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1 **Prevalence and breed predisposition for thoracolumbar intervertebral disc disease in cats**

2 Steven De Decker, Anne-Sophie Warner, Holger A Volk.

3 Clinical Science and Services, The Royal Veterinary College, University of London, Hatfield,

4 UK

5

6 Corresponding author: Steven De Decker, DVM, PhD, DipECVN, MvetMed, FHEA, MRCVS

7 Email: sdedecker@rvc.ac.uk

8 Address: Clinical Science and Services, The Royal Veterinary College, University of London,

9 Hawkshead Lane, North Mymms, Hatfield, Hertfordshire, AL9 7TA, UK

10 Tel: +44(0)1707 666366

11 Fax: +44 (0)1707 649384

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13 **Keywords:**

14 Disc degeneration; spinal; extrusion; protrusion; Persian; British shorthair

15

16 **Earlier publication:**

17 The results of this study were presented in abstract form (Poster) for the 28th symposium of the

18 European society of veterinary neurology - European college of veterinary neurology (ESVN-

19 ECVN), 18-19 September 2015, Amsterdam, The Netherlands

20

21

22 **Abstract**

23 *Objectives:* to evaluate the prevalence and possible breed predilections for thoracolumbar
24 intervertebral disc disease (IVDD) in cats.

25 *Methods:* Medical records and imaging studies of cats diagnosed with thoracolumbar IVDD
26 were retrospectively reviewed and compared to the general hospital population between
27 January 2008 and August 2014. The association between type of IVDD [i.e. intervertebral disc
28 extrusion (IVDE) or intervertebral disc protrusion (IVDP)] and breed, age, gender, duration
29 and severity of clinical signs was also evaluated.

30 *Results:* Of 12900 cats presented during the study period, 31 (0.24%) were diagnosed with
31 IVDD, including 17 purebred and 14 non-purebred cats. Of all presented purebred cats, 0.52%
32 were diagnosed with thoracolumbar IVDD. More specifically, 1.29% of all British Shorthairs
33 and 1.83% of all presented Persians were diagnosed with IVDD. Compared to the general
34 hospital population, purebred cats ($P=0.0001$), British Shorthairs ($P<0.0001$) and Persians
35 ($P=0.0006$) were significantly overrepresented with thoracolumbar IVDD. Affected purebred
36 cats were younger compared to affected non-purebred cats ($P=0.02$). Of 31 cats with IVDD,
37 19 were diagnosed with IVDE and 12 with IVDP. Cats with IVDE had a significantly shorter
38 duration of clinical signs ($P=0.0002$) and demonstrated more severe neurological deficits
39 ($P=0.04$) compared to cats with IVDP.

40 *Conclusions and relevance:* Although thoracolumbar IVDD is an uncommon condition in cats,
41 purebred cats, British Shorthairs, and Persians were overrepresented. It is currently unclear if
42 this represents a true breed predisposition or a higher likelihood of owners of purebred cats to
43 seek referral for advanced diagnostic imaging procedures.

