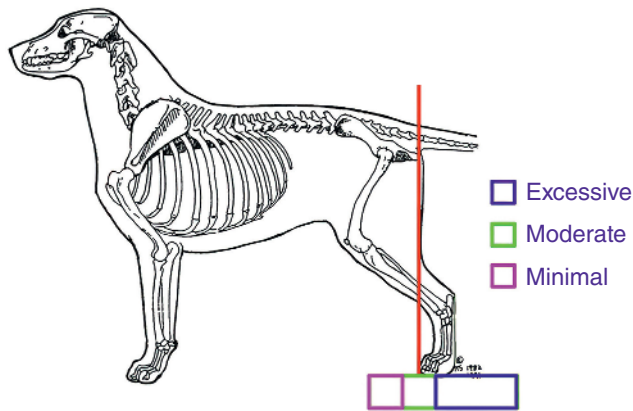


FIGURE 1.7 Pelvic limb angulation can be assessed by positioning the dog with the metatarsal bones perpendicular to the ground and then drawing a line perpendicular to the ground along the caudal aspect of the ischiatic tuberosity. For optimal function of the pelvic limbs, that line should pass within half of the dog's foot length cranial or caudal to the position of the dog's toenails. (Source: Zink and Schlehr (2020) / Frontiers Media S.A. / CC By 4.0.)

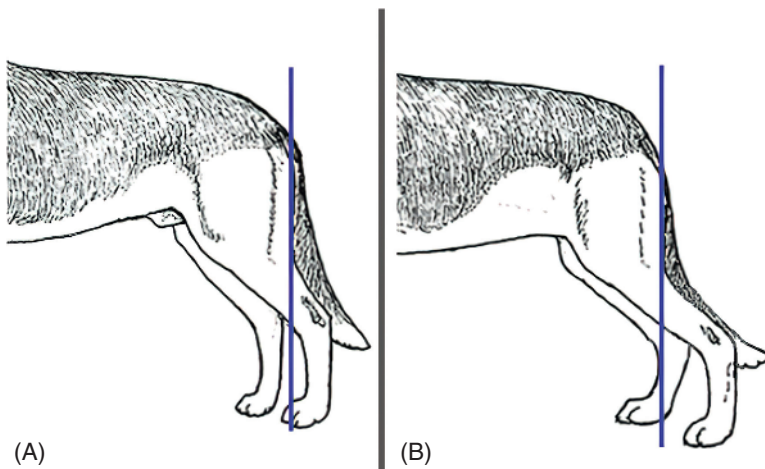


FIGURE 1.8 Comparison of different amounts of pelvic limb angulation. (A) Moderate pelvic limb angulation (B) and excessive pelvic limb angulation. (Source: Zink and Schlehr (2020) / Frontiers Media S.A. / CC By 4.0.)

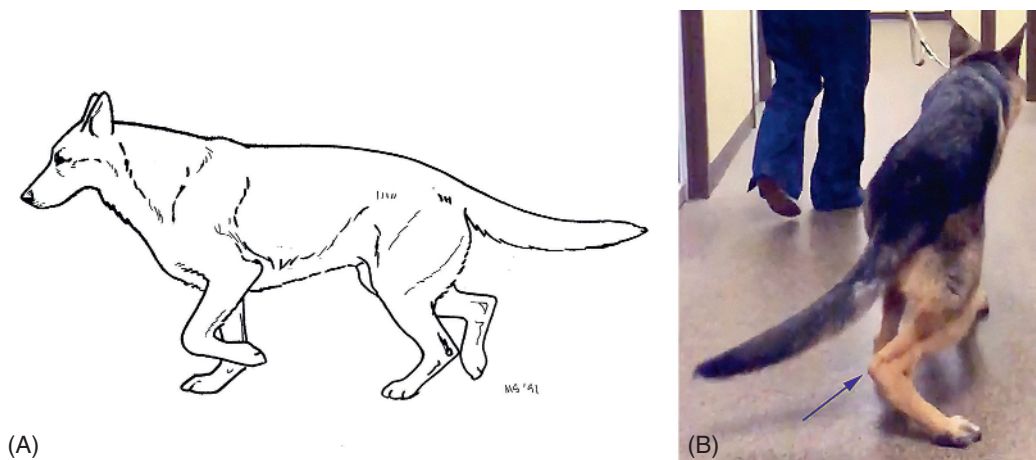


FIGURE 1.9 (A) Dogs with very angulated pelvic limbs often lack stability in the rear. (Source: Illustration by Marcia Schlehr.) (B) Image captured from a video of a 12-month-old, healthy German Shepherd Dog with excessively angulated pelvic limbs. (Source: Zink and Schlehr (2020) / Frontiers Media S.A. / CC BY 4.0.)

