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How long and low can you go?

Effect of Conformation on the Risk of Thoracolumbar Intervertebral Disc Extrusion in Domestic Dogs

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Who am I?

2006-2009	BSc Animal Behaviour and Welfare	University of Bristol
2009-2013	PhD Veterinary Science	Royal Veterinary College
2013	Research Assistant (Animal Welfare)	Royal Veterinary College
2013	Temporary Lecturer (Animal Behaviour and Welfare)	Queen's University Belfast
2014 -	Clinical Investigations Research Assistant	Royal Veterinary College

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Pedigree dog breeding: what's the problem?

Many breeds of pedigree dog suffer from **inherited disorders**, which can be due to:

- **Inbreeding** – particularly leading to homozygous recessive conditions
- The **breed standards** themselves, encouraging body shapes that are associated with disease

RSPCA (2009)

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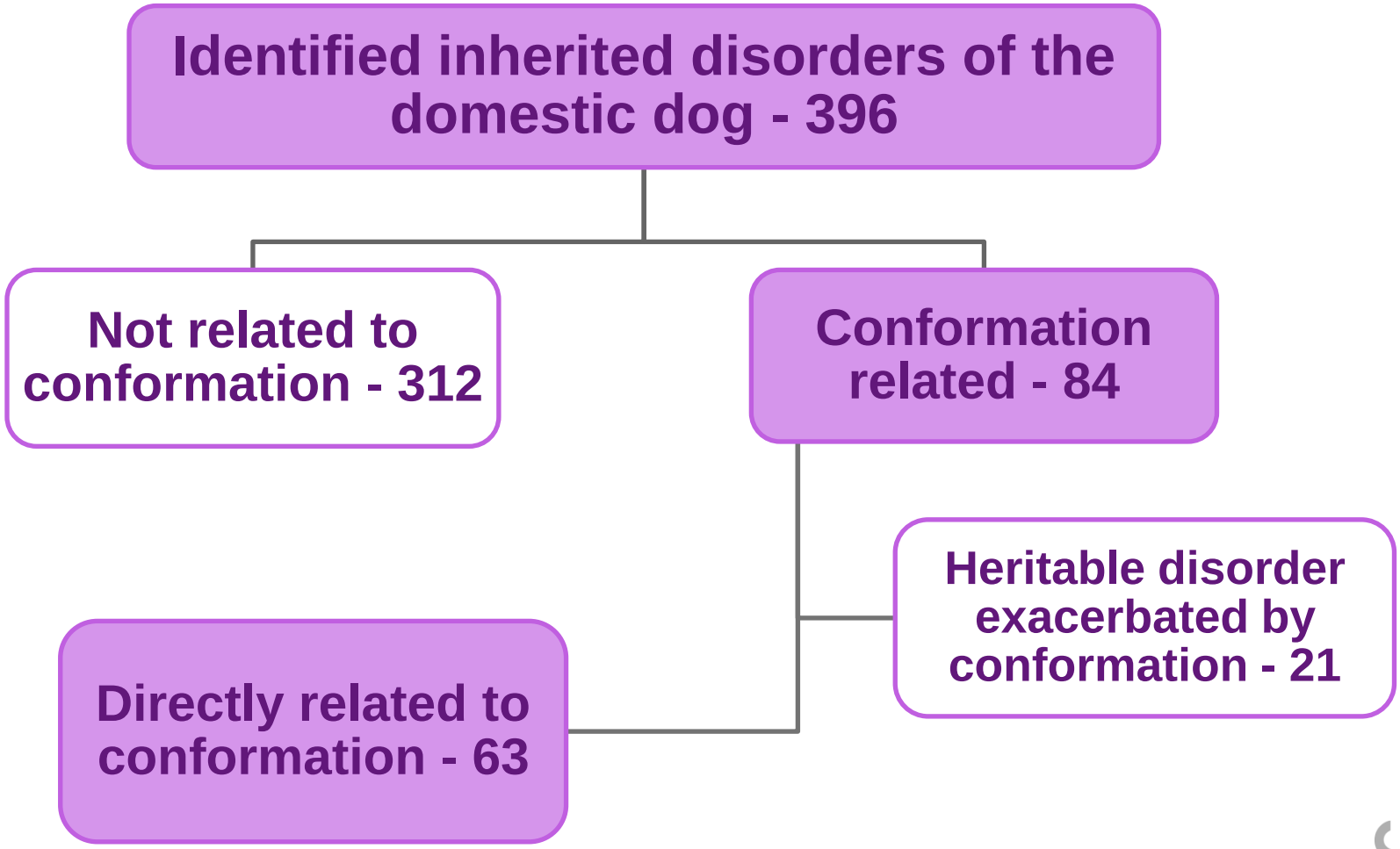
Inherited disorders of the dog



Asher et al (2009), Summers et al (2010)

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Conformation related diseases

- **Potentially severe welfare consequences** of some conformations, as a result of their **associations with inherited disorders**
- "Some traits are best regarded as **'defects',** and are **difficult to defend on welfare grounds**" *(*McGreevy and Nicholas, 1999)
- **Peer-reviewed literature is lacking**
  - Wealth of veterinary literature on the **'correction' and palliation**
  - **Sufficient evidence** that the problems caused are of **"significant welfare concern"** (Rooney and Sargan, 2009)

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Associations between inherited disease and conformation

- **Case series- overrepresentation of breeds with similar conformations**
- e.g. Brachycephalic breeds with exophthalmos
  - **– proptosis of the globe**

    e.g. Pekingese, Lhasa Apso, Shih Tzu

    (Gilger et al, 1995)

- **Quantitative risk analyses**

  e.g. BOAS *(Njikam et al, 2009)*

Risk factor	Cases N (%)	Controls N (%)	Unadjusted OR (95% CI)
BRA	39 (86.67)	96 (14.61)	37.98 (15.65-92.16)

- **No evidence of morphology and disease risk scaling**

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Aims of my research

- **Investigate the relationships between exaggerated conformations and the risk of inherited disorders**
  - Could inform **healthy conformational 'limits'** to aid breeders in their efforts to **achieve healthier body forms**
  - Raise dog welfare through **improved breeding practices**
    - ***Use measures that could be easily replicated by breeders i.e. external, available equipment***
- **Hypothesis**: **Exaggerated versions** of several quantifiable conformational traits are associated with a **higher risk** of specific disorders, which are **prevalent across several breeds** independent of genetic relatedness
- ***Breaking biological limits?***

Prioritising disorders

Asher et al (2009) GISID Scoring:

- Quantify **the impact of disorders identified as inherited**
- Scoring on several domains that may impact upon QoL:
    - **Impact upon behaviour (4)**
    - **Prognosis (4)**
    - **Treatment (4)**
    - **Potential complications (4)**

Scores of conformation linked conditions

- **Brachycephalic Airway Obstruction Syndrome**: 6-15
- **Intervertebral Disc Extrusion**: 5-12
- **Keratopathy syndrome**: 5-9
- **Entropion/Ectropion**: 2-9
- **Dystocia**: 2-6

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Intervertebral disc extrusion

- Most common spinal neurological disorder in dogs
- Results in spinal cord compression and injury
  - May cause **paresis**, **paralysis**, and **pain**, significantly affecting QoL
- Severe cases may result in **permanent paralysis**
  - Euthanasia or nursing dogs as long-term paraplegics
  - Use of mobility carts

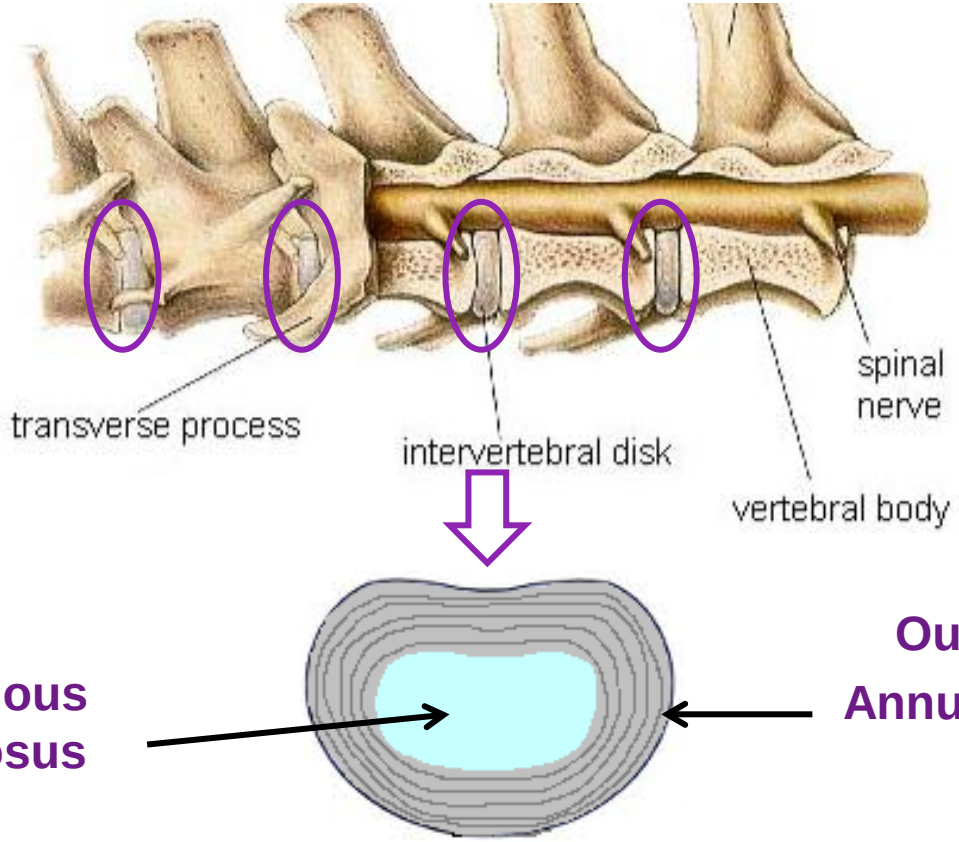
"Dachshund Carriage"
© British Pathe 1939

