HIP DYSPLASIA AND THE CARDIGAN CORGI

The hip joints may be the most important joints of the dog's skeleton. All the power that moves the dog forward is generated by the hind legs, and is transmitted to the rest of the body via the hip joints. Therefore, dysfunction of the hips is truly crippling.

The important issue is to decide whether available evidence indicates that currently available hip investigation systems provide an effective guide to breeders and whether hip dysplasia (HD) is sufficiently under genetic control within the Cardigan Welsh Corgi breed, so that breeders can select stock to produce sounder hips.

All hip grading systems around the world apart from PennHip rely on an assessment of the variation from the normal hip as described by D.D. Lawson (1963).*1 We do know that if only dogs with normal hips, as defined by D.D. Lawson, are bred from the disease can be eliminated in 4-5 generations (B.E. Henriccson et al 1972) *2

However the effectiveness of using x-ray and hip scoring as a tool to breed away from hip dysplasia is under the influence of three main factors:

Factor 1) Until quite recently only a small percentage of breeds had their hips scored. If you compare the numbers of a breed registered with the number actually hip scored, you will find that commonly 20% or less have had their hips scored. Even for those that have had their hips scored, there is usually nothing in place to stop a dog with a high score being bred and two of the few exceptions to this are the German Shepherds and the Rottweilers.

To use hip scoring as a tool to reduce the incidence of hip dysplasia across an entire breed, it has to be realised that there is no point in screening only some of the breeding stock. Unless all breeding stock is screened and only those with normal or near normal hips are bred from, no or only very slow progress will be made in controlling HD. Hip improvement within any given breed will continue to be limited because dogs are sometimes bred from regardless of their hip score.

Take the following scenario: A Golden Retriever with very poor hips becomes a popular sire because he has other good attributes and has won at a number of top shows. He mates with 10 bitches in a year and fathers 100 offspring. Half these will be male so in 2 years time his offspring are being used as sires so now you have the possibility that his genes have been disseminated through 5000 descendants. The breed as a whole might be making an effort to control HD but this dog alone would set things back a long way.

Factor 2) To maintain genetic diversity within a breed and to perpetuate other beneficial traits, breeders have to make choices about breeding not only HIPS,

but about breeding DOGS. Therefore breeding decisions cannot be made purely and wholly on the basis of hip status as there may also be other important factors to consider in relation to health, structure or temperament. Despite this, the investigation and assessment of hip health by the breeder provides a useful tool in decision making as it can be used to avoid breeding badly dysplastic dogs together and possibly compounding the problem or it can also indicate family trends towards either good or bad hips.

Factor 3) The cut off point of hip scores for breeding is set too high.

Perhaps it should be pointed out that corgis are hypochondroplastic dwarfs as are many other small-legged breeds. As a result of this, their joints tend not to conform to the definition of normal as has been derived from larger breeds such as German Shepherds and Golden Retrievers.

Configuration of the hips between breeds may differ and it certainly does in the breeds that are hypochondroplastic dwarfs. It is due to specific breed differences that many breed clubs set the standards that are acceptable for breeding within their breed.

No one is saying that corgis should have the same hips as German Shepherds but to define a normal hip for each breed would be a daunting task indeed. Also, the temptation to compare hip scores across breeds should be resisted as it is a bit like comparing apples with pears. What corgi breeders need to do is to examine enough dogs to decide what is the maximum hip score for the breed which is still acceptable for breeding.

How is an acceptable score for a breed reached? Once sufficient numbers of a breed have been assessed (100) a mean for that breed can be established and then the selection criteria should be that no one hip should have a score of greater than ½ the breed mean score (BMS). As the BMS drops so will the score that is acceptable for breeding. Such a control programme can be taken a step further by recording the hip status of offspring so that it can be determined which sires are tending to reduce the hip scores of their progeny. This type of scheme has the potential to reduce the degree of HD within a breed but to maintain genetic diversity, should not be made a mandatory requirement (remember we are not just breeding hips) and must be provided to breeders for guidance only.

Factor 4) Although an inherited condition, hip dysplasia will be variable in expression in any affected individual due to environmental factors during development. Therefore investigation of hip status by x-ray and scoring is at best merely looking at the presenting phenotype of the dog. There is currently no genetic test for hip dysplasia.