Some breeds of dogs have been bred for extreme pelvic limb angulation. One of these is the German Shepherd Dog of which many specimens have such extreme angulation that they are unable to stand in the standardized position. Instead, they must stand in a tripod position, with one pelvic limb in the standardized position with the metatarsals perpendicular to the ground and the other pelvic limb placed cranially under the body for better support. This extreme pelvic limb angulation causes the pelvis to drop, so that the dog's vertebral column is extremely sloped from cranial to caudal. Extreme pelvic limb angulation often cannot be compensated for by muscular strength, and when moving, these dogs frequently swing their tarsi lateral to medial each time the feet are planted. To the best of our knowledge, this extreme angulation provides no advantage in function. Any potential advantage in function is offset by instability. This breed tends to have laxity in many joints, which might reflect an inadvertent genetic drift toward increased extensibility of the tendons and ligaments.

CASE STUDY 1.2 Carpal Strain

SIGNALMENT

4 y.o. M/I German Shepherd Dog; 37 kg

HISTORY

Dog that works as a detection and apprehension police dog was chasing a suspect in an apartment complex when it leapt off a balcony 25 ft above the ground and landed on some shrubs. Dog was significantly lame on the left thoracic limb upon standing but it quickly became less severe as the dog kept moving. However, the lameness was again pronounced after a period of rest. Handler wanted the dog to be able to continue in his function as a police dog.

CLINICAL FINDINGS

Patient is in excellent physical condition, correct weight, well-muscled. Lameness was scored as 3/5 initially but decreased to a level of 1-2/5. The dog had the abundant angulation seen in many specimens of this breed. The left carpus was enlarged, with pitting edema present on the cranial aspect. Pain was elicited on palpation and flexion of the left carpus. Radiographs showed no fractures but subcutaneous swelling in a location consistent with the extensor tendons of the thoracic limb. MSK ultrasound revealed a grade II/III strain of the left extensor carpi radialis and of the left common digital extensor tendon.

DIAGNOSES

- Grade II/III strain of the left extensor carpi radialis
- Grade II/III strain of the left common digital extensor tendon

TREATMENT

Room rest for 2 weeks with bilateral carpal support wraps except when undergoing active rehabilitation exercises. Rehabilitation therapy consisted of laser therapy, therapeutic ultrasound, TENS, joint mobilizations, underwater treadmill walking (water at height of greater trochanter) to maintain musculature, and therapeutic exercises twice a week for 4 weeks. Carpus iced for 10 minutes after each rehabilitation and exercise period.

2-week recheck: Dog was walked twice daily with gradually increasing distances and speeds. Handler also performed daily gentle isometric, weight-shifting exercises as well as proprioception training including walking slowly forward and backward through a ladder placed flat on the ground as well as on a slight grade.

4-week recheck: Dog was walked slowly over uneven surfaces, up and down low steps, and through deep grass. The handler also introduced high-nines, down-to-sit-to-down, digging in blankets, sand, or water for a toy.

6-week recheck: Musculoskeletal ultrasound showed improved fiber pattern of both affected tendons. Patient started to work on progressively more difficult surfaces and was trotted for 5–10 minutes each day. At this time, patient was also used for detection work that required only mild-to-moderate exercise.

22-week recheck: Ultrasound of the left carpus showed normal tendon fiber structure and patient was cleared to return to work. The handler reported that the patient continued to perform

well but he chose to have patient wear carpal wraps when not working for the next 3 months.

COMMENTS

Hyperflexion and hyperextension injuries are not uncommon in German Shepherd Dogs. Understanding the unique structure of this breed helped the decision-making process during rehabilitation and was a significant component of the handler's decision to have the dog wear carpal wraps on an ongoing basis.

Pelvic Limb Structure, Caudal View

For most breeds, when viewing the pelvic limbs from the rear, the limbs should extend from the greater trochanter perpendicular to the ground, parallel to each other (Figure 1.10). An exception to this exists for many herding breeds, most notably the Border Collie. In these breeds, the pelvic limb frequently is externally rotated, so that the tarsi are positioned medially relative to the stifles and feet. This limb adaptation provides greater stability while herding as these dogs must lie down and stand up to reduce or increase, respectively, pressure on the sheep. Further, this pelvic limb conformation provides better contact of the toes with the ground when the dog needs to push off one pelvic limb when moving laterally in response to the sheep's movements. However, excessive external rotation of the pelvic limbs can result in the tarsi interfering with each other during the trot, which is inefficient. As with so many aspects of canine structure, moderation is ideal for optimal function.

