Results from an explorative screening program for elbow dysplasia in some breeds of dogs in Italy

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ABSTRACT

This paper aimed to present the first results of an explorative screening program currently running in Italy and focussing on the prevalence of a specific orthopaedic disorder, elbow dysplasia (ED), in some breeds of dogs commonly reared in Italy. Data consisted of radiographic findings taken on 1370 dogs (758 females and 612 males) of 6 breeds (Bernese Mountain dog, Cane Corso, German Shepherd , Golden Retriever, Labrador Retriever and Rottweiler) screened at an age of 20.6 ± 11.6 months. Radiographs were graded for both ED and hip dysplasia (HD) according to a four- (0 to 3) or a five-grade (A to E) linear system, respectively. Logistic regression analysis was used for studying the relationships between breed, sex, age of dogs at screening and HD diagnosis with the outcome of the diagnosis for ED. Prevalence of ED (ED score ≥ 1) for the pool of breeds involved was 25%, and Labrador Retriever (17%) and Rottweiler (40%) showed, respectively, the lowest and the highest prevalence of ED among breeds in the study. Prevalence of HD (grades C or higher) approached 15%. When compared to other breeds, Rottweiler and Bernese Mountain dogs showed significantly higher risk to be affected by ED (odds ratio 3.2 and 3.0, respectively). Conversely, sex did not significantly affect the onset of ED. When compared to the youngest group of dogs at screening (average: 14 months), the oldest group of screened dogs (average: 40 months) exhibited a significantly higher risk of being diagnosed as affected by ED (odds ratio: 1.9). A negative status of hip joints appeared positively associated with a negative status of elbow joints, and dogs diagnosed as affected by HD had a 40% increased risk of being diagnosed as affected by ED. In conclusion, results from this study demonstrated that ED has a noticeable prevalence in some Italian dog populations, particularly in heavy breeds. Screening of dogs for ED appeared feasible and should be performed at a standard age. Phenotypic association between hip and elbow dysplasia observed in this study suggests that the genetic relationships between these skeletal disorders should be investigated.

Key Words: Dogs; Elbow dysplasia; Hip dysplasia.

RIASSUNTO
PREVALENZA DELLA DISPLASIA DEL GOMITO IN ALCUNE RAZZE CANINE ALLEVATE IN ITALIA: PRIMI RISULTATI DI UN PROGRAMMA ESPLORATIVO DI CONTROLLO

Con la presente ricerca si intende presentare i primi risultati emersi da un programma esplorativo di controllo della displasia del gomito attualmente in corso in Italia su alcune razze di cani di peso medio ed elevato. I dati utilizzati derivano dagli esiti radiografici effettuati su 1370 soggetti (758 femmine e 612 maschi) appartenenti a 6 razze (Bovaro del Bernese; Cane Corso; Pastore Tedesco; Golden Retriever; Labrador Retriever; Rottweiler) sottoposti ad esame radiogra-

fico ad un'età di 20.6 ± 11.6 mesi. Le radiografie sono state sottoposte a valutazione per lo stato del gomito e delle anche; la diagnosi è stata espressa secondo un sistema lineare a 4 classi (punteggio da 0 a 3) nel caso della displasia del gomito, a 5 classi (da A ad E) nel caso della displasia dell'anca. I dati raccolti sono stati sottoposti ad analisi di regressione logistica per studiare le relazioni intercorrenti tra l'esito della diagnosi per la displasia del gomito e gli effetti di razza, sesso, età del cane al controllo radiografico ed esito della diagnosi per la displasia dell'anca. La prevalenza della displasia del gomito (punteggio ≥ 1) nel pool di razze esaminate è risultata pari a 25%, con una certa variabilità tra le razze; in particolare i soggetti di razza Labrador e Rottweiler hanno presentato la prevalenza inferiore (17%) e superiore (40%), rispettivamente. La prevalenza della displasia dell'anca (categoria C o superiore) è risultata dell'ordine del 15%. I soggetti di razza Rottweiler e Bovaro del Bernese hanno presentato un rischio significativamente superiore di diagnosi sfavorevole per la displasia del gomito rispetto a quelli appartenenti alle altre razze (odds ratio pari a 3.2 e 3.0, rispettivamente), mentre il sesso non ha significativamente influenzato l'insorgenza di displasia del gomito. L'età alla diagnosi è risultata significativamente associata ad una maggior frequenza di diagnosi sfavorevole di displasia del gomito, ed i cani sottoposti a controllo ad età avanzata (media 40 mesi) hanno presentato un rischio di insorgenza del disordine articolare del 90% superiore rispetto a quelli controllati ad età precoce (media 14 mesi). Uno stato negativo delle anche è apparso significativamente associato ad un negativo stato dell'articolazione del gomito, e i soggetti diagnosticati come displasici per le anche hanno evidenziato un rischio di presentare diagnosi di disordini articolari del gomito del 40% superiore rispetto ai soggetti giudicati esenti per la displasia dell'anca. In conclusione, i risultati emersi in questo primo screening hanno evidenziato che la displasia del gomito è un disordine scheletrico di sensibile prevalenza in alcune razze diffuse sul territorio nazionale, ed è quindi meritevole di attenzione tra i caratteri potenzialmente inseribili negli schemi di selezione del cane di razza pura. Il controllo esteso dei soggetti è una procedura proponibile a livello operativo e dovrebbe essere effettuata ad età standardizzata. L'associazione fenotipica tra displasia dell'anca e displasia del gomito emersa nella presente ricerca suggerisce di approfondire le indagini al fine di indagare l'eventuale esistenza di relazioni genetiche tra questi due disordini dell'apparato scheletrico.