Paralysed hind limbs

"Dog on wheels"
© British Pathe 1951

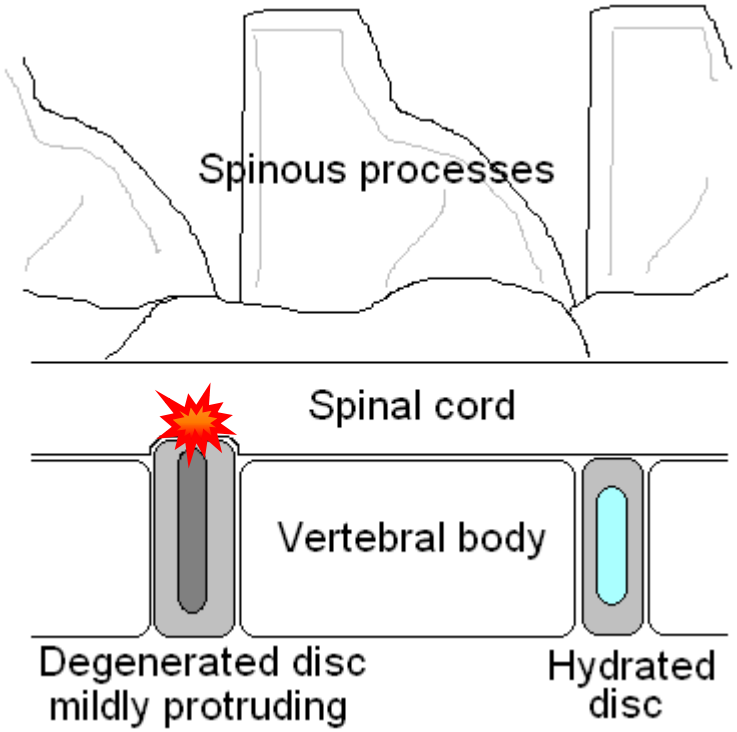
Intervertebral discs

- **Intervertebral discs** sit between bodies of two vertebrae and act as **mini shock absorbers** for the spinal column
- **Prevent trauma** to this flexible column of bones through which the spinal cord runs



Hansen Type II age-related degeneration

- With **AGE**, changes occur to this structure – **FIBROID METAPLASIA**
- The **gelatinous NP becomes fibroid** in older dogs, and can result in **disc protrusions** if the NP bulges dorsally



Disc 'protrusion'

- **In some dogs, other degenerative processes occur....**

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Chondrodystrophy

- **Chondrodystrophic (‘cartilage mal-development’)** breeds
- Altered **epiphyseal chondroblastic growth** and maturation results in **disproportionate dwarfism - ‘Long and low’ morphology**

Non-chondrodystrophic, proportional cross-breed unaffected by IVDE

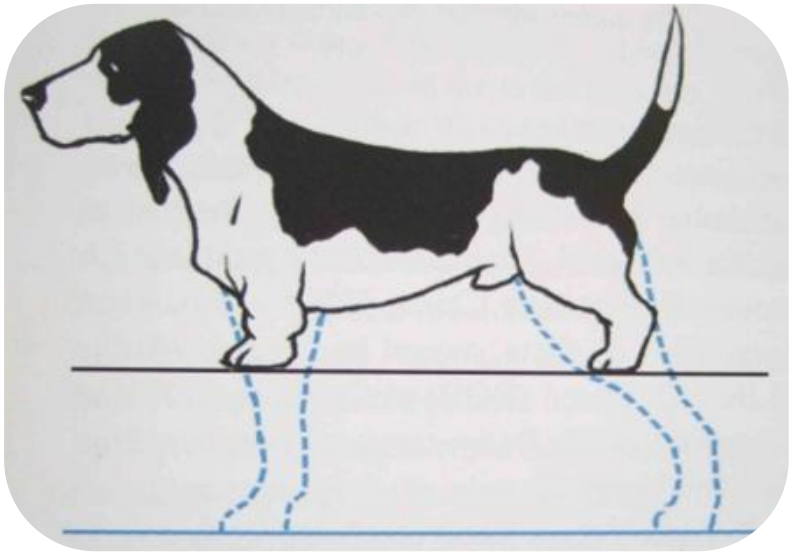

Diagram by Leon Verrier (L’Eleveur, 1939) showing how the Basset is a reduction of the *Grandchien*

Which breeds are chondrodystrophic?

Breed	Number of papers
Standard Smooth Haired Dachshund	**20**
Standard Long Haired Dachshund	**20**
Standard Wire Haired Dachshund	**20**
Miniature Wire Haired Dachshund	**20**
Miniature Long Haired Dachshund	**19**
Miniature Smooth Haired Dachshund	**19**
Beagle	11
Shih Tzu	7
Cocker Spaniel	7
French Bulldog	6
Pekingese	6
Miniature Poodle	5
Basset Hound	4
Corgi (Unspecified)	3
Lhasa Apso	3
Jack Russell Terrier	2
Yorkshire Terrier	2
Pug	1
English Bulldog	1
Bichon Frise	1
Maltese	1
Coton de Tulear	1
Havanese	1
West Highland White Terrier	1
Sealyham Terrier	1
Boston Terrier	1

Basset Hound with thoracolumbar IVDE, exhibiting the typical chondrodystrophic conformation

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Which have FGF4 mutation

- Growth-promoting protein Fibroblast Growth Factor 4 important in determining when bones stop growing

  - **Six breeds of Dachshund**
  - **Basset Hound**
  - **Grand and Petit Basset Griffon Vendeen**
  - **Cairn Terrier**
  - **Dandie Dinmont Terrier**
  - **Glen of Imaal Terrier**
  - **Lancashire Heeler**
  - **Norwich Terrier**
  - **Scottish Terrier**
  - **Skye Terrier**
  - **West Highland White Terrier**
  - **Yorkshire Terrier**
  - **Cardigan Welsh Corgi**
  - **Pembroke Welsh Corgi**
  - **Swedish Valhund**
  - **Chihuahua**
  - **Havanese**
  - **Japanese Chin**
  - **Pekingese**
  - **Shih Tzu**
  - **Tibetan Spaniel**

Chondrodystophy in breed standards?

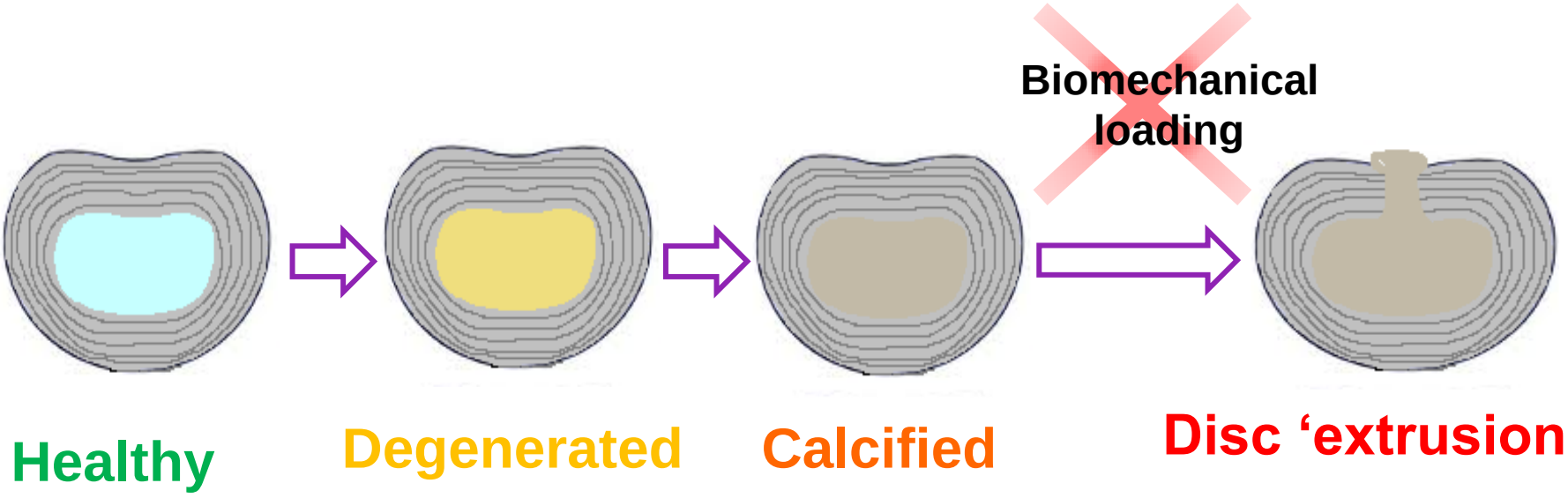
- Chondrodystrophy is **written into breed standards** through certain descriptors
  - **e.g. Dachshunds**, "***forearm short***", "***lower thigh short***" in comparison to "***body moderately long***"
  - **e.g. Dandie Dinmont Terrier**, ***body "long, strong and flexible" and "forelegs short"***
  - ***e.g. Basset Hound, body* "long and deep throughout length" and "forelegs short"**