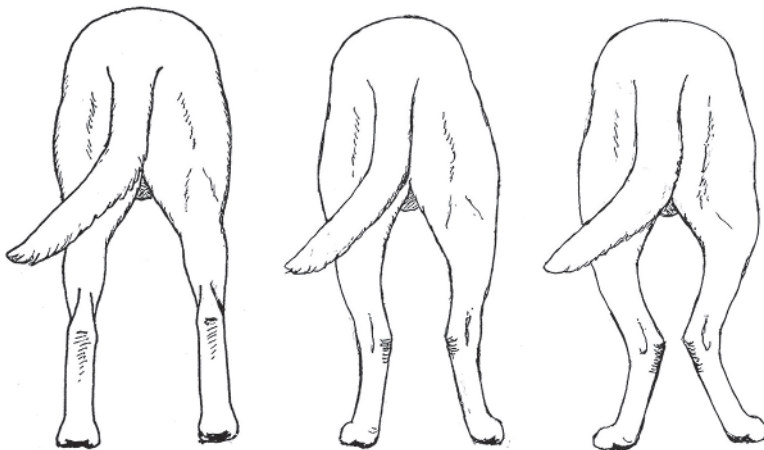


FIGURE 1.10 For most breeds, when viewing the pelvic limbs from the rear, the limbs should extend from the greater trochanter perpendicular to the ground, parallel to each other (left). The pelvic limbs of herding breeds often exhibit mild external rotation (center), but excessive external rotation (right) should be avoided. (Source: Zink and Schlehr (2020) / Frontiers Media S.A. / CC BY 4.0.)

THORACIC LIMB STRUCTURE

Thoracic Limb Structure, Lateral View

There are two different structural features to evaluate when assessing the angulation of the canine thoracic limb: the angle at which the scapula lies from vertical and the length of the humerus (Brown, 1986, pp. 34–36; Elliott, 2009, pp. 28–29; Zink & Schlehr, 2020). Each of these components appears to be inherited separately, and together they determine the efficiency with which the thoracic limb functions in the athletic dog.

Angle of the Scapula To evaluate thoracic limb angulation, the dog should be placed in the standardized, standing position described previously. The thoracic limb is highly mobile due to a lack of bony attachment to the trunk; by positioning the dog in this manner, the location of the thoracic limb relative to the spine is standardized for evaluation of thoracic limb angulation.

The angulation at which the scapula lies from vertical, also referred to as *shoulder layback*, is determined by measuring the angle between a line drawn perpendicular to the ground through the cranial aspect of the greater tubercle of the humerus and another line drawn from the cranial aspect of the greater tubercle of the humerus to the highest point of the dorsal rim of the scapula as in Figure 1.11. Cineradiographic images have determined that ideally this angle should be 30° (Elliott, 2009, pp. 28–29).

Dogs with greater angle of the scapula relative to vertical can extend the shoulder joint further and thus take longer steps with each thoracic limb, expending less energy when moving over a given distance. In addition, they tend to have more muscle development, particularly of the supraspinatus, infraspinatus, and triceps muscles, and less concussion on the shoulder joint particularly when landing with the limb in extension because the shoulder can better withstand eccentric contraction and absorb the shock (Figure 1.12). This is thought to reduce the risk of the most common repetitive strain injuries of the shoulder, biceps, and supraspinatus tendinopathy.

Length of Humerus A second structural variable of the canine thoracic limb is the length of the humerus. Ideally, the humerus should be long enough so that the elbow joint and thus the radius and ulna are positioned well under the body to better support the weight of the head, neck, and

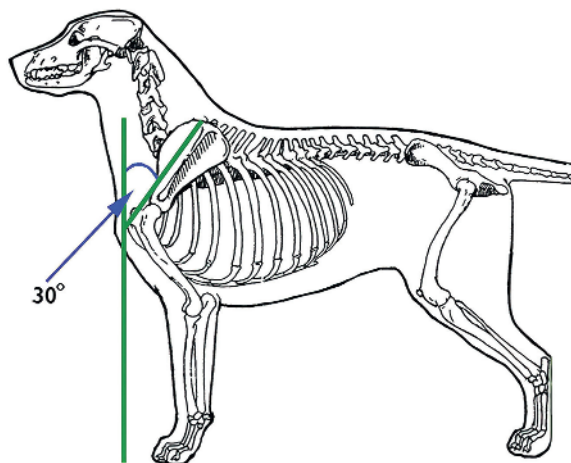


FIGURE 1.11 The angle of the scapula is determined by estimating the angle between a line perpendicular to the ground that passes through the cranial-most aspect of the greater tubercle of the humerus and a line between the cranial aspect of the greater tubercle that extends to the dorsal-most aspect of the dorsal rim of the scapula. Ideally this angle should be 30 degrees (arrow). (Source: Zink and Schlehr (2020) / Frontiers Media S.A. / CC By 4.0.)



FIGURE 1.12 Appropriate shoulder angulation results in less concussion when a dog lands with the thoracic limb in extension. (Source: Photo by Richard Knecht.)

