Using PennHIP in Breeding: A Veterinarian's Perspective

By Simon Verge, DMV

To optimize genetic progress, PennHIP recommends breeding dogs for which the DI is under the average (mean) value for their breed.

About the author

Simon Verge, DVM, is a Canadian veterinarian who has been breeding and raising Berners since 1991 under the registered kennel name of Hautbois. He has participated in 12 BMDCA Nationals since 1997. He has served as Board Chairman of the Bernese Mountain Dog Club of Quebec since 2006 and is a current member of the Canadian Kennel Club's Genetics and Medical Committee and Breeder Relations Committee.

In the first part of this series (published in the June 2009 edition of *The Alpenhorn*), the causes of hip dysplasia and coxo-femoral laxity as an indicator of the susceptibility to this disease were discussed. As well, the limitations of traditional techniques and the solutions afforded by the PennHIP technique (for which high heritability becomes a big advantage) were described. This second article is devoted to the interpretation of PennHIP results and their integration into a breeding selection program, such as experienced by the author.

Positioning with the Distractor Apparatus for PennHIP Distraction View
Photo: Courtesy of M. De Carufel, DVM, University of Montreal

Distraction index (DI)

The distraction index (DI) is a ratio obtained from the distraction X-ray by dividing the distance between femoral head and acetabular centers by the radius of femoral head; its range is usually between 0.1 and 1. In most cases, it will not be exactly the same for both hips on the same dog. It therefore is provided independently for each of the dog's two hips, but only the highest result will be used to compare an individual dog with others of the same breed. The DI is a ratio scale, meaning that a hip joint with DI of 0.6 has twice the passive laxity of a hip joint with DI of 0.3. The scale is also intuitive: a DI of 0.6 means that the femoral head is 60% subluxated (i.e., dislocated or misaligned) from the acetabulum. Lower DIs and tighter hips are always better hips.

PennHIP Report Content

A PennHIP report for a dog includes the DI for each hip, a subjective assessment of the presence and severity of degenerative joint disease (DJD), and the laxity ranking of the specific dog (based on the looser of the two hips) relative to other dogs of the same breed. This registry does not provide a passing or failing score. To optimize genetic progress, PennHIP recommends breeding dogs for which the DI is under the average (mean) value for their breed.

Variations in the Distraction Index (DI) from One Breed to Another

In 1994, Dr. Gail Smith at the University of Pennsylvania observed that breeds recognized to be at a low risk for hip dysplasia (< 1%) uniformly had very tight hips and a very low distraction index (Smith, 1994). In fact, 98% of the Greyhounds and the Borzois had a DI under 0.3, some of them being as low as 0.08. This supported the idea that 0.3 was to be a target value that scientifically represents the difference between healthy hips and those at risk for hip dysplasia.

The average DI for all breeds (a total of 80,746 dogs) was 0.50, the median (50th percentile) was 0.48, the 75th percentile was 0.38 and the 25th percentile was 0.61. (Editor's note: As used in this article, the greater the percentile, the better the result in terms of hip quality and hence the lower the DI score.) As a comparison, Figure 1 illustrates the rank order of mean (average) DIs for breeds for which

more than 200 PennHIP evaluations were performed. This compilation was done using the May 2009 PennHIP Distraction Index Laxity Profile (semi-annual update).

The boldfaced italicized breeds have a higher percentage of dysplastic dogs than Berners (according to OFA statistics).

Figure 1
Rank Order of Mean (Average) DIs for Breeds with More than 200 PennHIP Evaluations