- **Desired proportions in other standards**

Breed	Breed standard description of chondrodystrophy
Lhasa Apso	"Length from point of shoulders to point of buttocks greater than height at withers"
Shih Tzu	"Longer between withers and root of tail than height of withers"
Cardigan Welsh Corgi	"Body fairly long and strong, legs short, feet turned slightly outwards"

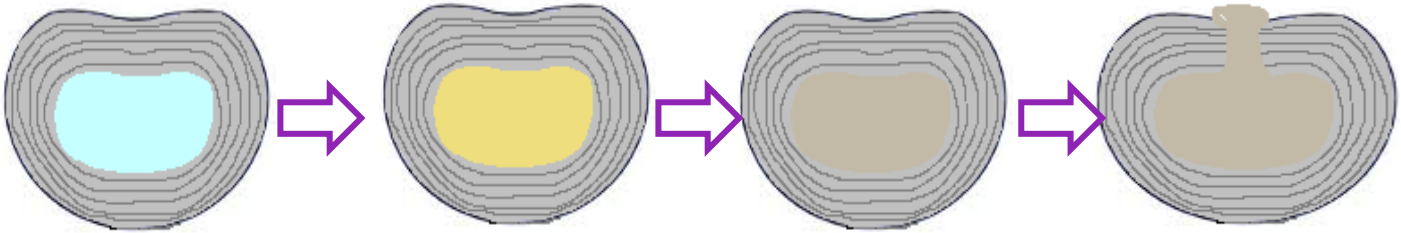
Hansen Type I ‘abnormal’ disc degeneration

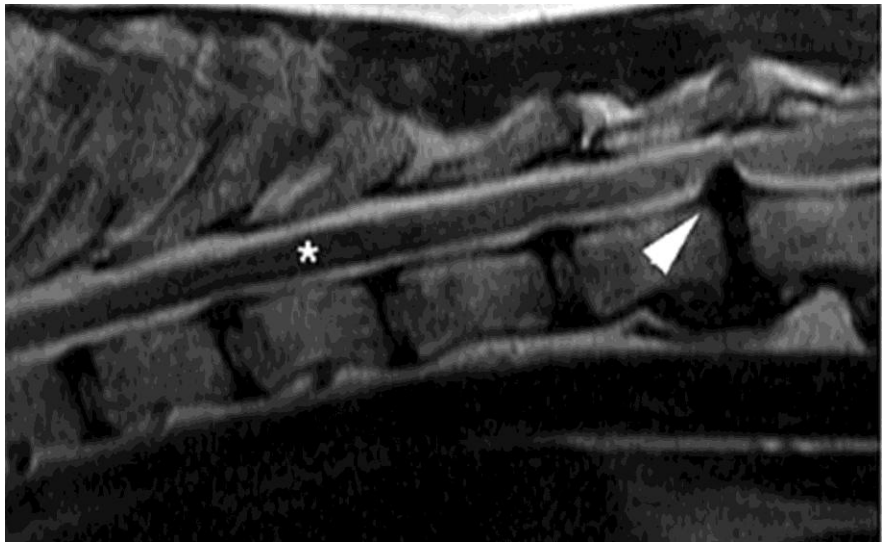
- In chondrodystrophic dogs, **abnormalities of the intervertebral discs are present at birth**, and are followed by an early, abnormal degenerative process ‘**CHONDROID METAPLASIA’** during growth
    - Nucleus changes from being a **jelly-like, virtually incompressible** structure, to a **hardened, calcified structure**, with **diminished shock-absorbing capabilities**



From calcification to extrusion

- Herniations **rarely** occur in dogs without disc calcifications
- Dogs with **several calcifications** at a particularly high risk





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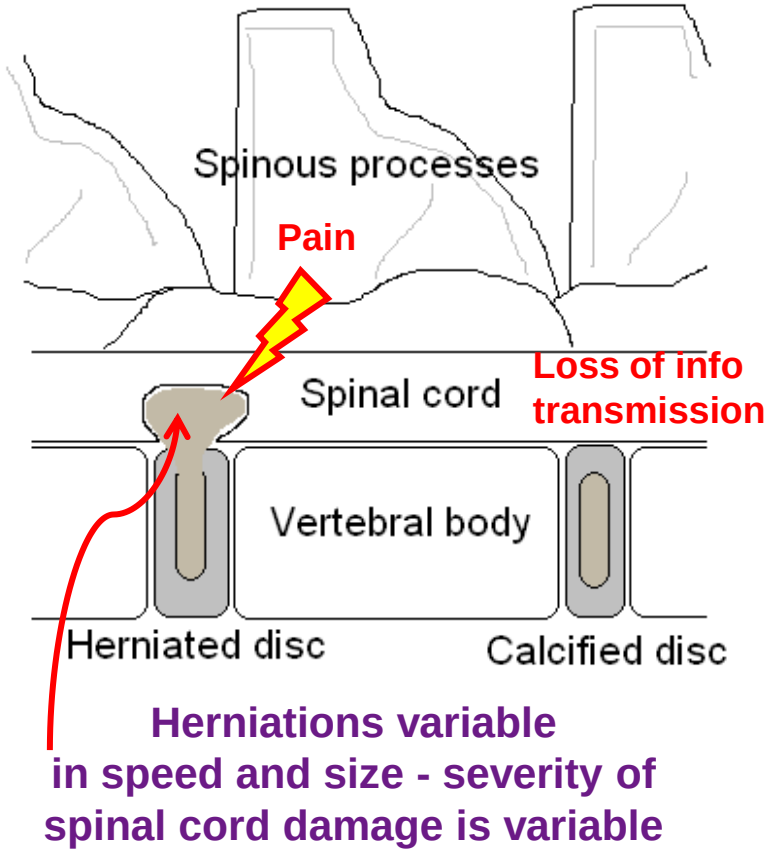
Disc herniation

- Clinical signs show when disc **impinges the spinal cord**
- Herniation - **calcified nucleus herniates** into the vertebral canal
- Vertebral canal only slightly larger than spinal cord - **trauma to the cord** highly likely



Herniations variable in speed and size - severity of spinal cord damage is variable

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A welfare problem? (CAWC, 2006)

I. **Can have a severe adverse impact on animals' feelings**
II. **These effects can be of long duration**
III. **Can affect large numbers of animals**
IV. **Has the potential to continue to do so generation after generation in the future**

- **Severe back pain**
- **Major surgical intervention**
- **Prolonged recovery - cage rest**
- **Long-term paraplegia**

- **Prevalence in Dachshunds** – as high as 19%-62%
- May be **undetected by owners**
- Currently **no screening programmes** (genetic or phenotypic) to **identify dogs at high risk of IVDE**

Risk factors for IVDE

- The majority of disc herniations occur in chondrodystrophic dogs aged between 3 and 7
- **Strong phenotypic relationship** between **chondroid metaplasia** and this form of **disproportionate dwarfism**
- i.e. Many of the dogs with this type of disc degeneration have this long and low body shape
  - **Pleiotropic effect** of the **chondrodystrophy gene?**
- Can dogs with a chondrodystrophic morphology have no co-occurring disc abnormalities?
  - Both are characterised by abnormal chondrocyte differentiation

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Risk factors for IVDE

- **Not all chondrodystrophic dogs appear to be at equal risk for disc calcification and extrusion**

- **Other factors may also influence these processes** and **increase** or **decrease** the risk in specific breeds, or in certain lines within breeds

- Continuous spectrum within and among breeds → **Multifactorial aetiology**

    - **Identify risk factors for an evidence-based strategy to reduce IVDE risk**

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Risk factors for IVDE
Environment and biomechanics

Environmental/ Biomechanical factors

Stair climbing
(Jensen and Ersboll, 2000)

Healthy body weight
(Habermehl, 1978)

