

Distribution of power across the hind limb joints in Labrador Retrievers and Greyhounds

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Objective—To quantify angular excursions; net joint moments; and powers across the stifle, tarsal, and metatarsophalangeal (MTP) joints in Labrador Retrievers and Greyhounds and investigate differences in joint mechanics between these 2 breeds of dogs.

Animals—12 clinically normal dogs (6 Greyhounds and 6 Labrador Retrievers) with no history of hind limb lameness.

Procedure—Small retroreflective markers were applied to the skin over the pelvic limb joints, and a 4-camera kinematic system captured data at 200 Hz in tandem with force platform data while the dogs trotted on a runway. Breed-specific morphometric data were combined with kinematic and force data in an inverse-dynamics solution for stance-phase net joint moments and powers at the stifle, tarsal, and MTP joints.

Results—There were gross differences in kinematic patterns between Greyhounds and Labradors. At the stifle and tarsal joints, moment and power patterns were similar in shape, but amplitudes were larger for the Greyhounds. The MTP joint was a net absorber of energy, and this was greater in the Greyhounds. Greyhounds had a positive phase across the stifle, tarsal, and MTP joints at the end of stance for an active push-off, whereas for the Labrador Retrievers, the only positive phase was across the tarsus, and this was small, compared with values for the Greyhounds.

Conclusions and Clinical Relevance—Gross differences in pelvic limb mechanics are evident between Greyhounds and Labrador Retrievers. Joint kinetics in specific dogs should be compared against breed-specific patterns. (*Am J Vet Res* 2005;66:1563–1571)

Knowledge of gait mechanics in human patients has reached a high degree of sophistication. Full inverse-dynamics analysis has been applied to the gait of horses and dogs.^{1–3} This method combines kinemat-

ic, morphometric, and force data in a segmental model of the limb, which yields information about the net moments around the limb joints in 2 or 3 dimensions and patterns of muscle work or joint power. Joint kinematic, moment, and power patterns are quite similar among human subjects, and the patterns tend to be conserved in patients with neuromuscular disability and subjects walking at various velocities; only the amplitudes of individual bursts within patterns vary from the typical patterns.^{4,5} The gait of dogs may be expected to vary slightly more in that differing conformations among breeds of dogs place limb segments and joints in variable positions during the gait cycle, especially at critical periods (eg, the initiation and termination of the stance phase).

It is recognized that some breeds of dog are predisposed to certain musculoskeletal pathologic conditions. Collies, especially Shetland Sheepdogs, are susceptible to disruption of the proximal intertarsal joint, which is caused by degeneration of the long plantar ligament.⁶ Large-breed dogs, such as the Great Dane, Doberman Pincher, and Irish Wolfhound, tend to avulse the origin of the long digital extensor muscles.⁷ Labrador Retrievers and Golden Retrievers are commonly affected by cranial cruciate ligament disease, whereas other breeds, such as the Greyhound, are rarely affected.⁸ Undoubtedly, genetics plays a role in these epidemiologic observations in specific dogs. However, given the differences in limb conformation among breeds, it may be expected that inherent biomechanical differences in joint function are responsible for alterations in joint loading patterns that may contribute to susceptibility to specific injuries or degenerative processes. Kinematic and kinetic gait analyses provide tools to study in vivo mechanics. However, to our knowledge, no studies have combined these techniques to address forces within or work generated across the hind limb joints of dogs with a normal gait. In 1 study,³ investigators modeled the forelimb joints of a group of 6 mixed-breed dogs during walking and documented wide variation in joint angular patterns and mechanics. Given the wide differences in conformation among breeds of dogs, it may be necessary to create normative, breed-specific gait databases for use in comparison with dogs with abnormal gaits.

The purpose of the study reported here was to combine kinematic, force, and morphometric data in an inverse-dynamics analysis of the mechanical function of the stifle, tarsal, and metatarsophalangeal (MTP) joints in clinically normal Greyhounds and Labrador Retrievers. These breeds were selected because they have distinctly different conformations.

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Materials and Methods

Animals—Six clinically normal Labrador Retrievers (2 males and 4 females; mean age, 6 years) and 6 clinically normal Greyhounds (3 males and 3 females; mean age, 6.5 years) with no recent history of lameness or other gait defects were used in the study. None of the dogs had a history of hind limb lameness. Mean \pm SD body weight was 32.3 ± 3.5 kg for the Greyhounds and 30.3 ± 3.6 kg for the Labrador Retrievers. Because the testing protocol involved no invasive procedures or discomfort to the dogs, ethical approval was granted by the university's internal ethical review board.

Morphometric data—To our knowledge, breed-specific morphometric data have not been published. Therefore, it was necessary to collect data on hind limb segments from cadavers of client-owned Labrador Retrievers and Greyhounds. Cadavers of 4 Greyhounds and 3 Labrador Retrievers euthanized for clinical reasons other than musculoskeletal disease were obtained. Dogs were of typical body condition, and informed consent was obtained from each owner in accordance with university guidelines.