44

45

46 **Introduction**

47 Although our knowledge of feline spinal cord diseases has increased continuously over years,
48 the diagnosis and treatment of the most common spinal disease processes, such as feline
49 infectious peritonitis and lymphoma, remain challenging^{1,2}, while less common feline spinal
50 disorders still need to be better characterised. A previous study, evaluating the prevalence of
51 histologically confirmed spinal disorders in cats, demonstrated that inflammatory/infectious
52 diseases represent the most common feline spinal disorders, followed by neoplastic and
53 traumatic disease processes. Intervertebral disc disease (IVDD) represented only 4% of all cats
54 with a spinal cord disorder³, while another study indicated that of 92 cats undergoing spinal
55 MRI, only 5 were diagnosed with IVDD.¹ It is therefore not surprising that only a limited
56 number of studies have described the clinical characteristics of feline degenerative IVDD.⁴⁻¹⁰
57 Its prevalence is considered low, no breed or sex predilection has been reported, affected cats
58 are generally older, and prognosis after surgical decompression is considered good.^{2,8,9}
59 Although both intervertebral disc extrusions (IVDE), or Hansen type-I IVDD, and
60 intervertebral disc protrusions (IVDP), or Hansen type-II IVDD, have been reported^{5,9}, its
61 currently unclear if both types of IVDD are associated with different disease characteristics in
62 cats. The situation is different in dogs. Degenerative IVDD is considered the most common
63 and best-characterised canine spinal condition.¹¹ Numerous studies have evaluated the
64 prevalence of thoracolumbar IVDD among the overall canine population¹², breed-specific risk
65 factors have been identified^{12,13}, and several studies have reported disease characteristics for
66 dogs with thoracolumbar IVDE or IVDP.^{14,15} The overall goal of this study was therefore to
67 evaluate the clinical presentation of feline thoracolumbar IVDD. More specifically the aims of
68 this study were to assess the prevalence and potential breed predisposition of feline
69 thoracolumbar IVDD and evaluate if IVDE and IVDP would be associated with different
70 disease characteristics. It was hypothesised that the prevalence of feline thoracolumbar IVDD

71 would indeed be low, that purebred cats would have an increased risk to suffer from IVDD,
72 and, similar to the situation in dogs, thoracolumbar IVDE and IVDP would be associated with
73 different disease characteristics.

74

75 **Material and Methods**

76 The digital medical database of the small animal referral hospital, Royal Veterinary College,
77 University of London was searched for cats diagnosed with thoracolumbar IVDD between
78 January 2008 and August 2014. Search terms included ‘intervertebral disc disease’, ‘disc
79 extrusion’, ‘disc protrusion’, ‘disc herniation’ and ‘disc prolapse’. Thoracolumbar IVDD was
80 defined as IVDE or IVDP between the first thoracic (T1) and seventh lumbar (L7) vertebra.
81 Cats were included if the clinical presentation and magnetic resonance imaging (MRI) studies
82 were both suggestive for degenerative IVDD and if the medical records and imaging studies
83 were available for review. Cats were excluded if the medical records or imaging studies were
84 incomplete or not available for review. Before inclusion, a board-certified neurologist (SDD)
85 reviewed all medical records and imaging studies to evaluate diagnostic accuracy. The
86 following information was retrieved from the medical records: clinical history, signalment,
87 duration, type, and severity of clinical signs, general physical and neurological examination
88 findings, and type of treatment initiated after diagnosis. Type of clinical signs was recorded as
89 spinal hyperaesthesia, ambulatory paraparesis, non-ambulatory paraparesis, or paraplegia as
90 the predominant clinical sign. Gradation of severity of neurological deficits was based on the
91 modified Frankel score ¹⁶, and was defined as paraplegia without nociception (grade 0),
92 paraplegia with nociception (grade 1), non-ambulatory paraparesis (grade 2), ambulatory
93 paraparesis and ataxia (grade 3), spinal hyperaesthesia only (grade 4), or no dysfunction. For
94 all included cats, a 1.5T MRI unit (Intera, Philips Medical Systems) was used to obtain a