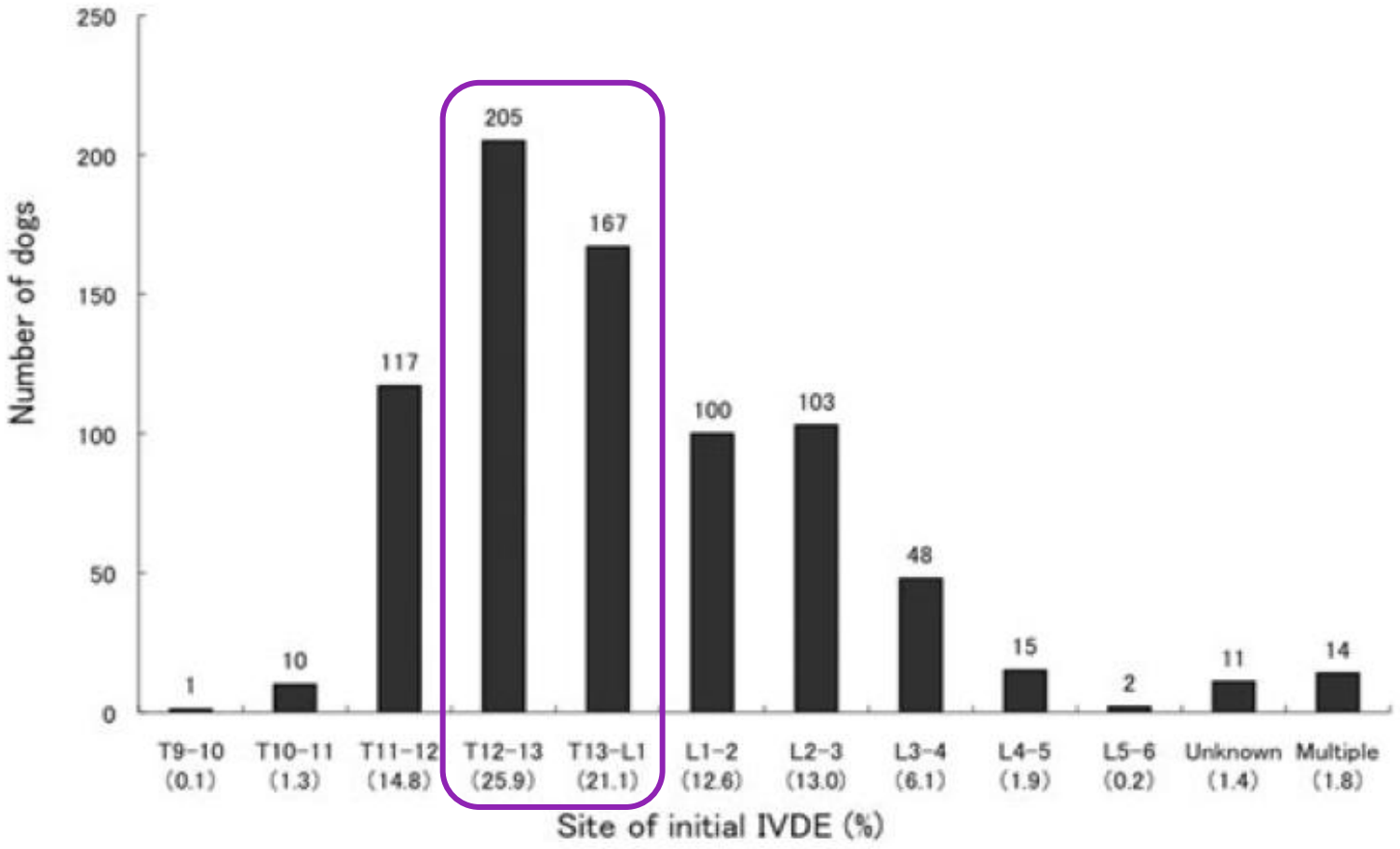
Increased duration of exercise
(Jensen and Ersboll, 2000)

Use in hunting
(Funquist and Henricson, 1969)

Adequate muscling
(Hoerlein, 1979)

Risk factors for IVDE
Environment and biomechanics

- Herniations observed most frequently at **high-motion sites** in the spine
- Biomechanical factors may **play a role in extrusion of calcified disks?**



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Risk factors for IVDE

Conformation: how long and low can you go?

- Biomechanical risk factors **not limited to environment – forces acting upon the disc** may additionally relate to **body conformation (shape)**

- Verheijen and Bouw (1982) argued that a **reduction in back length** may have a **beneficial effect** on incidence of IVDD in **chondrodystrophic breeds**

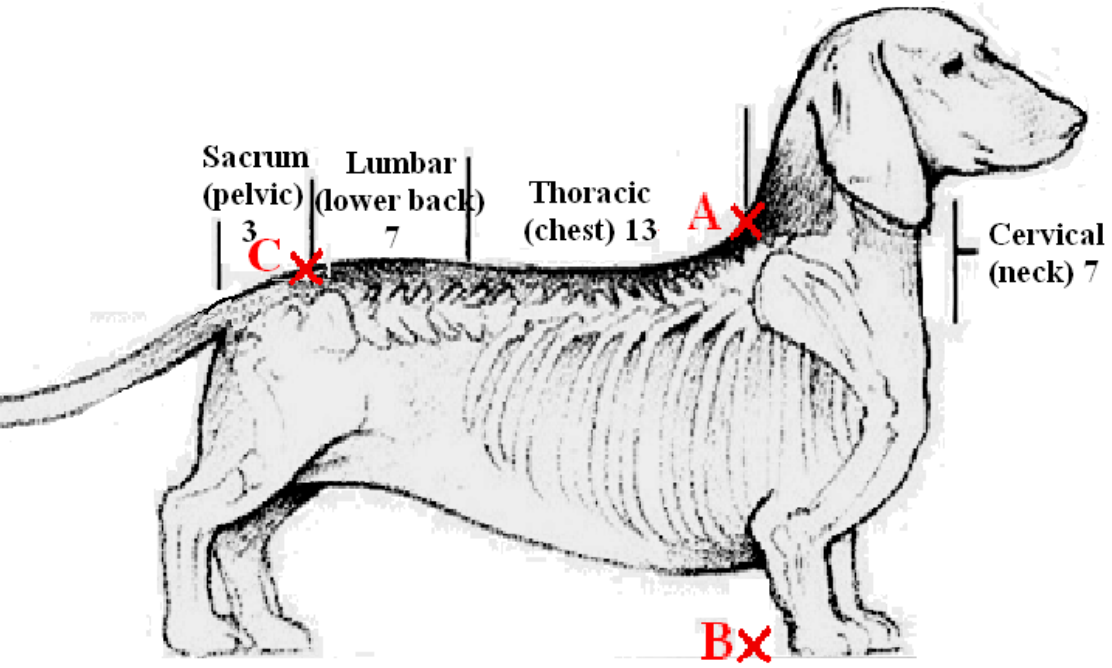
Risk factors for IVDE

Conformation: how long and low can you go?

Increased back length relative to leg length a risk factor?

- Dachshund – **most extreme morphology, relative risk 10-12x higher than other breeds**
- Previous study did not find effect BUT **limited to Dachshund only** population and **looked at herniations and protrusions combined** despite differing aetiologies **(Levine et al., 2006)**
- **Within-breed, longer backs increase severity of clinical signs**

Quantifying conformation: BL:HW



A) The mid-point of the withers - identified by palpation of the proximal borders of the scapulae

B) The sacrum - identified by palpation of the lumbosacral space, between the dorsal processes of L7-S1

Ratio = 1
(200 x 200)

Ratio = 1.33
(200 x 150)

Ratio = 1.67
(200 x 120)

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Research questions...

- **Are chondrodystrophic ‘long-and-low’ dogs at higher risk of IVDE?**
- **Specifically - are relatively longer backed dogs (exaggerated morphologies) at higher risk of IVDE?**

How did I go about this?

- **Cross-sectional, epidemiological study of dogs entering the Queen Mother Hospital for Animals (QMHA) at RVC**
- **December 2010 - January 2012**

- **Large referral population**
- **Multiple clinical services – wide variety of cases**
  - **Neurology and neurosurgery**
  - **Ophthalmology**
  - **Soft tissue surgery**
  - **Orthopaedics**
  - **Internal medicine**
  - **Dermatology**
  - **Cardiology**
  - **Oncology**

Recruiting study dogs

- **All dogs considered prior to arrival and excluded on a case-by-case basis if:**
  - **Unsuited to leaving wards/nursing** care
  - Too **painful/uncomfortable** to be handled
  - Known to be **aggressive** to humans
  - Isolated due **to risk of disease transmission**
  - Already recruited to a **separate clinical trial/study** within the study hospital




Morphometrics

Breed defining morphometrics (Sutter et al, 2008)

1. Muzzle length
2. Cranial length
3. Skull width
4. Eye width
5. Neck length
6. Neck girth
7. Chest Girth
8. Chest Width
9. Back length
10. Height at Withers
11. Height at Base of Tail
12. Circ. of right fore foot
13. Circ. of right hind foot
14. Palpebral fissure length

- BCS (Purina 9 pt scale)
- Weight (kg)

- Digital callipers
- Tape measures
- Stadiometer

- Standardised digital photographs
- Principle Components Analysis for overall skeletal size

