Prevalence of and risk factors for hip dysplasia and cranial cruciate ligament deficiency in dogs

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Objective—To evaluate prevalence of and risk factors for hip dysplasia (HD) and cranial cruciate ligament deficiency (CCLD) in dogs and determine change in prevalence over time.

Design—Cross-sectional study.

Animals—1,243,681 dogs for which information was reported to the Veterinary Medical Database between 1964 and 2003.

Procedures—Information on breed, sex, and age was collected, and prevalences and odds ratios were calculated.

Results—Castrated male dogs were significantly more likely than other dogs to have HD (odds ratio [OR], 1.21), and castrated male (OR, 1.68) and spayed female (OR, 2.35) dogs were significantly more likely to have CCLD. Dogs up to 4 years old were significantly more likely to have HD (OR for dogs 2 months to 1 year old, 1.22; OR for dogs > 1 to 4 years old, 1.48), whereas dogs > 4 years old were significantly more likely to have CCLD (OR for dogs > 4 to 7 years old, 1.82; OR for dogs > 7 years old, 1.48). In general, large- and giant-breed dogs were more likely than other dogs to have HD, CCLD, or both. Prevalences of HD and CCLD increased significantly over the 4 decades for which data were examined.

Conclusions and Clinical Relevance—Results suggested that sex, age, and breed were risk factors for HD, CCLD, or both in dogs and that prevalences of HD and CCLD have increased over time. (*J Am Vet Med Assoc* 2008;232:1818–1824)

Hip dysplasia and CCLD are 2 of the most common orthopedic problems in dogs,[1] and treatment of these conditions can be associated with substantial financial costs for dog owners.[2] Importantly, dogs affected by one of these conditions can be concurrently or subsequently affected by the other. Thus, information about factors associated with whether dogs would develop HD, CCLD, or both could help veterinarians optimize their diagnostic approach and educate their dog-owning clients.

Several previous studies have reported prevalences of these conditions and risk factors for their occurrence on the basis of data from the VMDB,[1,3,4] databases maintained by the Orthopedic Foundation for Animals and PennHIP,[5–8] and medical records of private veterinary practices[9] and veterinary medical teaching hospitals.[10–13] All of these previous studies, however, examined prevalence of and risk factors for HD or CCLD individually, and to our knowledge, there have been no studies of prevalence of or risk factors for HD and CCLD occurring together. In addition, these previous studies did not examine temporal changes in the prevalence of HD or CCLD.

Therefore, the purposes of the study reported here were to evaluate prevalences of HD and CCLD, alone and together, in dogs; to determine whether sex, age, and breed were risk factors for the occurrence of HD, CCLD, or both; and to determine changes in prevalences of HD and CCLD over time. We hypothesized that HD and CCLD were more

Abbreviations

CCLD	Cranial cruciate ligament deficiency
CI	Confidence interval
HD	Hip dysplasia
OR	Odds ratio
VMDB	Veterinary Medical Database

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Table 1—Prevalences of HD and CCLD in 1,243,681 dogs, grouped on the basis of sex and neuter status, that had been examined at veterinary medical teaching hospitals in North America between 1964 and 2003.

		Dogs with HD		Dogs with CCLD	
Group	Total No. of dogs	No. (%)	OR (95% CI)	No. (%)	OR (95% CI)
Sexually intact female	307,957	10,324 (3.35)	0.93 (0.91–0.96)	4,614 (1.55)	0.51 (0.49–0.53)
Spayed female	319,725	11,010 (3.44)	0.97 (0.95–0.99)	14,004 (4.54)	2.35 (2.30–2.40)
Sexually intact male	458,525	15,984 (3.49)	0.98 (0.96–1.00)	6,948 (1.57)	0.47 (0.46–0.49)
Castrated male	157,474	6,506 (4.13)	1.21 (1.18–1.24)	6,132 (4.06)	1.68 (1.63–1.73)

The OR represent the odds of HD or CCLD in that group, compared with the odds in all other dogs not in that group. Odds ratios for which the 95% CI does not contain 1 are significantly ($P < 0.05$) different from 1.

Table 2—Prevalences of HD, CCLD, and both HD and CCLD, identified concurrently or subsequently, in 1,243,681 dogs, grouped on the basis of age, that had been examined at veterinary medical teaching hospitals in North America between 1964 and 2003.

