Environmental Factors Impacting on the Development of Hip and Elbow Dysplasia

By Genevieve Alberts

The following article combines research from a number of sources to consider the potential impact that various environmental factors could have on the development of hip- and elbow dysplasia during the developmental stages of a puppy's life. These findings may inform how breeders educate the families of their puppies on suitable care for growing joints.

What Does Environment Mean?

In this context, "environment" refers to everything that could affect an animal that is NOT genetic, for example, the amount of food eaten by a puppy, how much exercise it gets etc. Before we consider the various environmental factors, let's first understand their relative impact on dysplasia. If you are going to change or improve a trait using selection, the trait must be genetic, and the degree to which genes play a role in the expression of the trait is called *heritability*.

The incidence and extent of hip and elbow dysplasia is influenced by both genes and environment, and it would be very useful to know the relative roles of genetics and environment in determining phenotype. How much can you improve a phenotype like hip score by selective breeding? How much can you improve it by controlling the environment? When you are selecting potential dogs for breeding, it would be very handy to know if the "better" dogs have better genes or just got lucky and had a better environment. This is heritability. the *variation* in a trait, not the trait itself and heritability is an attribute of a ***population***, not an individual, because you need to measure multiple individuals to determine variation. Heritability is a proportion which is expressed as a value between 0 and 1, or it can be expressed as a percentage (0% to 100%). Heritability tells you how much of the variation you see in a trait in a particular population of animals can be attributed to genetic differences in the animals.

The Heritability of Hip Dysplasia

If genetics accounts for most of the phenotypic variation, then selection of a particular dog based on phenotype will have a good chance of picking a dog with "good" genes for hips. On the other hand, if the heritability of a trait is low (e.g., 0.2, or 20%), that means that much of the variation you see in the trait among individuals (80%, in fact) is due to the environment (non-genetic factors) and not genetics. An analysis of some of the studies on heritability of hip dysplasia in Labradors indicates that heritability is relatively low – somewhere between 30% and 40%, depending on the study and population of dogs studied (see references at end). The heritability of hip dysplasia is only modest at best and non-genetic ("environmental") factors are responsible for a considerable amount of the variation. Similar studies on heritability of elbow dysplasia also indicate an environmental component (although there is a distinct genetic link).

Risk factors for hip dysplasia

(Hips are perfect at birth)

INCREASED RISK	DECREASED RISK
larger size at birth	smaller size at birth
larger size at 3 months	slower growth rate
poor traction in whelping box	good traction in whelping box
faster growth rate	food restriction
overnutrition	exercise on uneven ground
joint laxity @ 2 weeks	no joint laxity @ 2 weeks
stairs before 3 months	off-leash exercise @ 12 months
vigorous nursing	reared on farm/rural
born in fall or winter	born in spring or summer
spayed/neutered	

Carol Beuchat[1] believes that, because non-genetic factors can account for such a large part of the variation in hip phenotype, you might be able to substantially improve the hips in your puppies if you understand what those factors are and how to reduce their negative impact. This has received much less attention than genetics for some reason, but it should be possible to dramatically reduce hip dysplasia if we can deal with some of the non-genetic factors that seem to matter. The list below summarizes some of the key factors identified in research. Remember all hips are perfect at birth!

Food Consumption and Obesity

Food consumption and (therefore) the body weight of the puppy has a profound effect on the risk of developing hip dysplasia. The Purina Study is a 14-year-long multi-institutional project funded by Nestlé Purina that followed the lives

[1] Carol Beuchat, PhD – The Institute of Canine Biology (the author has completed an online course on canine hip and elbow dysplasia conducted by Carol Beuchat through the ICB and would highly recommend the course to anyone wanting to learn more on the subject)

of 48 Labrador Retrievers. Labrador puppies from 7 litters with lines known to have a high prevalence of hip dysplasia were paired at 8 weeks of age by gender and weight and then randomly assigned to two different groups. One group were allowed to "free feed" and the other group were fed 75% of the quantity consumed by the free feed group. Allowing puppies to free-feed from 8 weeks resulted in an increased rate of growth and a higher adult body mass compared with dogs on a restricted diet, who weighed 25% less from 1 year through adulthood.