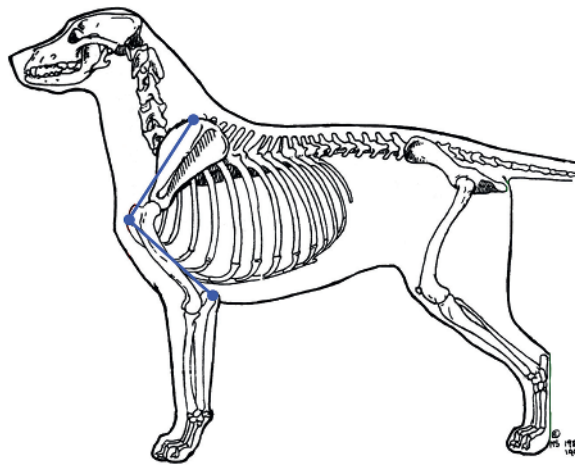


FIGURE 1.13 If a dog has a correct length humerus, a line from the dorsal-most point of the scapula to the cranial-most aspect of the greater tubercle of the humerus should be equal in length to a line drawn from the greater tubercle of the humerus to the top of the olecranon process. (Source: Zink and Schlehr (2020) / Frontiers Media S.A. / CC By 4.0.)

thorax. If a dog's humerus is of the optimal length, a line from the dorsal-most point of the dorsal rim of the scapula to the cranial aspect of the greater tubercle of the humerus should be equal in length to a line drawn from the cranial aspect of the greater tubercle of the humerus to the olecranon process (Figure 1.13). Note that these two lengths do not actually reflect the lengths of the scapula and humerus because the lines of measurement cross both the shoulder and elbow joints. However, as long as the dog is standing correctly, these measurements provide a useful rule of thumb to assess the relative lengths of these bones.

Another way to evaluate humeral length is to draw a vertical line through the center of the radius and ulna when the dog is in the standardized position. This line should intersect with the dog's topline at the junction of the neck and the back. When a dog has a short humerus, the entire

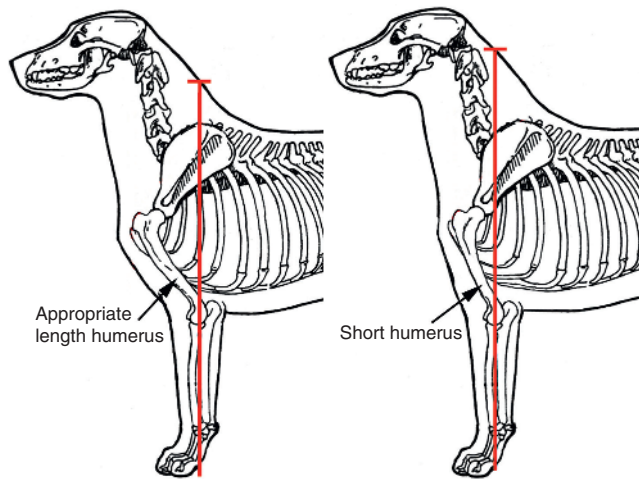


FIGURE 1.14 In a dog with an appropriate length humerus, a vertical line drawn through the radius and ulna intersects with the dog's topline at the junction of the neck and back. In a dog with a short humerus, that line intersects with the topline further cranially. (Source: Zink and Schlehr (2020) / Frontiers Media S.A. / CC By 4.0.)

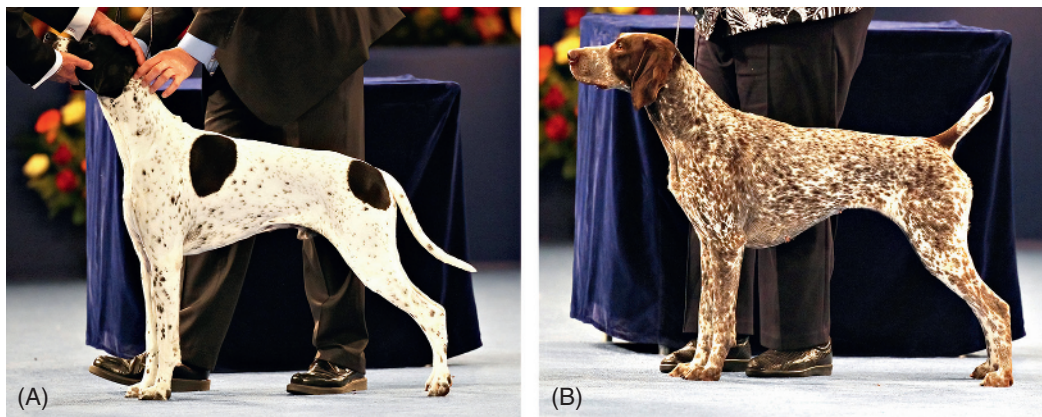


FIGURE 1.15 Two dogs with contrasting humeral length. (A) A Pointer with a short humerus, resulting in the distal thoracic limb being positioned too far cranially, and (B) a German Short-Haired Pointer with appropriate length of humerus. (Source: Photo by Steve Surfman.)

distal limb is positioned more cranially, resulting in a line that intersects the topline further cranially along the neck (Figure 1.14).

