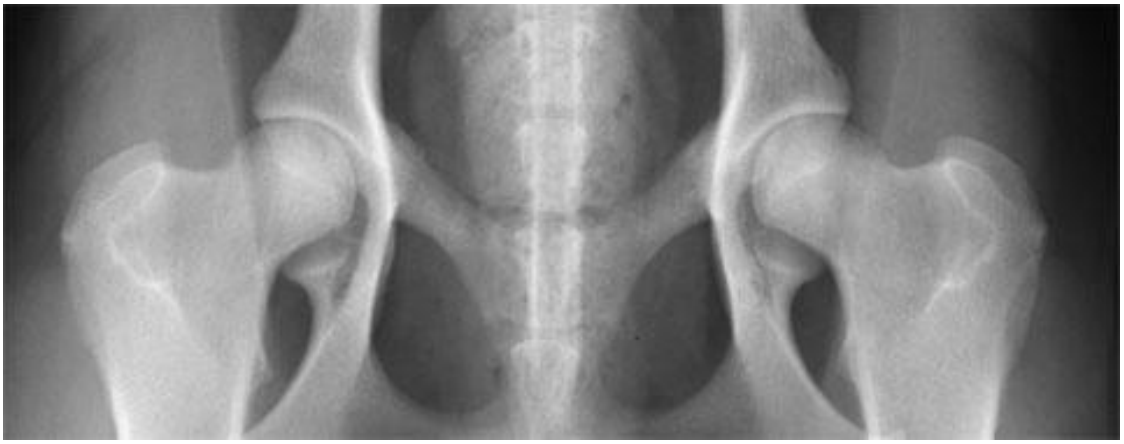
May 2023

Information and statement from the Scientific Committee of the Nordic Kennel Union (NKU/VK) regarding hip dysplasia screening



Short about hip dysplasia

Hip dysplasia, HD, was the first developmental joint disease recognised and has become the most widely studied orthopaedic disease in dogs. HD is an incorrect development of the hip joint which can give rise to osteoarthritis (inflammation) in the hip joint. Dysplasia alters weight bearing, leading to abnormal wearing of certain areas of the joint surfaces causing osteoarthritis. Joint laxity is an early sign of HD and it is generally accepted that joint laxity early in life is an important factor in the development of HD. However, the most obvious phenotypic expressions are malformation and osteoarthritis in hip joints.

HD can occur in any breed, but is most prevalent in large-sized and giant breeds and develops during the stage of rapid growth. The prevalence and clinical significance of HD vary considerably between breeds and among individual dogs within the same breed. Clinical signs of HD include gait abnormalities, difficulties in rising, walking and running, lameness and pelvic limb muscle atrophy with compensatory shoulder muscle hypertrophy. The clinical signs vary throughout the life of the dog with more severe signs in older dogs because the osteoarthritis is progressive.

Scoring of HD

Radiographic assessment is widely used for routine evaluation of hip status. Through radiographic screening subluxation of the hip joint can be demonstrated, as well as abnormal shape of the skeleton and signs of osteoarthritis. Internationally, there are four different grading procedures extensively used for radiographic assessment of HD. Hip grading in the United States and Canada is done according to the Orthopedic Foundation for Animals (OFA). In the United Kingdom, Ireland, Australia and New Zealand the hip scoring scheme of the British Veterinary Association (BVA) is used. In the rest of Europe, the grading protocol developed by the FCI is the most commonly used (Hedhammar, 2007). In addition, the University of Pennsylvania Hip Improvement Program (PennHIP) is widely used in the US, and to some extent in other countries.

Hip screening in the Nordic countries is performed according to the official protocol of the Fédération Cynologique Internationale (FCI). In the radiographic evaluation, the shape, depth and contour of the hip joint are considered as well as the fit between the hip joint head (femoral head) and hip joint socket (acetabulum). The position of the joint head inside the socket is also assessed, that is, if it is deeply located in the socket or if there is a subluxation or luxation. A further support for the assessment can be to measure Norberg's angle. In addition, an assessment is made as to whether there is osteoarthritic changes around the joint.