Cadaver specimens were disarticulated through the hip, femorotibial, tibiotarsal, and MTP joints on a plane perpendicular to the long axis of the proximal bone segment. Segments were weighed on a digital scale (accurate to 0.5 g); weight of each segment was recorded as a percentage of total body weight. The location of the center of gravity on the long axis of each segment was determined in accordance with a method that used a balance board technique.⁹ Briefly, a horizontal board was attached by a hinge to a stable mounting, with the unattached end of the board supported on a digital scale. Each segment was placed on the board with the proximal end oriented nearest the hinge point, and weight was recorded on the scale. Positioning and measurement was repeated 3 times. Also, 3 measurements were obtained with the segment oriented with the distal end nearest the hinge point. Location of the center of gravity of the segment was calculated from the moment created about the hinge point by the weight of the segment and was recorded as the distance from the proximal end of the segment by use of mean of the 6 measurements.

Gait measurements—Flat retroreflective markers (8 mm in diameter) were affixed to the skin overlying the centers of rotation for the hind limb of each of the 12 dogs. These centers were estimated by palpation of end points of the bones; manual flexion and extension of the joints after application of the markers was used to verify marker positions. Markers identified segments in accordance with the aforementioned morphometric model. The right and left hind limbs were marked for collection of kinematic data from both sides of the body to account for small variations caused by morphometric asymmetry and handedness in each dog. Following application of the markers, the dogs were allowed to become familiarized with the runway used for gait analysis by walking and trotting on it several times before data collection.

Kinematic data were collected by use of a 4-camera system^a synchronized with a force platform.^b Force and kinematic data were collected at 200 Hz for a period of 3 s/trial. The 4-camera and force platform systems were calibrated in the kinematic frame with the origin of the kinematic reference located at the center of the force platform. A calibrated volume of space (1.6 m in length \times 1 m in width \times 1 m in height) was recorded to enable tracking of markers through the stance phase of the hind limb on the force platform for a dog trotting in either direction. Cameras were arranged in a semicircle on 1 side of the runway at a height of 0.8 to 2 m, such that each marker could be recorded by at least 3 cameras for resolution of a 3-dimensional image of the hind limb during the stance phase.

A minimum of 5 stance phases was collected for each hind limb of each dog. Trials were considered acceptable when the paw of a trotting dog landed squarely on the force platform within the area bounded by the force transducers. Trials confounded by placement of the contralateral limb on the platform or by an avoidance reaction or other unnatural movement were discarded. An experienced handler led the dogs at their own preferred trotting speed, which was kept as consistent as possible for each dog during its set of trials.

Velocity calculations—Trotting velocity was calculated from marker displacements for the central stride during which the hind limb was in contact with the force platform. This was adjusted on the basis of the height of that dog when standing (floor to dorsal aspect of trunk at T3), and relative velocity was expressed in terms of statures per second to account for the effect of differences in body size and, therefore, stride length between the 2 breeds.

Kinetic calculations—Force and kinematic data were imported into a custom-designed program^c and combined with breed-specific morphometric data by use of inverse dynamics^{9,10} to calculate joint angular excursions, joint reaction forces, net joint moments, and net joint powers in the sagittal plane for the stifle, tarsal, and MTP joints and the net moment at the hip joint. Moments on the cranial or dorsal side of the joints were assigned positive values, and moments on the caudal or palmar side of the joints were assigned negative values. Segment inertial quantities were neglected on the basis that these are extremely small, especially in the distal portions of the limbs, and have a negligible effect on stance-phase mechanics. Output from right and left limbs was combined after adjusting stance-phase durations to mean stance time and adjustment of forces to body weight, which yielded mean values for each dog. These were then used to determine the mean value among all dogs and plotted as mean \pm SD values to reflect between-subject variation. Finally, the net moments at the hip, stifle, tarsus, and MTP joints were added to calculate the total support moment for the hind limb throughout the stance phase. For this calculation, the sign of each net joint moment was positive when the moment contributed to support of the trunk during the stance phase. In this way, extensor moments at the hip and stifle joints and plantarflexor moments at the tarsal and MTP joints would combine positive signs to indicate a total support moment that resisted the effects of gravity.

Statistical analysis—Two-sample *t* tests (assuming equal variance) were used to test for differences between breeds in trotting velocity and joint reaction forces.

Results

Morphometric data of cadaver specimens—Mean values for cadaver specimens were calculated (Table 1). Segmental center of gravity locations were similar between the 2 breeds, but the proximal segments were heavier in the Greyhound when their weights were expressed as a percentage of body weight.

Gait measurements—Mean joint angular excursions, net joint moments, and net joint powers were determined for the Labrador Retrievers and Greyhounds. Graphs for both breeds were plotted on the same time and amplitude scales to allow appreciation of differences in length of the stance phases, amplitude of moments, and amplitude of powers. Overall, the Greyhounds had a shorter stance-phase duration (mean, 0.16 seconds), compared with that for the Labrador Retrievers (0.21 seconds). Mean \pm SD trotting velocity was significantly ($P = 0.01$) higher for the Greyhounds (3.13 ± 0.12 m/s), compared with trotting

velocity for the Labrador Retrievers (1.98 ± 0.14 m/s). Mean relative velocity, as calculated from the height of each dog, was significantly ($P = 0.01$) higher in the Greyhounds (4.31 ± 0.04 statures/s), compared with values for the Labrador Retrievers (3.85 ± 0.04 statures/s).

Stifle joint—The stifle joint of Labrador Retrievers flexed from ground contact through midstance and then remained flexed through the end of the stance phase (Figure 1). In contrast, the stifle joint of Greyhounds flexed until approximately midstance and then extended

Table 1—Morphometric data of the hind limbs obtained from cadavers of 4 Greyhounds and 3 Labrador Retrievers.