When these dogs were screened for hip dysplasia and secondary osteoarthritis (i.e., arthritis that arises as a consequence of hip dysplasia), about 12% were diagnosed as dysplastic at 1 year old, while in the restricted food group only about 3% were dysplastic. From there, the proportion of dogs with normal hips dropped quickly in the free feeding group; about 50% had hip osteoarthritis by age 6, and 80% by 9 years. In the restricted food group, only about 20% of dogs had hip osteoarthritis by 8 years, and only 50% by 12 years! The dogs' hips were all OFA scored at two years of age and there were distinct differences in their scores depending on which group they were in.

This is a very interesting result because the feeding experiment didn't start until the puppies were 8 weeks old and everybody had the same diet until then. The data show that food consumption after 8 weeks old had no effect on joint laxity, but it made a huge difference in the OFA hip scores. According to Carol Beuchat there is an interplay of two factors, laxity and body weight, in the development of hip dysplasia. Greater laxity results in earlier development of dysplasia, and greater weight is associated with more severe damage.

Body size & type

Hip dysplasia is often characterized as a "large breed" disorder, but the data reveal a different picture.

According to the OFA's online statistics for hip dysplasia (November 2015), there are many large breeds towards the top of the list - Dogue de Bordeaux, Otterhound, Neapolitan Mastiff, St. Bernard, etc - but sitting among them at #2 is the Pug, which is a toy breed (but 72% dysplastic!). There are also large breeds at the bottom of the list that have among the highest levels of excellent hips, including the Saluki, Borzoi, and Greyhound.

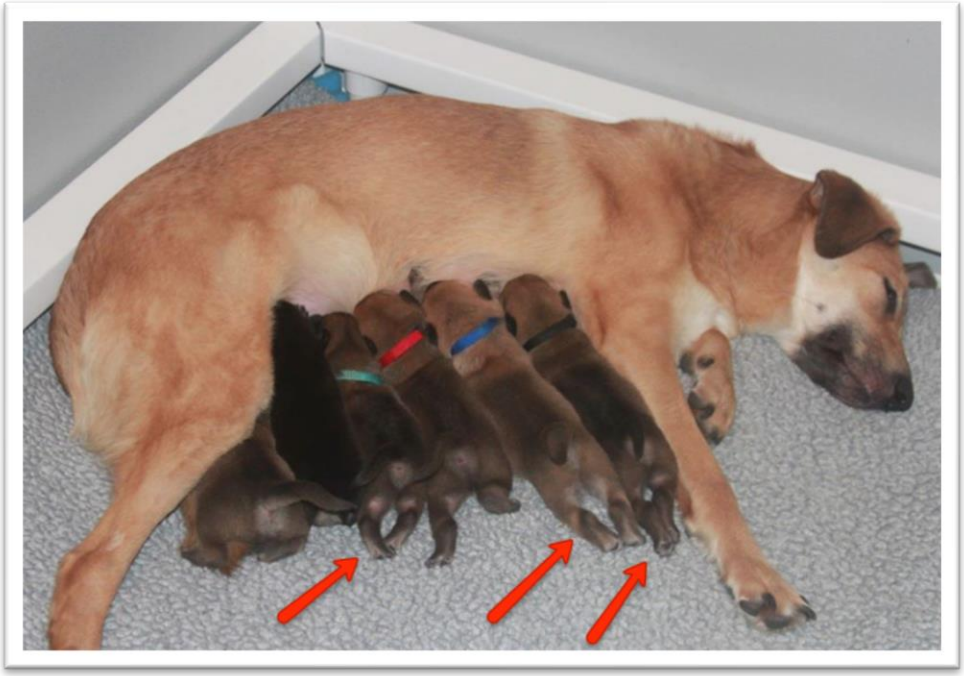
These basic data do not support the generalization that hip dysplasia is a "large breed" disorder. In fact, instead of size, it is body type - robust vs slender - that correlates best with the rankings for hip score. Breeds that typically have poor hip ratings are substantially heavier for their height than breeds that tend to have excellent hips. It is this physiology that explains why Labradors have a worse than average risk of being pre-disposed to HD.