Hip joints are scored in five categories from A to E, where A and B correspond to two different scoring levels of normal (non-dysplastic) hip joints. The grades C, D and E represent mild, moderate and severe dysplasia, respectively. Hip joints are radiographed with the dog positioned on its back with the hind legs extended. According to the FCI protocol, anaesthesia or sedation during screening has been mandatory since 1991. The protocol states that the dog needs to be sufficiently sedated so that the muscles are completely relaxed during radiographic screening. This is a prerequisite for being able to evaluate whether a subluxation is present or not. The minimum age for establishing an official diagnosis in most breeds is 12 months. Some giant breeds have an age limit of 18 months.

Why HD screening?

HD is a hereditary disorder. The aim of the HD programme is to use HD screening records as an indication of hip joint quality in order to gradually reduce the proportion of dogs showing clinical signs of HD by selection of breeding animals. It should be emphasised that although HD screening gives an indication of hip joint quality, it is not possible to determine whether an individual dog has - or will develop - clinical issues related to HD based on radiographic status alone. HD screening and evaluation within the HD health programme is thus not intended to determine the individual's clinical status, but is first and foremost a tool for selection of breeding animals on a population level. ***The strength of this kind of screening is the possibility to screen a large number of dogs, in a relatively simple, standardised and cost-efficient way. And to make the results public for breeders and potential puppy buyers.***

Calibration and harmonisation of screening within the Nordic countries

The Nordic countries have a globally unique organisation of Kennel Club (KC) scrutineers, the NKU X-ray panel, meeting regularly, to maintain quality and harmonisation in radiographic screening of hip dysplasia (HD) and elbow dysplasia (ED) in dogs. HD and ED screening in the Nordic countries is performed according to the most recent official protocols of the Fédération Cynologique Internationale (FCI) and International Elbow Working Group (IEWG), respectively. In addition, this group serves as an appeal panel for contested screening results within the Nordic Countries.

The NKU X-ray panel was appointed by the NKU/AU and consists of all the individual scrutineers in the Nordic kennel clubs (DKK, FKK, NKK and SKK). To become a KC scrutineer comprehensive experience and qualification are required. This group (currently comprising 14 specifically trained veterinarians) evaluates annually a combined total of approximately 50 000 HD and 35 000 ED radiographs.

The panel assembles biannually to harmonise matters regarding radiographic screening of HD and ED. The primary aim of the panel is to discuss and agree on formalities and procedures related to screening and calibration between countries and scrutineers and avoiding potential biases from occurring.

Individual HD screening radiographs are submitted to the KCs from veterinary clinics in each country for official evaluation by the appointed KC scrutineers. ***All screening results are made freely accessible to the public through the KCs individual web sites. Thus, issues with selective reporting known from many countries are prevented.***

HD screening as a predictor of clinical hip status

As already stated, the main purpose of the HD programme is to use the screening records as selection criteria for improved hip health in the population. For a successful breeding programme, the trait recorded as the basis for genetic evaluation, i.e., hip status of the dog at screening, needs to be closely correlated with the breeding goal trait, i.e., clinical hip status. This implies that the radiographic assessment of hip status needs to be a good predictor of subsequent clinical problems related to HD.

In order to investigate the association between the dog's screening results for HD, and later clinical problems related to the hip joints, a study was conducted in the early 2000s in which screening data from the Swedish Kennel Club was merged together with insurance data from Agria, based on the registration number of each dog (Malm et al., 2010). By examining the extent to which dogs with different grading of HD suffered a life and/or a veterinary claim related to HD later in life, conclusions could be drawn regarding the relevance of HD screening to clinical joint health.

The study showed that there was a strong and highly significant association between the dog's screening result at a young age and later clinical problems and euthanasia due to HD. ***Notably, dogs with moderate or severe HD at screening had a markedly increased risk of later clinical problems related to HD, compared with dogs assessed as free or mild.*** This indicates that records from hip screening in young adult dogs provide valuable information about later clinical problems related to HD.

The strong association between radiographically assessed hip status and subsequent incidence of hip-related veterinary care and mortality suggests that hip screening records can be used for selection in breeding against clinical problems related to the hip joint. However, the usefulness of hip screening as a diagnostic tool for predicting clinical problems in individual dogs was found to be unsatisfactory and breed-dependent.

Screening results as basis for selection

The risk of a dog developing HD depends on both genetic and environmental factors. Several studies have concluded that the inheritance of HD, as assessed by radiographic screening, is complex (quantitative) with heritability estimates ranging from 0.2 to 0.6. In other words, 20-60% of the observable variation in hip status between dogs within a breed is due to genetics. ***This clearly indicates that HD can be reduced by selection***.