Breed	Variable	Foot	Metatarsus	Crus	Thigh
Greyhound	Body weight (%)*	0.18	0.45	1.41	6.95
	Center of segment (%)†	50	50	38	48
Labrador Retriever	Body weight (%)*	0.20	0.45	1.32	
	Center of segment (%)†	50	50	42	50

*Represents the percentage of total body weight. †Represents center of gravity location as a percentage of the distance from the proximal end of the segment.

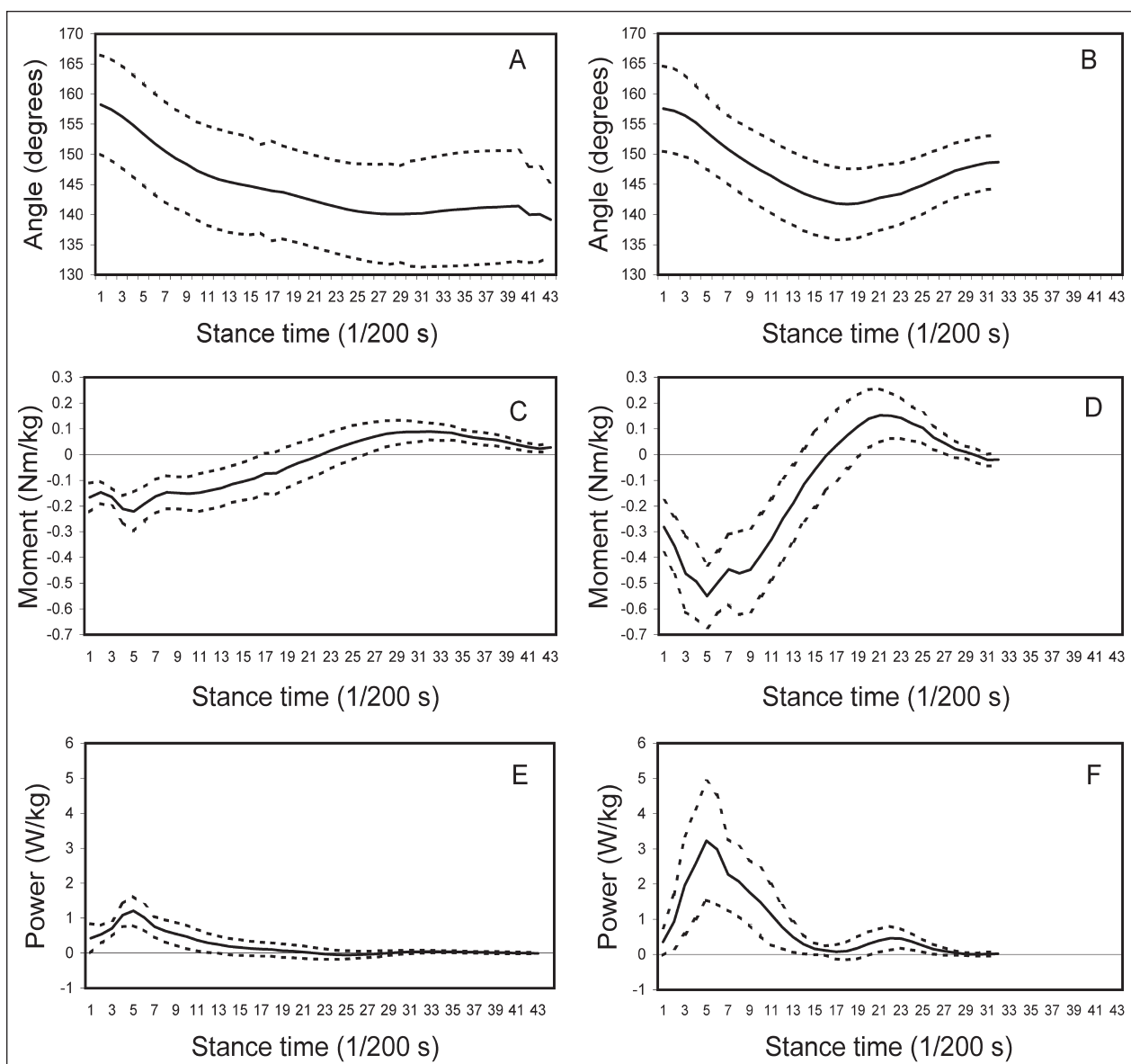


Figure 1—Mean (solid line) and SD (dashed lines) for joint angle (A and B), net joint moment (C and D), and net joint power (E and F) for the stifle joints of 6 Labrador Retrievers (A, C, and E) and 6 Greyhounds (B, D, and F) during the stance phase.

during the late stance phase. The moment across the stifle joint in Labrador Retrievers was flexor from ground contact until roughly midstance and then extensor until the end of the stance phase. Greyhounds had the same pattern, but the amplitude of the flexor moment was more than twice as large in the Greyhounds, compared with that for the Labrador Retrievers. This was apparent in the power patterns for the stifle joint in that the amplitude of the power burst in the early stance phase for the Greyhounds was approximately 3 times that measured in the Labrador Retrievers. The Greyhounds also generated a small amount of positive work from their stifle extensors in the second half of the stance phase, which indicated a push-off phase coincident with observed extension of the stifle joint. This positive burst was not observed in the Labrador Retrievers.

