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Prevalence and co-occurrence of hip dysplasia and elbow dysplasia in Dutch pure-bred dogs

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ABSTRACT

Hip as well as elbow dysplasia (HD, ED) are developmental disorders leading to malformation of their respective joints. For a long time both disorders have been scored and targeted for improvement using selective breeding in several Dutch dog populations. In this paper all scores for both HD and ED, given to pure bred dogs in the Netherlands from 2002 to 2010, were analyzed. Heritabilities and correlations between HD and ED were calculated for the 4 most frequently scored breeds. Heritabilities ranged from 0.0 to 0.37 for HD related traits (FCI-score, osteoarthritis, congruity, shape and laxity (Norberg angle); FCI: Fédération Cynologique Internationale) and from 0.0 to 0.39 for ED related traits (IEWG score, osteoarthritis, sclerosis and indentation; IEWG: International Elbow Working Group). HD related traits showed high genetic and residual correlations among each other but were only to a minor extent correlated with ED related traits, which also showed high correlations among each other. Genetic correlations were higher than residual correlations. Phenotypic and genetic trends since 2001 for the four most scored breeds were slightly positive but decreasing over time, indicating that selection over the past decade has not been effective.

1. Introduction

Hip and elbow dysplasia are two common developmental orthopedic disorders in dogs which can cause lifelong disability. Both are considered complex diseases with multiple genes as well as environmental factors influencing susceptibility to these disorders (Distl et al., 1991; Swenson et al., 1997a,b; Mäki et al., 2000, 2002; Malm et al., 2008; Stock et al., 2011; Lewis et al., 2011).

The prevalence of hip dysplasia (HD) ranges from 0 to 74% (OFA) within the different breeds and heritability estimates have been reported ranging from 0.1 to 0.6. Heritability indicates which part of the differences observed between dogs is due to genetics. Elbow dysplasia (ED) shows similar diversity in reported prevalence from 0 to 64% (Orthopedic Foundation for Animals: OFA), and heritability estimates from 0.1 to 0.77 (Hedhammar et al., 1979; Guthrie and Pidduck, 1990; Grøndalen and Lingaas, 1991; Distl et al., 1991; Swenson et al., 1997a,b; Mäki et al., 2000, 2002; Malm et al., 2008; Hou et al., 2010; Stock et al., 2011; Lewis et al., 2011).

To reduce prevalence, screening programs have been implemented for both HD and ED in the Netherlands. For several breeds HD scoring is mandatory for breeding, although the maximum score allowed differs between breeders' clubs, depending on the prevalence of HD and the size of the HD-free breeding population. Screening for ED

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is not so common yet and is restricted to a few breeds in which the breeders club is actively involved in reducing the prevalence of ED.

HD and ED may become clinically evident during or just after the fast growth period. Breed differences in growth rate during this period might partly explain the differences in frequency between breeds and even between sexes of the same breed (Mäki et al., 2002). Although HD and ED are observed in all sizes of dogs, they are especially frequent in large breed dogs, which have a relatively high rate of longitudinal bone growth.

Little is known about the co-occurrence of HD and ED in dogs, though a slight phenotypic correlation has been reported in a Finnish cohort of Rottweilers (Mäki et al., 2000) and in a limited French multiple-breed data-set including Bernese Mountain Dogs, Rottweilers and other breeds (Cachon et al., 2010). Genetic correlations between HD and ED within one breed have also been reported, ranging widely between breeds from −0.09 in Golden Retrievers to 0.37 in Rottweilers (Mäki et al., 2000, 2002; Malm et al., 2008; Hartmann et al., 2010; Stock et al., 2011; Lewis et al., 2011).

The objective of this study is to estimate the prevalence of HD and ED in the Netherlands, and to assess whether there are differences in prevalence between the sexes. In addition, the genetic and residual relationship between HD and ED scores are reported in the four breeds most frequently screened for both HD and ED, i.e. the Labrador Retriever (LR), Golden Retriever (GR), Bernese Mountain Dog (BMD), and Newfoundland (NF).