For many diseases with a mendelian (simple recessive) inheritance breeding decision can be based on genetic test results. However, the complex nature of HD implies that DNA tests are presently not available. At least not with sufficient accuracy to be useful in breeding. In the future, methods like genomic selection (i.e., prediction of breeding values based on molecular genetic information through establishment of association between genetic markers and HD status) might be an option. ***Currently, selection of breeding animals has to be based on phenotypic information, i.e., screening results.*** However, breeding indices can be applied for more accurate genetic evaluation (se below).

The effect of several genes as well as non-genetic factors results in a continuous variation for hip quality, in the same way as for example height and weight. However, for HD we are not able to measure all this underlying continuous variation based on radiographic status. Therefore, it has been necessary to divide the appearance of the hip joint into different categories (A-E). ***In practice, this means that not all dogs, with for example HD grade C, are identical with respect to genetic joint quality, but it is not possible to assess where the dog is on the underlying scale in terms of joint quality based on the individual's HD grade alone*** (Figure 1).

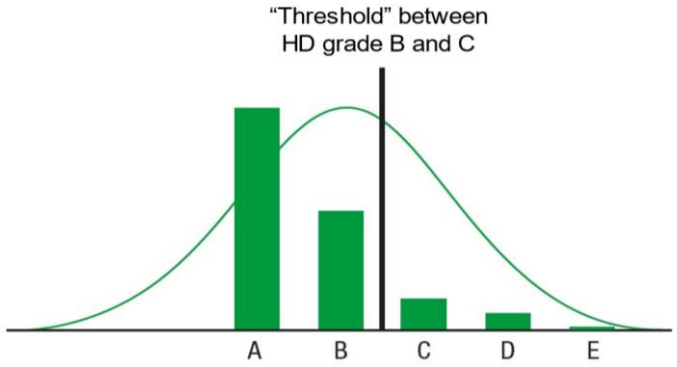


Figure 1. Hip dysplasia, HD, is graded as a categorical trait on a scale from A to E, but the underlying variation in the trait is continuous. Hence, two dogs with, for example, HD grade C may have different genetic conditions, even if it is not possible to differentiate them based on individual screening record alone.

The complex and categorical nature of HD implies that the phenotype of the individual dog, i.e., the screening record, alone is not a perfectly accurate predictor of what the dog can be expected to inherit to its offspring with respect to hip quality. In addition, the phenotypic record is influenced also by non-genetic factors. This makes genetic evaluation based on radiographic hip status alone imprecise, limiting the genetic progress.

Genetic improvement in HD

Despite efforts to reduce the prevalence of HD by means of genetic health programmes for many years, HD is still an issue in several breeds. In some breeds, lack of genetic progress may be partly explained by the extent to which breeders prioritise joint disease in selection, in relation to other traits in the breeding goal. Also, increased use of foreign stud dogs may lower genetic progress due to less accurate genetic evaluation and/or possibly a lower genetic level with respect to HD in some other counties.

Moreover, genetic progress based on selection on screening results (phenotypic selection) is easier to achieve when phenotypic variation is large. ***When HD screening was implemented many years ago, drastic improvements were observed in the 1970s and 1980s (Hedhammar, 1986).*** For example, screening and selection for better hip status in German Shepherds in the Swedish Armed Forces during the 1960s and 1970s lead to a dramatically lowered frequency of HD, from over 50 percent dysplastic dogs initially to 28 percent of dogs born in 1975.

Nowadays, a large proportion of dogs in breeds where health programmes for HD were established long ago are graded as A or B. This makes phenotypic selection based on screening records less

efficient. In addition, environmental changes over time, e.g., technical developments and changes in sedation routines, have led to increased possibilities to detect dysplastic dogs and thus counteracted phenotypic improvement and potentially caused an increase of dogs graded as C (mild dysplasia) in some breeds (SKK, 2019). Hence, despite continued genetic improvement in many breeds, phenotypic trends do not show the same trend due to environmental factors with an opposite effect. ***However, a decline in proportion of dogs grades as D and E (moderate and severe dysplasia) can still be observed in many breeds, implying a decreased risk of clinical cases.*** Below is an example of phenotypic and genetic trends in Labrador Retrievers in Sweden (Figure 2).