Breed	Count	Mean DI	50th %tile	% Dysplastic (OFA)	OFA Rank
Belgian Malinois	561	**0.35**	0.32	5.5	126
Rhodesian Ridgeback	432		0.33	5.2	128
Doberman Pinscher	383	**0.37**	0.36	6.1	116
German Shorthaired	594		0.35	4.5	134
Dalmatian	213	**0.40**	0.39	4.7	132
Great Dane	728		0.38	12.0	80
German Wirehaired	302	**0.41**	0.38	9.1	98
Old German Shepherd	522		0.38		
Shiloh Shepherd	544		0.39	21.1	28
Weimaraner	418		0.39	8.7	102
Wirehaired Pointing	338	**0.42**	0.39	7.7	107
German Shepherd	8650	**0.43**	0.40	19.1	39
Vizsla	463		0.39	7.2	108
Boxer	506	**0.46**	0.44	10.9	89
Irish Setter	217		0.44	12.2	78
Australian Shepherd	802	**0.47**	0.44	5.8	122
Border Collie	1156	**0.48**	0.45	11.1	87
Flat-coated Retriever	280		0.46	4.3	135
Giant Schnauzer	211		0.46	18.2	46
Great Pyrenees	247		0.46	9.2	97
Bullmastiff	1137	**0.49**	0.48	24.6	24
Labrador Retriever	18627		0.46	12.1	79
Leonberger	224		0.47	14.1	64
Standard Poodle	1612		0.48	12.4	74
English Mastiff	646	**0.50**	0.50	19.5	35
English Springer Spaniel	669		0.50	13.5	67
Spinone Italiano	202		0.48	15.6	54
Australian Cattle Dog	250	**0.51**	0.50	15.1	60
Gorden Setter	222		0.50	19.6	33
Alaskan Malamute	268	**0.52**	0.50	11.5	83
Chesapeake Bay	447		0.52	20.9	29
Greater Swiss Mountain	460		0.52	19.0	40
Bouvier des Flandres	352	**0.53**	0.52	15.1	59
Brittany	418		0.52	15.1	58
Shetland Sheepdog	306		0.50	4.8	131
American Bulldog	2211	**0.54**	0.54	32.9	17
Bernese Mountain Dog	**1482**		**0.54**	**16.2**	**51**
Samoyed	217		0.50	11.2	85
Soft-coated Wheaten	276		0.53	4.6	133
South African Boerboel	737		0.54		
American Pit Bull	*539*	**0.55**	0.55	23.8	26
Golden Retriever	12177		0.54	20.0	32
Rottweiler	2080		0.54	20.4	31
Airedale Terrier	697	**0.56**	0.55	11.5	82
American Staffordshire	317		0.57	26.0	21
Portugese Water Dog	288		0.55	13.1	69
Akita	303	**0.58**	0.58	13.1	72
English Setter	679		0.58	16.6	50
Newfoundland	1473		0.59	25.3	22
Cane Corso	799	**0.60**	0.61	40.1	10
Cardigan Welsh Corgi	251		0.61	18.5	43
Saint Bernard	267	**0.64**	0.66	46.9	6
Pembroke Welsh Corgi	402	**0.66**	0.65	18.1	47
Dogue De Bordeaux	591	**0.67**	0.68	55.8	3

"Traditional hip screening methods rely solely on the hip-extended view to evaluate both the presence of hip arthritis and joint laxity.

"...while the hip-extended view can detect existing arthritic changes, it often conceals hip laxity, thereby giving a false impression of joint tightness.

"...in the absence of arthritic changes, the hip-extended view does not reliably distinguish between dogs that are disease-susceptible and those that are not."

From the PennHIP Brochure.

Correlation Between DI and Susceptibility to Degenerative Joint Disease (DJD)

The relationship between the distraction index (DI) and degenerative joint disease (DJD) follows a curve that is specific to each breed. A comparative study between Rottweilers and German Shepherd Dogs showed that the same DI might represent a differing risk of DJD from one breed to another (Popovich, 1995). For example, a distraction index of 0.4 represented less than a 10% chance of DJD for a Rottweiler while more than a 40% chance of disease for German Shepherd Dogs. The proposed explanation for the difference in risk was the greater muscling of Rottweilers and their lesser angulation, which limited the risk that a passive laxity would lead to a functional laxity and eventually lead to DJD. It was therefore important to express the results in a cohort of dogs of the same breed. In this same study, they showed that for the Rottweilers and the German Shepherd Dogs, each increase of 0.1 in the DI increased the odds of developing disease (DJD) by factors of 2.9 and 4.1, respectively. In 2001, Smith published a study that included German Shepherd Dogs, Golden Retrievers, Labrador Retrievers and Rottweilers (Smith GK, Mayhew PD, et al., 2001). In that study, a DI of 0.6 represented a 15% risk for DJD if it was a Labrador Retriever and 60% for a German Shepherd Dog. Overall, PennHIP considers that a DI over 0.7 represents a high susceptibility for DJD; clearly for some breeds a DI substantially less than 0.7 also represents a considerable susceptibility for DJD.

A reliable compromise that I now tend to use is to have PennHIP done between 12 and 18 months and to ask at the same time for a preliminary opinion from the OFA on both hips and elbows.