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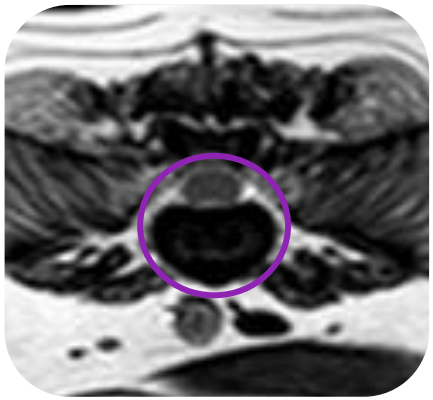
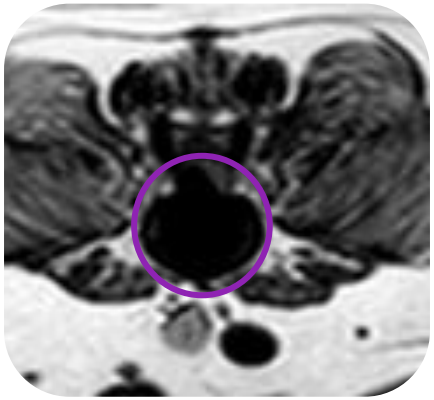
Clinical classification

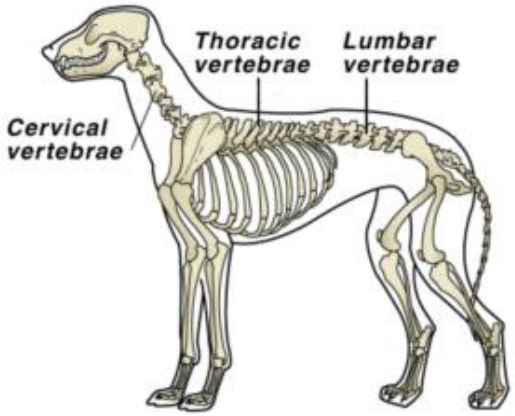
‘AFFECTED’
Thoracolumbar disc extrusion confirmed through diagnostic imaging (MRI/Myelography/CT) and/or surgery



Normal disc



Herniated disc



- **‘SUSPECTED’: Following neurological examination, IVDE identified as a differential (spinal hyperesthesia, ataxia and/or paresis) but no further imaging or surgery *(excluded from analyses due to uncertainty)***
- **EXCLUDED: Disc PROTRUSION or CERVICAL disc disease diagnosed**
- **‘UNAFFECTED’: not suspected to have disc disease and with no history of IVDD**

Statistical analysis

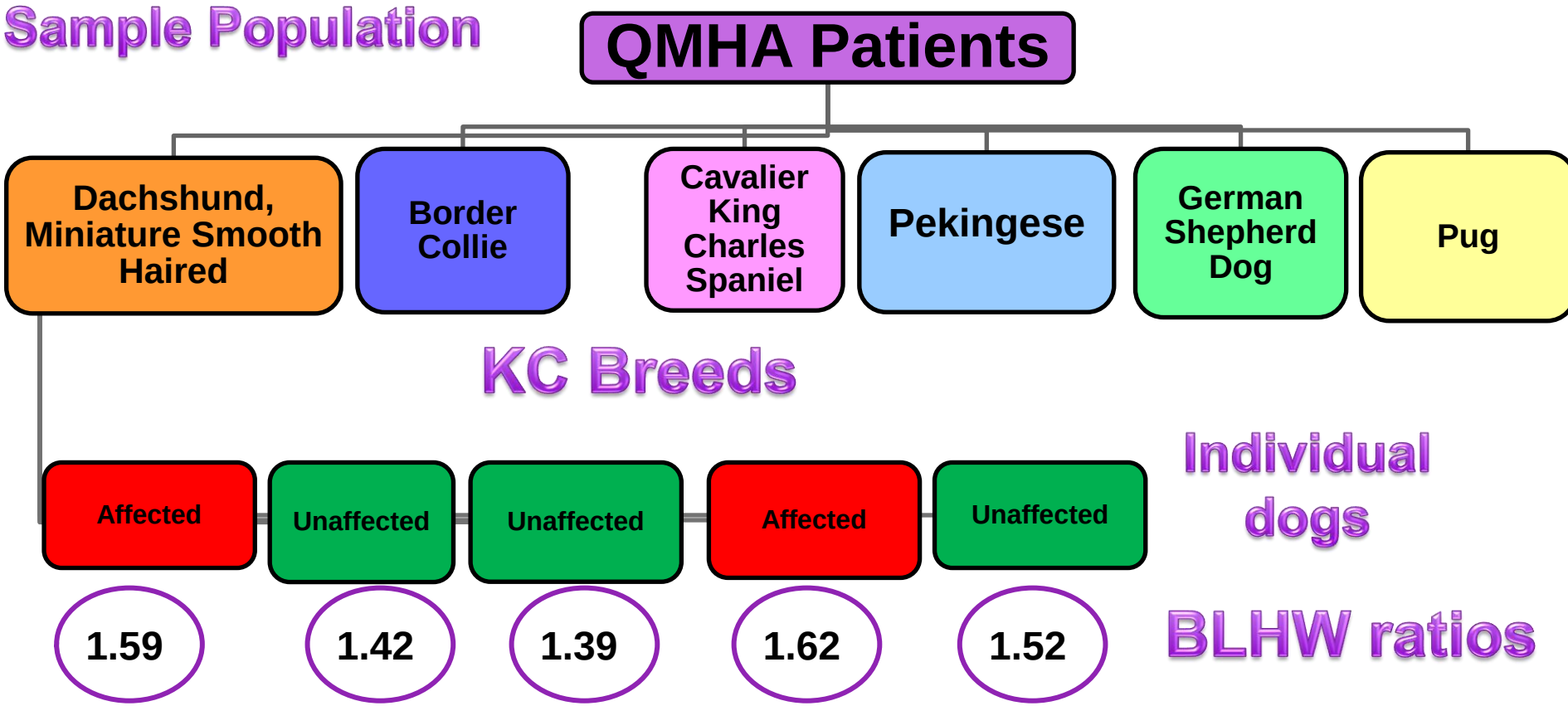
Generalised linear mixed models (in R)

- **Response variable**= Disease present (1/0)
- **Random effect =** Breed
- **Predictors tested**
  - Signalment
  - BCS
  - Weight (kg)
  - Individual morphometric predictors
  - Principle Component 1 (overall size)

➢ Best fitting model determined by AIC values, lack of collinearity etc.

➢ Calculated **probability of being affected** from model parameters for each breed; hold other parameters steady and vary predictor of interest

Statistical analysis



Population demographics

N	700
Pure:cross bred	87% pure bred
Neuter status	72% neutered
Sex	57% male
Median (range) BCS	5 (range: 2-8)
Mean +/-SE age	5.17+/-0.13
Mean+/-SE weight (kg)	21.5+/- 0.55

97 breeds represented – Top 10

1. **Labrador Retriever** (8.1%)
2. **German Shepherd Dog** (5.1%)
3. **Dachshund, Miniature Smooth** (4.6%)
4. **Pug** (4.6%)
5. **Border Collie** (4.0%)
6. **Cavalier King Charles Spaniel** (3.7%)
7. **Golden Retriever** (3.3%)
8. **Jack Russell Terrier** (3%)
9. **Springer Spaniel** (2.9%)
10. **Cocker Spaniel** (2.6%)

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Which dogs were affected by IVDE?

Classification	Type 1 TL
N	79
Pure Bred: Cross (%)	**83.5 Pure**: 16.5 XB
Male: Female (%)	**59.5 M**: 40.5 F
Neutered: Entire (%)	**77 N**: 23 E
Median BCS, Range	**5.5** (4.5-7.5)
Age (years)	**6.14** +/- 0.34
mean +/- SE (95% CI)	(5.45 – 6.82)
Weight (kg)	**12.3** +/- 0.98
mean +/- SE (95% CI)	(10.3 – 14.2)

Which dogs were affected by IVDE?
Breeds

TOP 10 AFFECTED BREEDS

1. **Miniature Smooth Haired Dachshund - 21 cases**
2. Cross breeds - 13 cases
3. Cocker Spaniels - 7 cases
4. Jack Russell Terriers - 6 cases
5. **Miniature Long Haired Dachshunds - 5 cases**
6. **Miniature Wire Haired Dachshunds -3 cases**
7. Shih Tzu – 3 cases
8. Border Collie - 3 cases
9. Pekingese – 2 cases
10. Cavalier King Charles Spaniel – 2 cases

The Dachshund breeds (MSH, MLH, MWH, SSH) comprised 38% of cases combined (30/79 cases)

Affected cross breeds included:
'Basschund' (Basset x **Dachshund)**
'Jackshund' (Jack Russell x **Dachshund)**
'Papchiweenie' (Papillion x Chihuahua **x MSH Dachshund)**
'Puggle' (Pug x Beagle**)**