Substrate

There is evidence that the type of substrate puppies were on in the whelping box prior to weaning affects hip phenotype. In a study, Boxer puppies raised on a floor covered with a "slippery" material were 1.6 times more likely to develop clinical signs of hip dysplasia (van Hagen et al 2005). The definition of "slippery" in this study was a little loose, including both newspaper and tarpaulin, while "non-slippery" included carpet, rubber, blankets, sawdust, or straw. In addition, Krontveit et al 2012 found that puppies that were exercised from weaning to 3 months in a run with a soft surface (dirt or grass) had a lower risk of dysplasia than puppies exposed to hard substrates like wood, asphalt, or concrete.

Carol Beuchat believes that most substrates people are using in their whelping boxes provide inadequate traction for puppies. We expect puppies to be crawling for the first few weeks, so seeing them crawl doesn't register as "too slippery to walk." It is *potentially* the single most important thing determining the ultimate hip status of a dog if slipping results in damage to the round ligament that attaches the head of the femur to the wall of the acetabulum. Joint laxity at two weeks of age is a significant early indicator of the development of HD later.

The easiest way to tell if puppies are slipping is if you can see the pads on the underside of the paw. If the back feet are slipping, the leg will end up fully extended to the rear with the pad facing upwards. If the puppy is crawling, the front legs will be doing what looks like the breast stroke, with the legs stretched out to the side and moving to the rear but the pad is not on the ground.



Beuchat believes that substrates such as newspaper, wood floors, slippery tiles, blankets, sheets, towels and quilts are usually too slippery. The idea is to make sure the legs are under the body.

Riser noted that if hip laxity develops in a young puppy (less than 3 or 4 months), it can be kept in a cage so it will spend more time sitting. Whilst not suggesting that a puppy should be crated all the time, encouraging a puppy to sit correctly as much as possible makes sense. If the legs are staying under the dog, the head of the femur stay where it belongs in the hip socket.

Exercise

The Krontveit study of large breeds found that the type of exercise the puppy was exposed to affected the risk of dysplasia. Puppies that lived on a farm from birth to weaning had a 30% lower risk of dysplasia than those from suburbia, presumably because of the sort of exercise they were exposed to. During the post-weaning period through 3 months, puppies that used stairs daily had an elevated risk of dysplasia, and those that got daily off-lead exercise in park-like terrain had a lower risk. Likewise, a study of adult Labradors in Sweden found that regular exercise chasing a ball or stick thrown by the owner more than doubled (2.2 to 2.6 times) the risk of hip dysplasia (Sallander et al 2006), and these activities have also been linked to development of osteochondrosis (Slater et al 1992). Why these particular activities increase the risk of developing hip dysplasia is unclear but perhaps it involves intensity or repetition.

In addition, puppies do not need long walks or vigorous exercise. Playing in the garden is sufficient for pups under 5 months old. If you take a puppy out on a leash, a rule of thumb often mentioned is no more than five minutes walking per day, for each month of age.

Endocrine & Spay/Neuter

This is a controversial area in rescue circles but bears mention. Spay/neuter status can be associated with differences in the incidence of hip dysplasia, but there are differences by breed, sex, and age. Various studies have found a positive correlation between early neutering (before 12 months) and incidence of HD. It is not clear why. Beuchat muses that it could be endocrine, or differences in body mass, or the timing of growth plate closure. Hopefully there will be more studies that shed some light on the factors involved but in the meantime, the best advice would be to postpone neutering until the dog is older than 6 months, or even better, once the growth plates have closed at say, 12-18 months.

Nutrition

There is no evidence that nutrient *deficiencies* of any sort can result in hip dysplasia (Nap et al 1991), but *excesses* of some vitamins and minerals can contribute to development of skeletal disease. Improper levels of some key minerals and "over-nutrition" (excess caloric intake) can have huge effects, especially in puppies. Calcium and phosphorus (among other minerals) are required in the diet in specific amounts and proportions for proper bone development. Getting the proper balance of calcium and phosphorus in the diet is especially critical in large dog breeds. Vitamin D is important for absorption of calcium and phosphorus from the gastrointestinal tract, so the control of calcium balance depends on the correct levels of vitamin D.

Hopefully by applying what we are learning about the impact of environmental factors on the development of HD and ED, we can help our puppy buyers reduce the incidence thereof.

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