1 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 toward prevention of future injury, is a critical partner to 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 re-injury 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 for retraining them to perform their specific duties. This is best accomplished by attending athletic/working dog training sessions and competitions.

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). 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

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beginning after World War II, there has been an exponential growth in the number of sporting events devised by people to challenge their abilities to train their dogs for competition. The field of canine sports medicine began with veterinarians working predominantly with racing Greyhounds. Veterinarians now work with dogs that participate in dozens, if not hundreds, of different canine sports and working roles.

Canine sports medicine is the branch of veterinary medicine 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 (Box 1.1), and encourages significant collaboration between individuals with different areas of expertise. In addition, canine sports medicine is intimately linked to canine rehabilitation, where veterinarians, physical therapists, and veterinary technicians have an opportunity to work together to return injured canine athletes and working dogs not only to health but to full performance.

There are many advantages for veterinarians and rehabilitation professionals working with canine athletes and working dogs (Box 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.

Box 1.1 Fields included in canine sports medicine

- Anatomy and biomechanics
- Exercise physiology
- Sports conditioning
- Rehabilitation
- Orthopedics
- Internal medicine
- Pulmonology
- Cardiology
- Neurology
- Gerontology
- Nutrition
- Integrative medicine

Box 1.2 Advantages of working with clients with canine athletes and working dogs

- 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 have teams consisting of health professionals with diverse expertise who work on maintaining and regaining the athletes' health and fitness. Canine sports medicine and rehabilitation professionals likewise play a pivotal role in helping the clients with canine athletes and working dogs to 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 physical condition.

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 the professional to develop relationships with clients that last through generations of dogs.

Canine athletes and working dogs often enter the rehabilitation program at a much healthier level and 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. Clients with canine athletes and working dogs are generally enthusiastic about participating in studies that will help provide information that they can use to become more efficient in training and more successful in competition 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 between $80,000 and $100,000 for a dog that had a single Best in Show win, and $250,000–500,000 for a dog that has won more than 100 Best in Show awards (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 per year to have professional handlers train and compete with their dogs. Most agility 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 agility competitors will spend $10,000–25,000 per 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 clients with canine athletes and working dogs. As a result, they 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 to their fullest potential.

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

In addition, an understanding of the 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 duties. This is best accomplished by attending athletic/working dog training sessions and competitions. Local competitions can readily be found by searching the Internet. The sports medicine/rehabilitation professional is strongly encouraged to attend local training and practice sessions for a variety of sports and working functions. Clients' videos and photos of their dogs working or training often capture evidence of potential tissue stresses that can lead to injury.

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, working 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 who can communicate with them about that work.

Types of canine performance and working activities

Canine sports and pleasure activities

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, and tracking.

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

This chapter provides brief information on only a few of the most popular and most physical canine sporting events. However, Table 1.1 provides a comprehensive list of popular companion

Table 1.1 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/
Obedience	A sport in which judges instruct handlers to have their dogs perform a number of 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 to 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/index.cfm
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 small hurdles 10 ft apart, retrieve a ball that is ejected by pressing a pedal on a box, then return over the hurdles	www.flyball.org/
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 http://usddn.com
Dock diving	A game in which dogs compete by jumping for distance from a dock into a body of water	http://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 nosework	A sport in which dogs search rooms, containers, a vehicle, and an outdoor area for a specific scent	www.funnosework.com/ https://www.nacsw.net
Barn hunt	A sport in which dogs hunt and find rats safely concealed in ventilated PVC tubes that are hidden among bales of straw	https://barnhunt.com
Performance events		
Lure coursing	A sport in which dogs chase white plastic bags (to imitate prey) that are moved along the ground by a battery-operated string and pulley system	http://www.akc.org/events/lure-coursing/ www.akc.org/events/lure_coursing/ www.asfa.org/
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 parimutuel betting	en.wikipedia.org/wiki/Greyhound_racing
Herding	A competition in which herding breeds herd sheep, cattle, or ducks over a specified course and move selected animals into a pen	www.usbcha.com/ www.akc.org/events/herding/

Table 1.1 (*Continued*)

Sport	Brief description	Website(s) and description
Field trials/ hunt tests	Sports in which retrievers, setters, pointers, spaniels, and poodles retrieve upland gamebirds on land and in water	www.akc.org/events/hunting_tests/retrievers www.akc.org/events/hunting-tests/pointing-breeds www.akc.org/events/hunting_tests/spaniels www.akc.org/events/field_trials/beagles/
Earthdog tests	A test in which terriers and Dachshunds run through underground tunnels to find a caged rat	http://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 coonhounds	www.akccoonhounds.org/
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
Schutzhund, French ring sport	Competitions that combine obedience, tracking, and protection work	en.wikipedia.org/wiki/Schutzhund https://www.germanshepherddog.com/about/schutzhund-training/ http://www.ringsport.org/index.php?pg=ringsport
Mushing	An endurance competition in which dogs pull sleds (or land rigs) over a specified course, which may vary from 1 to 1150 miles	https://en.wikipedia.org/wiki/Mushing
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

and performance events with websites that provide a wealth of additional information.