Risk of IVDE by BLHW

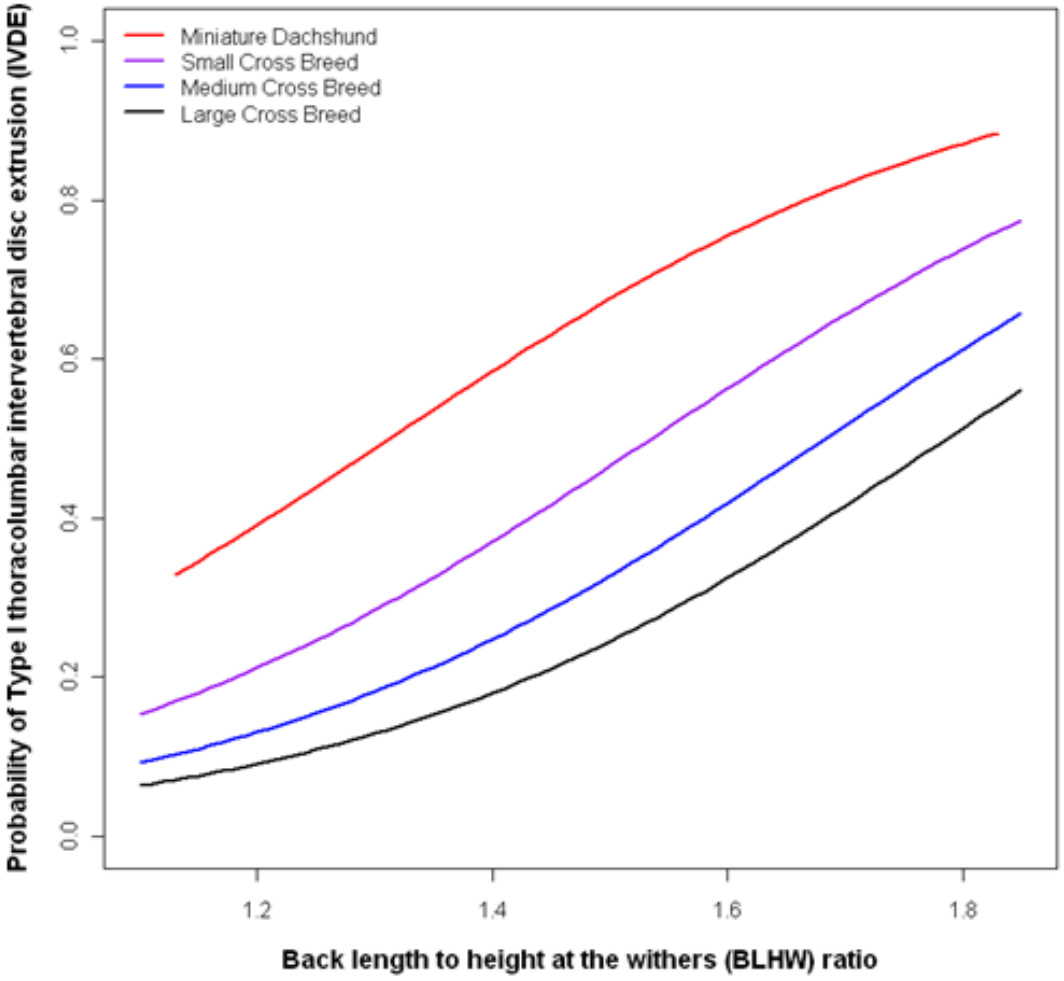
	Breed	Mean BL:HW	SE	N	N (%) IVDE
The 15 longest breeds	Dachshund, Miniature Long Haired	**1.66**	0.03	16	5 (32%)
	Dachshund, Standard Long Haired	**1.64**	-	1	0 (0%)
	Dachshund, Standard Smooth Haired	**1.59**	0.01	2	1 (50%)
	Dandie Dinmont Terrier	**1.59**	-	1	1 (100%)
	Pekingese	**1.57**	0.04	3	2 (67%)
	Pembroke Welsh Corgi	**1.52**	0.26	2	0 (0%)
	Dachshund, Miniature Smooth Haired	**1.51**	0.03	32	21(65%)
	Basset Hound	**1.40**	0.03	7	1 (14%)
	Dachshund, Miniature Wire Haired	**1.38**	0.04	3	3 (100%)
	Coton de Tulear	**1.34**	-	1	1 (100%)
	Cardigan Welsh Corgi	**1.31**	0.03	2	1 (50%)
	Shih Tzu	**1.30**	0.03	13	3 (51%)
	Lhasa Apso	**1.29**	0.09	4	0 (0%)
	Bichon Frise	**1.28**	0.05	6	0 (0%)
	Chinese Crested	**1.25**	-	1	0 (0%)

Risk factors for IVDE

Predictor	Odds Ratio (95% CI OR)	SE	z	*p*
BL:HW	50.3 (7.58-333.9)	0.96	4.06	<0.001
PC1	0.56 (0.36-0.87)	0.51	-2.60	0.009
BCS	1.62 (1.14-2.31)	0.46	2.68	0.007
Age	1.10 (0.99-0.47)	0.05	1.93	0.053

1. Longer back
2. Smaller size
3. More overweight
4. Older

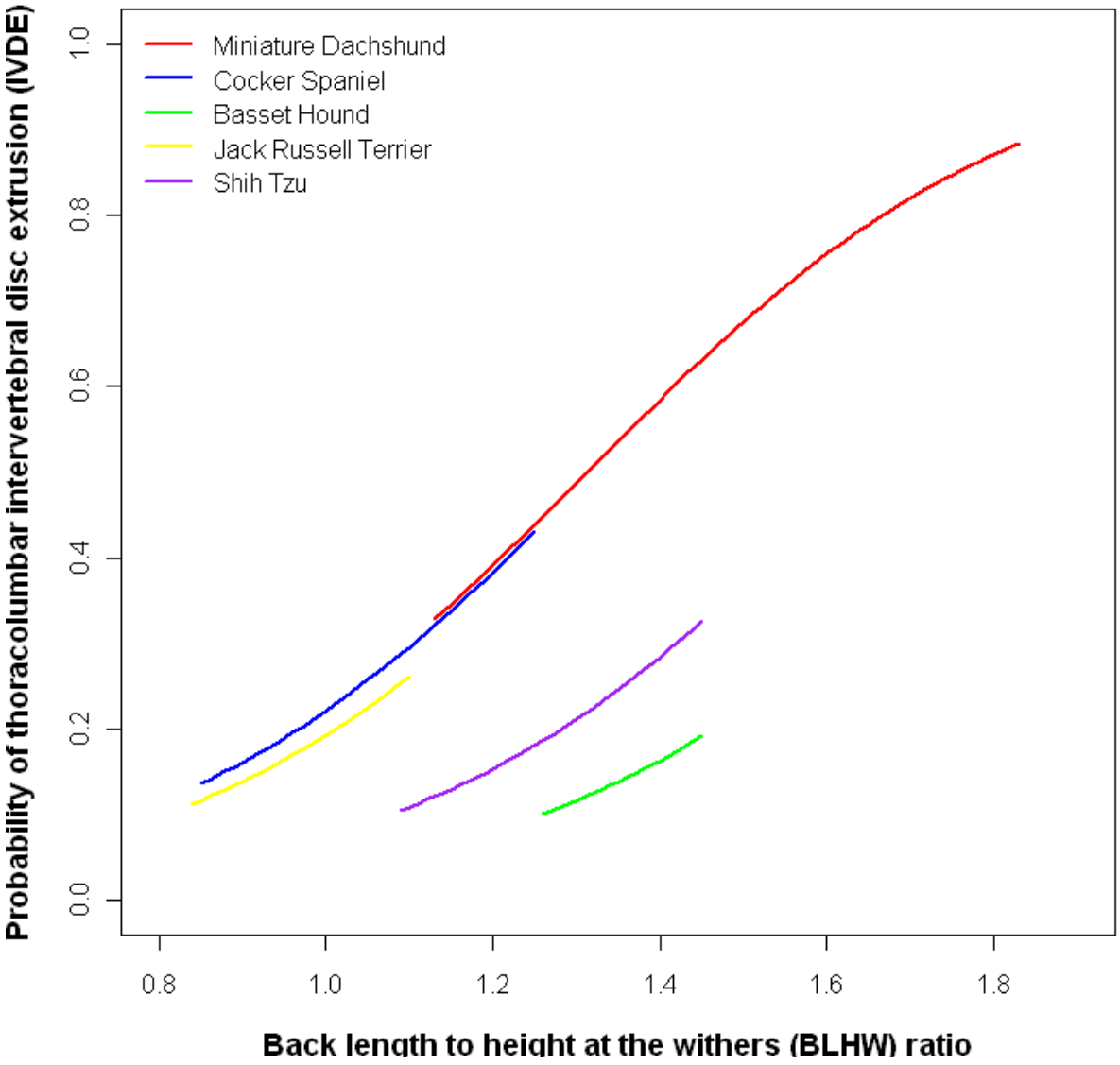
Risk factors for IVDE



Longer back

	Mean BL:HW
Dachshund, Miniature Long Haired	1.66
Dachshund, Standard Long Haired	1.64
Dachshund, Standard Smooth Haired	1.59
Dachshund, Miniature Smooth Haired	1.51
Dachshund, Miniature Wire Haired	1.38

Risk factors for IVDE



Longer back

(by breed)