Tarsal joint—Joint angle, moment patterns, and power patterns of the stifle joint were similar between Greyhounds and Labrador Retrievers, except the

amplitudes of the moments and powers were nearly twice as large in the Greyhounds (Figure 2). Both breeds generated an extensor moment across the tarsus throughout the stance phase, which peaked immediately before midstance. The extensors absorbed energy as the muscles lengthened, controlling the rate of tarsal joint flexion in the first half of the stance phase, and then contracted concentrically to extend the tarsal joint for an active push-off in the second half of the stance phase.

MTP joint—Angular and mechanical patterns of the MTP joint differed grossly between the 2 breeds (Figure 3). Flexion of the MTP joint in Labrador Retrievers was not detected until almost midstance, whereas the MTP joint in Greyhounds was an effective absorber of energy as it dorsiflexed after ground contact and through midstance. This energy was returned in a burst of positive work at the end of the stance phase, whereas the push-off burst was negligible in the Labrador Retrievers.

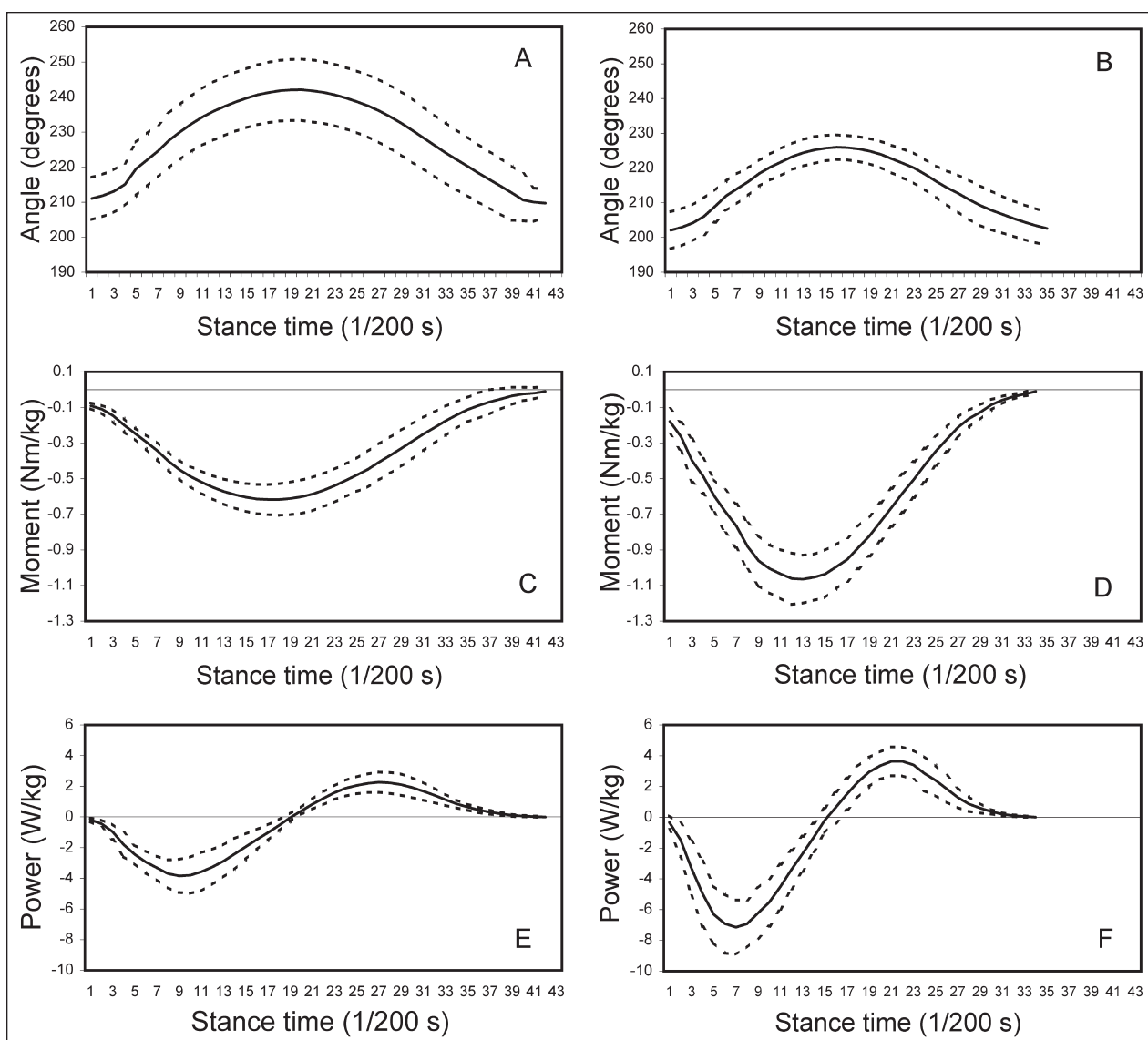


Figure 2—Mean (solid line) and SD (dashed lines) for joint angle (A and B), net joint moment (C and D), and net joint power (E and F) for the tarsal joints of 6 Labrador Retrievers (A, C, and E) and 6 Greyhounds (B, D, and F) during the stance phase.