Parole chiave: *Cani, Displasia del gomito, Displasia dell'anca.*

Introduction

Malformation of the elbow joint in dogs, generally referred to as elbow dysplasia (ED), is an orthopaedic disorder that is widespread in several dog breeds (Breur *et al.*, 2001). The most common lesions causing this disorder are ununited anconeal process, fragmented coronoid process and osteochondritis disseccans, and they can occur independently or in conjunction with one another (Hazewinkel, 2003).

As hip dysplasia, ED develops within the first months of a dog's life during the period of rapid growth (Mäki, 2004), and is mostly reported in fast growing and large mature weight breeds (Guthrie and Pidduck, 1990; Beuing *et al.*, 2000). Elbow dysplasia may cause clinical symptoms, such as changes in gait, pain and lameness (Read *et al.*, 1996), and can negatively affect the working performance of dogs (Mäki, 2004).

Diagnosis of ED is based on a radiographic examination, and a standardized grading system, currently adopted in most screening programs, is suggested by the International Elbow Working Group (IEWG).

Canine elbow dysplasia is known to be a partly inherited disease in several dog breeds, showing a quantitative mode of inheritance (Mäki, 2004). Heritability of ED has been estimated in some dog populations, and estimates are reported to range from 0.10 to 0.77 (Beuing *et al.*, 2000; Mäki *et al.*, 2000). Both Beuing *et al.* (2000) and Mäki (2004) concluded that the genetic background underlying ED seems strong enough to apply successful breeding strategy for achieving genetic progress by selection, and Swenson *et al.* (1997) reported that a screening and control program for ED could be economically profitable for some breeds at increased risk, such as Rottweiler and Bernese Mountain dog.

Based on these results, an explorative screening program for ED on some dog breeds in Italy has been started in cooperation with the Centre for the Screening of Skeletal Diseases (CeLeMaSche). This paper aimed to present the first results of this screening program, focussing on the prevalence of ED found for some breeds commonly reared in Italy.

Material and methods

Data collection

Data comprised of screening results of 1370 dogs of 6 breeds (Bernese Mountain dog, Cane Corso, German Shepherd, Golden Retriever,

Labrador Retriever and Rottweiler), 758 females and 612 males, enrolled from 2000 to 2003 in the screening program for elbow dysplasia arranged by CeLeMaSche. The screening program was specifically designed to investigate the prevalence of elbow dysplasia in the Italian dog population. Dogs involved were at least 1 yr old, and breeders and owners taking part in the study were asked to involve all their adult dogs in order to ensure the randomness of the screening process.

Radiographs of elbow joints were taken by 235 veterinarians and graded for elbow dysplasia by a single panelist. Radiographic diagnoses were performed in accordance with the international standardised screening procedure for ED (Flückiger, 2003). The age of the dogs at examination ranged from nearly 1 to 8.5 years; the average age at screening was 20.6 months, with a large variability (SD = 11.6) useful for exploring the possible relationship between age at screening and status of the elbow joints.