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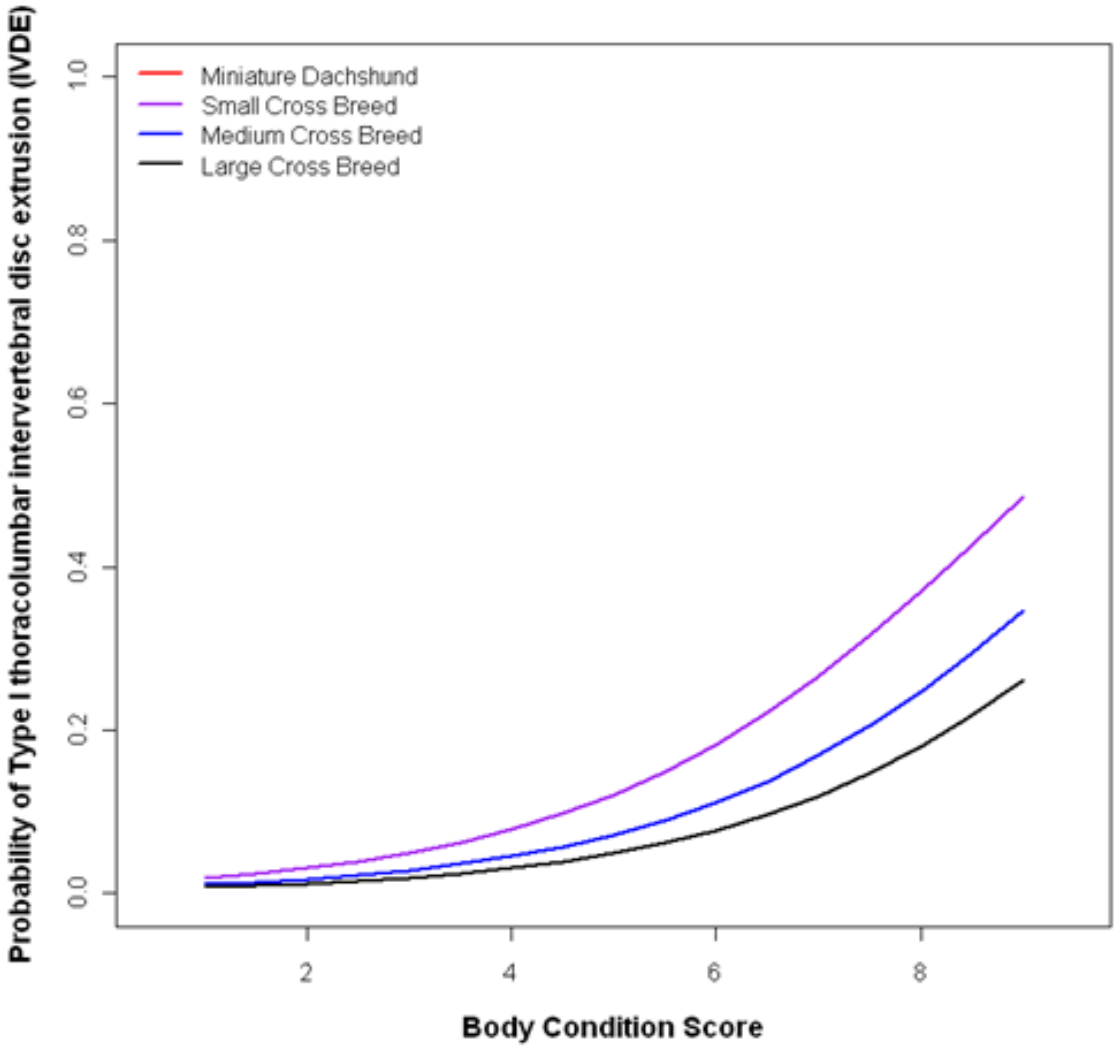
Risk factors for IVDE



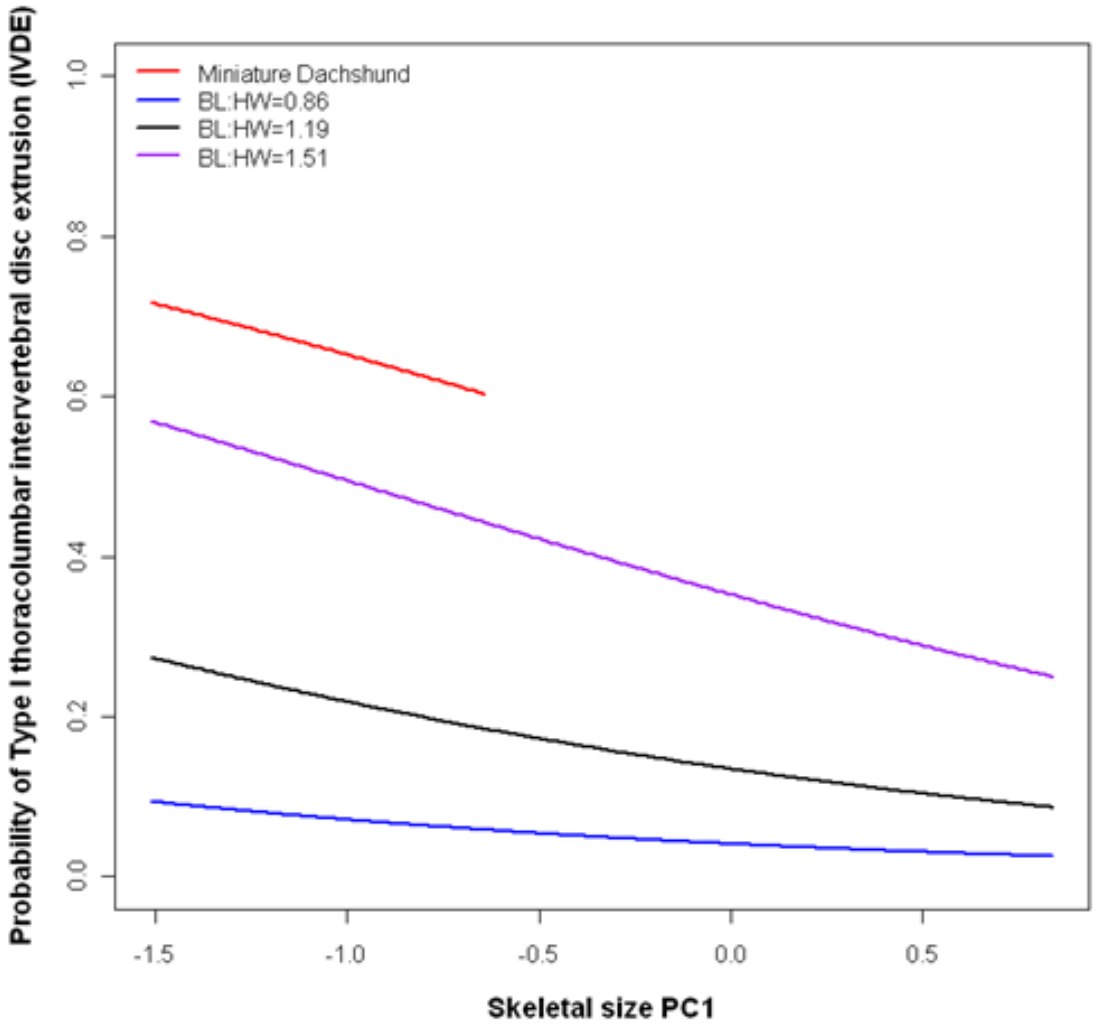
More overweight

Overweight dogs (BCS >5/9) 1.9x more likely to be affected than dogs ideal or underweight (BCS <5/9)

Exacerbating factor

Healthy weight maintenance advised by vets in at-risk breeds (previously based on anecdote)

Risk factors for IVDE



Smaller body size

- Reflect degree of **dwarfism**?
- Different **biomechanics**?

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Why were Mini Daxis so affected?

- Why are Miniature Dachshunds particularly predisposed to IVDE?

Combination of....

- **High BL:HW values (relatively long)** (mean BL:HW 1.5)
- **Low PC1 values (small)** (mean PC1: -1.18)
- **Large % overweight** in pet population

- The ‘perfect storm’ of risk factors

Discussion points
What about Standards?

- Specific estimates modelled for the Miniature Dachshund breeds due to their **high-risk morphology** and **high representation in this study**.

- Standard Dachshund varieties were **relatively rare in this study population** (n=3) but should **still be considered high-risk** due to their morphology.

Dachshund, Standard Long Haired	**1.64**
Dachshund, Standard Smooth Haired	**1.59**

- Other poorly represented long and lows also considered high-risk e.g. Corgi breeds, Peke, Dandie Dinmont

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Discussion points
What about the other Daxi breeds?

Why are there differences between the different varieties?

- Slight differences in morphology but need to look at a larger sample
- Different predispositions to disc calcification? Genetics?

	Mean BL:HW	N	N (%) IVDE
Dachshund, Miniature Long Haired	**1.66**	16	5 (32%)
Dachshund, Standard Long Haired	**1.64**	1	0 (0%)
Dachshund, Standard Smooth Haired	**1.59**	2	1 (50%)
Dachshund, Miniature Smooth Haired	**1.51**	32	21(65%)
Dachshund, Miniature Wire Haired	**1.38**	3	3 (100%)

Do FCI dachshunds show similar levels of IVDE?