Dogs with a humerus of the optimal length have less concussion, particularly on the elbow joint, and tend to have more well-developed thoracic limb muscles. To the extent that both scapular angle and humeral length deviate from ideal, thoracic limb function will be compromised. Two dogs with contrasting thoracic limb structure can be seen in Figure 1.15.

Thoracic Limbs, Cranial View

When viewed from the front, the standing dog's thoracic limbs should form a straight line perpendicular to the ground from the foot to the body, with minimal bend at carpus or elbow as seen in Figure 1.16 (left). When the thoracic limbs are not straight when viewed from the front, as in the dog on the right in Figure 1.16, which demonstrates bilateral carpal valgus deformities,

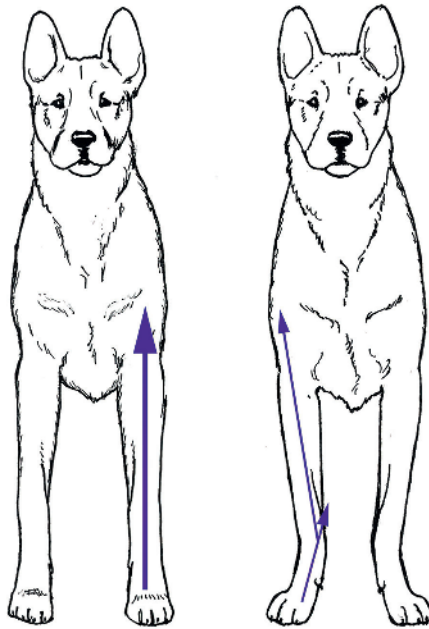


FIGURE 1.16 When viewed from the front, the thoracic limbs should form a straight line perpendicular to the ground (left). Angled limbs (right) dissipate the power output during movement (arrows). (Source: Zink and Schlehr (2020) / Frontiers Media S.A. / CC By 4.0.)

the same amount of muscular effort results in dissipation of the power output on movement. In addition, this can increase stress on the medial collateral ligaments and the tendons that support the joint.

In the relaxed standing dog, it is normal for the thoracic limbs to be slightly externally rotated with the feet positioned with the toes pointing slightly laterally. It is believed that this provides stability for the standing dog, just as externally rotated feet do in the standing human. This should not be confused with the valgus deformity seen on the right in Figure 1.16. When the dog gaits, the thoracic limbs internally rotate on their axes and the feet strike the ground with the toes pointing cranially, providing the most efficient grip on the ground and transfer of power to the body. In contrast, when a dog with valgus deformity gaits, the foot remains externally rotated and the carpal deformity persists.

Limb angulation is not a static feature of dogs; angulation can change in response to injury and level of fitness. Dogs with injuries to the thoracic or pelvic limb generally tend to straighten the limbs, letting the bones take over more of the function of supporting the limbs. In addition, dogs that are not optimally conditioned will have reduced angles in the thoracic and/or pelvic limbs because they do not have the muscular strength to fully support the limb in the optimally angled position. One way to monitor progress during rehabilitation after an injury is to observe the improvement in angulation of the limbs when the dog is standing in the standardized position.

BALANCED ANGULATION

The thoracic and pelvic limbs should have approximately equal, or balanced, angulation. This is important for coordination of movement, particularly at the trot, when diagonally opposite thoracic and pelvic limbs strike the ground at the same time (see Chapter 2). If the thoracic limbs,

for example, have less angulation than the pelvic limbs, they will have a shorter stride length and therefore a shorter cycle time than the pelvic limbs, making it difficult for diagonally opposite limbs to strike the ground at the same time. In addition, less angulated limbs are generally less muscular than more angulated ones. The most common form of lack of balance is when dogs have less thoracic than pelvic limb angulation (Figure 1.17).

As is evident from the previous discussions, there are both advantages and disadvantages to the different structural variations in dogs. A summary of the effects of different structural extremes on the function of active dogs is provided in Table 1.5.