		Dogs with HD		Dogs with CCLD		Dogs with HD and CCLD	
Age	Total No. of dogs	No. (%)	OR (95% CI)	No. (%)	OR (95% CI)	No. (%)	OR (95% CI)
2 months to 1 year	262,010	10,699 (4.08)	1.22 (1.19–1.25)	1,094 (0.42)	0.13 (0.12–0.14)	139 (0.05)	0.14 (0.12–0.17)
> 1 to 4 years	357,841	16,232 (4.54)	1.48 (1.45–1.51)	8,529 (2.38)	0.91 (0.89–0.93)	1,166 (0.33)	1.11 (1.04–1.19)
> 4 to 7 years	248,217	6,951 (2.80)	0.75 (0.73–0.77)	9,783 (3.94)	1.82 (1.78–1.87)	1,096 (0.44)	1.66 (1.54–1.78)
> 7 years	375,613	9,942 (2.65)	0.67 (0.65–0.68)	12,292 (3.27)	1.48 (1.45–1.51)	1,355 (0.36)	1.31 (1.22–1.40)

Table 3—Prevalence of HD in dogs, grouped on the basis of breed, that had been examined at veterinary medical teaching hospitals in North America between 1964 and 2003.

Breed	No. of dogs	No. (%) with HD	OR (95% CI)	*P* value
Newfoundland	5,005	859 (17.16)	5.77 (5.35–6.21)	< 0.001
Saint Bernard	11,473	1,687 (14.70)	4.87 (4.62–5.13)	< 0.001
Old English Sheepdog	6,890	765 (11.10)	3.46 (3.21–3.74)	< 0.001
Rottweiler	19,358	2,038 (10.53)	3.33 (3.18–3.49)	< 0.001
German Shepherd Dog	79,098	8,115 (10.26)	3.61 (3.52–3.71)	< 0.001
Samoyed	7,917	704 (8.89)	2.70 (2.50–2.92)	< 0.001
Golden Retriever	46,941	3,995 (8.51)	2.70 (2.61–2.80)	< 0.001
Alaskan Malamute	5,296	413 (7.80)	2.33 (2.10–2.58)	< 0.001
Labrador Retriever	73,596	5424 (7.37)	2.34 (2.28–2.41)	< 0.001
Chow Chow	8,084	521 (6.44)	1.90 (1.73–2.07)	< 0.001
Airedale Terrier	5,190	323 (6.22)	1.82 (1.63–2.04)	< 0.001
English Setter	7,806	402 (5.15)	1.49 (1.35–1.65)	< 0.001
Bulldog	9,888	437 (4.42)	1.27 (1.15–1.40)	< 0.001
English Springer Spaniel	13,535	594 (4.39)	1.26 (1.16–1.37)	< 0.001
Border Collie	5,228	221 (4.23)	1.21 (1.06–1.38)	0.054
Brittany Spaniel	9,541	403 (4.22)	1.21 (1.09–1.34)	0.003
Irish Setter	17,278	682 (3.95)	1.13 (1.04–1.22)	0.026
Great Dane	14,482	563 (3.89)	1.11 (1.02–1.21)	0.127
Weimaraner	5,749	195 (3.39)	0.96 (0.83–1.11)	0.961
Australian Shepherd	8,958	274 (3.06)	0.86 (0.76–0.97)	0.125
German Shorthaired Pointer	8,536	250 (2.93)	0.83 (0.73–0.94)	0.030
Standard Poodle	12,168	340 (2.79)	0.79 (0.70–0.88)	0.000
English Pointer	7,443	172 (2.31)	0.65 (0.56–0.75)	< 0.001
Afghan Hound	4,409	98 (2.22)	0.62 (0.51–0.76)	< 0.001
Boxer	15,453	327 (2.12)	0.59 (0.53–0.66)	< 0.001
Siberian Husky	11,259	226 (2.01)	0.56 (0.49–0.64)	< 0.001
American Staffordshire Terrier	5,556	102 (1.84)	0.51 (0.42–0.62)	< 0.001
Shetland Sheepdog	16,815	307 (1.83)	0.51 (0.45–0.57)	< 0.001
Shar-Pei	5,009	83 (1.66)	0.46 (0.37–0.57)	< 0.001
Basset Hound	10,444	167 (1.60)	0.44 (0.38–0.52)	< 0.001
Dutch Pug	6,070	93 (1.53)	0.42 (0.35–0.52)	< 0.001
Dalmatian	9,209	125 (1.36)	0.37 (0.31–0.45)	< 0.001
Collie	21,343	286 (1.34)	0.37 (0.33–0.41)	< 0.001
Doberman Pinscher	34,154	458 (1.34)	0.37 (0.33–0.40)	< 0.001
Lhasa Apso	10,038	103 (1.03)	0.28 (0.23–0.34)	< 0.001
Pekinese	10,507	102 (0.97)	0.27 (0.22–0.32)	< 0.001
American Cocker Spaniel	44,058	382 (0.87)	0.23 (0.21–0.26)	< 0.001
Shih Tzu	11,287	82 (0.73)	0.20 (0.16–0.25)	< 0.001
West Highland White Terrier	6,388	41 (0.64)	0.18 (0.13–0.24)	< 0.001
Beagle	18,503	115 (0.62)	0.17 (0.14–0.20)	< 0.001
Pomeranian	9,055	53 (0.59)	0.16 (0.12–0.21)	< 0.001
Fox Terrier	5,779	32 (0.55)	0.15 (0.11–0.21)	< 0.001
Miniature Poodle	47,997	245 (0.51)	0.14 (0.12–0.15)	< 0.001
Greyhound	5,435	20 (0.37)	0.10 (0.06–.016)	< 0.001
Boston Terrier	9,968	36 (0.36)	0.10 (0.07–0.14)	< 0.001
Yorkshire Terrier	13,645	49 (0.36)	0.10 (0.07–0.13)	< 0.001
Toy Poodle	17,416	49 (0.28)	0.08 (0.06–0.10)	< 0.001
Maltese	5,277	14 (0.27)	0.07 (0.04–0.12)	< 0.001
Chihuahua	12,586	29 (0.23)	0.06 (0.04–0.09)	< 0.001
Miniature Schnauzer	19,917	39 (0.20)	0.05 (0.04–0.07)	< 0.001
Miniature Dachshund	7,546	13 (0.17)	0.05 (0.03–0.08)	< 0.001
Dachshund	32,312	50 (0.15)	0.04 (0.03–0.05)	< 0.001
Scottish Terrier	5,913	7 (0.12)	0.03 (0.02–0.07)	< 0.001