In addition, the value of the hip evaluations themselves is directly related to the ability of the individual examiner and the scoring method in use. Hip evaluation and assessment methods around the world are not uniform, therefore the actual value of assessing hip x-rays and assigning a designated "score" is directly influenced by the variable ability of those assessing the films and the subjective nature of this, plus the lack of standardised, globally based methods of assessment.

As mentioned previously all of the world's hip assessment methods depend on determining the degree the hips vary from a 'defined' normal. Some use a subjective assessment by an individual or a panel of individuals such as the OFA does. Alternatively, the scoring system used in Australia, New Zealand, the UK and Singapore is an attempt to make the assessment more objective.

To sum up; - While the predisposition to canine hip dysplasia is inherited, the apparent failure to decrease the incidence of HD after years of hip scoring in certain breeds is due to multiple factors.

The most important being:

1) Not all breeding stock is screened.

2) The cut off point for breeding is too high.

3) Breedings are still made regardless of any individual dog's hip score.

4) Hip x-ray and hip scoring can only assess the presenting appearance of hip phenotype of the individual dog, not its actual genetic status for hip dysplasia.

SO WHAT EXACTLY IS HD?

Hip dysplasia (HD) simply stated means an "abnormal formation" of the hip joint. Think of the condition first as looseness in a joint that should be snug - then most of the problems attendant to hip dysplasia are a result of this "looseness". The normal anatomy of the hip joint is a classic ball and socket joint. The head of the femur (the ball) is supposed to fit smoothly and exactly into the acetabulum (the socket). If the head of the femur does not fit snugly, it will be slipping and bumping around somewhere in the neighbourhood of the acetabulum, and this will damage the relatively delicate surfaces of the joint. A perfect joint has living layers of tissue on the surface of both bones; if that is damaged, there may be bone rubbing on bone, which is both destructive and painful.

The overt signs of HD vary from decreased exercise tolerance to severe crippling.

They include: a reluctance or inability to go up or down stairs, difficulty in rising from a sitting or prone position, bunny-hopping gait when running, stiffness early in the morning that improves as the dog warms up, change in disposition due to pain, lameness after exercise, wobbly gait, a clicking sound when walking, and many others.

Research on hip dysplasia suggests that HD is a more complex disease than was first thought. There are five biological factors that contribute to HD, and there are often severe interactions between those factors.
[1] Genetic control within a breed.
[2] Nutrition of the growing puppy
[3] Exercise as the puppy is growing
[4] Floor surfaces the puppy is exposed to.
[5] Differences in conformation between a breed, and the wolf ancestors of all dogs.

To this list of biological causes, we could add a catch-all to include technical, policy, and technique difficulties, which are essentially artefacts of the evaluation systems.

There are no simple answers or solutions to the problem of HD. However, many aspects of the disease have been repeatedly and independently documented and are generally accepted by the scientific community. Five important ones are:
[i] Two physical features contribute to HD, the structure of the bone in the joint, and the tightness or laxity of the ligaments which hold the joint together. The latter is less known and studied.

[ii] The genetic component of canine hip dysplasia is thought to be caused by the presence of many genes (polygenic inheritance), although recent studies provide weak support for the idea of a major gene which might control the whole range. While no environmental cause has been demonstrated experimentally, many environmental factors may contribute to HD's expression in a particular dog (its phenotype).

Most authors have concluded that HD has to be considered a quantitative genetic trait that is expressed differently in various breeds and is influenced by environmental effects such as nutrition. *3

[iii] One other feature of selection in polygenic systems of inheritance has never been examined in relation to HD, but cannot be ignored. Many genes have more than one function, so that when selection is made for any particular allele, other unknown but inter-related systems may also be affected. Individual genes are on chromosomes which carry many genes and if we are severe with selection for one factor, as we wish we could be for HD, we may inadvertently eliminate some desirable genes as well. Therefore by discarding individuals for one undesirable

trait on a particular chromosome, we may also remove other desirable traits from the gene pool.

Put simply, even if genes for HD could be identified, current knowledge confirms that genes for any trait may be inherited in "blocks" of genetic material and therefore selecting solely for hip status would not only cause the loss of genetic diversity, but may inadvertently cause the loss of genes for many other important and beneficial traits. Good and bad genes for HD do not exist in isolation, and we must expect that other systems will be affected by selection solely for good hips.