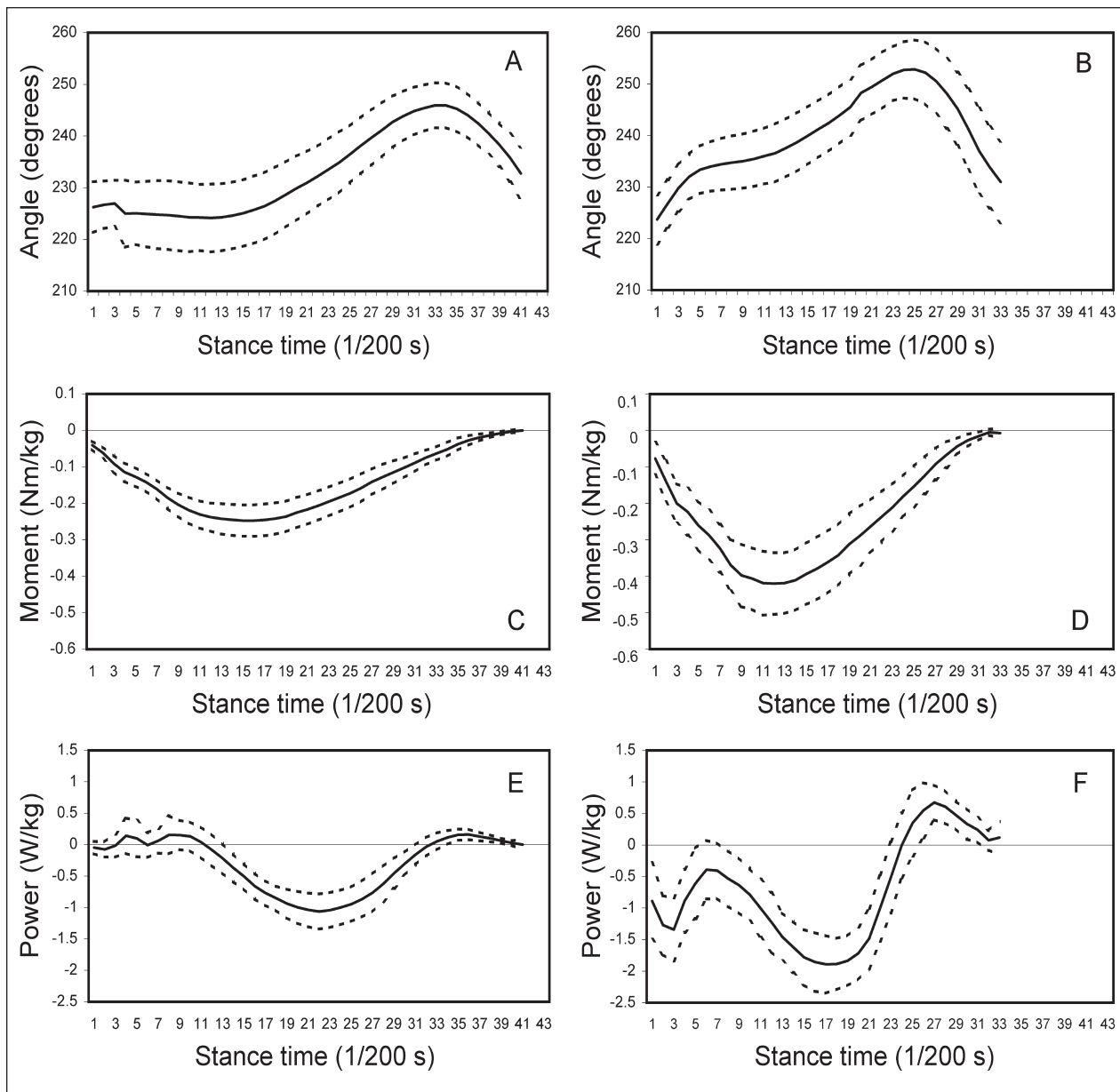


Figure 3—Mean (solid line) and SD (dashed lines) for joint angle (A and B), net joint moment (C and D), and net joint power (E and F) for the metatarsophalangeal joints of 6 Labrador Retrievers (A, C, and E) and 6 Greyhounds (B, D, and F) during the stance phase.

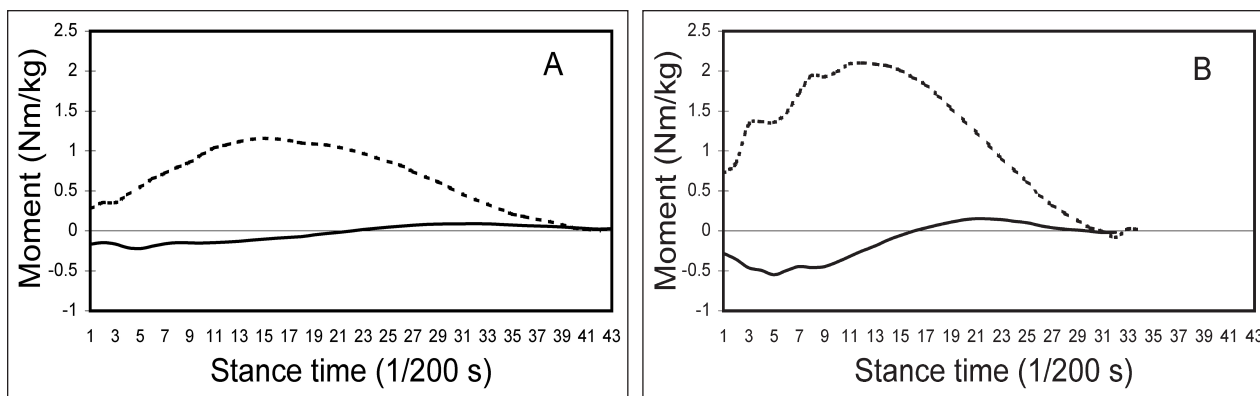


Figure 4—Total support moment (dashed line) and joint moment for the stifle joint (solid line) for 6 Labrador Retrievers (A) and 6 Greyhounds (B). Total support moment was calculated as the sum of the moments at the hip, stifle, tarsus, and metatarsophalangeal joints.