Both elbows were radiographed, with one mediolateral view of each elbow joint. The radiographic diagnosis of ED has been based on the presence of arthrosis and/or primary lesions such as: - malformed or fragmented medial coronoid process (FCP); - ununited anconeal process (UAP); - osteochondrosis of the medial humeral condyle (OC/OCD); - massive incongruity of the articular surface (step, subluxation) (INC). The elbow findings were scored according to severity of the arthrosis and/or the presence of a primary lesion using the IEWG (International Elbow Working Group) protocol, based on a four grade linear system (Table 1): grade 0 = normal elbow joint; grade 1 = mild arthrosis; grade 2 = moderate arthrosis; grade 3 = severe arthrosis or primary ED.

Simultaneously to the screening for elbow dysplasia, radiographs of hip joints were taken and graded for hip dysplasia by a unique panelist according to the FCI method (Willis, 1989); a 5-grade linear system was used, and scores ranged as follows: A = excellent hip conformation; B = normal hip conformation; C = mild dysplastic changes; D = moderate dysplastic changes; E = severe dysplastic changes. The data also included information on dog identification, sex, breed, date of birth and date of x-ray screening.

Statistical analysis

Statistical analysis was performed using logistic regression procedure, in order to express the influence of a set of independent variables on the frequency of a disorder complex. To this purpose, grades of ED were transformed as a binary trait; dogs with grade = 0 for ED were considered not affected, and dogs graded 1, 2 or 3 for ED were considered affected.

In the present study the risk of occurrence of elbow dysplasia due to selected explanatory variables has been evaluated through an odds ratio (OR), a multiplicative measure of risk that ranges from 0 to infinity. The null value of an OR of 1 is assigned to levels of explanatory variables included in the intercept of the logistic regression model, thus representing the "reference condition" for comparisons. An OR > 1 or an OR < 1 means an increased or decreased risk of disease occurrence, respectively, and implies that a given level of explanatory traits is predisposing or protecting a dog with respect to the occurrence of the disorder when compared to the reference condition.

In order to provide the odds ratio, logistic regression analysis was performed using the LOGISTIC procedure of SAS (SAS/STAT, 1990) according to the following model:

$$\ln\left[\frac{\pi(X)}{1-\pi(X)}\right] = \mu + \sum_{i=1}^{5} b_{1i}B_{iz} + b_2 S_z + \sum_{j=1}^{2} b_{3j}A_{jz} + b_4 HD_z$$

where: $\ln\left[\dfrac{\pi(X)}{1-\pi(X)}\right]$ is the logit of Y (Y = 1 for affected by ED, Y = 0 for not affected by ED) and $\pi(X)$ is the probability that Y = 1;

μ is the intercept, expressing the "reference" animal (Labrador Retriever, female, x-rayed when it was young and not affected by hip dysplasia).

Categorical independent variables of concern were defined as follows:
- breed effect (B); five dummy variables were created and Labrador Retriever was used as reference breed (intercept of the model), as it was the breed with the largest number of screened dogs;
- sex of the dog (S); one dummy variable was created and female was used as reference sex (intercept of the model);
- age of dogs at screening (A); it was classified into three classes (young, intermediate and old)

Table 1.   The International Elbow Working Group (IEWG) scoring system for elbow dysplasia.

| Elbow Dysplasia Grading		Radiographic Findings
0	Normal elbow joint	Normal elbow joint, no evidence of incongruency, sclerosis or arthrosis
I	Mild arthrosis	Sclerosis of ulnear trochlear notch or, step=/> 2 mm between radius and ulna or osteophyte formation less than 2 mm high
II	Moderate arthrosis	Osteophyte formation 2 to 5 mm high
III	Severe arthrosis or primary elbow dysplasia	Osteophyte formation over 5 mm high and/or primary elbow dysplasia such as ununited anconeal process; malformed or fragmented medial coronoid process; osteochondrosis of the medial humeral condyle

according to the within breed mean and standard deviation. Two dummy variables were created and young class was used as reference age (intercept of the model);

- hip dysplasia diagnosis (HD); dogs graded 'A' or 'B' were considered not affected, and dogs graded 'C', 'D', or 'E' were considered affected. One dummy variable was created and the reference class concerned dogs not affected by hip dysplasia (intercept of the model).