Agility

Agility is an international sport in which owner/handlers direct dogs over a course consisting of 15–20 obstacles, including jumps (Figure 1.1), tunnels, weave poles, seesaws, A-frames, dog walks, sometimes tables, 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 rubberized flooring. The handler can walk the course ahead of time to determine strategies to compensate for differences in his or her own running speed versus that of his or her dog, and for the different physical and training strengths and weaknesses of the handler and the dog. The height that agility dogs are required to jump is determined by their height at the withers (a point just cranial to the highest point

Figure 1.1 Dog jumping during agility competition.

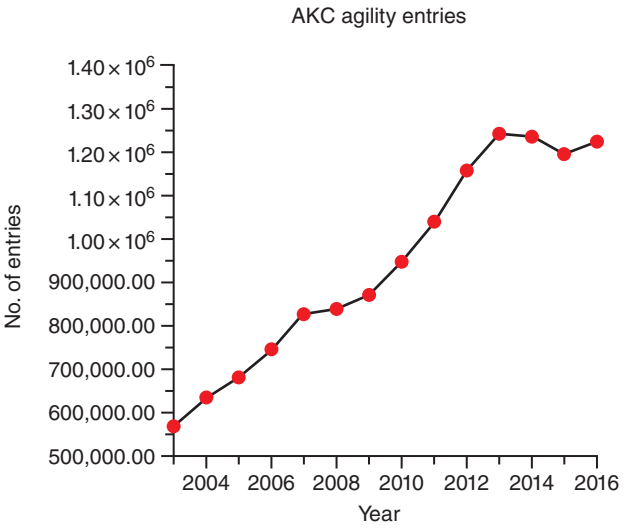


Figure 1.2 The number of entries in American Kennel Club agility trials increased steadily until 2013, when it leveled off, in part due to increased numbers of other organizations holding agility trials and an increasing number of other sports available for dogs. Source: Data from American Kennel Club. Available at: http://www.akc.org/events/agility/statistics/

of the dorsal rim of the scapula). Depending on the organization, dogs can compete in agility as early as 15 months of age, and as a result they begin training at an inappropriately young age.

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; Figure 1.2). There are dozens of organizations that host agility events internationally, including the AKC, the Canadian Kennel Club, the Kennel Club (United Kingdom), the United States Dog Agility Association, the UK Agility International, the Agility Association of Canada, the United Kennel Club, the Fédération Cynologique Internationale, the North American Dog Agility Council, Canine Performance Events, Teacup Dog Agility Association, Australian Shepherd Club of America, and Dogs on Course North America.

Since the sport of agility involves speed and jumping, agility dogs commonly suffer injuries to the soft tissues, including those to the thoracic limb (especially the shoulder, such as biceps and supraspinatus tendinopathies and medial shoulder syndrome), and to the pelvic limb (particularly the hips and stifles, such as iliopsoas strain and cranial cruciate ligament (CCL) insufficiency) (Levy *et al*., 2009; Cullen *et al*., 2013).

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 people 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 both 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 1.3), sitting when stopped, coming when called, lying down when asked, and staying in position in the presence of other dogs when the handler is about 50 feet away or out of sight. Higher levels of obedience competition include retrieving a dumbbell or a glove when directed, jumping various styles of jumps, selecting a dumbbell with the handler's scent from a group of dumbbells scented by someone else, and

Case Study 1.1 Carpal strain

Signalment: 4-y.o. M/I German Shepherd Dog that works as a detection and apprehension police dog.

History: Dog was chasing a suspect in an apartment complex when it leapt off a balcony 25 feet above the ground and landed on some shrubs. Dog was significantly lame upon standing but the lameness became less severe over the next minute or two if the dog kept moving. However, the lameness was again pronounced when the dog started moving 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 a large German Shepherd Dog in excellent physical condition, at a correct weight, and well-muscled. On presentation, lameness was scored as 3 on a scale of 6. After 3 minutes of walking, the lameness decreased to a level of 1 to 2. The dog had the typical abundant angulation that is 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.

Diagnosis: Left carpus—strain of the extensor carpi radialis and the lateral and common digital extensor tendons.

Treatment: Room rest for the initial 2 weeks of rehabilitation therapy with bilateral carpal support wraps at all times throughout the rehabilitation period, except when undergoing active rehabilitation exercises. Patient treated with laser therapy, TENS, joint mobilizations, underwater treadmill walking to maintain musculature, and therapeutic exercises twice a week for 4 weeks. Beginning 2 weeks after the initiation of therapy, the dog was walked twice daily with gradually increasing distances and speeds. Handler also performed daily proprioception training including walking slowly forward and backward through a ladder placed flat on the ground as well as on a slight gradation. Carpus iced for 10 minutes after each rehabilitation and exercise period. Four weeks after initiation of therapy, handler began to walk patient slowly over uneven surfaces, up and down low steps, and through deep grass. By 6 weeks post-injury, patient began to work on progressively more difficult surfaces and was trotted for 5 to 10 minutes each day. At this time, patient was also used for detection work that required only moderate exercise. By 8 weeks after the injury, patient went back to work and performed well. Handler 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.

staying in place in the presence of other dogs when the handler is out of sight.