common in large- and giant-breed dogs and that prevalences of HD and CCLD had increased significantly over time due to increased recognition of both HD and CCLD.

Materials and Methods

Data for the present study were obtained from the VMDB, which consisted of a collection of medical record information supplied by 27 veterinary medical teaching hospitals in North America. The database was searched for information on all dogs examined for any reason at participating institutions between 1964 and 2003. Individual dogs were included in the study only if information on sex, age, and breed had been included; each dog was included only once. Dogs < 2 months old were excluded from the study.

For all dogs in the study, information was obtained on whether HD, CCLD, or both had ever been diagnosed. Multiple coding options for HD and CCLD were available when submitting information to the VMDB. Thus, dogs were considered to have HD if they had a coded diagnosis of HD, hip joint osteoarthritis, hip joint arthrosis, degenerative changes of the hip joint, or hip joint pain. Dogs were considered to have CCLD if they had a coded diagnosis of cranial cruciate ligament tear, cranial cruciate ligament rupture, stifle joint laxity, or stifle joint arthritis.

For analyses involving sex, categories that were used consisted of sexually intact female, sexually intact male, spayed female, and castrated male. For analyses involving age, categories that were used consisted of 2 months to 1 year, > 1 to 4 years, > 4 to 7 years, and > 7 years. For analyses involving breed, only those breeds represented by ≥ 4,000 individuals were evaluated. For analyses involving changes in prevalence over time, data were divided into four 10-year intervals (1964 to 1973, 1974 to 1983, 1984 to 1993, and 1994 to 2003).

Prevalence was calculated by dividing the number of dogs with HD, CCLD, or both by the total number of dogs at risk. Sex, age, and breed were evaluated as possible risk factors for HD, CCLD, or both by calculating ORs and their 95% CIs. Odds ratios represented the odds of the condition in a specific group of dogs, compared with the odds of the condition in all other dogs in the population. An OR > 1 indicated that dogs in that group were more likely to develop the condition than were dogs that were not in that group; an OR < 1 indicated that dogs in that group were less likely to develop the condition than were dogs that were not in that group. Likelihood ratio χ^2 tests were used to

Table 4—Prevalence of CCLD in dogs, grouped on the basis of breed, that had been examined at veterinary medical teaching hospitals in North America between 1964 and 2003.