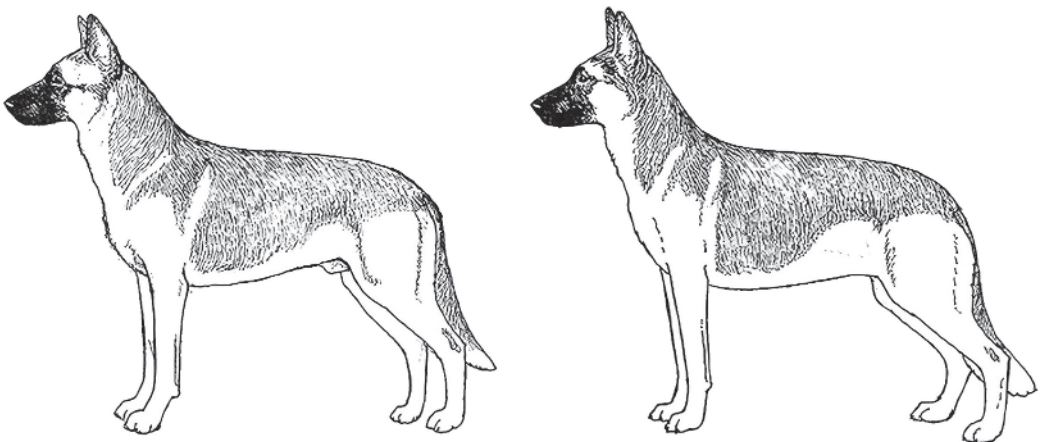


FIGURE 1.17 Balanced angulation in a Belgian Malinois (left). The dog on the right is out of balance, with less thoracic limb angulation than pelvic limb angulation. (Source: Zink and Schlehr (2020) / Frontiers Media S.A. / CC By 4.0.)

Table 1.5 Canine structure–function correlates

Structure		Function	
		Advantages	Disadvantages
Thoracic Limb	Upright scapula	Head held higher in conformation	Shorter stride length, so more steps required to cover ground Increased concussion, particularly on shoulder joints More repetitive stress injuries to shoulder More effort required to clear higher jumps
	Short humerus	None	Shorter stride length (slower) Increased concussion, particularly on the elbow joints
Pelvic Limb	Minimal rear angulation	Able to turn faster	More torque on the stifle
	Excessive rear angulation	Longer stride lengths, so fewer steps to cover ground	Slower turns Less accurate foot placement due to rear limb instability More torque on the coxofemoral joint More hyperextension injuries

THE FEET

The shapes of dogs' feet vary depending on their original function. Dogs whose original function was to move over rocky or uneven ground tend to have *cat feet*, in which the first phalangeal bones of digits II–V are of equal length causing the toes to form an arch around the central pad (Figure 1.18A). These feet are analogous to the knobby tires of an all-terrain vehicle, which have improved grip on uneven surfaces when moving forward and turning.

In contrast, dogs whose original function was to run in straight lines tend to have elongated or *hare feet* (Figure 1.18B), in which the first and second phalanges of the third and fourth digits are longer than those of the second and the fifth. This shape of foot provides an advantage when running straight, analogous to the slick tires of a race car. The sports medicine and rehabilitation professional should be aware of variations in foot shape and should not assume that dogs with hare feet, which are less common, are abnormal.

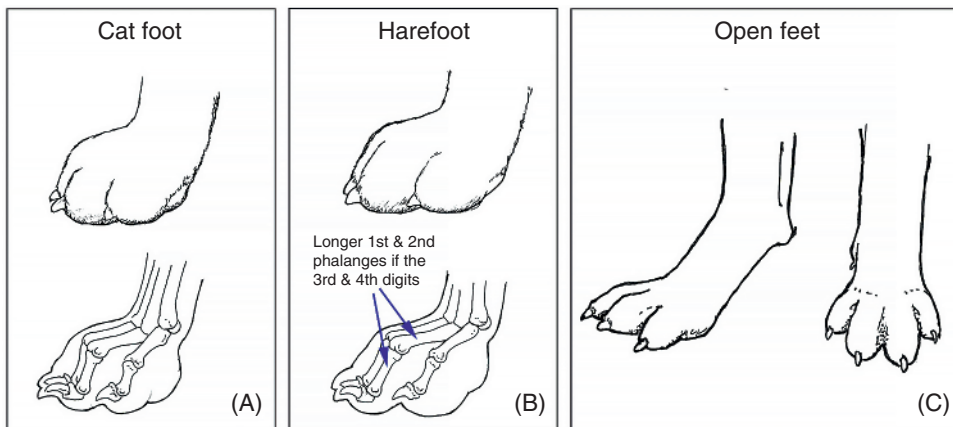


FIGURE 1.18 (A) A catfoot in which the first phalanges all are of equal length and the toes form an arch around the central pad. (B) A harefoot in which the first and second phalanges of digits III and IV are longer than those of digits II and V. (C) Open feet in which the phalanges are flattened and spread out. (Source: Zink and Schlehr (2020) / Frontiers Media S.A. / CC By 4.0.)

