FOUR LEG NEWS

Muscle Types, Uses, and Breed Specific Differences!

HAPPY NEW YEAR Everyone! I wish you all the best in the upcoming year. To get you off to a brain-building start, I'm presenting to you this edition of Four Leg News, all about Muscles in Dogs! Muscle types, breed differences, muscle uses, etc. I don't think that any of these would be the typical studies that would cross your desk. However, I do think they are the kind of studies that give you a fundamental base-level scientific knowledge to build upon and might stimulate your creativity for things to try in a canine rehab practice. Enjoy the read, and CHEERS TO YOU and all you will do in 2018!

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Ferrari vs SUV? Why Greyhounds don't need to slow down in the turn

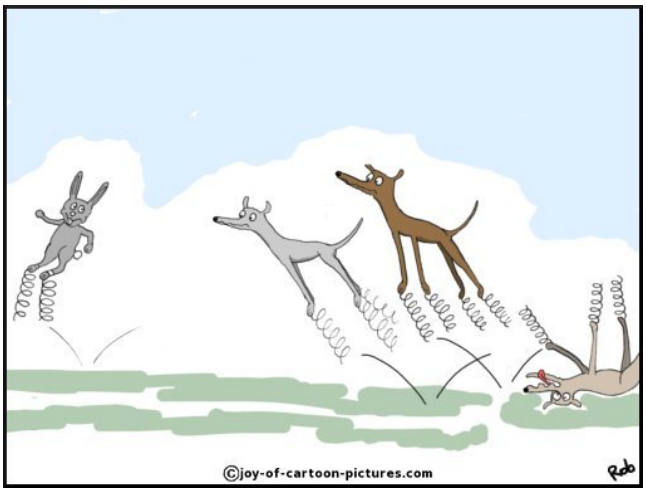
Usherwood, J.R., Wilson, A.M., *No force limit on greyhound sprint speed* Nature, 438(8), pp. 753-754, 2005.

The speed at which an athlete can move is limited by the speed at which they can move their limbs and by how much force those limbs can withstand while in contact with the ground. In a human athlete, speed of limb movement is directly limited by the requirement to keep the force applied to the limb constant. The muscles responsible for locomotive power are the same muscles that are responsible for weight bearing and are loaded by weight-induced compression forces along the leg. When force is increased on those muscles by the addition of centripetal acceleration while rounding a corner, the result is the requirement to increase the length of time the foot is in contact with the ground and therefore reduce the speed of the stride. It becomes impossible for a human athlete to maintain the same speed while rounding a corner as they do on the straight away.

Dogs and other cursorial quadrupeds, however, don't have that problem. In this study 40 greyhounds were observed via video footage during training. 17 were watched in the first straightaway on a track and going through the first bend, and 23 were observed in the second straightaway into the second bend. In all cases the foot-contact timing did not significantly change between the straightaways and the bends. The dogs were not required to increase their foot contact time in response to increased force on their weight bearing mechanisms through the turn, despite a calculated increase in effective weight of 71%.

The reason for this is that in these animals the speed of the limb comes from torque of the hip and extension of the back, which act independently of the weight bearing, which is on the forelimbs. The rears of these dogs therefore have noticeably muscular hip retractors, while

the forelimbs are bone and tendon, which highly pennate muscles that act like springs. While the rear limbs and hips are capable of providing explosive power, the front limbs are able to support considerable force. Locomotion and weight bearing, therefore, are two separate mechanisms, so there is no limitation on speed through the corner as opposed to through the straightaway.

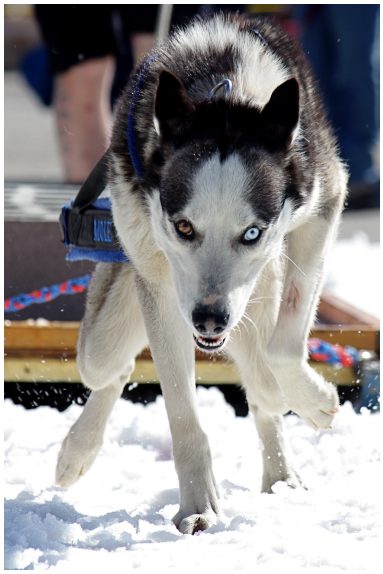


Thoughts as they might pertain to rehab:

Perhaps this 71% increase in force around the bend impacts the front limbs more so, and is the reason that wrist injuries are so common in racing greyhounds, coursing hounds, and sprinting sled dogs. I would also analyze the study and put forth that a fully-functioning, pain-free back would be critical to speed in any running activity.