2. Material and methods

2.1. Animals

From 2002 to 2010 a total of 35,046 pedigree dogs of various breeds were screened for HD, ED, or both (Table 1). In total dogs of 214 breeds were screened for HD, and dogs of 117 breeds were screened for ED. Heritability, and residual and genetic correlations were determined in the four breeds most frequently screened for both HD and ED, i.e. LRs, GRs, BMDs and NFs. In these four breeds, screening for both disorders is mandatory in order to allow breeding with these dogs. The Dutch Kennel Club (www.raadvanbeheer.nl) provided pedigree files, which included the sex of dogs. Pedigrees from 1990 onwards were electronically available.

2.2. Phenotyping

Official HD grading as regulated by the Fédération Cynologique Internationale (FCI, 2010) requires a ventrodorsal radiographic view of the hip joints with extended hind limbs; the HD-score ranges from A (free of HD) to E (severely affected by HD) (Brasss, 1989; Morgan et al., 2000). The Dutch screening panel takes four different characteristics into account, i.e. osteoarthritis (OA) (6 levels), joint congruity (8 levels), shape/contour of the acetabulum and femoral head (4 levels), and laxity of the hip joints (Norberg angle, continuous scale). Only laxity is registered for both hip joints separately; other characteristics have one overall assessment each. The HD scoring was performed on a weekly basis by a team of three experts (diplomates in radiology or othopedic surgery) simultaneously. Team members independently scored the anonymous radiographs. The final score was obtained by majority vote. When animals were scored with HD-C or higher, they were considered dysplastic.

Official ED screening as regulated by the International Elbow Working Group (IEWG) requires at least two, but preferably four radiographic views of each elbow. In the Netherlands, four radiographic views are required for scoring in LRs, GRs, BMDs, Rottweilers, German Shepherd Dogs and Bordeaux Dogs; a medio-lateral view with flexed elbow (MLflexed), a medio-lateral view with extended elbow (MLextended), a craniocaudal view (CrCd) and a craniolateral–caudomedial view (CrLCdM) (Voorhout and Hazewinkel, 1987). All other breeds minimally require a MLextended and a CrLCdM radiographic view. Elbow radiographs were scored according to IEWG guidelines; for each elbow the degree of OA was assessed (4 levels) at five standardized locations, the presence of osteosclerosis (2 levels), and the presence of an indentation of the humeral condyle (2 levels) was recorded. In case any of the four primary causes for ED (i.e. fragmented medial coronoid process (FCP), elbow incongruity (INC), osteochondritis dissecans (OCD) and/or ununited anconeal process (UAP)) could be observed or was suspected, this was also recorded (free, suspect or affected). These characteristics together determined the final ED grade (IEWG). Similarly to the HD-scoring a team of three experts scored the radiographs independently and the final grade was obtained by majority voting. Dogs which were scored grade 1 (or higher) were considered dysplastic. HD and ED screening occurred separately in time.

All characteristics that were scored for both HD and ED, except for laxity (Norberg angle), were scored using an ordinal scale. Distances between levels are not necessarily equal and to estimate these distances, a normal distribution underlying all categories was assumed. All available HD records ($n = 34{,}620$) and ED records ($n = 9788$) were used to ascertain the prevalence and calculate the category mean for each level (Fig. S1, Van Grevenhof et al., 2009).

2.3. Heritability and correlation calculations

Single trait and multi-trait (bivariate) analyses were conducted using the program ASReml (Gilmour et al., 2009). A single trait analysis using model 1 tested whether breed and age at screening were significantly associated with HD and ED, and the underlying characteristics that were scored for HD (including OA, congruity, shape and laxity) or ED (including OA, sclerosis and indentation) for all breeds (y_{ijk}).

$$y_{ijk} = \mu + \text{breed}_i + \text{age}_j + e_{ijk} \quad \text{(model 1)}$$

where μ represents the mean, breed is a fixed effect, age at screening (in days) is a covariate (age_{HD} or age_{ED} depending on the category), and e is the residual. Data on sex of the animal was available only for the four most scored breeds.