Obedience dogs that are campaigned heavily in the sport most commonly experience chronic strain injuries to the shoulders, such as supraspinatus tendinopathy. This especially 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 waiting for the judge's orders, the competitor proceeds around a course of 10 to 20 designated stations with the dog in heel position. At each station, a sign provides instructions regarding the specific exercise required of the dog. In contrast to obedience competition, in rally trials handlers are allowed to verbally encourage their dogs while on course. Due to the non-concussive nature of this sport, injuries are uncommon.

Conformation

Conformation is a competition in which a judge evaluates individual purebred dogs for how

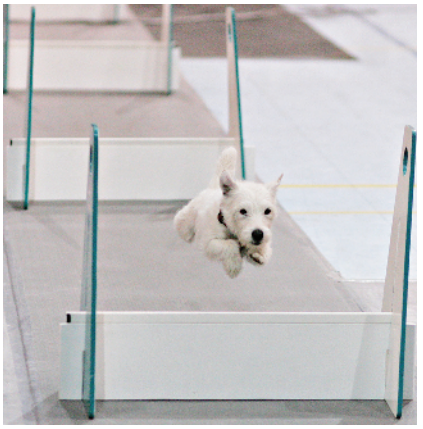
Figure 1.3 Dog heeling during obedience competition. Note the position of the dog's head as it watches the handler, ready to change directions when necessary, always staying in heel position at the handler's left side.

closely the dog conforms to the established standards for its breed. A conformation dog show is not a comparison of one dog with another, but rather a comparison of each dog with the dog's written and illustrated breed standard. The judge evaluates dogs both in a standing position and at a trot. The number of entries annually in this performance event is in the millions.

Flyball

Flyball began as a sport in California in the late 1960s and early 1970s and quickly spread to become an international pastime. In this sport, two teams of four dogs race against each other from a start/finish line, over four jumps placed 10 feet apart to a box that releases a ball to be caught when the dog presses a spring-loaded pad; the dogs then race back over the jumps to their handlers while carrying the ball (Figure 1.4). Two teams run in a heat against each other, with the winning 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 December 2016 was 14.18 seconds. Thus, each dog ran the 102-ft course in an average of 3.545 seconds. This suggests that the dogs are running at over



(A)

(B)

Figure 1.4 **(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: Photos by Steve Surfman.

30 mph when they hit the box. In a typical tournament, dogs might participate in over 25 heats per 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 and/or supraspinatus tendinopathy, medial shoulder syndrome, coxofemoral arthritis, and iliopsoas strain.

Field trials/hunt tests

Field trials and hunt tests require dogs to retrieve upland game birds, such as duck and pheasant, on land and sometimes water, simulating hunting situations where dogs find and retrieve shot birds for hunters (Figure 1.5). Field trials are 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 less complex 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).

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.

Figure 1.5 Golden Retriever returning to handler after retrieving a duck during a hunt test. Source: Photo by Steve Surfman.

Working dog activities

A vital aspect of canine sports medicine and rehabilitation is working with dogs that perform critical functions for society, including police dogs, detection dogs, search and rescue dogs, and service dogs (Table 1.2). 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 handlers.

When dealing with a working dog, it is important for the canine sports medicine and rehabilitation professional to ask the handler to describe the specific activities his or her dog must perform as a part of its duties, since the work that these dogs do varies tremendously

Table 1.2 Working dog activities

Category	Type of work
Search and rescue	Wildland Urban Cadaver Avalanche
Detection	Drugs Explosives Food 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

between jurisdictions. 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 examine the equipment the dog wears while at work. Some dogs may wear only a collar for their work, while others may 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 experience injuries and disorders that are often 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 gracilis myopathy, which is seen most often in German Shepherd Dogs (Steiss, 2002). For detailed information on working dogs and their injuries, see Chapter 21.

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 longer periods of time. It is easy to see that the majority of 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 musculoskeletal health for all dogs.

Canine structure and its effects on performance

With each performance and working task come 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 (Miller *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 those structure/function relationships that this chapter addresses. Of equal importance to those working with the performance or working dog is an understanding of the ways in which an individual dog uses those structures to perform its particular job. It is also important to be conscious of 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. 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 because it weighs one-fifth as much (Figure 1.6). This does not mean that Corgis cannot be successful agility dogs—they are, in fact, 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 heavy-set structure in mind.