Results

Average ED score for the entire data set was 0.35 (SD = 0.67). General distribution of dogs by elbow score is shown in Figure 1. Prevalence of elbow dysplasia estimated in the present study for the pool of breeds involved was 25%, with a slightly

Figure 1.   Percentage distribution of dogs (n=1370) by elbow score.
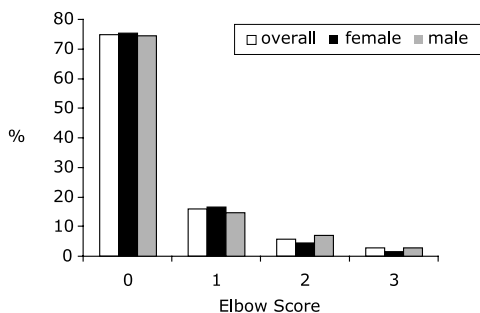
higher value for males than for females. Three-quarters of the sampled dogs were diagnosed ED = 0 and were considered to be unaffected by elbow dysplasia. About 18% of the dogs screened showed mild arthrosis (ED = 1), and the percentage of dogs exhibiting moderate or severe arthrosis was 5 and 2%, respectively. Males tended to present higher frequency of mild and severe ED (scores 2 or 3) than females (6.5 vs 4.2 and 2.3 vs 1.7, respectively).

Considering hip dysplasia (data not shown) 85% of dogs were scored unaffected or borderline (A + B), whereas 15% of dogs presented at least a mild grade of hip dysplasia (C + D + E). Frequency of dogs with severe hip dysplasia was extremely low (0.51%).

Number of screened dogs and distribution of ED scores by breed and sex are presented in Table 2. Frequency of affected dogs varied from breed to breed, and prevalence of elbow dysplasia ranged from nearly 17% in Labrador Retrievers to nearly 40% in Rottweilers.

Nearly two-third of Bernese Mountain dogs were scored 0 for ED, without significant differences between males and females; conversely, the percentage of male dogs that scored 3 for ED was much larger than that found in females.

The prevalence of ED found in the present study for Cane Corso approached 18%, and females exhibited an higher prevalence than males; however, the frequency of scores exceeding 1 was negligible in this breed.

In German Shepherds the prevalence of ED appeared close to 20%, and males showed an higher frequency of mild and moderate arthrosis than females.

Labrador Retriever was the breed with the lowest prevalence of ED among those taken into account in this study, exhibiting 17% of dogs radiographically affected. Conversely, nearly one quarter of Golden Retrievers did not reveal an optimal status for elbow joints.

The Rottweiler showed the highest prevalence of ED among the breeds taken into account, and over 40% of Rottweilers screened in this study had an ED score equal to or higher than 1. Moreover, in this study Rottweiler females showed a higher percentage of affected dogs than males. Surprisingly, although the high prevalence of ED and the relatively large number of Rottweiler dogs screened, no dog graded 3 was found.

Results of logistic regression evidenced that breed significantly affected the risk of a negative radiographic diagnosis for ED. Odds ratio of elbow dysplasia diagnosis for the breeds considered are presented in Figure 2. The Labrador Retriever was taken as the breed of reference, being the breed with the highest number of dogs screened.

Figure 2. Odds Ratio (OR) of breed on elbow score (reference breed: Labrador Retriever).
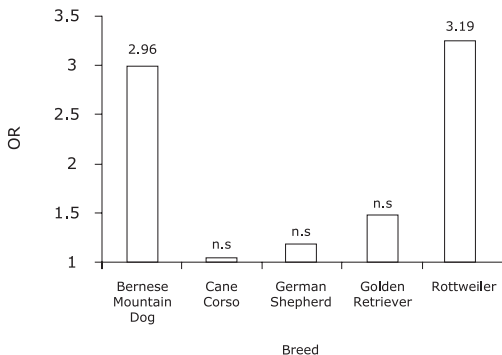

Compared to Labradors, Bernese Mountain dogs and Rottweilers appeared to have a significantly higher risk to be affected by elbow dysplasia (OR= 2.96 and 3.19, respectively). Conversely, the Cane Corso, German Shepherd and Golden Retriever breeds performed similarly to the Labrador with respect to the risk of developing elbow arthrosis.

Logistic regression analysis evidenced that, when compared to females, male dogs did not significantly affect the onset of elbow arthrosis (data not shown), thus confirming the tendential inconsistency across breeds seen earlier when prevalence of ED in females was compared to that of males (Table 2).