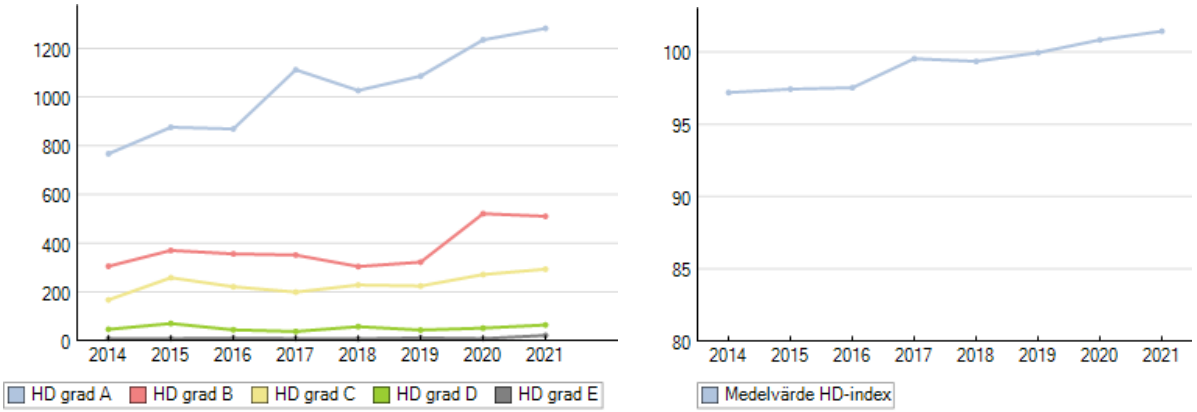


Figure 2. Phenotypic trend (number of dogs by HD grade and birth year) and genetic trend (average HD breeding index by birth year) for Labrador Retrievers in Sweden born 2014-2021. While the phenotypic trend shows an increase in the number of dogs with mild dysplasia (HD grade C), the genetic trend indicates genetic progress, i.e. increased average breeding index over time.

Breeding index for a more accurate genetic evaluation

For a more accurate evaluation of the breeding value, it is valuable to also account for information about hip status of close relatives (parents, siblings and possible offspring). This can be done routinely by implementation of statistical methods for estimation of breeding values (index), also called EBVs. When predicting breeding indices, all available information about HD results for relatives are taken into account and adjustment for systematic non-genetic factors such as clinic and age at screening is done simultaneously. Hence, indices make it possible to get a more accurate estimate of what hip quality an individual dog may be expected to inherit to its offspring. ***Using breeding indices, also dogs with the same HD grade can be differentiated with respect to expected breeding value*** (Figure 3).

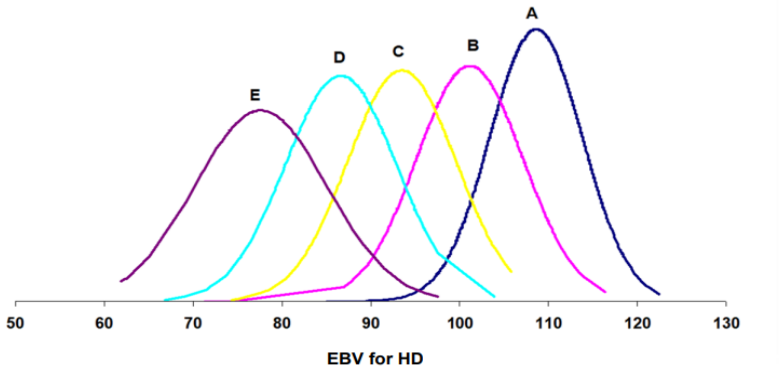


Figure 3. Distribution of breeding indices for dogs with different HD grades (example from data for Bernese Mountain Dogs). Dogs with better hip status will in general get a higher (better) index. There is, however, an overlap between the curves illustrating the effect of also taking information about relatives and non-genetic factors into account in the statistical model for prediction of breeding indices.

By using selection based on breeding indices instead of screening records alone, a faster genetic gain and accordingly a more rapid reduction in dogs graded as dysplastic could be expected. Moreover, the genetic trend based on breeding indices, as opposed to the phenotypic trend, makes it possible to more accurately monitor the genetic change. Statistical models for prediction of breeding values have been used extensively in breeding of livestock for several years.