Due to the insertion of the superficial digital flexor tendon on the second phalanx, the dog's toes are sprung, allowing for absorption of impact. Chronic stretch of the superficial digital flexor tendon of one or more toes can change the overall shape of the foot, often flattening the position of the phalanges, resulting in increased concussion. Further, many older dogs and dogs of certain breeds such as the German Shepherd Dog have *splayed* or *open* feet (Figure 1.18C), in which the toes are flat and separated, forming a fan shape. These feet do not help reduce concussion and can predispose dogs to repetitive strain injuries of the more proximal limb structures.

THE DEWCLAWS

Many dogs have their front dewclaws removed at approximately three days of age in the belief that dewclaws are nonfunctional digits and out of concern that they might become injured in active dogs. Breeders who compete in conformation often believe that the removal of these digits makes the legs appear straighter when viewed from the front.

The front dewclaws appear to be nonfunctional when the dog is in a standing position because they are not in contact with the ground. However, the dewclaws do contact the ground when dogs are cantering or galloping, particularly when in contact with the ground where it can help stabilize the thoracic limb, reducing torque on the carpus and proximal limb when the dog is turning (Figure 1.19). Examination of structures associated with the front dewclaws substantiates that these are functioning digits. There are four tendons that connect the dewclaw to the muscles of the limb



FIGURE 1.19 When a dog's lead leg is on the ground during the gallop or canter, the dewclaw is in contact with the ground and acts to stabilize the carpus if the dog turns. Here a Corgi's dewclaw can be clearly seen touching the ground while turning during herding activity.

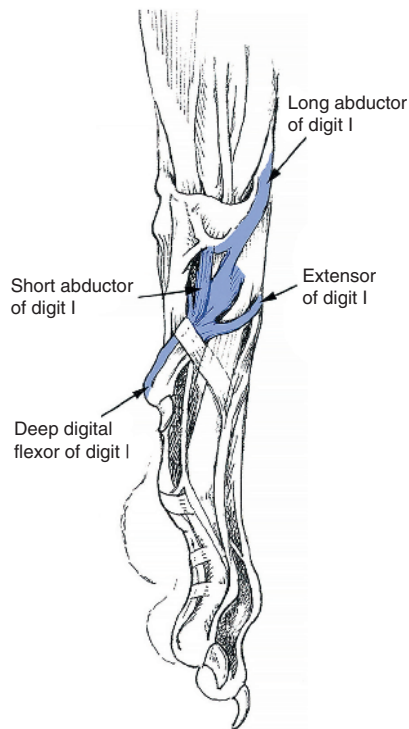


FIGURE 1.20 Anatomical diagram of the medial side of the canine left thoracic limb demonstrating the tendons that connect with the dewclaw. These tendons, with their associated muscles, confirm that the dewclaw is a functioning digit. (Source: Zink and Schlehr (2020) / Frontiers Media S.A. / CC By 4.0.)

(Figure 1.20) demonstrating that this digit does in fact have a function. Further, one study showed that in dogs competing in agility, the dewclaw is the least likely toe to be injured and that dogs that have had their dewclaws removed are more likely to injure the other digits (Sellon *et al.*, 2018).

The dewclaws can function to save a dog's life. When dogs slip through the ice of a pond (or intentionally go swimming in water with ice-covered areas), they can only lift themselves out of the water and onto the ice by using dewclaws to function as little ice picks on the medial side of each leg to dig into the edge of the ice (Figure 1.21).



FIGURE 1.21 The dewclaws help a dog lift itself out of water onto ice. By rotating the legs medially, the dewclaws act as little ice picks to grip the ice and pull the dog out of the water. (Source: Illustration by Marcia Schlehr.)

Virtually all wild carnivores have front dewclaws, providing further evolutionary proof that they have a function. Note, however, that dewclaws on the pelvic limb are almost always vestigial and should be removed within a few days of birth, except in those breeds such as the Great Pyrenees, Beauceron, Icelandic Sheepdog, Briard, and a few others for which the breed standards specify the presence of rear dewclaws.

THE TAIL

The tail provides a counterbalance for dogs when they turn, either when running or swimming. It also helps raise the dog's rear after the apex of trajectory of a jump, thus rotating the dog's front end downward, so that the dog will land on its front feet. Dogs use whatever length of tail they have for a counterbalance. The shorter the tail is docked, the more acute the angle at which the tail is bent laterally on turning. Dogs that have completely docked tails, such as Rottweilers and Australian Shepherds, angle their bodies sideways when turning, banking into turns like a racecar (Figure 1.22). The potential long-term physical effects of this accommodation on the limbs and vertebral column are not known.



FIGURE 1.22 Differences in the way that dogs with a tail (A) and without a tail (B) angle their bodies when turning. (Source: Photo by SpotShots.)