The distribution of dogs by elbow score for age at screening is shown in Figure 3. The frequency of

Figure 3. Percentage distribution of dogs by elbow score for age at screening (young: 14 months; intermediate: 18 months; old: 40 months).
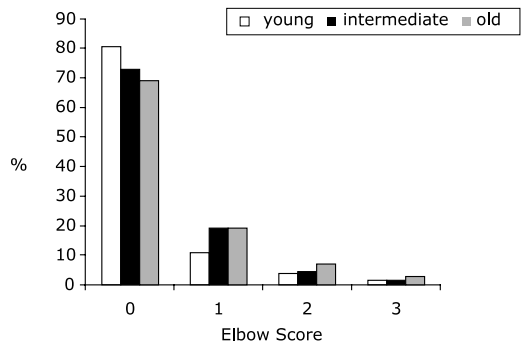
dogs exhibiting a normal elbow joints status tended to decrease with increasing age at screening: the prevalence of ED ranged from 19 to 27 to 32% for dogs screened at young (14 ± 1.6 months), intermediate (18 ± 4.2 months), or old age (40 ± 14.8

Figure 4. Percentage distribution of dogs by elbow score (0 to 3) for year of birth.
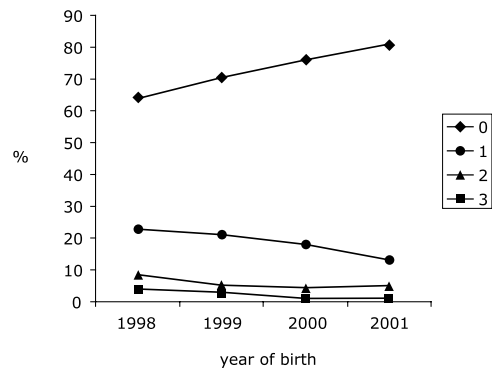
Table 2. Screened dogs (n=1370) and distribution of elbow dysplasia (ED) scores for breeds and sex.

Breed	Screened dogs, n.	Percentage of dogs by ED score			
		0	1	2	3
Bernese Mountain dog:					
- overall	142	62.7	23.9	9.9	3.5
- female	89	62.9	25.9	10.1	1.1
- male	53	62.3	20.7	9.4	7.6
Cane Corso:					
- overall	87	81.6	16.1	2.3	0.0
- female	40	80.0	20.0	0.0	0.0
- male	47	83.0	12.8	4.2	0.0
German Shepherd:					
- overall	309	80.3	14.9	2.9	1.9
- female	151	85.4	12.6	0.0	2.0
- male	158	75.3	17.1	5.7	1.9
Golden Retriever:					
- overall	242	76.8	15.3	5.0	2.9
- female	133	75.9	18.1	3.7	2.3
- male	109	78.0	11.9	6.4	3.7
Labrador Retriever:					
- overall	335	83.0	11.6	2.7	2.7
- female	211	84.4	10.4	2.8	2.4
- male	124	80.7	13.7	2.4	3.2
Rottweiler:					
- overall	255	59.6	29.4	11.0	0.0
- female	134	56.7	32.8	10.5	0.0
- male	121	62.8	25.6	11.6	0.0

months), respectively. Generally, the younger the dogs at screening, the lower the percentage of mild, moderate or severe arthrosis tended to be. Parallelly, the risk for a diagnosis of ED was significantly higher for the oldest dogs as compared to the youngest (OR = 1.90), whereas an intermediate age at screening did not appear to be a significant risk factor for ED occurrence as compared to the young age at screening (data not shown in table).

The distribution of dogs by elbow score for year of birth is given in Figure 4. The percentage of dogs with normal elbow joints status (grade 0) tended to increase in the recent years and, as a consequence, the percentage of affected dogs decreased. This is particularly evident for the fre-

quency of dogs graded 1, which decreased by nearly one half between 1998 and 2002. However, the effect of birth year was partially confounded with that of age at screening, because the more recent the birth year, the higher the percentage of young dogs screened for ED.

Hip dysplasia diagnosis was significantly associated with the risk of outbreak of ED, and dogs affected by hip dysplasia showed a 41% increased risk of being affected by ED.