Pound for pound who is stronger?

Helton, W.S., *Performance constraints in strength events in dogs (Canis lupus familiaris)* Behavioural Processes, 86, pp. 149-151, 2011.



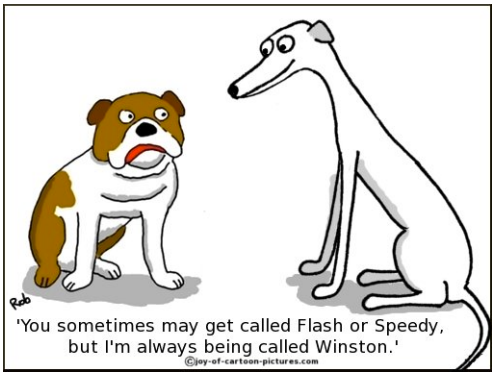
While the study by Usherwood and Wilson (2005) explores what are and are not the limiting factors in speed for the racing dog, in this study Helton looks at some possible physical trade offs of performance in the dog bred for strength.

Using data collected from the International Weight Pulling Association (IWPA) which governs organized canine weight pulling competitions where dogs pull large amounts of weight over short distance as a show of strength, 108 brachycephalic dogs (American Pitbull Terriers, American Bulldogs, and Bernese Mountain Dogs) and 109 dolichocephalic dogs

(Samoyeds, Siberian Huskies, and Alaskan Malemutes) were compared in their performance. These breeds were selected based on their numbers participating in the sport, and the kennel club conformation requirements as to head size and body ratio, with the examples of the “more brachycephalic” breed standards requiring a head that is oversized in relation to body size, with a shorter broader muzzle, and the “more dolichocephalic” breed standards stating heads are in proportion to body size. Neither group, however, is an extreme of either head type. Performance was analyzed based on weight of the competitor and their maximum pull weight.

On average the brachycephalic dogs were smaller but when the body weights were equivalent, the brachycephalic breeds were stronger and pulled more weight. The difference in anatomy is the likely explanation.

Of course the limiting factor for this study is that there is no way to compare in the same way the difference between these two groups of dogs in distance pulling events such as mid and long distance sled racing, as there are no brachycephalic breeds competing in sanctioned distance pulling competitions, likely because they are considered inappropriate for the task.



Rehab Implications?

Hmm… I’m struggling on this one. All I can think of is ‘how’ we might be able to incorporate ‘pulling’ into a rehab regimen. Of course, if the dog is used to the task, then it would be a great way to add a functional component to a rehab program.

Functional trade offs for speed vs strength

Pasi, B.M., Carrier, D.R., Functional trade-offs in the limb muscles of dogs selected for running vs. fighting Journal of Evolutionary Biology, 16, pp. 324-332, 2003.

The researchers here wanted to investigate the tradeoffs made when an animal is designed for speed or for strength of fight, and whether or not being good at one creates functional structural limitations on the other in the dog. This study tests three hypotheses regarding differences in the limb muscles of greyhound, built for speed, and pit bulls, bred for fighting strength.

Why not be oneself? That is the whole secret of a successful appearance. If one is a Greyhound why try to look like a Pekinese?
-Edith Sitwell

1. That fighting breeds will be better muscled in the distal limbs to account for an increase in agility, balance and opponent manipulation.

The distribution of muscle mass that has the greatest effect on rotational inertia during running (those that are associated with the stylopodia and the zeugopodia) was measured in both the front and hind limbs. There was a significant difference in this distribution between the two breeds. In front limbs 22.6% of muscle mass was below the elbow in the greyhound, compared to 27.5% in the pit bull. In the hind limb 12.4% of muscle mass was below the knee in the greyhound and 15.7% in the pit bull.

This pattern of reduced distal muscle mass in the limbs has evolved repeatedly in animals specialized for fast running speeds and accounts for a reduction in the work

required to oscillate the limbs during locomotion, allowing for faster maximum running speeds, which are limited only by the rate at which the limbs can be moved. The phrase, light footed, comes to mind. The pit bulls, on the other hand, better served not by top speed, but by brief and rapid acceleration and agility, where a heavier and stronger distal limb structure would be advantageous.

2.That running breeds will have a higher capacity for elastic storage and recovery of strain energy in the tendons of distal limb muscles.