[iv] The only current means for reducing the occurrence of HD at the breed level is by selectively breeding for normal hips. The problem with that approach is that breeders are not in a position to breed solely for hips but must consider the dog as a whole.

[v] Radiography is the accepted means for evaluating the status of the bone in the joint, and there are recent methods for measuring laxity of ligaments.

We like to think of genes as "blueprints', which they are. Also, the final result, in the case of hips, is a relatively hard structure. But the mechanical analogy breaks down when we consider that, as a puppy grows, the bones are not calcified, they are cartilage. Also, not all parts of a puppy grow at the same rate, in terms of time and size, and that relative growth can be affected by nutrition. That can mean, for example, that a puppy whose hips would be fine if he grew up on a wolf diet of raw prey, might, if on another diet, have his bones growing faster than his muscles and ligaments in the 3 - 8 month-old period when growth is most rapid. At this point it is possible that hips genetically pre-disposed to HD could be seriously damaged if growth and exercise get out of balance with each other.

When the transition was made from feeding dogs home made rations to commercial pet foods, the first dog foods were developed by livestock feed manufacturers. In livestock, young animals are fed so as to grow as fast as possible to reach market size as young as possible. By 1990 it had become evident that this approach was not appropriate for dogs, especially for larger breeds. Therefore, modern puppy foods are not as rich and differ from adult rations mostly in vitamins and minerals. So, the bad effects of puppy food on hips may be less now (2007) than they were decades ago.

Add to that too much or too little exercise during this critical period, and you easily see that further damage could occur, through changes in muscle mass and muscle tone. That is called interaction by statisticians, where the combined effect of two factors is either greater or less than the sum of the effects of the two factors studied separately. Add to the mixture the concept that raising dysplasia-prone breeds on slippery floor surfaces, and you observe that a puppy which is growing too fast, and stressed by too much exercise may have its legs slip out

sideways and thereby stretching the ligaments. So there is large potential for disruption of the normal growth of healthy hips by a variety of environmental factors, and the potential for destructive interaction is significant.

Policies and policy differences between the two major systems of hip assessment affect the estimates of heritability of the results. You may have your dog x-rayed for submission to OFA in the USA, (but the comment is equally valid for other national hip registries), but, between you and your veterinarian, you may decide not to submit that dog. That should mean that OFA estimates of the prevalence of good hips in a breed will be overestimated, if obviously bad hips are not submitted.

PennHip requires that every dog examined by their procedure must be submitted to the database. However, while that may be a better approach, there is no requirement that all individuals in a litter be examined. The latter requirement would put estimates of heritability on a sounder basis. The onus here rests with breeders and fanciers of a breed. National veterinary registers, and OFA, provide well-honed techniques for assessing hips, but unless all members of a breed or breeding line are submitted, progress in elimination of hip dysplasia will be slow.

Statistically, it is said that the PennHip Distraction Index has a higher heritability than OFA ratings. But even that heritability is relatively low. Another advantage of PennHip is that their lead-up studies indicated that the technique produces reliable measures even at less than six months of age. Unfortunately, several veterinarians familiar with PennHip say that there are problems in applying the technique to dwarf-legged dogs.

Depending on the system used, examination of radiographs of hips has a considerable subjective component, so hip scores may vary depending on who reads the x-rays. Most of the national hip rating schemes try to offset that by requiring more than one expert to read the pictures.

Several veterinarians have suggested that owners may mask some of the heritability of HD by taking extra care with puppies. For example, there are some who carry puppies up and down stairs for the first year of their lives, to help prevent them from becoming dysplastic. In doing so, they may mask genetic dysplasia by trying to keep the puppies" normal".

There are at least two ways of thinking about hip dysplasia. While one is that it is a genetically inherited condition and we should be able to improve dog breeds by careful selection, the consensus is that we have made some improvement but in some breeds not nearly as much as we want. As mentioned previously this could be due to the over use of 'popular sires' which may carry the genes for HD, or the fact that dogs will continue to be breed regardless of poor hip scores.

The second way is to admit that the growth process is dynamic, and the structures are relatively fragile during some periods of growth. When a dog has inherited genes for hip dysplasia the expression of those genes and the resultant health of the dog's hips is, partly at least, due to environmental events during its growth.

What do we know about hip dysplasia in the wild ancestors of dogs? There do not seem to have been any studies of the incidence of dysplasia among wolves, coyotes and jackals.