Somatotypes

The concept of somatotype (overall body type) in humans was originally popularized by Dupertuis and Sheldon (1947). They described

Figure 1.6 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.

three body types based on height, leg length, and mass: ectomorphic, endomorphic, and mesomorphic. A similar categorization can be made in dogs. Ectomorphic dogs tend to have a smaller bone structure and be light in mass relative to their height. A key structural feature of these dogs is that the distance between the ground and the olecranon process is greater than the distance from the olecranon process to the dorsal rim of the scapula when the dog is standing with radius and ulna perpendicular to the ground. This added length of the distal limb raises the dog's center of gravity and gives it an advantage by giving it a longer stride length and greater ease in jumping. However, this higher center of gravity also causes these dogs to be less agile at turning, just as a Volkswagen bus has poorer cornering ability than a Corvette. Typical ectomorphic breeds include most of the sighthounds, Weimaraners, German Short-Haired Pointers, Belgian Tervuren and other long-legged, lighter breeds.

At the other extreme, the endomorphic breeds tend to carry more weight on their frame. This group includes all of the chondrodystrophic dwarfs, which have foreshortened limbs, as well as Clumber Spaniels, Newfoundlands, and other heavy-set breeds. The distances from the ground to the olecranon process and from the olecranon process to the dorsal rim of the scapula are typically equal in these breeds, even in the chondrodystrophic dwarfs. Because of their relatively heavier weight, these dogs have a biomechanical disadvantage in performance events requiring speed and agility.

The mesomorphic breeds lie in between these two extremes and in general are of moderate build with equal distance between the ground and the olecranon and the olecranon and the dorsal rim of the scapula. Most of the highly successful breeds in sports that require speed and agility are mesomorphic. Some typical mesomorphic breeds include Golden Retrievers, Labrador Retrievers, Border Collies, Beagles, and Border Terriers. Their moderate body type means that mesomorphic breeds are often successful in diverse sports.

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:

$$\text{Weight:Height (W : H) ratio} = \text{body weight (in pounds) divided by height at the withers (in inches)}$$

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 70/24 = 2.9, while a male Corgi's W:H ratio is 30/11 = 2.7. This suggests that, despite the obvious size differences in these two breeds, their musculoskeletal systems actually experience similar stresses. Clients with dogs that have a W:H ratio above 2.5 should be advised to train and compete only on surfaces that are nonslip and highly compressible and to frequently train at lower jump heights to reduce the effects of repetitive strain on the musculoskeletal system.

Pelvic limb structure

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, also referred to as *rear angulation* by those who study and evaluate canine structure (Brown, 1986; Elliott, 2009). Pelvic limb angulation is best assessed by having the dog stand with the metatarsals oriented perpendicular to the ground (Figure 1.7). The distance between a line drawn perpendicular to the ground along the caudal aspect of the metatarsals and the ischial tuberosity provides a rule-of-thumb approximation of the amount of pelvic limb angulation. The longer that line is, the more pelvic limb angulation the dog has. Figure 1.8 shows two dogs of the same breed with substantially different pelvic limb angulation.

There are advantages and disadvantages to having abundant pelvic limb angulation. Dogs with a lot of pelvic limb angulation are able to take longer strides with the pelvic limbs, and thus expend less energy moving from A to B because they take fewer steps. Excessive pelvic limb angulation is often associated with instability, however, since it can require tremendous muscular strength and coordination to stabilize a very angulated rear (Figure 1.9). As a result, dogs with straighter pelvic limbs 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. For most performance dogs, moderate pelvic limb angulation is the best compromise. Note that an appropriate fitness program is needed to optimize the angulation that each dog was genetically meant to have because appropriate musculature is required to support the dog with the limbs in an angulated conformation.

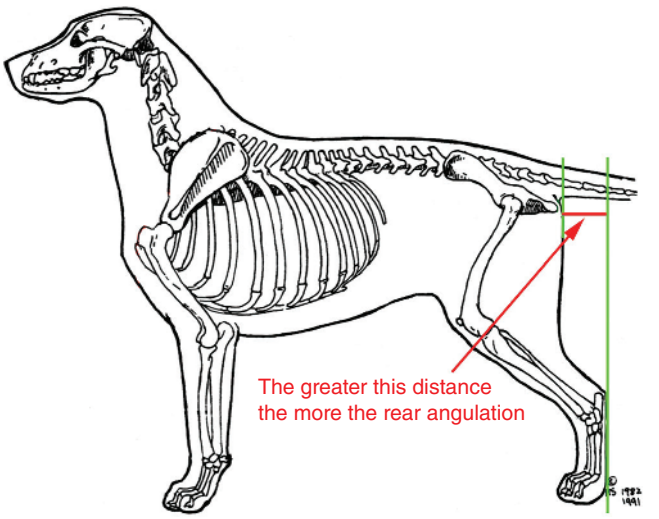


Figure 1.7 Pelvic limb angulation can be assessed by positioning the dog with its metatarsal bones perpendicular to the ground then drawing a line perpendicular to the ground along the caudal aspect of the metatarsals. The longer the distance between that line and the ischiatic tuberosity of the pelvis, the more pelvic limb angulation the dog has. Source: Illustration by Marcia Schlehr.

