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Body conformation in Great Danes with and without clinical signs of cervical spondylomyelopathy

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ABSTRACT

It has been suggested that a combination of large head and long neck cause abnormal forces on the cervical vertebral column and are involved in the pathogenesis of cervical spondylomyelopathy (CSM) in Great Danes. The aim of this study was to compare the body conformation of 15 clinically normal and 15 CSM-affected Great Danes. There were no statistically significant differences between clinically normal and CSM-affected Great Danes in any body measurements. There were no significant associations between body conformation and the severity of neurological signs or cervical vertebral body dimensions determined by magnetic resonance imaging in CSM-affected Great Danes. The results of this study do not support the hypothesis that differences in body conformation related to head size, neck length, and body height and length, play a role in the pathogenesis of CSM in Great Danes.

Introduction

The etiology of cervical spondylomyelopathy (CSM) in dogs is unknown, but is presumed to be multifactorial, with possible contributions from genetic, congenital and nutritional factors, fast growth rate, body conformation and abnormal forces on the cervical vertebral column (Wright et al., 1973; Hedhammar et al., 1974; Selcer and Oliver, 1975; Hazewinkel et al., 1985; Jaggy et al., 1988; Lewis, 1992; Burbidge et al., 1994, 1999; da Costa, 2010). Giant breeds of dogs are most often affected by osseous-associated CSM, in which there is absolute vertebral canal stenosis secondary to proliferation of the vertebral arch, articular processes and/or pedicles, causing spinal cord compression and foraminal stenosis (da Costa, 2010; Gutierrez-Quintana and Penderis, 2012).

There are reports of CSM in various giant breeds, including Great Danes, Bernese mountain dogs, Bull Mastiffs and Boerboel dogs (Wright et al., 1973; Raffe and Knecht, 1978; Olsson et al., 1982; Lewis, 1992; Gray et al., 2003; Eagleson et al., 2009). In the Great Dane, it has been suggested that a combination of large head, relatively long neck and rapid growth may cause abnormal forces on the cervical vertebral column and be involved in the pathogenesis of CSM (Wright et al., 1973). However, there are no previous objective investigations into the association of these factors with CSM in Great Danes.

Burbidge et al. (1994) correlated various body measurements in neurologically normal and CSM-affected Doberman Pinschers with the severity of neurological signs and radiographic abnormalities, but found no statistically significant associations. However, there are multiple differences in body size, age of affected dogs and type of compressive lesions in Doberman Pinschers and Great Danes with CSM (da Costa, 2010). Therefore, the results of a study investigating the possible role of body conformation in the pathogenesis of CSM in Doberman Pinschers should not be extrapolated to giant breed dogs.

Cervical spondylotic myelopathy is the most common cause of chronic compressive myelopathy in people >55 years of age and shares similarities with canine CSM (da Costa, 2010; Singh et al., 2012). Larger cervical vertebral bodies have been associated with an increased risk of this disease in people (Hukuda et al., 1996; Singh et al., 2012). The aim of this study was to compare the body conformation of clinically normal (control) Great Danes and Great Danes with CSM. In CSM-affected Great Danes, we also investigated whether body conformation was related with the severity of neurological signs or cervical vertebral body dimensions (length and height) as measured on magnetic resonance images (MRI).

Materials and methods

Study subjects

The study was conducted in accordance with the guidelines and with approval of The Ohio State University Clinical Research Advisory Committee and the Institutional Animal Care and Use Committee (approval number 2011A00000027). Written owner consent was obtained prior to study enrollment. Two groups of client-owned Great Danes were prospectively enrolled from April 2011 to October 2012. All dogs underwent complete blood counts, serum biochemical profiles, body measurements and MRI of the cervical vertebral column. The first group consisted of

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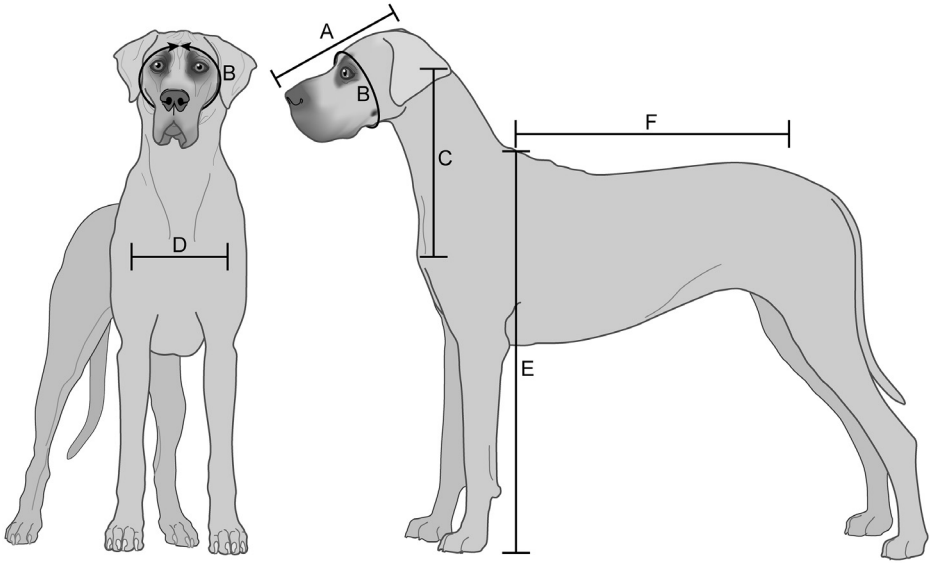

Fig. 1. Diagram depicting the body measurements obtained in each Great Dane. (A) Head length. (B) Head circumference. (C) Neck length. (D) Base width. (E) Height at the withers. (F) Back and loin length.