Breeding indices are generally standardised around 100, which corresponds to the breed average in each breed. The higher the index the better hips the dog is expected to inherit to its offspring. Hence, a dog with an index above 100 can be expected to produce offspring with better hip quality than the breed on average. ***Matings where the average breeding index of the parents is above 100 (or in other words, the parents' sum is above 200) can be expected to contribute to genetic progress of hip quality in the breed.***

Breeding indices need to be updated routinely in order to include new information on screening records that are added to the database over time. In the Nordic countries, national indices for HD are available through the webservices of the respective KC. In the future, exchange of information to enable a joint Nordic genetic evaluation of HD in relevant breeds, i.e., Nordic breeding indices, would be valuable.

Recommendations for breeding

The NKU Scientific committee would like to give the following advice with respect HD and breeding:

The general recommendation is to use dogs with normal hip status (HD grade A or B) for breeding. However, in some cases it may be justified to use dogs in breeding with a hip status worse than grade B, with respect to other important traits and/or the long-term development of the population regarding genetic variation. ***If a dog with hip status worse than grade B is used in breeding, it is important to ensure that the mating does not entail an increased risk of clinical problems due to HD in the offspring.*** The committee would like to emphasize that the use of dogs with screening result worse than grade B in breeding should be sparse and the offspring should be carefully

evaluated. In the next generation, preferably dogs with normal hips or a breeding index greater than 100 should be seen as potential breeding animals.

Dogs graded as severe HD, grade E, should never be used for breeding. Dogs with moderate HD, grade D, should only be used in exceptional cases and then mated only to dogs with normal hip status (HD grade A or B) or in a combination where the expected breeding index of the litter is greater than 100 (i.e., the sum of the parents' indices is greater than 200). Regardless of HD grade, it is never acceptable to use dogs in breeding that have clinical signs of HD. For breeding bitches, special attention should be given also to the presence of osteoarthritic changes considering particularly the welfare aspect surrounding gestation and parturition.

In breeds with access to breeding indices for HD, breeding decisions should be based on the dog's index rather than the HD grade. The index provides a more accurate prediction of the dog's breeding value than the screening result itself. ***The general recommendation is that the breeding index of the mating, i.e., the average index of the parents should be greater than 100 (or in other words, the parents' sum should be above 200).*** This recommendation implies that the offspring is expected to get an index above breed average. If mating with a foreign stud dog which does not have a breeding index, the recommendation is that the other dog should have an index greater than 100. The foreign breeding animal should have HD grade A or B.

In breeds that do not have access to breeding indices for HD, selection of breeding animals should preferably be based not only on the individual's own screening record, but also take into account information about screening results for close relatives (e.g., parents, siblings and any previous offspring) for a more accurate evaluation.

General statement regarding HD screening

Based on the information above, the Scientific Committee of the Nordic Kennel Union (NKU/VK) would like to make the following general statement regarding HD screening:

The Nordic HD screening programmes are comprehensive, transparent and unique with respect to harmonisation and calibration. NKU/VK would like to emphasise that the primary aim of HD screening is to use the screening records as basis for selection of breeding animals in order to gradually reduce the proportion of dogs showing clinical signs of HD. Research indicates that dogs with moderate and severe HD at screening have markedly increased risk of clinical problems related to HD, compared with dogs assessed as free or mild. Hence, the breeding programme should first and foremost aim for a decreased prevalence of dogs graded as D and E.

Although HD screening gives an indication of hip joint quality, it is not possible to determine the individual's clinical hip status based on the radiographic status alone. The strength of this kind of screening is the possibility to screen a large number of dogs, in relatively simple and cost-efficient way, thereby providing a reliable basis for genetic evaluation of breeding animals and of the breed as a whole. Screening programmes for HD have successfully reduced the prevalence of HD in many breeds. However, for continued

progress application of breeding indices offer a more accurate tool for evaluation and selection of breeding animals. Therefore, when available selection should be based on breeding indices rather than screening records for individual dogs. For improved accuracy of breeding indices, screening a large part of the population is of great value.

Hip dysplasia is one of many traits to consider in the overall breeding programme. Measures against HD should be prioritised with respect to other traits and breed-specific needs and conditions.

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