Breed	No. of dogs.	No. (%) with CCLD	OR (95% CI)	*P* value
Newfoundland	4,551	405 (8.90)	3.77 (3.40–4.18)	< 0.001
Rottweiler	18,886	1,566 (8.29)	3.58 (3.40–3.78)	< 0.001
Labrador Retriever	72,364	4,192 (5.79)	2.56 (2.47–2.64)	< 0.001
Bulldog	9,983	532 (5.33)	2.17 (1.99–2.37)	< 0.001
Boxer	15,962	836 (5.24)	2.14 (2.00–2.30)	< 0.001
Chow Chow	7,903	340 (4.30)	1.73 (1.55–1.93)	< 0.001
American Staffordshire Terrier	5,684	230 (4.05)	1.62 (1.42–1.82)	< 0.001
Saint Bernard	10,148	362 (3.57)	1.42 (1.28–1.58)	< 0.001
Alaskan Malamute	5,047	164 (3.25)	1.29 (1.10–1.50)	0.018
Airedale Terrier	5,029	162 (3.22)	1.27 (1.09–1.49)	0.027
American Cocker Spaniel	44,733	1,057 (2.36)	0.92 (0.87–0.98)	0.092
German Shorthaired Pointer	8,545	259 (3.03)	1.20 (1.06–1.35)	0.045
Miniature Poodle	49,206	1,454 (2.95)	1.17 (1.11–1.24)	< 0.001
Golden Retriever	44,185	1,239 (2.80)	1.11 (1.05–1.17)	0.007
Great Dane	14,315	396 (2.77)	1.09 (0.98–1.20)	0.430
Dalmatian	9,338	254 (2.72)	1.07 (0.94–1.21)	0.774
West Highland White Terrier	6,525	178 (2.73)	1.07 (0.92–1.25)	0.838
Samoyed	7,399	186 (2.51)	0.99 (0.85–1.14)	0.998
Toy Poodle	17,808	441 (2.48)	0.97 (0.88–1.07)	0.944
Beagle	18,842	454 (2.41)	0.94 (0.86–1.04)	0.684
English Springer Spaniel	13,260	319 (2.41)	0.94 (0.84–1.05)	0.776
Yorkshire Terrier	13,912	316 (2.27)	0.89 (0.79–0.99)	0.226
German Shepherd Dog	72,613	1,630 (2.24)	0.87 (0.83–0.92)	< 0.001
Australian Shepherd	8,874	190 (2.14)	0.84 (0.72–0.97)	0.113
Siberian Husky	11,272	239 (2.12)	0.83 (0.73–0.94)	0.038
English Pointer	7,426	155 (2.09)	0.81 (0.69–0.95)	0.094
Chihuahua	12,818	261 (2.04)	0.79 (0.70–0.90)	0.003
Shar-Pei	5,028	102 (2.03)	0.79 (0.65–0.96)	0.139
Border Collie	5,109	102 (2.00)	0.78 (0.64–0.95)	0.098
Brittany Spaniel	9,318	180 (1.93)	0.75 (0.65–0.87)	0.002
Standard Poodle	12,054	226 (1.87)	0.73 (0.64–0.83)	< 0.001
Doberman Pinscher	34,330	634 (1.85)	0.71 (0.66–0.77)	< 0.001
Weimaraner	5,654	100 (1.77)	0.69 (0.56–0.84)	0.003
Lhasa Apso	10,112	177 (1.75)	0.68 (0.59–0.79)	< 0.001
English Setter	7,518	114 (1.52)	0.59 (0.49–0.71)	< 0.001
Maltese	5,340	77 (1.44)	0.56 (0.45–0.70)	< 0.001
Pomeranian	9,133	131 (1.43)	0.55 (0.47–0.66)	< 0.001
Shetland Sheepdog	16,732	224 (1.34)	0.52 (0.45–0.59)	< 0.001
Scottish Terrier	5,985	79 (1.32)	0.51 (0.41–0.64)	< 0.001
Boston Terrier	10,063	131 (1.30)	0.50 (0.42–0.60)	< 0.001
Fox Terrier	5,820	73 (1.25)	0.48 (0.38–0.61)	< 0.001
Basset Hound	10,392	115 (1.11)	0.43 (0.35–0.51)	< 0.001
Old English Sheepdog	6,185	60 (0.97)	0.37 (0.29–0.48)	< 0.001
Afghan Hound	4,352	41 (0.94)	0.36 (0.27–0.49)	< 0.001
Irish Setter	16,745	149 (0.89)	0.34 (0.29–0.40)	< 0.001
Collie	21,219	162 (0.76)	0.29 (0.25–.034)	< 0.001
Dutch Pug	6,022	45 (0.75)	0.29 (0.21–0.38)	< 0.001
Pekinese	10,479	74 (0.71)	0.27 (0.21–0.34)	< 0.001
Miniature Schnauzer	20,004	126 (0.63)	0.24 (0.20–0.29)	< 0.001
Shih Tzu	11,269	64 (0.57)	0.22 (0.17–0.28)	< 0.001
Greyhound	5,445	30 (0.55)	0.21 (0.15–0.30)	< 0.001
Dachshund	32,329	67 (0.21)	0.08 (0.06–0.10)	< 0.001
Miniature Dachshund	7,549	16 (0.21)	0.08 (0.05–0.13)	< 0.001