- Need more data!
- May still be ‘too long’ so **still at-risk** despite being shorter in the body

Discussion points
Prevalence

- The estimates here are based on a **referral population** of companion dogs, and the prevalence of IVDE in the **general population is likely to be lower**.
  - e.g. 65% of Miniature Smooth Haired Dachshunds
  - e.g. 32% of Miniature Long Haired Dachshunds

- Overall prevalence of IVDD in UK population 6.8% (Dachshund Breed Council, 2012).
  - Included young dogs outside of the 'high-risk' age range of 3-7 years
  - When categorised by age group, **prevalence in dogs over 10 was higher and more aligned with the existing literature** e.g. 38.3% of >10 year old Standard Smooth Haired Dachshunds affected, 26.1% Miniature Smooth Haired (Dachshund Breed Council, 2012).

- US-based study incidence ~19% in Dachshunds generally, but much higher incidence in some Dachshund families (62% affected; Ball et al., 1982).
- May be differences between show dog and companion dogs
  - But many show dog offspring will go to pet homes – shared genetics

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Influences on changes to breed health

- Need to tackle IVDE in Dachshunds to reduce the prevalence of this serious disorder – but how?

Influences on change include...

- Breeders
- Breed standard
- Kennel Club
- Judges
- Pet owners
- Veterinary surgeons

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Tackling IVDE
Changing breed standards

- **Independent Inquiry into dog breeding** - Prof Sir Patrick Bateson
  - **"Breeding from dogs with extreme morphologies that can damage or directly threaten health and welfare should be avoided"**
  - **"Where welfare problems exist in a breed, the breed standards should be amended specifically to encourage the selection of morphologies that will improve welfare"**

- **January 2009** - Kennel Club released revised breed standards, with **changes made to 78 breeds** - changes to remove or reduce harmful morphological characteristics of some breeds

"If a feature or quality is desirable it should only be present in the right measure"

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Tackling IVDE
Changing body shapes - Proportions

- **Quantitative limits** to breed characteristics may be warranted
  - Thresholds to how extreme a phenotype can be before the risk of conferring an inherited disorder becomes 'unacceptably' high

- **"Guidelines for the revision of breeding policies", from the Council of Europe (1995)**
  - **"Maximum and minimum values are set for the proportion between length and height of short-legged dogs and the shortness of the muzzle"**

- **Quantitative ratios and diagrams to encourage the necessary changes (Bateson, 2010)**

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Tackling IVDE
Changing body shapes

- Evidence that **exaggerated back length** poses an **increased risk** of intervertebral disc herniation
- Need to **avoid these extreme shapes** to reduce risk
  - All of the represented Dachshund breeds were in the top 10 longest breeds - ***how can we encourage conformational change and promote safe shapes***?

- Are further **breed standard revisions** required to ensure that extreme phenotypes are not selected for?
  - Include **quantitative limits** and remove ambiguity
    - What is an *unacceptable* risk?

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Tackling IVDE
Changing body shapes - Proportions

- Fédération Cynologique Internationale (FCI) Dachshund breed standard "*The body length should be in harmonious relation to height at withers, about 1 to 1,7 - 1,8*" (Fédération Cynologique Internationale, 2001),
- Kennel Club standard, "*Height at the withers should be half the length of the body, measures from breastbone to rear of thigh*" (The Kennel Club, 2009b)
- Recommend that the focus in standards should be on back length (withers to sacrum) over body length, because prominent sternums (breast bones) may disproportionately influence body length

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Tackling IVDE
Judging

- Influence of dog-showing as a tool for change should not be underestimated
  - The **training and education of judges to ensure that they reward only dogs with healthy morphologies** in the show-ring is an area to focus upon.

- The **Swedish Kennel Club** produce **breed-specific instructions** that highlight morphometric risk factors to judges in at-risk breeds (Svenska Kennelklubben, 2010).
  - e.g. the Cardigan Welsh Corgi

    "*exaggeration of body length and excessive shortness of legs*" highlighted as an area of **risk** in this breed
- Not mentioned for other 'high-risk' breeds but is equally applicable.

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Kennel Club Initiatives
Breed Watch

"Particular points of concern for individual breeds may include features not specifically highlighted in the breed standard including current issues. In some breeds, features may be listed which, if exaggerated, might potentially affect the breed in the future."

- Body weight/condition included for the 3 Mini breeds 
- Could include back length – avoiding excessive length 

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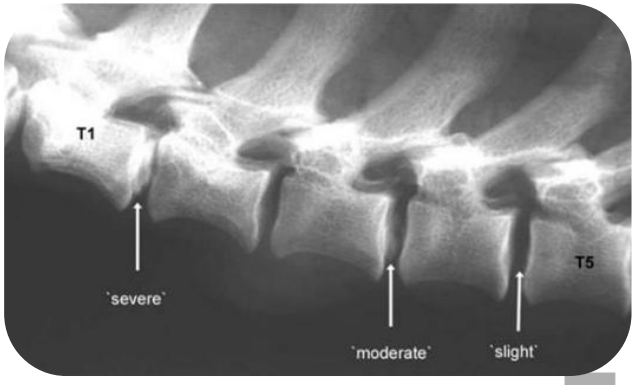
Tackling IVDE
Screening programmes for IVDE

- >30 years ago it was proposed that breeding dogs should have **as many radiologically-confirmed uncalcified discs as possible**
  - In Scandinavia, **screening programmes** exist based on **levels of disc calcification in young, potential breeding dogs**.
- Recommended that dogs with **more than 4 calcified discs at 2 years of age should not be used for breeding**
  - Good indicator of severe degeneration and significantly predicts to the risk of developing IVDE later in life (Jensen et al., 2008).
- Breeding from dogs with 3-4 calcifications is further restricted, allowing only 1-2 litters to be produced and progeny to be screened before further breeding (Jensen et al., 2008)
- Will it reduce prevalence long term?



Tackling IVDE
Genetic testing

- A recent study identified a major locus on chromosome 12 **affecting disc calcification** in Dachshunds, with variation in the CFA12 disease-associated locus appearing to be a major determinant in respect to disc calcification (Mogensen et al., 2011).

- Genetic testing could potentially be used to screen for dogs that have a high risk of developing disorders related to calcified discs.
  - ***Suitable genetic tests for this trait are not yet available.***

- Mogensen and colleagues conceded that in spite of very clear segregation of haplotypes in this locus, the disease is still very likely affected by **additional genetic** and **environmental factors**.
  - As such, breeding strategies for high-risk breeds are likely to be required to be **multi-faceted, with a combination of measures taken to reduce the overall risk.**
- **MORE RESEARCH NEEDED!**

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Tackling IVDE
Genetic testing

- Caveat....

If the genetics involved in causing **calcified and degenerative discs** are the **same, or closely connected to, the genes causing chondrodystrophy** – (the short-legged characteristic of the breed), it may be unlikely that the disease could be eliminated from the breed without a **fundamental change** in its body shape

Tackling IVDE
Out-crossing

- Out-crossing may be a viable way of altering the morphology of existing high-risk breeds
- Bring them towards a more **moderate, lower-risk shape**, if the **required phenotypic variability does not exist** within these breeds at present

- Careful selection of breed to facilitate this change, to ensure **IVDE risk is lowered**
  - e.g. Jack Russell and Dachshund breeds both affected, as was a cross of these breeds
  - Prevalence data of IVDE in the proposed breed
  - Histological examination of their intervertebral discs

- A non-chondrodystrophic breed for the out-cross would be preferable in such cases

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Tackling IVDE
Owner education

- **Education** of **puppy buying public**
  - Buying from responsible, health-orientated breeders
    - “How to buy a puppy” guides
  - Husbandry – avoiding overweight/obese dogs
    - Encouraging appropriate exercise
    - “Handbag dogs” – Miniature Dachshunds – avoid!!

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Tackling IVDE
Breeders

- **What is best breeding practice for IVDE prevention at present?**
  - Only using dam and sire without history of disc problems
    - Checking history of IVDE in the line?
  - Avoiding breeding from dogs until they are older than the typical age at which IVDD occurs (4-7 years)
  - Keeping track of pups (inc. those sold to pet homes) – request owners report back on disc problems

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Conclusions
Next steps

***Actively discouraging exaggeration* (back length, size)**

***Keeping dogs lean* - educating owners**

More research - How can we identify the healthiest dogs to breed from?

- Genetics – identify lower risk dogs
- Longitudinal studies of different shapes over time
- Fundamental research about differences between high and low risk breeds e.g. how they move
- Study more ‘moderate’ FCI dachshunds - compare

- Implement screening programmes?

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Acknowledgements

- **BBSRC/RVC Quota Studentship and UFAW Research and Project Award**
- **Staff of the Clinical Investigations Centre and the Queen Mother Hospital for Animals (QMHA), RVC**
- **Owners and dogs included in the study**

Thank you for listening!