Discussion

The figures of prevalence of ED found in the present study for the breeds taken into account

generally fit well with the statistics reported by OFA (Orthopedic Foundation for Animals, 2004), which probably holds the largest database for skeletal diseases in the world. Prevalence of ED and number of evaluations reported by OFA for the selected breeds taken into account in this study were as follows: 41.0% from nearly 5000 Bernese Mountain dogs; 19.8% from nearly 20,000 German Shepherd dogs; 41.3% from nearly 8000 Rottweiler dogs. However, OFA reported for both Retriever breeds a lower prevalence of ED than in the present study, with a frequency of affected dogs approaching 12% in both nearly 10,000 Golden and nearly 24,000 Labrador Retrievers. No data for comparisons were available in literature concerning Cane Corso. Statistics on ED have been reported for national Rottweiler populations from Norway (Grøndalen and Lingaas, 1991), Sweden (Swenson *et al.*, 1997), Germany (Beuing et al, 2000) and Finland (Mäki *et al.*, 2000); the prevalence in those studies ranged between 40 and 55%, confirming the relatively high frequency of affected animals in this breed.

Results of logistic regression evidenced that breed, age at screening and diagnosis of hip dysplasia significantly affected the risk of a negative radiographic diagnosis for ED, whereas sex was not relevant in predicting the outbreak of ED. The Bernese Mountain dog and Rottweiler showed a significantly higher risk of elbow arthrosis diagnosis with respect to the other breeds in this study. The relatively higher predisposition of these breeds in developing elbow arthrosis is in agreement with ED statistics from OFA, where Bernese Mountain dogs and Rottweilers rank second and third, respectively, among all tested breeds for prevalence of ED.

Sex did not significantly affect the outcome of ED diagnosis, and prevalence examination by sex in the selected breeds taken into account gave inconsistent indications. In the literature, sex effect frequently appeared significant in affecting ED score: Mäki *et al.* (2000) found that males had slightly worse elbow joints than females in Finnish Rottweilers; similar results were reported for the same breed in Germany by Beuing *et al.* (2000). Both authors assumed that the sex effect could be due to the different growth rate of male and female dogs. However, Swenson *et al.* (1997) found inconsistent direction for sex effect when elbow arthrosis data from Bernese Mountain dogs and Swedish Rottweilers were analysed. It is possible that sex effect could vary among breeds, but data in this study were limited for testing this hypothesis.

The prevalence of ED tended to increase with increasing age at screening, and from logistic regression analysis age was a significant risk factor in diagnosis of elbow arthrosis. Also Mäki *et al.* (2000) found that age at screening significantly affected ED variation, and status of elbow joints worsened with increasing age at screening. Conversely, Beuing *et al.* (2000) did not find any significant effect of age at examination on elbow dysplasia analysis of German Rottweiler population. Swenson *et al.* (1997) found a significant relationship between age at radiographic evaluation and severity of elbow arthrosis and suggested that, when developing a control program for ED, all dogs should be screened at a similar age. From a practical point of view, a regular control of dogs for ED could be arranged at the same time as the examination for hip dysplasia, which is officially required by several breed associations when dogs reach an age ranging between 12 and 18 months, according to the typical breed size.

The proportion of unaffected dogs tended to increase linearly moving from earlier to later birth years. Also Beuing *et al.* (2000) found a positive relationship between year of examination and the proportion of unaffected dogs, whereas Mäki *et al.* (2000) reported a slight unfavourable environmental trend but a favourable genetic trend for ED in the Finnish Rottweiler. In the present study the apparent positive phenotypic trend observed is probably due mainly to the partial confounding between birth year and age at screening caused by the fact that the proportion of dogs that were young at screening tended to increase with the advancing of birth year. Conversely, it seems very difficult to hypothesize a phenotypic (and genetic) trend for ED in Italian dog population. Some type of phenotypic selection against ED has probably been made by several breeders, but obtaining a real gain in a few years through such means seems unlikely because ED is a trait with a moderate value of heritability (Mäki *et al.*, 2000) and the number of the screened stud dogs is still scarce.

Conclusions

In conclusion, results from this study provide evidence that elbow dysplasia is a skeletal disease with a relatively high prevalence for some breeds of dogs which are commonly found in Italy. The explorative screening program showed that a regular control for elbow joints status is feasible. The screening should be carried out at a standard age and could be performed at the same time when dogs are officially examined for hip dysplasia. The prospective is to arrange a wider screening program for elbow dysplasia, with the aim of investigating genetic parameters in order to propose selection strategies to decrease the prevalence of this disease. A "healthy skeleton" index combining hip end elbow dysplasia breeding values could be an attractive prospect in this regard. Finally, in order to prevent pre-selection of diagnosis information and to ensure a reliable data set, the results of examinations should not influence the registration of dogs or their official use for breeding purposes.

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