compare prevalences of HD, CCLD, and both among groups. Standard software[a] was used for all analyses. Values of $P < 0.05$ were considered significant.

Results

Information was obtained on 1,243,681 dogs examined at the participating institutions between 1964 and 2003. Hip dysplasia had been diagnosed in 43,825 (3.52%) dogs, CCLD had been diagnosed in 31,698 (2.55%), and HD and CCLD had been diagnosed, concurrently or subsequently, in 3,756 (0.30%).

Sex—Sex was identified as a risk factor for HD and CCLD. Sexually intact female and spayed female dogs were significantly less likely than other dogs to be identified as having HD (**Table 1**). In contrast, castrated male dogs were significantly more likely than other dogs to be identified as having HD. The odds of HD in sexually intact male dogs was not significantly different from the odds of HD in other dogs. Spayed female and castrated male dogs were significantly more likely than other dogs to be identified as having CCLD, whereas sexually intact female and sexually intact male dogs were significantly less likely than other dogs to be identified as having CCLD.

Age—Age was identified as a risk factor for HD, CCLD, and both HD and CCLD. Dogs between 2 months and 1 year old and dogs > 1 to 4 years old were significantly more likely than other dogs to be identified as having HD (**Table 2**), whereas dogs > 4 to 7 years old and dogs > 7 years old were significantly less likely than other

Table 5—Prevalence of HD and CCLD, identified concurrently or subsequently, in dogs, grouped on the basis of breed, that had been examined at veterinary medical teaching hospitals in North America between 1964 and 2003.