95 diagnosis of IVDD. Magnetic resonance imaging was performed under general anaesthesia and
96 included a minimum of T2-weighted (repetition time [RT] [ms], echo time [TE], [ms]
97 3333/110) and T1-weighted (TR/TE, 515/15) sagittal and transverse images. Selected products
98 for induction and maintenance of general anaesthesia were at the discretion of the anaesthetist
99 responsible for the case. The location and number of affected intervertebral disc spaces were
100 noted and each intervertebral disc herniation was further characterised as IVDE (or Hansen
101 Type-I disc disease) or IVDP (or Hansen Type-II disc disease). The differentiation between
102 IVDE and IVDP was based on previously evaluated MRI criteria¹⁵ and where possible; the
103 type of IVDD was verified by the surgical reports. More specifically, MRI findings compatible
104 with midline instead of lateralised intervertebral disc herniation and partial instead of complete
105 intervertebral disc degeneration were considered suggestive for IVDP, while a single instead
106 of multiple intervertebral disc herniation and dispersed disc material not confined to the
107 boundaries of the affected intervertebral disc space were considered suggestive for IVDE.¹⁵
108 Although evaluation of treatment was beyond the scope of this study, medical management
109 typically consisted of a combination of strict rest for 4 weeks and non-steroidal anti-
110 inflammatory drugs, followed by gradual increase in activity over the following 4-6 weeks.
111 Surgical management consisted of a decompressive hemilaminectomy.

112 Data analysis was performed using standard statistical software package (Prism 6, GraphPad
113 Software Inc., La Jolla, CA). A chi-square test was used to compare the prevalence of purebred
114 and non-purebred cats and to evaluate the prevalence of breeds that were included more than
115 twice in the list of affected breeds (Domestic shorthair, Domestic longhair, British shorthair,
116 and Persian). A Mann Whitney U test was used to compare age, weight, duration of clinical
117 signs, and grade of neurological deficits between cats with IVDE and IVDP. A Fisher's exact
118 test was used to compare gender and presence of spinal hyperaesthesia between cats with IVDE
119 and IVDP. Values of $P < 0.05$ were considered statistically significant.

120

121 **Results**

122 Of 12900 cats presented during the study period at our referral hospital, 31 were diagnosed
123 with IVDD, including 17 purebred and 14 non-purebred cats. Included breeds were Domestic
124 shorthair, Domestic longhair, British shorthair, Persian, Bengal, Siamese, Havana Brown,
125 Maine Coon, Sphynx, and American Shorthair (**Table 1**). The prevalence of IVDD during the
126 study period was 0.24% for all presented cats overall, 0.15% for all presented non-purebred
127 cats, 0.52% for purebred cats, 1.83% for Persians, and 1.29% for British shorthairs. Compared
128 to the overall feline population, purebred cats ($P=0.0001$), British shorthairs ($P<0.0001$), and
129 Persians ($P=0.0006$) were significantly overrepresented. The group of affected cats included
130 16 neutered males and 15 neutered females aged between 9 months and 12 years and 4 months
131 (mean, 9 years and 6 months; median, 9 years). The cat affected at 9 months of age had
132 surgically confirmed IVDE. Affected purebred cats were significantly younger than affected
133 non-purebred cats. Included purebred cats were aged between 9 months and 13.7 years
134 (median, 7.6 years), while affected non-purebred cats were aged between 1.3 and 15.3 years
135 (median, 12.2 years). Duration of clinical signs ranged from 12 hours to 6 years (mean, 120
136 days; median, 15 days) and included spinal hyperaesthesia (n=4), ambulatory paraparesis
137 (n=17), non-ambulatory paraparesis (n=6), and paraplegia (n=4) as the predominant clinical
138 sign. In 23 of 31 cats spinal hyperaesthesia could be elicited on spinal palpation. Severity of
139 neurological deficits varied from grade 0 (n=2), grade 1 (n=2), grade 2 (n=6), grade 3 (n=17),
140 and grade 4 (n=4). There were no significant differences between purebred and non-purebred
141 cats for bodyweight gender, duration and type of clinical signs, severity of neurological
142 deficits, or presence of spinal hyperaesthesia ($P>0.05$). Magnetic resonance imaging
143 demonstrated a total of 33 intervertebral disc herniations in 31 cats; a single intervertebral disc
144 herniation was seen in 29 cats and two separate intervertebral disc herniations in 2 cats. The