The most dramatic results were seen here, where the potential to store and recover elastic strain energy in the in-series tendons was more than double (2.3x) in the ankle of the greyhound vs the pit bull.

To find such a significant different in two animals within the same species is an impressive demonstration of the role of artificial selection between the breeds. The ability to store and recover elastic strain increases the anaerobic stamina of the greyhound by reducing the metabolic energy required. Races are won not just by the fastest animal, but by the animal that can maintain their pace throughout the length of the track. The spring action of the ankle and toe extensor muscles also allows for the reduction in muscle mass on the distal limb, therefore reducing the rotational inertia of the limb and allowing the dog to achieve a greater maximum speed.

This is where we see one of the most non-compatible functional trade-offs between the greyhound and the pit bull. While the pit bull loses running speed by having less stretchy and springlike tendons they gain the advantage of being able to instead transfer the force to their opponents and maintain balance while resisting external force.

3. That there will be a difference in extensor muscle strength distribution in the forelimbs vs the hind limbs dependent on whether the dog was bred for fighting or running.

Measured using the average cross-sectional area of the muscles it was found that greyhounds have 21% less of the elbow extensor muscles in comparison to the knee extensor muscles, and 29% less in the wrists than in the ankles. By comparison, the pit bulls did not have a significantly different average cross-sectional area in wrist muscles vs ankle muscles, and the elbows had 11% greater than the knees. This showed the distribution of strength was towards the rear in the running breed and even, or sometimes towards the front, in the fighting animals.

When animals run the rear is generally responsible for acceleration and the front is responsible for deceleration. Again, these results correspond with the faster rear of the greyhound and the ability of the pit bull to stop and change direction on the front frequently while fighting.

Laurie's Thoughts on The Rehab Implications:

I think this study is fascinating! From a rehab perspective, we might want to slowly incorporate burst activities and running drills to rehab a sight hound. For the bully-breeds and other stocky-type dogs, perhaps tug of war, keep away games, or soccer- / goalie-type activities should be added into rehab.

Muscle Fibre Differences

Aguera, E., Diz, A., Vazquez-Auton, J.M., Vivo, J., Monterde, J.G., *Differences in Fibre Population in Dog Muscles of Different Functional Purpose* Anatomy Histologia Embryologia, 19, pp. 128-134, 1990.

The researchers in this study took twenty-seven purebred adult dogs (a sampling of German shepherds, Spanish greyhounds, Spanish mastiffs, and Iberian hounds). These dogs were chosen due to their breed differences in locomotory capacity, specifically the ability of the

greyhound to sprint at high speeds for short distances, the iberian hound which is an endurance runner, and the non-running mastiffs bred for largely sedentary work. The German shepherd was selected as it fits into what is considered the average body size and type for the domestic dog and is a multi-use breed suitable for various types of work. The goal of the study was to determine if there was a difference in muscle fibres within the breeds themselves.

By nature a philosopher is not in genius and disposition half so different from a street porter, as a mastiff is from a greyhound.

- Adam Smith

The researchers investigated the differences in muscle fibre population by taking samples from muscles with different functional purposes: tibialis cranialis (extensor), flexor digitalis medialis (flexor), and pectineus muscles (adductor). Specifically, the researchers were intrigued by the suggestion that muscle fibre population differs depending on the functional purpose, and that there is a genetic factor contributing to this.

Histochemical analysis was done using ATPase (pH 9.4) and an IBAS-2 Kontron image analyzer was used to assess fibres.

Within the breeds there were slight but statistically significant differences in muscle population between type I (slow-twitch) and type II (fast-twitch) muscle types, though in the mastiff these population differences were not significant expect in comparison between m. pectineus and both m. tibialis and cranialis and m. flexor digitalis medialis. This supports the theory that muscle fibre population of each muscle differs according to the functional purpose of that muscle.

When making comparisons between the breeds there was consistency in the fibre population between the adductors when compared to the other muscles, suggesting that the function of the adductor was similar across all four breeds.

The differences occurred in the flexor and extensor muscles, with the greatest differences seen between the two sight hounds, and the other two breeds. The sight hounds, as predicted, had a greater population by proportion of type II fibres in both breeds, accounting for their greater speed and reduction in endurance over time, since type I fibres are more resistant to fatigue. Similar results have been observed in studies of horses and sheep.

Aguera, E., Diz, A., Vazquez-Auton, J.M., Vivo, J., Monterde, J.G., *Muscle Fibre Morphometry in Three Dog Muscles of Different Functional Purpose in Different Breeds* Anatomy Histologia Embryologia, 19, pp. 289-293, 1990.