Figure 1.8 Two Golden Retrievers – one with abundant pelvic limb angulation **(A)** and one with minimal pelvic limb angulation **(B)**.

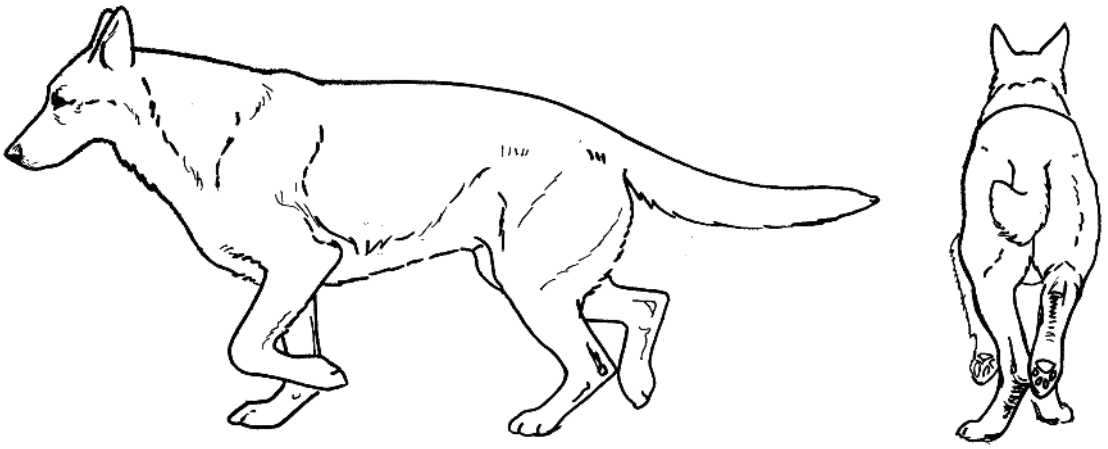


Figure 1.9 Dogs with very angulated pelvic limbs sometimes lack stability in the rear. Source: Illustration by Marcia Schlehr.

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 must be placed for examination in conformation shows with one pelvic limb in the standing position with the metatarsals perpendicular to the ground but the other pelvic limb placed under the body so that the feet are placed in a tripod configuration for better support. This extreme pelvic limb angulation causes the pelvis to be placed closer to the ground, so that the dog's vertebral column is extremely sloped from cranial to caudal. This extreme angulation often cannot be compensated for by muscular strength, leaving these dogs to swing their tarsi lateral to medial each time the feet are planted. To the best of our knowledge, this extreme angulation provides no advantages in function. Any potential advantage in function is offset by instability. This breed tends to have laxity in many joints, which may reflect an inadvertent genetic drift toward increased extensibility of the tendons and ligaments.

At the other extreme are breeds with very straight pelvic limb angulation. These tend to be breeds derived from dogs whose original purpose was guarding, such as the Shar-Pei and Chow Chow. Biomechanically, having an angle at the stifle that is closer to 180 degrees when the dog is bearing weight on the pelvic limb tends to increase the potential torque along

Case Study 1.2 Subclinical soft tissue shoulder injury

Signalment: 9 y.o. F/S (spayed at 5 years of age) Golden Retriever competing in agility, obedience, and hunt tests.

History: Patient had been competing in AKC agility at the excellent level approximately one to two weekends per month for the past several years. During the last 4 years, patient would frequently refuse to enter weave poles. When client restarted weave poles, patient would complete them. This happened only during competition, and never when training at home or in training facilities. Client requests complete examination to determine whether any orthopedic problems exist that might result in this change in performance.

Clinical findings: Patient in excellent physical condition, at a correct weight, and generally well-muscled. Pain elicited on flexion of right shoulder. Patient also shows sensitivity on palpation of the psoas musculature and at the insertion of the iliopsoas muscles on the lesser trochanters of both femurs. Musculoskeletal ultrasound shows alterations of echogenicity at the musculotendinous junction of the right supraspinatus tendon and both iliopsoas tendons.

Diagnosis: Right thoracic limb supraspinatus tendinopathy. Bilateral iliopsoas strain.

Treatment: Client advised to cease agility competitions and keep patient in a large pen or room during the day. Rehabilitation therapy, including laser, ultrasound, underwater treadmill work, and therapeutic exercises beginning with gentle stretching, then progressing to isometric, then concentric contraction, then eccentric contraction, instituted twice per week for 4 weeks, then once per week for 4 weeks. Patient then gradually reintroduced to agility by working on short sequences of low jumps with minimal turns, gradually increasing the length of sequences, 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. Patient competing successfully in agility 6 months after the diagnosis.

Comments: This case is typical of agility dogs in a number of 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 at which the dog runs during competition. Knowing the requirement for changes in lead legs while performing the weave poles helped direct the veterinarian toward a thoracic limb injury. This dog likely only had problems during competition because she was trained on grass but competed on relatively slippery surfaces; this was noted on video.
(2) Agility dogs frequently have subclinical abnormalities that do not present as overt lameness.
(3) Agility dogs frequently have more than one musculoskeletal injury.

the axis of the limb; this may result in an increased risk of cranial cruciate ligament rupture.