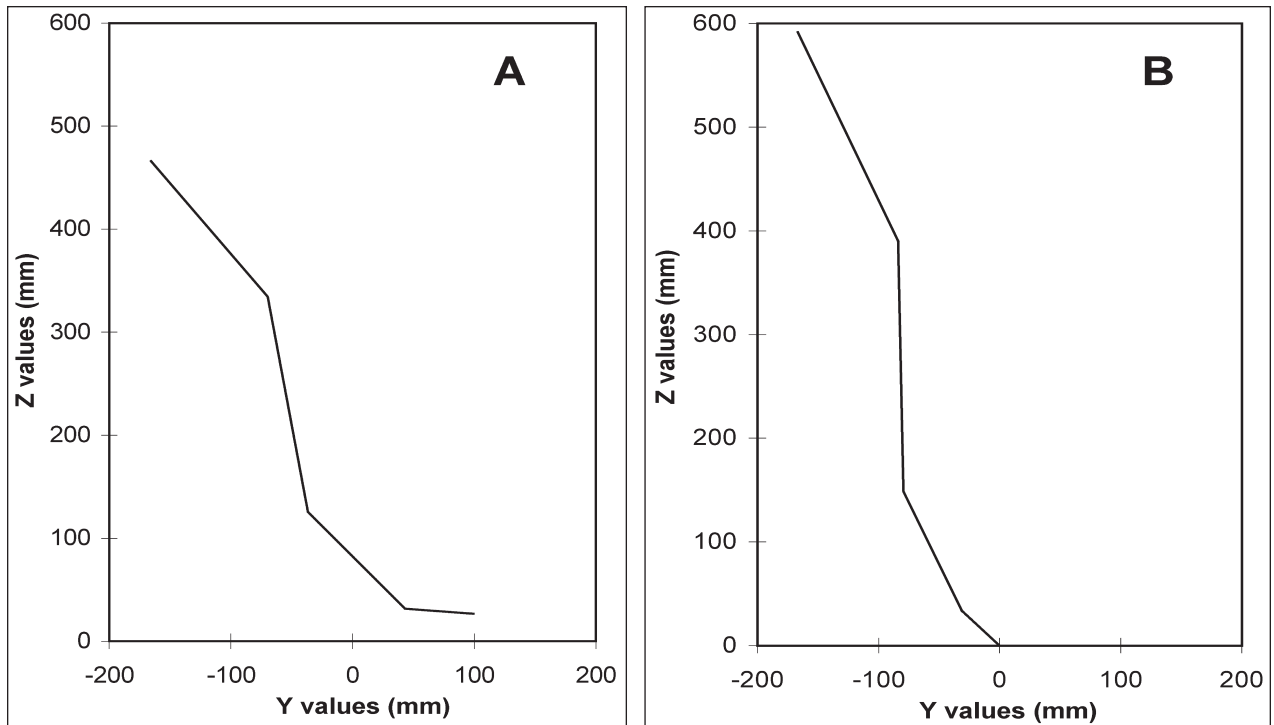


Figure 5—Schematic depiction of the sagittal plane orientation of the hind limb of Labrador Retrievers (A) and Greyhounds (B) at the instant the foot makes ground contact. Horizontal (Y) and vertical (Z) distances are indicated.

Table 2—Body weight–adjusted joint reaction forces calculated from kinematic, force, and morphometric data for the metatarsophalangeal (MTP), tarsal, stifle, and hip joints of Greyhounds and Labrador Retrievers.

Breed	Joint	F _z (N/kg)	F _{y,br} (N/kg)	F _{y,pr} (N/kg)
Greyhound	MTP	11.3	-0.42	1.21
	Tarsal	11.2	-0.35	1.19
	Stifle	11.0	-0.68	1.03
	Hip	9.1	-0.36	1.28
Labrador Retriever	MTP	7.0*	-0.61	0.88*
	Tarsal	6.9*	-0.62†	0.83†
	Stifle	6.8*	-0.84	0.69†
	Hip	6.0*	-0.63	0.55*

*,†Value differs significantly (**P* < 0.001; †*P* < 0.01) from corresponding value for Greyhounds.
F_z = Vertical joint reaction force. F_{y,br} = Craniocaudal joint reaction force during the braking portion of the stance phase. F_{y,pr} = Craniocaudal joint reaction force during the propulsive portion of the stance phase.

Total support moment—The total support moment had positive values throughout the stance phase, as calculated by assigning positive values for moments on the caudal side of the hip, tarsus, and MTP joints and cranial side of the stifle joint (Figure 4). Extensor musculature dominated in support of body weight and contribution to retraction of the limb. Total support moment in Greyhounds was almost double the magnitude of the Labrador Retrievers. However, when the moment of the stifle joint of Labrador Retrievers was examined for its contribution to the total limb moment of support, the peak stifle moment during the propulsion phase accounted for 30% of the total moment at that instant, compared with only 12% in the Greyhounds. In each breed, the remainder came from the moments resulting from the combined actions of muscles crossing the hip, tarsus, and MTP joints.