DNA research suggests that all modern dogs are derived from several lineages of the gray wolf population of East Asia and the Old World, as the DNA makeup of wolves and dogs is almost identical. Advances in genetic research looking at mitochondrial DNA (mtDNA) has shown that the domestic dog is an extremely close relative of the gray wolf, differing from it by at most 0.2% of mtDNA sequence. In comparison, the gray wolf differs from its closest wild relative, the coyote, by about 4% of mitochondrial DNA sequence. *4,5,6,7.

While archeological sources suggest dogs diverged from that stock some 10-15,000 years ago, some studies of Mitochondrial DNA research suggests that domestication occurred as much as 125,000 years ago due to the fact that dogs possess gene sequences not found present in the wolf, *8. The wolf stock itself has been around for an estimated 7,000,000 years, and itself must have been subject to a lot of natural selection.

From that basic wolf stock came dog breeds as diverse as Chihuahuas, Irish Wolfhounds, etc. and corgis.

So we have taken a single wild blueprint, and manipulated it into a huge variety of different forms. And, we have done that in a very short time, that is, roughly the last 200 years. If you strip away the bunk and fantasy of most breed histories, you can't find much solid evidence that many breeds actually existed before 1850. And for those that did, many have changed dramatically since then. So what are the implications of such rapid changes in size and relative weight for the hip joints?

The generalization is that small breeds rarely suffer from dysplasia, giant and large breeds almost all have degrees of dysplasia, and in between you have to look breed by breed. In that middle range the rule of thumb is that breeds that are heavier built are more likely to suffer from dysplasia and this represents an important contributor to hip dysplasia which possibly cannot be affected by breeder selection. Strict selection for hip health alone may result in most dogs having the general size and proportions of the ancestral wolf.

Breeds which have muscle to skeleton relationships similar to the small wolves of Iran are relatively free of HD, so the greyhound is the 'perfect' breed as far as

hips are concerned. The further dog breeds deviate from this basic design, the more likely it may be that a breed will be subject to dysplasia. That observation leads to the prediction that progress in reducing the incidence of serious dysplasia will not be the same in every breed. Many breeds have deviated too far from the basic design. Small breeds have gone a beneficial way, while some large breeds have travelled a more dangerous path.

IS HD A PROBLEM IN CARDIGAN CORGIS?

[1] Hip dysplasia is known to occur in Cardigan Corgis. That said, crippling disease from this cause is quite uncommon.
[2] Some veterinary specialists speculate as to whether corgis can be assessed by conventional techniques. The short legs and heavy muscles make proper positioning for x-ray more of a challenge and complicate reading the results. Vets performing PennHip have made similar comments.
[3] Environmental variables such as diet, exercise and floor surface are involved in the development of hip dysplasia in large and heavy breeds. The potential effects of these variables are unknown in Cardigan Corgis.

Cardigans are on the small end of middle sized, but purely by observation, their weight seems to have increased by over 40% in the past 40 years or so. They are heavily muscled, but on a sturdy skeleton. But then, they have dwarf limbs, and no one seems to know the implications of dwarf legs on dysplasia.

Cardigans have a broader muscle mass about their hips than most breeds, and that may help stabilize the joints. Some veterinarians have stated that they are not sure how to x-ray dwarf-limbed breeds; because the muscles hold the joint differently than in longer-legged breeds and PennHip specialists have expressed similar reservations. That makes it uncertain whether current methods of studying hip dysplasia actually apply to dwarf-legged breeds. Much more study specific to dwarf-legged breeds is required before we can be sure that current x-ray techniques are fully applicable to Cardigans.

Cardigans in North America are much more involved in activity sports than they were 30 years ago. Is that showing up deficiencies in hip structure that would not have shown up in the kennel dogs and couch potatoes of 1950-1980? Generally speaking, serious cases of hip dysplasia appear to be uncommon in Cardigans.

It has often been claimed that dogs that can lie flat with their hind legs stretched out behind them do not have HD. Experience has shown that, however, is untrue. Photos of one young dog show that he can do this and he does not express any clinical signs of having HD, yet when tested his Pre-lim was MILD and the x-ray showed hardly any socket. This dog lives on a farm where he exercises all day and his tight muscles enable him to keep his legs from falling out of his hips. He may yet prove to show signs later in life when he slows down

and isn't so active and physically fit. His litter brother, on the other hand, could not walk at nine months.