Breed	No. of dogs	No. (%) with HD and CCLD	OR (95% CI)	*P* value
Newfoundland	4,268	122 (2.86)	10.01 (8.33–12.02)	< 0.001
Rottweiler	17,555	235 (1.34)	4.71 (4.12–5.38)	< 0.001
Saint Bernard	9,904	118 (1.19)	4.08 (3.39–4.90)	< 0.001
Bulldog	9,556	105 (1.10)	3.74 (3.08–4.55)	< 0.001
Labrador Retriever	68,738	566 (0.82)	3.05 (2.79–3.34)	< 0.001
Chow Chow	7,618	55 (0.72)	2.42 (1.85–3.16)	< 0.001
German Shepherd Dog	71,411	428 (0.60)	2.12 (1.91–2.34)	< 0.001
Boxer	15,216	90 (0.59)	1.99 (1.61–2.45)	< 0.001
Golden Retriever	43,167	221 (0.51)	1.74 (1.52–2.00)	< 0.001
Airedale Terrier	4,891	24 (0.49)	1.63 (1.09–2.44)	0.121
Alaskan Malamute	4,906	23 (0.47)	1.56 (1.03–2.35)	0.208
Samoyed	7,244	31 (0.43)	1.42 (1.00–2.03)	0.280
American Staffordshire Terrier	5,477	23 (0.42)	1.39 (0.92–2.10)	0.468
Old English Sheepdog	6,146	21 (0.34)	1.13 (0.74–1.74)	0.956
Great Dane	13,963	44 (0.32)	1.04 (0.78–1.41)	0.994
Brittany Spaniel	9,164	26 (0.28)	0.94 (0.64–1.38)	0.992
English Springer Spaniel	12,977	36 (0.28)	0.92 (0.66–1.27)	0.967
Basset Hound	10,303	26 (0.25)	0.83 (0.57–1.23)	0.837
German Shorthaired Pointer	8,306	20 (0.24)	0.80 (0.51–1.24)	0.791
Australian Shepherd	8,702	18 (0.21)	0.68 (0.43–1.09)	0.451
Siberian Husky	11,054	21 (0.19)	0.63 (0.41–0.96)	0.199
Irish Setter	16,623	27 (0.16)	0.53 (0.37–0.78)	0.012
Border Collie	5,015	8 (0.16)	0.53 (0.26–1.05)	0.335
West Highland White Terrier	6,357	10 (0.16)	0.52 (0.28–0.97)	0.217
Doberman Pinscher	33,749	53 (0.16)	0.51 (0.39–0.67)	< 0.001
English Pointer	7,281	10 (0.14)	0.45 (0.24–0.84)	0.086
Dalmatian	9,096	12 (0.13)	0.43 (0.25–0.77)	0.032
Shetland Sheepdog	16,529	21 (0.13)	0.42 (0.27–0.64)	0.001
Shar-Pei	4,932	6 (0.12)	0.40 (0.18–0.89)	0.148
English Setter	7,413	9 (0.12)	0.40 (0.21–0.77)	0.044
Dutch Pug	5,984	7 (0.12)	0.39 (0.18–0.81)	0.077
Lhasa Apso	9,946	11 (0.11)	0.36 (0.20–0.66)	0.007
American Cocker Spaniel	43,719	43 (0.10)	0.32 (0.23–0.43)	< 0.001
Beagle	18,406	18 (0.10)	0.32 (0.20–0.51)	< 0.001
Weimaraner	5,559	5 (0.09)	0.30 (0.12–0.71)	0.040
Standard Poodle	11,838	10 (0.08)	0.28 (0.15–0.52)	0.000
Pomeranian	9,009	7 (0.08)	0.26 (0.12–0.54)	0.002
Maltese	5,267	4 (0.08)	0.25 (0.09–0.67)	0.030
Collie	21,073	16 (0.08)	0.25 (0.15–0.40)	< 0.001
Yorkshire Terrier	13,606	10 (0.07)	0.24 (0.13–0.45)	< 0.001
Shih Tzu	11,212	7 (0.06)	0.20 (0.10–0.43)	< 0.001
Boston Terrier	9,938	6 (0.06)	0.20 (0.09–0.44)	0.000
Pekinese	10,410	5 (0.05)	0.16 (0.07–0.38)	< 0.001
Miniature Poodle	47,772	20 (0.04)	0.13 (0.09–0.21)	< 0.001
Scottish Terrier	5,908	2 (0.03)	0.11 (0.03–0.45)	0.003
Toy Poodle	17,372	5 (0.03)	0.09 (0.04–0.23)	< 0.001
Miniature Dachshund	7,535	2 (0.03)	0.09 (0.02–0.35)	0.000
Afghan Hound	4,312	1 (0.02)	0.08 (0.01–0.54)	0.011
Miniature Schnauzer	19,882	4 (0.02)	0.07 (0.02–0.17)	< 0.001
Chihuahua	12,559	2 (0.02)	0.05 (0.01–0.21)	< 0.001
Dachshund	32,265	3 (0.01)	0.03 (0.01–0.09)	< 0.001
Fox Terrier	5,747	0 (0)	N/A	N/A
Greyhound	5,415	0 (0)	N/A	N/A

Table 6—Prevalences of HD and CCLD as a function of time in dogs that had been examined at veterinary medical teaching hospitals in North America between 1964 and 2003.

Time period	Total No. of dogs	No. (%) of dogs with HD	No. (%) of dogs with CCLD
1964–1973	136,838	6,363 (4.65)	2,470 (1.81)
1974–1983	324,434	10,471 (3.23)	6,685 (2.06)
1984–1993	407,944	15,057 (3.69)	11,311 (2.77)
1994–2003	230,415	11,923 (5.17)	11,216 (4.87)

dogs to be identified as having HD. In contrast, dogs > 4 to 7 years old and dogs > 7 years old were more likely than other dogs to be identified as having CCLD, and dogs 2 months to 1 year old and dogs > 1 to 4 years old were less likely than other dogs to be identified as having CCLD. Finally, dogs > 1 to 4 years old, dogs > 4 to 7 years old, and dogs > 7 years old were more likely than other dogs to be identified as having both HD and CCLD, whereas dogs 2 months to 1 year old were less likely than other dogs to be identified as having both HD and CCLD.

Breed—Breed was identified as a risk factor for HD, CCLD, and both HD and CCLD. Breeds with the highest odds of being identified as having HD included the Newfoundland, Saint Bernard, Old English Sheepdog, Rottweiler, and German Shepherd Dog (**Table 3**). Breeds identified as having a significantly lower odds of having HD, compared with other dogs, included the Miniature Schnauzer, Chihuahua, Maltese, Toy Poodle, Miniature Dachshund, and Dachshund.