HISTORY TAKING FOR THE CANINE ATHLETE AND WORKING DOG

Because of the variety of activities in which canine athletes and working/assistance dogs participate, canine sports medicine veterinarians and rehabilitation professionals should query the client in detail about specific aspects of the patient's training and competition for the sports or jobs in which the patient participates. The following are some items of additional information that should be gathered when taking the history of a canine athlete.

AGE AT WHICH TRAINING WAS INITIATED

It is important that the bodies of young puppies not be stressed inappropriately with high or repetitive impact stress. A history of early skill training might suggest the presence of repetitive strain.

GONADECTOMY STATUS

Several orthopedic conditions are more prevalent in gonadectomized dogs, sometimes regardless of the age of gonadectomy. These include osteosarcoma (Priester & McKay, 1980; Ru *et al.*, 1998; Cooley *et al.*, 2002; Hart *et al.*, 2016; Hart *et al.*, 2020a, 2020b), CCL insufficiency (Whitehair *et al.*, 1993; Duval *et al.*, 1999; Slauterbeck *et al.*, 2004; Duerr *et al.*, 2007; Hart *et al.*, 2014, 2016, 2020a, 2020b; Simpson *et al.*, 2019; Waters *et al.*, 2023; DeForge *et al.*, 2024; and Moxon *et al.*, 2025), hip dysplasia (Spain *et al.*, 2004; van Hagen *et al.*, 2005; Hart *et al.*, 2014, 2016, 2020a, 2020b), elbow dysplasia (Hart *et al.*, 2020a, 2020b), patellar luxation (Vidoni *et al.*, 2005), and osteoarthritis (Simpson *et al.*, 2019; Graves *et al.*, 2023). Several behavioral conditions also are more prevalent in gonadectomized dogs, such as fear of storms, separation anxiety, fear of noises, fear of gunfire, timidity, excitability, submissive urination, aggression, hyperactivity, and fear biting (Zink *et al.*, 2014; Farhooody *et al.*, 2018). Several other neoplasias (Zink *et al.*, 2014; Kent *et al.*, 2018; Hart *et al.*, 2016, 2020a, 2020b) and immune disorders (Sundberg *et al.*, 2016) are reported to have a higher incidence in gonadectomized dogs.

AGE AT WHICH THE DOG WAS SPAYED OR NEUTERED

Dogs that are gonadectomized before puberty grow to be taller (Salmeri *et al.*, 1991). This growth can be disproportionate given that the growth plates close at different ages, potentially predisposing the prepubertally gonadectomized dog to orthopedic injuries.

ATHLETIC/WORKING EVENTS IN WHICH THE DOG PARTICIPATES

This provides information on the specific types of physical actions that the patient undertakes during training, competition, and just for fun.

NUMBER OF EVENTS IN WHICH THE DOG COMPETES, HIGHEST TITLES ACHIEVED IN ATHLETIC EVENTS, LEVEL AT WHICH THE DOG IS CURRENTLY COMPETING

This provides an estimate of how much training and competition the dog has experienced, the total amount of work the dog has performed at its age, and the amount of repetitive strain on the dog's musculoskeletal system.

ORGANIZATIONS UNDER WHICH THE DOG COMPETES

Different organizations can have widely varying athletic requirements. Knowing the organization under which the dog competes provides information on intensity of the dog's physical activities.

DIFFICULTIES IN PERFORMANCE EVENTS

This can provide information about a specific problem that the dog is experiencing that might not be obvious during a physical examination. Dogs that knock bars when jumping, for example, often have issues that affect the pelvic limbs such as iliopsoas strain. Dogs that have difficulty entering or finishing the agility weave poles may have subtle injuries to the thoracic limbs, particularly the shoulders.

AMOUNT AND TYPE OF EXERCISE THE PATIENT EXPERIENCES IN A TYPICAL WEEK

The client should be asked for specific details about how much strength, endurance, proprioception, flexibility, and skill training the patient undertakes during an average week. This gives the clinician an idea of the knowledge of the client about exercise, the commitment of the client to the patient’s success in athletics, and potentially the amount of concussion the dog experiences.

DIET AND SUPPLEMENTS

It is important to be sure that the patient is being provided with evidence-based nutrition and supplements that are appropriate for its physical tasks. Obtaining this information also provides the canine sports medicine and rehabilitation professional with information regarding the level of knowledge and commitment of the client, since developing a strong base of knowledge regarding nutrition generally requires time and commitment.

GOALS FOR THE DOG

This information helps the sports medicine and rehabilitation professional direct their clinical efforts toward the client’s goals. For example, a conditioning program designed for a dog whose owner/handler wants to do agility for fun and relaxation would be quite different from that of an aspiring world-class competitor.

WEBLIOGRAPHY

^aQuarter Moon Goldens (2012). Video demonstrating how dogs use their dew claws to safely exit icy waters.

<https://www.youtube.com/watch?v=r4XflsMEk-k> (accessed April 25, 2024).

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