Positioning for PennHIP Compression View
Photo: Courtesy of M. De Carufel, DMV, University of Montreal

Distraction Index (DI) Variations in the Bernese Mountain Dog

PennHIP releases a semi-annual report of its data. In May 2009, the database had results for 1482 BMDs. The mean DI for our breed was 0.54, with a range between 0.22 and 1.16. The 25th percentile was 0.65, 50th was 0.54, 60th was 0.50 and 75th was 0.43. This means that a Berner whose DI is 0.43 has tighter hips than 75% of the other Berners included in this registry. Although one statistical bias was removed by the requirement that all X-rays must be sent directly by an accredited veterinarian to PennHIP, another still remains. Most breeders who decide to use PennHIP are probably more concerned with hip dysplasia than the general population and are probably screening bloodlines that already were selected through traditional registries. Hence, most PennHIP dogs are probably part of an already selected population. I therefore suspect that if we would conduct a PennHIP study on a large group of randomly selected Berners, the average DI for that group probably would be greater than 0.54 (which is the mean and median DI published for our breed).

Correlation between DI and Final Classification by Traditional Hip-Extended Registries

In a study comparing OFA score with DI in a pool of 260 large-breed dogs, a large proportion of dogs officially given scores of Excellent, Good, or Fair had DI scores over 0.3 (considered within the DJD susceptible range). Specifically, 53% of the dogs that scored OFA "Excellent," 77% of the dogs that scored OFA "Good," and 93% of the dogs that scored OFA "Fair" were looser than 0.3, which is considered to be the target value to guarantee the impossibility of developing DJD. Traditional radiographs being less prone to reveal this occult passive hip laxity, the OFA-type screening method may then unwittingly pass dogs for breeding that have considerable susceptibility for developing and transmitting DJD (Smith, 2004).

In July 2009, the Berner-Garde registry included DI data for 239 of the 1482 Bernese Mountain dogs (16.1%) contained

Figure 2
OFA/GDC Hip-grade Categories for 123 BMDs
Diagnosed with HD or Officially Certified as Free of HD after 24 months of Age

Final OFA/GDC Certifications	Number of Dogs	Mean DI	DI Range
Excellent or EN	18	**0.39**	0.27 – 0.58
Good or GN	63	**0.44**	0.25 – 0.74
Fair or AN	22	**0.48**	0.30 – 0.70
Mild	15	**0.63**	0.45 – 0.96
Moderate	3	**0.72**	0.45 – 0.88
Severe	2	**0.77**	0.65 – 0.89

in the PennHIP database. The mean DI for these 239 dogs was 0.48 compared to a mean DI of 0.54 for the breed. The data submitted to Berner-Garde database tend to be oriented toward normal dogs. Figure 2 is a partitioning according to the OFA categories of the 123 Berners that had been either diagnosed with HD or officially certified free of HD after the age of 24 months (OFA or GDC).

Despite the small number of dogs (123 out of 239) for whom the correlation with final certifications can be established, I can point out the following four trends: (1) the mean DIs correlate with the final certifications and have almost doubled between dogs classified as Excellent and dogs that are moderately to severely dysplastic; (2) most dogs (all except two) who received "Excellent" ratings had a DI under 0.54 (the mean DI for this breed); (3) all dysplastic dogs had a DI equal to or over 0.45; and (4) some dogs with a distraction index over 0.70 might be declared normal by traditional registries if there were no arthrosis when the X-rays were taken and if the lack of sedation contributed to hiding passive laxity.

The Personal Opinion of a Breeder-Veterinarian and PennHIP User

As a Berner breeder with an accumulated use of nearly 60 PennHIP exams performed at the Faculty of Veterinary Medicine of the University of Montreal since 1996, I am personally convinced not only of the predictive value of this technique when done on young dogs (4-6 months) but especially of the added value in the decision-making process for strict genetic selection against hip dysplasia. In my view, the traditional hip-extended technique as supported by the OFA has produced too many false negative results to be used alone. PennHIP provides all the information contained on the hip-extended radiograph plus the added benefit of a quantified passive hip laxity (DI) measurement.

Because the costs of the PennHIP technique are uniformly higher than those of a traditional hip-extended view, it is utopian to think breeders will use it on whole litters. But I'm convinced that these costs could be afforded and depreciated over the breeding career of each of our stud dogs and bitches.

I do not have a strong opinion about the age at which a PennHIP exam should be done. The earlier the X-rays are done (4-6 months), the quicker we can make a judgment about the orthopedic merits of a dog (before beginning its show career), but precision won't be as good since hip laxity might slightly increase with age, and it would also be premature to assess the elbows at the same time. Later, the measure of laxity will be more accurate, and it could be done at the same time as other orthopedic certifications to reduce the overall cost (if we wait until 24 months of age for OFA). A reliable compromise that I now tend to use is to have PennHIP done between 12 and 18 months and to ask at the same time for a preliminary opinion from the OFA on both hips and elbows. Hip dysplasia is far from being the only genetic criterion for selection in this breed, but we need to acknowledge that close to 40 years of selection with traditional registries has failed to eradicate hip dysplasia from the breed. It may be time to use other techniques. Laxity being the main factor leading to the development of hip dysplasia, it is necessary to optimize methods of measuring it. As no method allows a measure of functional laxity, the distraction index to measure passive laxity, PennHIP, remains better than the traditional hip-extended view results. Objectivity and heritability alone are enough to justify its use. Heritability was originally estimated to be 0.45 for German