Breeds with the highest odds of being identified as having CCLD included the Newfoundland, Rottweiler, Labrador Retriever, Bulldog, Boxer, Chow Chow, American Staffordshire Terrier, and Saint Bernard (**Table 4**). Breeds identified as having a significantly lower odds of having CCLD, compared with other dogs, included the Miniature Dachshund, Dachshund, Greyhound, Shih Tzu, Miniature Schnauzer, and Pekingese.

Breeds with the highest odds of being identified as having both HD and CCLD included the Newfoundland, Rottweiler, Saint Bernard, Bulldog, Labrador Retriever, and Chow Chow (**Table 5**). Breeds identified as having a significantly lower odds of having both HD and CCLD, compared with other dogs, included the Miniature Dachshund, Miniature Schnauzer, Chihuahua, Fox Terrier, Afghan Hound, and Greyhound.

Change in prevalence over time—For each of the 4 time periods examined, prevalence of HD during that period was significantly different from prevalence during the other periods (**Table 6**). Prevalence of HD was lower during the period from 1974 to 1983 than the prevalence during the period from 1964 to 1973 but increased thereafter. Similarly, for each of the 4 time periods examined, prevalence of CCLD during that period was significantly different from prevalence during the other periods. Prevalence of CCLD increased steadily during the 4 periods examined.

Discussion

Results of the present study suggested that sex, age, and breed were risk factors for HD, CCLD, or both in dogs. Castrated male dogs were significantly more likely than other dogs to have HD, and castrated male and spayed female dogs were significantly more likely to have CCLD. Dogs up to 4 years old were significantly more likely to have HD, whereas dogs > 4 years old were significantly more likely to have CCLD, and dogs > 1 year old were more likely to have both HD and CCLD. In general, large- and giant-breed dogs were more likely than other dogs to have HD, CCLD, or both. Finally, prevalences of HD and CCLD had increased significantly over the 4 decades for which data were examined.

Data for the present study were obtained by searching the records of the VMDB, which provided information on dogs examined for any reason at any of the 27 participating veterinary medical teaching hospitals in North America, including dogs examined because of a specific disease or condition and overtly healthy dogs undergoing routine examination. Although the population of dogs included in the VMDB did not necessarily represent the general population of dogs in North America, data in the VMDB were obtained from a large number of institutions covering a wide range of hospital, patient, and client demographics. In addition, the data entry protocol for the VMDB allowed for entry of multiple diagnostic codes for any individual dog, so that dogs examined for a nonorthopedic problem in which HD or CCLD was identified serendipitously would still be recorded in the database as having this condition. As a result, we believe our findings have broad applicability to the population of dogs in North America.

Previous studies[1,3–13] examining prevalences of and risk factors for HD and CCLD in dogs have generally used information from more restricted databases. Use of a source such as the Orthopedic Foundation for Animals database may be useful in determining the prevalence of HD in that diagnoses were made by board-certified radiologists,[7] but the data may not be representative of the general population of dogs because of selection bias. To minimize the effects of selection bias, we elected to use information from the VMDB in the belief that this information would be more representative of the general population of dogs. In addition, use of the VMDB allowed us to examine changes in prevalence over time.

The overall prevalence of HD in the present study (3.52%) was substantially lower than prevalences reported in previous studies.[5–8,10] For example, a previous study[5] involving data from a single veterinary medical teaching hospital found that the prevalence of HD in Rottweilers was 41% to 53% and the prevalence in Golden Retrievers was 69% to 73%, depending on the definition of HD. In the present study, prevalences of HD in these breeds were 11.8% and 9.3%, respectively. The cause of this large disparity in prevalence of HD between the present and previous studies is unknown. It is possible that a diagnosis of HD was not entered into the VMDB for some dogs that did in fact have the

condition. This may have occurred if clinical signs of HD were not evident at the time the dog was examined at the veterinary medical teaching hospital or if diagnostic testing for HD was not performed because other conditions were accorded a higher priority. Importantly, however, the coding protocol for the VMDB allowed for diagnoses other than those associated with the primary problem to be recorded. Nevertheless, it seems likely that not all dogs with HD were identified as having this condition in the VMDB. Thus, breed prevalences reported in the present study may be falsely low. Even if this were the case, ORs calculated in the present study should not have been greatly affected by this reporting bias, as all of the groups should have been affected to the same extent.