In most breeds when viewing the pelvic limbs from the rear, the limbs should extend from the greater trochanter perpendicular to the ground and be parallel to each other. The exception to this is in breeds whose functions require the dog to make quick turns, such as herding dogs, most notably the Border Collie. In these breeds the stifle is externally rotated, such that the tarsi are positioned medial relative to the feet. This limb adaptation provides greater stability as the dog is required to frequently 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 turning in response to the sheep's movements.

Thoracic limb structure

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 humerus (Brown, 1986; Elliott, 2009). 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 either the angulation of the scapula or the length of the humerus, the dog should be positioned with the radius and ulna perpendicular to the ground, with the head up and the nose pointing forward (Figure 1.10). 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 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 1.10. Cineradiographic images have determined this angle should ideally be 30 degrees (Elliott, 2009).

In contrast to pelvic limb angulation, there are no disadvantages to a dog having greater angle of the scapula. Dogs with greater scapular angle are able to take longer steps with each thoracic limb, thus expending less energy going from A to B. 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 1.11).

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 to place the dog's radius and ulna well under the body when the dog is standing with the radius and ulna perpendicular to the ground. If a dog's humerus is the optimal length, a line from 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 1.12).

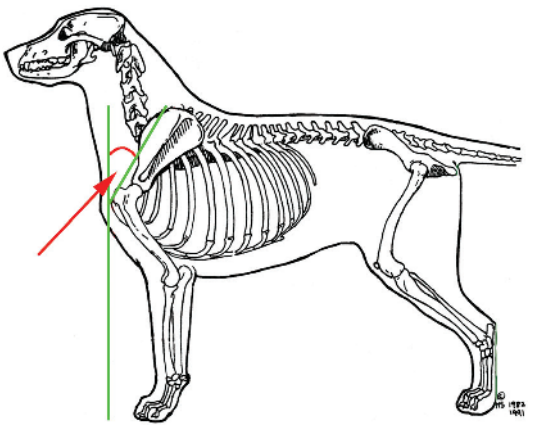


Figure 1.10 Shoulder angulation is determined by measuring the number of degrees from vertical at which the scapula lies. Ideally this angle should be 30 degrees (arrow). Source: Illustration by Marcia Schlehr.

Figure 1.11 Good shoulder angulation results in less concussion when a dog is landing with the forelimb in extension.

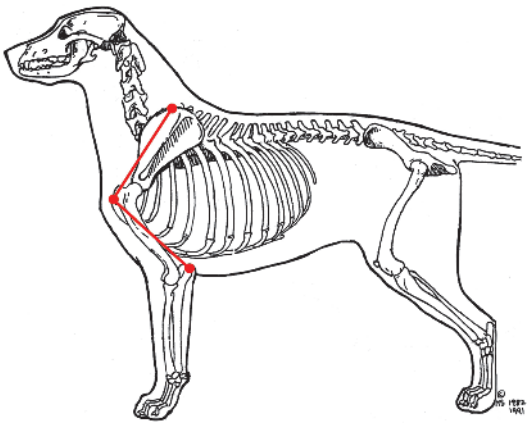


Figure 1.12 If a dog has a correct length humerus, a line from the highest point of the scapula to the greater tubercle of the humerus should be equal in length to a line drawn from the greater tubercle of the humerus to the top of the olecranon process. Source: Illustration by Marcia Schlehr.

A simpler way of evaluating humeral length is to draw a vertical line through the center of the radius and ulna. 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 distal limb is positioned more cranially, resulting in a line that intersects further cranially along the neck (Figure 1.13).

Dogs with a humerus of the optimal length have less concussion, particularly on the elbow joint, and tend to have more well-developed biceps and triceps 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 1.14.