Depictions of representative trials were used to identify conformational and postural differences between the 2 breeds (Figure 5). The depictions were constructed by drawing lines to connect the joint markers and represented the positions of the limb segments at the initiation of the stance phase. The hind limb of Greyhounds was much more upright in position. In particular, the MTP joint was especially in a position where it could dorsiflex in the early stance phase to absorb some of the forces at impact. The hind limb in Labrador Retrievers was relatively more protracted at the instant of ground contact. The upright posture of the limb in Greyhounds was probably responsible, in part, for the shorter stance duration, but was also implicated in the peak joint reaction forces (Table 2). Body weight–adjusted vertical joint reaction forces were higher in all joints of the Greyhounds, whereas horizontal braking forces in the

Labrador Retrievers were similar to those in the Greyhounds despite the difference in velocity. Horizontal propulsive forces were higher in the joints of Greyhounds.

Discussion

Gross differences in gait mechanics were evident between these 2 breeds of dogs. In addition to kinematic differences at the stifle and MTP joints, shapes of the power patterns at these joints also differed grossly despite similar moment patterns because power was calculated as the product of the net joint moment and joint angular velocity. Consequently, the powers should vary at the same point that kinematic patterns vary. Patterns for the tarsal joint were quite similar; only local amplitudes of the curves varied.

The differences observed between breeds in joint moment and power amplitudes were undoubtedly affected by differences in trotting velocity. In a comparison of ground reaction forces during trotting between these same 2 breeds,¹¹ investigators reported that both groups trotted at virtually the same absolute self-selected velocity and that this velocity (2.46 m/s) represented a moderate-speed trot. However, Greyhounds in that study were only 5 months of age, and Labrador Retrievers were 6 to 18 months old. Furthermore, they reported no significant differences between breeds for combined forelimb and hind limb vertical forces, although advanced placement of the hind limb of Greyhounds was associated with a significantly larger hind limb vertical force. Temporal alignment of the forelimb and hind limb braking and propulsive forces caused total instantaneous braking and propulsive forces to be larger in the Labrador Retrievers, although forelimb and hind limb horizontal forces did not appear to differ from those measured in the Greyhounds of that study.¹¹

Mean age of the dogs in the study reported here was 6 years, and this probably bears on the velocity differences observed between the breeds and the discrepancy with the results reported elsewhere.¹¹ After adjusting for body weight, we found that Greyhounds in our study had greater vertical joint reaction forces at all hind limb joints (Table 2). However, horizontal joint reaction forces during braking were larger in the Labrador Retrievers and were largest at the stifle joint in both breeds. Differences in velocity likely contributed to the larger joint moment and power amplitudes but were unlikely to be responsible for the shapes of the kinematic and power patterns, which differed grossly between the 2 breeds.

It is difficult to adjust variables for velocity between breeds. Both groups in the study reported here were allowed to trot at their own, self-selected speeds in an attempt to depict gait mechanics at typical velocities relevant to each dog. Forcing a horse to trot faster or slower than the preferred velocity can result in higher energy cost and lower efficiency¹²; therefore, it has been proposed that animals will self-select a velocity within each gait that minimizes energy cost.¹³ In human gait studies, velocity is sometimes adjusted by reporting it in terms of the number of statures per second because taller people will have longer strides than

shorter people but will cover their own stature in the same amount of time.¹⁴ In our study, we found that adjusting velocity against standing stature still resulted in significant differences in relative velocity between breeds, which indicated that body size was not the only influence on the chosen velocity. In human gaits, velocity can affect the amplitudes of local power bursts, whereas the overall shape of the power pattern persists.⁵ Likewise, the shapes of power patterns can persist in horses across a range of walking and trotting speeds, in which only local burst amplitudes varied.^{15,16} The angle and power patterns for the stifle and MTP joints of our study varied in local burst amplitudes and, importantly, their shapes as well, which suggested that the mechanical function of the joints differs. Missing from this analysis was the effect that velocity had on power patterns within specific dogs. We attempted to maintain trotting velocity as consistent as possible among trials within dogs. Additional studies will be necessary to investigate whether velocity affects the shape of the power patterns in addition to the burst amplitudes, although analysis of studies^{5,15,16} conducted on humans and horses suggests that the shapes will not be affected.

Muscles crossing distal limb joints do negative (eccentric) work as they lengthen to absorb energy during weight acceptance in the early stance phase, and they then typically do positive (concentric) work in the late stance phase to provide an active push-off when the foot is caudal to the more proximal joints. The more vertical attitude of the limb in Greyhounds, with extended MTP and tarsal joints, gives it potential to absorb more energy in the early stance phase, much of which is returned during the late stance phase to contribute to forward propulsion. In this manner, tendons crossing the distal joints allow a limb to behave like a spring. The horizontal position of the foot of Labrador Retrievers at the beginning of the stance phase does not allow dorsiflexion of the MTP joint until the metatarsus begins to rotate forward over the paw in midstance. The phase of negative work at this joint through midstance is not followed by a positive burst of any amplitude, implying that the flexors of the MTP joint contribute little to propulsion in Labrador Retrievers.