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Shepherd Dogs and Labrador Retrievers (Leighton, 1997), and then 0.64 for Golden Retrievers (Smith, Lafond, et al., 2000) compared to 0.22 for a subjective hip score. In the OFA technique, heritability for Bernese Mountain Dogs was estimated to be only 0.30 (Reed, Keller G, et al., 2000) Fighting hip dysplasia requires the use of precise and objective measurement techniques keyed to the highest heritability.

Greater heritability is key to improving the rate of expected genetic change when mating a dog and a bitch. This expected genetic change is equal to the heritability multiplied by the selection pressure. Selection pressure is the deviation of the parental mean hip laxity from the population mean.

In one study (Kapatkin, Mayhew, & Smith, 2002), two tight-hipped German Shepherd Dogs were bred from the 95th percentile of the breed for an extreme selection pressure. The German Shepherd Dog population average DI was 0.39 and the parental average DI was 0.2, so the selection pressure applied was 0.19. The average DI for the 9 puppies born was 0.27, all puppies being under the average for their breed. The realized heritability for this mating was (0.39-0.27)/(0.39-0.20)=0.63.

I think that it would be realistic to select toward Berner bloodlines with a DI under 0.45, this number representing for now the lower DI that leads to a dysplastic Berner (according to the data included in Berner-Garde). To reach such a goal with an actual current mean of 0.54 in our breed, we also should identify dogs and bitches that show exceptional hip quality (helping to increase the selection pressure that we may need in some cases) and really deserve an Excellent rating. These are dogs to be used to get an extreme selection pressure against hip dysplasia on the progeny of a particular bitch or bloodline. For them, I would expect a DI under 0.35. As previously discussed, traditional registries unfortunately may certify Berners with high DIs through a Fair or even Good rating.

Positioning with Distractor Apparatus for the PennHIP Distraction View
Photo Courtesy of M. De Carufel, DMV, University of Montreal

The relationship between selective breeding and genetic diversity is an important consideration, discussed elsewhere in this and other issues of *The Alpenhorn,* as well as extensively in the literature. Of the 329 PennHIP dogs included in the Berner-Garde database, 13.4% have a DI equal to or under 0.35, 29.7% have DIs equal to or under 0.40, and 44.7% of them already have a DI under 0.45. While agreeing that one must be cautious about the effects of selective breeding on genetic diversity, I note that judicious use of the PennHIP data can have beneficial effects on maintaining diversity. In my case, PennHIP has sometimes helped me maintain desirable traits from bitches who were less than desirable in terms of hip quality by applying the highest selection pressure possible when making my decision for a suitable stud dog with whom to breed them. Without their PennHIP data, I would not have bred them, depriving the breed of extremely valuable bloodlines in other aspects.

Once in a while, I was surprised that two littermates, who would both eventually be OFA-certified as Good, had a huge difference in their DIs. For the tightest bitch, selection pressure was not important, and I could decide to use a non-PennHIP stud dog; but for the other one, my only good option was to strive to improve the hip quality of the progeny through the use of the safest available stud dog in terms of hip quality. Through the years, I have also had some bad experiences with stud dogs who were OFA Fair-certified or OVC-certified (no gradation with them) when I found looser DIs on their progeny when mated to bitches with mean DIs. These stud dogs were what I'm now considering as false negative diagnoses from traditional registries.

Comparison of Positioning for PennHIP Distraction View (Left) and the Hip extended View Used by both-PennHIP and OFA-type "traditional" registries (Right).
Photos Courtesy of M. De Carufel, DMV, University of Montreal

Upon reading *The Alpenhorn* PennHIP series of articles, Berner breeders should have a better understanding of the PennHIP technique and may be more inclined to try it. Based on the data presented here, there is strong scientifiic argument for the Bernese Mountain Dog Club of America to include PennHIP as an option in their CHIC program, following the example of 71 other AKC breed clubs that currently include PennHIP in their CHIC programs.

Sharing Opinions and Experiences about PennHIP

If you are interested in sharing information about your experience with PennHIP, please join other breeders at the following Yahoo group: http://pets.groups.yahoo.com/group/pennhipberners or send an e-mail to: PennHIPBerners@yahoogroups.com

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