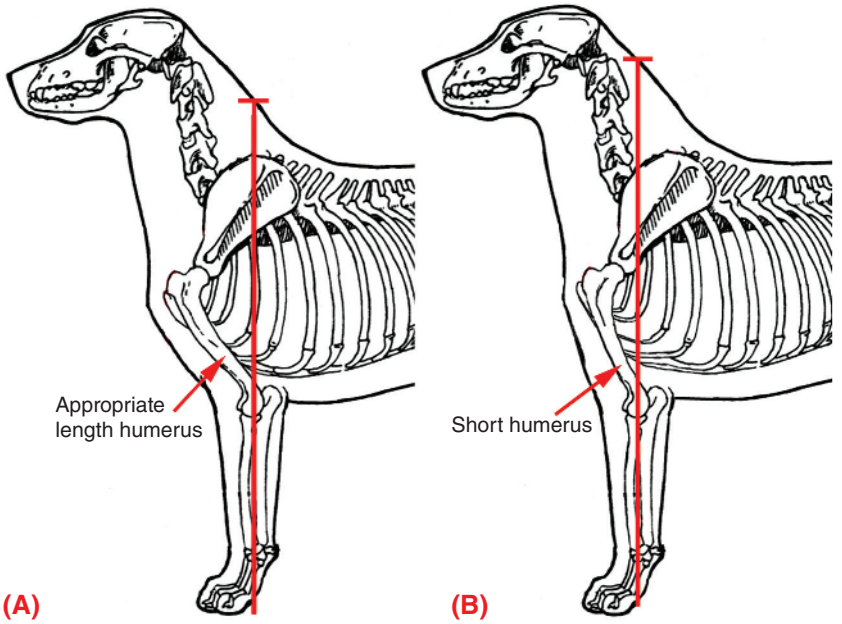


Figure 1.13 In a dog with an appropriate length humerus **(A)**, a vertical line drawn through the radius and ulna intersects with the dog's topline near the highest point of the scapula. In a dog with a short humerus **(B)**, that line intersects with the topline further cranially, along the neck. Source: Illustrations by Marcia Schlehr.

Figure 1.14 Two dogs with contrasting humeral length: a Pointer with a short humerus **(A)** and a German Short-Haired Pointer with appropriate length of humerus **(B)**. Source: Photos by Steve Surfman.

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 limb or pelvic limb generally tend to straighten the limbs, letting the bones and ligaments 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 limbs 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 in rehabilitation after an injury is to observe the improvement in angulation of the limbs when the dog is standing.

As is evident from the previous discussions, there are both advantages and disadvantages to most of 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 1.3.

The feet

There are two broad categories for shapes of dogs' feet depending on their original function. A dog whose original function was to move over rocky or uneven ground tends to have what is termed *cat feet* in which the toes are all of equal length and form an arch around the central pad (Figure 1.15). These feet could be considered analogous to the knobby tires of an ATV, which have improved grip on uneven surfaces both when moving forward and turning. In contrast, dogs whose function was to run in straight lines tend to have *hare feet*, in which the third and fourth digits are longer than the second and the fifth. This type of foot provides an advantage when running straight and is analogous to the slick tires of a race car. The sports medicine and rehabilitation professional should be aware of the variation of foot shape and

Table 1.3 Canine structure-function correlates

	Advantages	Disadvantages
Body type		
Ectomorphic	Easier to jump Longer stride length (faster)	Harder to turn (high center of gravity) Harder to balance on narrow surfaces (high center of gravity)
Mesomorphic	Ability to participate well in many different sports	None
Endomorphic	Easier to balance on narrow surfaces (low center of gravity)	Harder to jump Harder to accelerate/decelerate Harder to run fast Harder to turn More repetitive stress injuries
Thoracic limb		
Upright scapula	Head held higher in conformation	Shorter stride length, so more steps to cover ground (slower) Increased concussion Harder to jump high More repetitive stress injuries to shoulder
Short humerus	None	Shorter stride length (slower) Increased concussion
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 pelvic limb instability More torque on the coxofemoral joint More hyperextension injuries

should not assume that dogs with hare feet, which are less common, have an abnormality. Due to the insertion of the superficial digital flexor tendon on the distal 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.

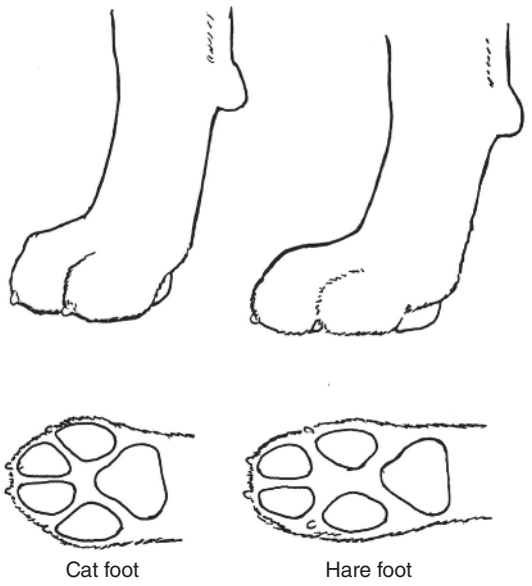


Figure 1.15 Cat foot (left) in which the toes are all of equal length and form an arch around the central pad, and hare foot (right) in which the third and fourth digits are longer than the second and the fifth. Source: Illustrations by Marcia Schlehr.

The dewclaws

Many dogs have their front dewclaws removed at 3 to 5 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 and bearing weight on their thoracic limbs (Figure 1.16). At that point, the dewclaw is available to dig into the ground to help stabilize the thoracic limb and reduce torque to the carpus and proximal limb when the dog is turning. Examination of structures associated with the front dewclaws substantiates that they do have function. There are four to five tendons that connect the dewclaw to the muscles of the limb (Figure 1.17) demonstrating that this digit does in fact have a function.