In Cardigans, there may be an important difference between dysplasia as seen on x-rays, and functional dysplasia, which hurts the dog. In other words, many dogs with mediocre hips as indicated from x-ray, live long, happy and pain-free lives and never go on to develop degenerative joint disease and arthritis. In another example, Norwegian elkhounds tend to have relatively shallow hip sockets so many do not pass OFA, but that does not reduce their performance in the field. Perhaps the socket depth is compensated for by tighter ligaments? That is not yet known.

Being subjective, an OFA screening should not be taken as completely predictive of hip dysplasia as actual physical expression of the genes for hip dysplasia is known to be variable, and the true genetic status of the dog may therefore be masked. OFA results must also be considered in light of family history, environmental factors, nutrition, and importantly, the structural components of the system (ligamentation, muscling etc) which radiological screening is not capable of assessing.

A heritable defect such as hip dysplasia, which does not always show expression in the individual carrying genes for the condition, will be very hard to breed out using selection based purely upon phenotype (or appearance). Evaluation via hip x-ray is not a diagnostic tool for a dog's genotype but solely for its presenting phenotype, therefore some dogs which are genetically dysplastic but raised under ideal conditions may appear normal in phenotype and therefore have acceptable hips, yet they are able to pass the genes for hip dysplasia on to the next generation.

The Hardy-Weinberg Law of population genetics states that, in the absence of selection, the frequency of particular genes does not change from generation to generation. For HD that means that failure to x-ray breeding stock in a randomly bred, “wild” population would not cause the prevalence of HD to rise unless other factors were involved. However in dog breeding where strong selection for certain characteristics is the normal practice, genes for hip dysplasia could be unknowingly selected for along with other traits.

PROBLEMS IN ASSESSING CARDIGAN HIPS

We must also consider the Cardigan/hypochondroplastic hip. It will be shallower and looser than a non-dwarfed hip. If you showed a Cardigan film to an orthopaedist and told him/her it was a Labrador the dog would promptly fail its hip assessment.

The mean distraction index in the corgi breed group is around 0.6; that would be a horrifying score to a breeder of tighter-hipped longer-legged dogs. In fact, if you

got a 0.6 on a Lab, you'd be told to expect joint disease in the future. Yet in the Cardigan Welsh Corgi there exist loose-hipped, shallow socketed little dogs that somehow seem to keep going for well into their second decade.

Unfortunately, OFA will not discuss the issue of testing dwarf breeds and no allowance for the different characteristics of dwarf breeds is made by any of the available hip evaluation systems. One vet was on the OFA evaluators list for years, that was until he started voicing his opinion that you can't evaluate a dwarf breed the same way you do a normal growth breed. He was asked to retire from the evaluation list by OFA. He also quit PennHip X-raying when two healthy and happy show Shi Tzus came in for PennHip evaluations. He was certified and had performed several films for PennHip prior to these two dogs. Both dogs went home sore and never recovered from their ordeal. It was later found both dogs had failed severely with OFA on their hips. PennHip claimed their method was not at fault as any dog with severely dysplastic hips most likely will suffer damage when the technique required for proper PennHip evaluation is done.

CONCLUSIONS

[1] Hip dysplasia is a genetically based, heritable defect but variable in expression (phenotype). It is thought to be polygenic in inheritance, with the possible involvement of a major gene or gene series and multifactorial in expression. Environmental variables such as diet, exercise and floor surface are known to be involved in the development of hip dysplasia in large and heavy breeds. The potential effects of these variables are unknown in Cardigan Corgis.

[2] Hip dysplasia is known to occur in Cardigan Corgis. That said, crippling disease from this cause is quite uncommon in this breed.

[3] Some veterinary specialists have expressed doubt as to whether corgis can be assessed by conventional techniques. The short legs and heavy muscling make proper positioning for x-ray more of a challenge, and this may complicate reading the results. Vets performing PennHip have made similar comments.

[3] Hip x-rays can only reveal the presenting phenotype of the dog, not its true genotype nor its potential to pass on genes for HD.

[5] Hip dysplasia is difficult to breed out unless selection is heavily based on this trait. Such narrow selection is impractical due to reduction in genetic diversity and the potential loss of other desirable traits.

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