In the present study, prevalences of HD and CCLD increased significantly over the 40-year study period, although prevalence of HD did decrease during the period from 1974 to 1983. Previous studies[14,15] have reported decreases in HD prevalence over time, but they did not examine the prevalence of HD over as long a time period as used in the present study. Although the causes of this increase in prevalence are not known, we do not believe that the increase in prevalence of HD or the increase in prevalence of CCLD over time was due to a true increase in the underlying frequencies of these conditions. Rather, we suspect that the increases in prevalence were due to increased recognition of these conditions by veterinarians, making it more likely that dogs with these conditions would be identified. In particular, given the reported success of selective breeding programs specifically directed at decreasing the prevalence of HD in dogs,[14,15] we do not believe that the frequency of HD truly increased over the period of our study. In the case of CCLD, we cannot think of any reasons for why the frequency of this condition would have increased in the general population of dogs during our study period and believe that increased recognition of CCLD as an important orthopedic disease was the cause of the increase in prevalence that we found. Although we did not examine obesity, it has been associated with HD and CCLD. Thus, we cannot rule out the possibility that an increase in obese dogs over time has actually led to the increase in the frequency of CCLD and HD diagnoses that we saw.

We were not able to determine in the present study why castrated male and spayed female dogs were more likely than other dogs to have CCLD; however, previous studies have found similar increases in the odds[13] and prevalence[3] of CCLD in neutered dogs. This may, in part, be associated with the greater likelihood of obesity in neutered dogs, in that numerous studies[16–18] have shown that obesity is significantly more common in neutered dogs, and a relationship between obesity and CCLD has been reported.[3,13] Unfortunately, information on body weight or body condition score could not be reliably obtained from the VMDB, so we could not assess whether either of these were risk factors for CCLD. On the other hand, it is possible that owners of neutered dogs were more likely than owners of sexually intact dogs to have their dogs evaluated for orthopedic disease and treated for CCLD, which would have falsely decreased the apparent prevalence of CCLD in sexually intact dogs and altered our calculated ORs. Also, it is possible that a relatively larger proportion of dogs representing breeds with a high prevalence of CCLD, such as Rottweilers and Labrador Retrievers, were neutered, compared with dogs representing breeds with a low prevalence of CCLD, which also would have altered our ORs. However, when we examined sex differences within specific breeds, such as Rottweilers and Labrador Retrievers, we found the same significant predisposition for CCLD among neutered dogs.

In the present study, dogs ≤ 4 years old were more likely to have HD than were older dogs and dogs > 4 years old were less likely to have HD than were younger dogs. Because HD is a developmental disease, dogs that have not developed clinical signs of HD by 4 years of age are less likely to be identified as having HD after this time. Conversely, dogs > 4 years old were more likely than younger dogs in the present study to have CCLD, whereas dogs ≤ 4 years old were less likely to have CCLD than older dogs. The higher prevalence of CCLD in older dogs was in agreement with results of a previous study.[3] In contrast, another study[13] found that large-breed dogs were predisposed to develop CCLD at a young age, and similar findings have been reported elsewhere.[9,12] Unfortunately, our data were not subdivided by breed and age, so we were unable to determine whether large-breed dogs were more likely to develop CCLD at a young age.

We also found in the present study that dogs > 1 year old were more likely than younger dogs to have both HD and CCLD. Further research is needed to delineate the reasons for this. However, we suggest that a possible explanation for this is that when older dogs are evaluated because of hind limb lameness, veterinarians tend to test for both HD and CCLD.

Several limitations of using data from the VMDB for this type of study must be acknowledged. Most importantly, diagnoses entered into the database cannot be retrospectively confirmed or denied; therefore, all results rely on correct reporting of data. In addition, only information from dogs examined at one of the participating veterinary medical teaching hospitals is included in the VMDB. Therefore, information for dogs whose owners were not referred to a veterinary medical teaching hospital and for dogs whose owners did not pursue diagnostic testing at a veterinary medical teaching hospital is not included. Thus, although the large number of cases included in the present study resulted in more precise estimates of prevalence and ORs, it also allowed for magnification of any inherent biases in data from the VMDB in relation to the general population of dogs. For example, it is possible that fewer small-breed dogs with CCLD were examined at veterinary medical teaching hospitals because these dogs were treated by their referring veterinarians, thereby falsely decreasing the prevalence of CCLD in small-breed dogs. Although the VMDB cannot account for this possibility, it does allow for coding of multiple diagnoses for each patient. Therefore, a small-breed dog that was examined for a reason unrelated to orthopedic disease and that was being treated or had been treated by the referring veterinarian for HD or CCLD could still be recorded as having this condition.

a. Excel 2003, Microsoft Corp, Redmond, Wash.

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