The negative work across the tarsal joint was greater than the positive work for both breeds examined here, indicating that the tarsal joint is a net absorber of energy. Furthermore, positive work by the tarsal extensors in the second half of the stance phase is partly coincident with energy absorption at the MTP joint, which decreases the effect of the concentric work across the tarsus. Nevertheless, there were combined discrete bursts of positive work at the stifle, tarsal, and MTP joints for an active push-off in the Greyhounds, likely contributing to the larger horizontal joint reaction forces in that breed. Tarsal joint excursion was greater in the Labrador Retrievers, and analysis of the power curves suggests that the tarsal extensors are the main contributors to positive power during the terminal portion of the stance phase. Combined with the observation that the MTP joint did not change its angular position in the early stance phase of Labrador

Retrievers, it appears that the proximal segments of the pelvic limb move forward over the paw after ground contact through flexion of the tarsal joint. Moments and powers for the tarsal joint reveal that this motion is resisted and controlled by eccentric activity of the tarsal extensors. Although the gastrocnemius muscles control flexion of the tarsal joint in the early portion of the stance phase, they also contribute to the observed flexor moment across the stifle joint.

In a similar manner, the stifle joint also had gross differences in angular excursions and kinetic patterns between the 2 breeds. The stifle joint of Labrador Retrievers flexed through the early portion of the stance phase and midstance, and it remained flexed for the remainder of the stance phase. This was in contrast to the stifle joint of Greyhounds, which flexed and then extended for a small but active contribution to push-off. In both breeds, the moment across the stifle joint was flexor for the first half of the stance phase, indicating net activity by the stifle flexors (semimembranosus, semitendinosus, biceps femoris, and gastrocnemius muscles). The 2-joint semimembranosus, semitendinosus, and biceps femoris muscles are active to extend the flexed hip in the early portion of the stance phase and have a secondary flexor effect at the stifle joint. The gastrocnemius muscles help to control flexion of the tarsus joint during the first half of the stance phase but also contribute a flexor effect at the stifle joint. Gravity and ground reaction forces combine with this net flexor moment to cause flexion at the stifle joint, probably against a stabilizing cocontraction by the quadriceps muscle, which eventually becomes dominant at midstance when the vector for the ground reaction force passes the stifle joint. This reverses the moment from flexor to extensor and, in the case of Greyhounds, caused active extension of the stifle joint.

Cocontraction of antagonistic muscle groups at any joint yields a cloudy picture of joint mechanics. The power calculated at a joint depends on the net joint moment and angular velocity of the joint excursion. When cocontraction of muscles stabilizes a joint against motion, then angular velocity and calculated power will be low. This may well be the case at the stifle joint, where intuitively the stifle extensors must be coactive with the flexors, given the angular position of the joint at the time of ground contact.

The total support moment is the net sum of all the moments around the hind limb joints (Figure 4). In the first half of the stance phase, the total moment is the sum of the positive (extensor) moments from the hip, tarsal, and MTP joints minus the negative (flexor) moment at the stifle joint. After approximately midstance, the stifle moment becomes extensor and is added to the other positive moments. The peak magnitude of the stifle moment during the late stance phase in Labrador Retrievers was 30% of the total support moment at the same instant, despite the low power output from muscles crossing the joint. In contrast, the stifle moment in Greyhounds was only 12% of the total moment. This suggests that during the late stance phase, the relative contribution of the stifle support mechanism plays a larger role in Labrador Retrievers.

A number of degrees of freedom generate a sup-

port moment that will support the trunk against gravity and provide the braking and propulsive impulses required for forward velocity. The total support moment can be distributed across all 4 joints in several ways, each of which yields the same overall moment. Additional studies will be required to evaluate whether this stifle moment is a contributor to degeneration of the cranial cruciate ligament observed in Retriever-type dogs.

We did not account for the effects of segmental inertia when calculating inverse dynamics. The sum of the moments around the center of gravity of a segment is equal to the product of segment inertia and the segment's angular acceleration. Inertia is a function of the distance of the segment's center of gravity from the rotating joint and the segmental weight, which tends to be disproportionately small in the distal aspect of limb segments. Similarly, angular acceleration is small during the stance phase. Therefore, the product of these 2 small quantities would make a negligible impact on calculations of the joint moment. Inertial properties are much more important in the swing phase when the limb segments are subject to rapid acceleration at the beginning of the swing and rapid deceleration at the end of the swing as the angular trajectory of the limb is reversed for controlled limb placement. There is a need to develop a database of breed-specific morphometric tables, including regression models of segment center of gravity locations and inertial properties, for the inverse-dynamics method to be applied accurately. Errors caused by gross differences in conformation and body condition among and within breeds may overshadow subtle changes in the moment and power patterns caused by clinical conditions when an accurate morphometric model is not used. Kinetic patterns reported in another study³ were quite variable and likely affected by application of a single, generic morphometric model to the mixed-breed subjects. In the study reported here, breed-specific segment weight and center of gravity locations were used, and the kinetic calculations indicated large-scale differences between the 2 breeds.

Analysis of results of the study reported here revealed that mechanics of joints of the hind limb vary between Greyhounds and Labrador Retrievers. Greyhounds combine bursts of positive work across the stifle, tarsal, and MTP joints for an active push-off during the terminal portion of the stance phase, whereas Labrador Retrievers only activate their tarsal extensors, although this may be confounded by the cocontraction of muscles around the stifle joint. It would be helpful to combine joint kinetic patterns with electromyographic analysis for a complete assessment of the manner by which muscle coactivation affects joint motion. We also conclude that comparison of limb mechanics must account for between-breed differences and that separate breed-specific databases must be constructed before comparisons can be made between lame and clinically normal animals within a breed.

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 - b. Model 9287, Kistler Instrumente AG, Winterthur, Switzerland.
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