Using the same dogs as the study discussed above the researchers further investigated the properties of the muscle samples using the same sampling and analyzing techniques. This time the researchers investigated the differences in muscle fibre size.

No statistically significant differences between type I and type II muscle fibre size was found within the German Shepherd, Mastiff, or Greyhound breeds. However, the Iberian hound had significant differences in type I fibres between the extensor and flexor muscles tested, and also a significant difference between the type II fibre size in the flexor and adductor muscles. In both cases the flexor muscle fibres were larger in minimum diameter.

So, why the difference within the Iberian hounds and not the other breeds? The researchers speculate that there may be a relationship to body size, but couldn't draw any solid conclusions based on the data collected.

Laurie's thoughts on these studies:

Firstly, I don't understand why they classified the cranial tibial muscle as an extensor. Secondly, I don't understand why they chose these muscles! These are all small muscles. I'd be more interested in the differences between bigger muscles like quads and hamstrings, or gastrocs and triceps. But it is what it is. So, from a Rehab Professional's

'Why do You Care?' perspective, I guess you might care because to rehab a Mastiff, you could justifiably spend more time working on static weight bearing exercises, and with sight hounds, you again might want to incorporate bursts and strong muscle contractions into your rehab.

Latorre, R., Gil, F., Vazquez, J.M., Moreno, F., Mascarello, F., Ramirez, G., *Morphological and histochemical characteristics of muscle fibre types in the flexor carpi radialis of the dog* Journal of Anatomy, 182, pp. 313-320, 1993.

We saw in the other studies discussed that there is a different distribution of muscle fibre type between forelimbs and hind limbs of mammals. Specifically that the forelimbs are characterized by type I muscle fibres and the hind limbs are characterized by type II muscle fibres, supporting the conclusion that the hind limbs are responsible for locomotion while the forelimbs are for postural support. These differences in characteristics vary between species based on lifestyle and within species based on pronounced artificially bred differences.

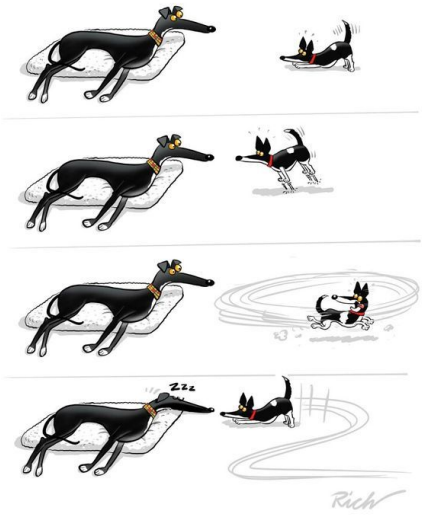
"Hey! Andy actually caught it! Hang on, Andy!"

However, the distribution of fibre types within a single muscle can also be so compartmentalized that it is possible that these two compartments of the same muscle could work independently of each other. This study investigates that possibility in the canine flexor carpi radialis (FCR).

Fifteen medium mix breed dogs were used for the study. The FCRs were removed and dissected.

The canine FCR is a clear example of compartmentalization. The two parts, the medial (radial) and lateral (cubital), are separated in transverse section by a band of connective tissue. Each has a distinct distribution of fibre type, and with that different histochemical function.

The radial section consists of a majority of type I fibres (fatigue resistant, slow twitch fibres) and the cubital section of type II fibres (fast twitch). It's possible then that the activity of each compartment is independent depending on what activity the limb is engaged in. That the radial sections are more active during postural weight bearing and the cubital section plays the primary role in flexion during locomotion. Within the separate portions themselves there is also fibre type distribution variation. In the radial compartment type I fibres increase nearest the insertion points and in the cubital compartment they increase in proportion near the centre, suggesting that each portion of the muscle also has different functional requirements.



Understanding the role of these muscle fibres, and where they are located/how they are distributed/oriented in the muscles provides important insight for the application of training programs designed to change muscle type percentages, or disorders such as myopathy (either natural or experimental) that may cause other changes within the muscle fibres.

Rehab implications:

With this study, I see a need for understanding the primary fibre composition of a muscle in order to select rehab therapies. In particular, when using an E-stim unit, if the muscle was primarily comprised of type 2 fibres, then perhaps you would use 30 - 60Hz, but if it were primarily slow twitch (Type 1 fibres), the 2 - 4 Hz might be more in order. Or, a little of each kind of stimulation might be in order in the case of the Flexor Carpi Radialis!