145 most affected intervertebral disc space was L2-L3 (n=6), followed by T11-T12 (n=5), L3-L4,
146 L6-L7 (n=4 for each), T12-T13, T13-L1, L1-L2 (n=3 for each), T2-T3 (n=2), T8-T9, T9-T10,
147 and L5-L6 (n=1 for each). Of 31 cats with IVDD, 19 were diagnosed with IVDE and 12 with
148 IVDP. Cats with IVDE had a significantly longer duration of clinical signs (mean duration of
149 clinical signs 4 versus 72 days; $P=0.0002$) and demonstrated more severe neurological deficits
150 (mean neurological grade of 3.2 versus 4.1; $P=0.04$) compared to cats with IVDP. There was
151 no significant influence of breed, gender, age, or the presence of spinal hyperaesthesia on the
152 type of intervertebral disc herniation ($P>0.05$). Fifteen cats underwent surgery, 14 cats
153 underwent medical management, and 2 cats were euthanised at the moment of diagnosis
154 without treatment attempted. Surgery confirmed the suspected type of intervertebral disc
155 herniation (IVDE or IVDP) on each occasion. The surgical appearance of IVDE was
156 characterised as sequestered calcified intervertebral disc material without physical connection
157 with the ruptured annulus fibrosus. The surgical appearance of IVDP was characterised by a
158 focal or broad based dorsal displacement of the intervertebral disc without any defect in the
159 outer layers of the annulus fibrosus.

160

161 **Discussion**

162 This study evaluated the prevalence, possible breed predisposition, and clinical presentation of
163 thoracolumbar IVDD among a population of cats referred to a university teaching hospital. Our
164 results confirm that degenerative IVDD should be considered a rare condition in cats. The
165 prevalence of this disorder was only slightly higher than reported previously.⁹ It was 0.24% in
166 the current study, while a previous study documented a prevalence of 0.12% of all cats
167 presented at a North American university teaching hospital.⁹ Although other reasons cannot be
168 excluded, this possibly reflects continuous developments in veterinary medicine with advanced

169 imaging procedures, including MRI, performed in an increasing number of cats. Alternatively,
170 the results of our study suggest a possible breed predisposition for feline thoracolumbar IVDD.
171 It can therefore not be excluded that differences in breed distribution among geographical
172 locations has contributed to a difference in disease prevalence. It is currently unclear why cats
173 are only rarely affected by IVDD compared to other domesticated small animals, such as
174 dogs.¹² A recent study, evaluating the histopathological characteristics of the feline
175 intervertebral disc identified possible feline-specific changes in the annulus fibrosus.¹⁷ While
176 the nucleus pulposus demonstrated histological changes comparable to those found in canine
177 intervertebral discs, the feline annulus fibrosus showed distinct depositions of
178 glycosaminoglycans and contained a high degree of chondrocyte-like cells ranging into the
179 outer annulus fibrosus.¹⁷ It is currently however unclear if these changes indeed protect the feline
180 intervertebral disc against degeneration and herniation.

181 In agreement with previous studies, the domestic shorthair was the most common breed to have
182 thoracolumbar IVDD.^{2,8,9} However, when taking the relative popularity of the presented breeds
183 into account, purebred cats were significantly overrepresented. More specifically, Persians and
184 British shorthairs were more commonly diagnosed with thoracolumbar IVDD compared to
185 other breeds. It is currently unclear why these specific purebred cats were overrepresented
186 compared to the general hospital population. The aetiology of canine IVDD is considered
187 multifactorial with genetic, anatomical and biomechanical factors involved.¹⁸ Developments
188 in the knowledge of canine IVDD have demonstrated an important role of genetic factors in the
189 development of IVDD.¹⁹⁻²¹ Identified genes are associated with the chondrodystrophic
190 phenotype, which is characterised by dogs with relative long spines and short limbs.^{19,20} The
191 Dachshund, the dog breed most commonly affected by IVDD, is the prototype of such a 'long
192 and low' chondrodystrophic dog breed and this type of body conformation is indeed considered
193 a major risk factor for the development of thoracolumbar IVDD.¹³ The Persian and British