The dewclaws can actually function to save a dog's life. When dogs slip through the ice of a pond (or intentionally go swimming in freezing

(A)

(B)

Figure 1.16 When a dog's legs are 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 **(A)**. A Corgi's dewclaw can be clearly seen touching the ground while turning during herding activity **(B)**. Source: **(A)** The Dog Camp. **(B)** Jessica Viera.

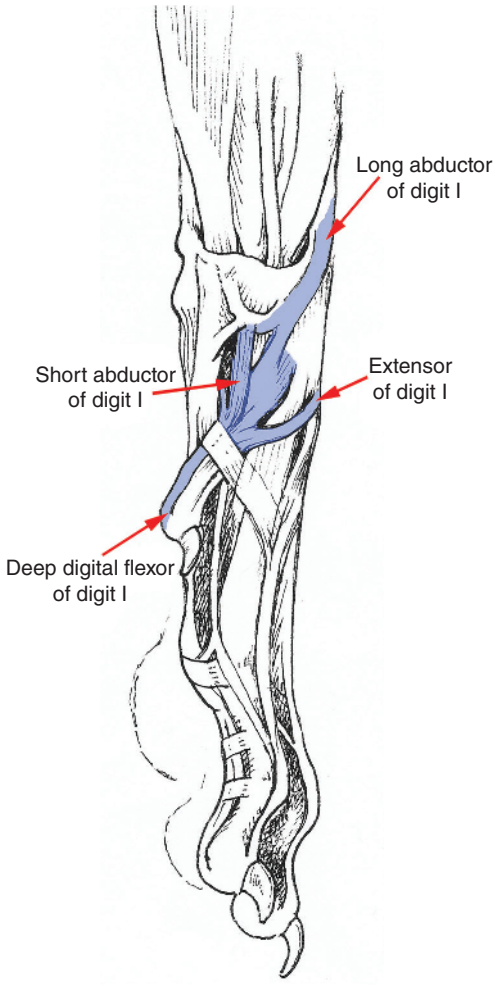


Figure 1.17 Anatomic diagram of the medial side of a dog's left forelimb demonstrating the tendons that attach to the dewclaw. These tendons, with their associated muscles confirm that the dewclaw is a functioning digit. Source: Illustration by Marcia Schlehr.

water), they cannot lift themselves out of the water and onto the ice without the use of the dewclaws acting as little ice picks on the medial side of each leg (Figure 1.18).

Finally, virtually all wild carnivores have front dewclaws, providing further evolutionary proof that they must 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

Figure 1.18 The dew claws 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.

perhaps a few others whose breed standards specify the presence of rear dewclaws.

The tail

The tail provides a counterbalance for dogs when they turn, either when running on land or swimming in water. It also helps raise the dog's rear after the apex of the 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 1.19). The potential long-term physical effects of this accommodation on the limbs and vertebral column are not known.

History-taking for the canine athlete and working dog

Because of the variety of activities in which canine athletes and working 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 in which the patient participates. The following are some items of additional information that

Figure 1.19 Differences in the way that dogs without a tail **(A)**, and with a tail **(B)**, angle their bodies when turning. Source: Photos by SpotShots.

should be gathered when taking the history of a canine athlete.

- **Age at which training started.** It is important that the bodies of young puppies not be stressed inappropriately with high or repetitive impact stress. Chapter 10 provides guidelines for age-appropriate training.
- **Gonadectomy status.** Several orthopedic conditions have been shown to be more prevalent in gonadectomized dogs, sometimes regardless of the age of gonadectomy. These include osteosarcoma (Priester and McKay, 1980; Ru *et al*., 1998; Cooley *et al*., 2002), CCL insufficiency (Whitehair *et al*., 1993; Duval *et al*., 1999; Slauterbeck *et al*., 2004; Duerr *et al*., 2007; Hart *et al*., 2014), hip dysplasia (Spain *et al*., 2004; van Hagen *et al*., 2005; Hart *et al*., 2014), and patellar luxation (Vidoni *et al*., 2005).
- **Age at which the dog was 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.
- **All 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 reveals how much training and competition the dog has experienced and provides information on the total amount of work the dog has performed at its age.
- **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 the intensity of the dog's physical activities.
- **Difficulties in performance events.** This can provide information about the specific problem that the dog is experiencing, which might not be obvious during a physical examination. Dogs that knock bars when jumping, for example, often have issues that involve the pelvic limbs.
- **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 canine sports medicine and rehabilitation professional an idea of the knowledge of the client about exercise and the commitment of the client to the patient's success in athletics.

- **Diet and supplements.** It is important to be sure that the patient is being provided with nutrients and supplements that are appropriate for its physical tasks. 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 requires time and commitment on the part of the client.
- **Goals for the dog.** This information helps the sports medicine and rehabilitation professional to appropriately direct their clinical efforts toward the client's goals. For example, a conditioning program designed for a dog whose owner wants to do agility for fun and relaxation would be quite different from that of an aspiring world class competitor.

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