The role of the intercostal muscles in locomotion

Carrier, D.R., *Function of the intercostal muscle in trotting dogs: Ventilation or locomotion?* Journal of Experimental Biology, 199, pp. 1455-1465, 1996.

The intercostal muscles are associated with the function and ventilation of the lungs, however these same structures exist in boney fishes known to use a buccal pump to fill their lungs, meaning their intercostal muscle structures, while present, are not associated with with breathing. Additionally, the structural orientation of these muscles on the rib cage of terrestrial animals is not readily explained by their function during inspiration and expiration.

This study investigates whether the function of the intercostal muscles is more readily associated with locomotion, rather than ventilation.

The electrical activity of the intercostal muscles was monitored in four female mix breed dogs via surgically implanted EMG electrodes in the trunk muscles. This was done twice, with two sets of electrodes implanted at different times, monitoring three sites in the intercostal musculature. Specifically, sites in the sternal ribs and sites in the diaphragmatic ribs.

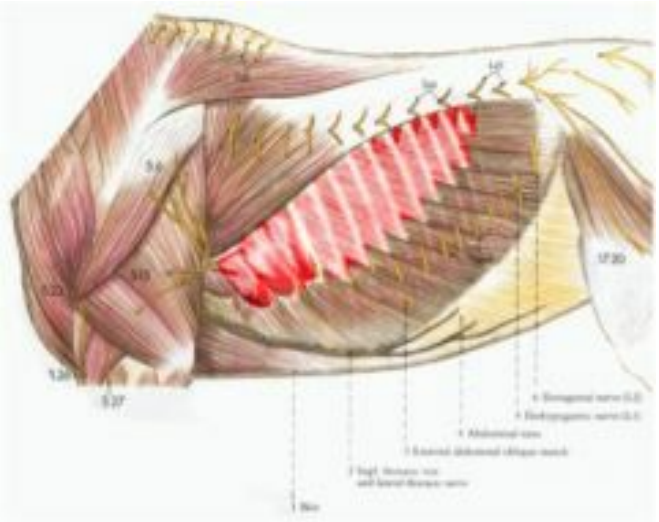
Happily, at the end of this particular study, the implants were removed, the young dogs were spayed, and they were adopted into pet homes. (Yay!)
They were monitored as they stood still, and when they were moving at a trot on an treadmill. To account for the thermoregulatory panting that occurs during exercise, the dogs were also monitored standing still while panting for thermoregulatory reasons.

When standing, either breathing normally or panting, the intercostal muscle activity correlated with breathing.

When trotting breathing can either be coupled or uncoupled with the rhythm of locomotion. When coupled, it is one breath per step. Generally an uncoupling can occur when the dog has begun to pant for thermoregulatory reasons and the pace is then slowed so that the rate of breathing no longer matches the pace of movement. This is where the results of the test became interesting. When breathing was coupled with locomotion the activity of the intercostal muscles matched the activity of thermoregulatory panting while standing still. But when breathing and locomotion became uncoupled the activity of the intercostal muscles remained related to the locomotor cycle, not to breathing. This was observed in all four dogs in every recorded instance where the ventilation and locomotor cycles became uncoupled. This suggests that any role the intercostal muscle play in ventilation is secondary to the role they play in locomotion, and when the two are no longer in sync, the locomotion role (likely to stabilize the rib cage while in motion and allow the transfer of force through the limbs to the ground) takes precedence. That said, it does not mean that there is not some importance in the role of the intercostal muscles in ventilation during locomotion as across many species coupling of ventilation and locomotion is the common default.

And how does this relate to rehab practice?

On this study, I would say that rib dysfunction and pain could contribute to breathing dysfunctions and locomotory dysfunctions as well. I would also say that we should be palpating along the intercostal muscles to evaluate and treat in any of our sporting dogs.



It seems wrong and unfair that Christmas, with its stressful and unmanageable financial and emotional challenges, should first be forced upon one wholly against one's will, then rudely snatched away just when one is starting to get into it. Was really beginning to enjoy the feeling that normal service was suspended and it was ok to lie in bed as long as you want, put anything you fancy into your mouth, and drink alcohol whenever it should chance pass your way, even in the mornings. Now, suddenly, we are all supposed to snap into self discipline like lean teenage greyhounds.

-Helen Fielding