194 Shorthair are genetically related breeds with the Persian being the foundation breed of the
195 ‘Persian family members’, which includes the British Shorthair, Scottish Fold, and Selkirk Rex.
196 All these breeds share the brachycephalic structure of the head.^{22,23} Although such breed
197 development strategies result in members of different, but closely related, breeds to share the
198 same general and genetic health concerns²³, it remains currently unclear if a relationship exists
199 between the brachycephalic phenotype, other conformational changes, and ultimately,
200 thoracolumbar IVDD. Alternatively, it cannot be excluded that the results of our study do not
201 reflect a true breed predisposition, but rather the willingness of owners of financially more
202 valuable purebred cats to seek referral for advanced diagnostic procedures.

203 In agreement with previous findings⁹, cats with thoracolumbar IVDD were generally old with
204 most affected cats being 8 years or older. The results of this study however demonstrated that
205 affected purebred cats were significantly younger than non-purebred cats. Although this age
206 difference can be considered an illustration of their presumed predisposition for thoracolumbar
207 IVDD, it cannot be excluded this finding represents again an increased willingness of owners
208 to seek referral and pursue expensive diagnostic evaluations in relative younger cats.

209 In agreement with previous studies^{5,9}, two types of thoracolumbar intervertebral disc
210 herniation were seen in affected cats; IVDE and IVDP. Intervertebral disc extrusions are
211 characterised by herniation of degenerated and calcified nucleus pulposus through a fully
212 ruptured anulus fibrosus, while IVDP is characterised by a focal and more gradual extension
213 of the anulus fibrosus into the vertebral canal.¹⁸ Although similar histopathological
214 abnormalities are seen in both types of intervertebral disc herniation²⁴, IVDE and IVDP are
215 associated with different clinical characteristics in dogs.^{14,15,25} Intervertebral disc extrusions
216 are typically associated with an acute onset of severe neurological signs, while dogs with IVDP
217 typically present with milder clinical signs and a chronic, progressive clinical history.^{14,15,25} In
218 agreement with these findings, cats with IVDE and IVDP demonstrated differences in their

219 clinical presentation. Cats with IVDE had a shorter duration of clinical signs before
220 presentation and had more severe neurological deficits compared to cats with IVDP. These
221 differences are not surprising and most likely reflect the pathophysiological differences
222 between both types of IVDD. Intervertebral disc extrusions are characterised by a sudden
223 extrusion of calcified and fragmented nucleus pulposus, which results in both contusion and
224 compression of the spinal cord.²⁶ It is therefore not surprising that affected cats typically
225 demonstrated an acute onset of severe spinal cord dysfunction. In contrast, IVDP is typically
226 associated with gradual spinal cord compression without contusion. Affected cats therefore
227 typically presented with a more gradual onset of milder clinical signs.

228

229 **Conclusions**

230 Thoracolumbar IVDD should be considered an uncommon disease in cats. Its prevalence is
231 however higher in purebred cats, especially Persians and British Shorthairs. Further studies are
232 necessary to evaluate if this finding represents a true breed predisposition or an increased
233 willingness to pursue advanced diagnostics in financially more valuable pedigree cats. Two
234 types of intervertebral disc herniations, IVDE and IVDP, occur in cats. In agreement with
235 findings in dogs, cats with IVDE present with a shorter duration of clinical signs and milder
236 neurological deficits compared to cats with IVDP.

237

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243 **Conflict of Interest**

244 The authors do not have any potential conflicts of interest to declare.

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314 **Figure Legends**

315 **Table 1.** Breed distribution of 31 cats diagnosed with thoracolumbar intervertebral disc

316 disease

Affected breed	Number of cats
Domestic shorthair	9
Domestic longhair	5
British Shorthair	5
Persian	4
Bengal	2
Siamese	2
Havana Brown	1
Maine Coon	1
Sphynx	1
American Shorthair	1

317