15 dogs that were defined as clinically normal (controls) based on a normal neurological examination and no history of neurological disease. Only dogs ≥1 year of age were eligible for enrollment as control dogs. The second group included 15 Great Danes exhibiting clinical signs and neurological examination findings consistent with CSM, with confirmation of the diagnosis by MRI.

Body measurements

Six body dimensions were measured for each dog using a soft fabric metric tape (Burbidge et al., 1994): (A) head length: distance from the occipital prominence to the tip of the nose; (B) head circumference: circumferential distance of the head at the level of the supraorbital prominences; (C) neck length: distance from the wing of the atlas to the greater humeral tubercle, measured in a neutral position; (D) base width: distance between the greater humeral tubercles (E) withers height: standing height from the dorsocranial point of the scapula to the ground; (F) back and loin length: distance from the dorsocranial point of the scapula to the level of the greater trochanter of the femur measured along the midline of the vertebral column (Fig. 1). The weight of each dog was also recorded.

Gait grading

A video (at least 2 min) of the gait of each CSM-affected dog was obtained at the time of study enrollment and used to assign a neurological grade to each CSM-affected Great Dane. Gait was graded for each thoracic and pelvic limb as follows: grade 0, normal limb; grade 1, abnormal use of the limb <40% of steps; grade 2, abnormal use of the limb for 40–70% of steps; and grade 3, abnormal use of the limb for >70% of steps. Signs of paresis (i.e., knuckling, scuffing, dragging) and general proprioceptive ataxia (inconsistent limb/foot placement) were considered to represent an abnormal use of the limb. If the grade assigned to the right and left thoracic limbs differed, the worse grade was used as the overall grading for that pair of limbs. The same process was followed for the pelvic limb gait grading. The thoracic limb grade (0–3) and the pelvic limb grade (0–3) were summed for each dog, producing an overall final gait grade of 0–6. For the purpose of determining statistical associations between body measurements and severity of neurological signs, dogs with gait grades of 1 and 2 were categorized as mild, those with grades of 3 and 4 were considered to be moderate and those with grades of 5 and 6 were categorized as severe.

Magnetic resonance imaging protocol and vertebral body measurements

MRI of the cervical vertebral column was performed under general anesthesia using a 3.0 Tesla magnet (Achieva 3.0 T, Philips Healthcare) and a surface coil (Achieva, Philips Healthcare). Dogs were positioned in dorsal recumbency with the head and neck in neutral position. Seven intervertebral spaces (cervical vertebrae C2-C3 through thoracic vertebrae T1-T2) were imaged in all dogs. For the purpose of this study, only sagittal T1-weighted images (TR 700 ms; TE 8 ms; field of view 30 cm; slice thickness 3 mm with no interslice interval) were used to obtain the vertebral body measurements. MRI measurements were obtained using software for medical imaging analysis (ClearCanvas Workstation, ClearCanvas Inc.). Mid-sagittal T1-weighted images were used to measure vertebral body length and vertebral body height from C3 to C7 (Fig. 2). Vertebral body length was defined as the distance between the most dorsocranial and the most dorsocaudal point of the same vertebral body (De Decker et al., 2011a, 2011b). Vertebral body height was defined as the maximum height of the cranial aspect of the vertebral body determined by a line drawn parallel to the cranial vertebral endplate. Intra-observer agreement was calculated by repeating the vertebral body measurements three times in four randomly selected dogs (two controls, two CSM-affected) at least 1 week apart.

Data analysis

Linear regression analyses with adjustments for sex, age and weight were used to compare the body measurements between control and CSM-affected Great Danes, and to test if there was any difference between body dimensions and the severity of neurological signs, or between the body dimensions and vertebral body height and length in CSM-affected Great Danes. When investigating the association between body measurements and severity of signs, the severity of neurological signs based on gait grading was classified as mild, moderate or severe. Body measurements were compared among the three categories of severity (mild vs. moderate, mild vs. severe,

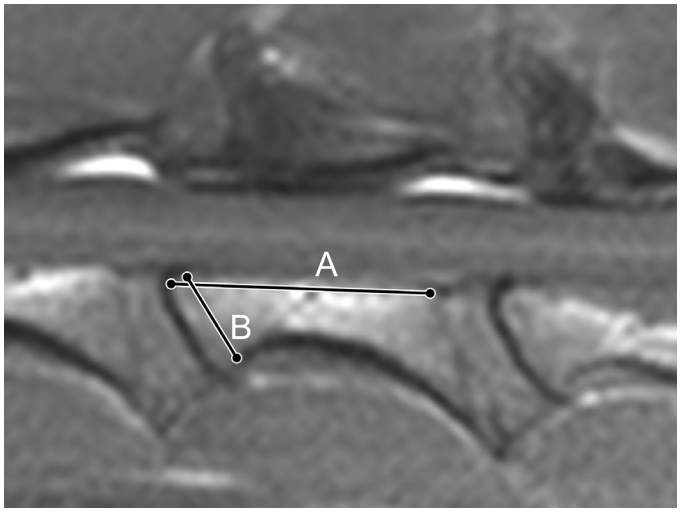

Fig. 2. Mid-sagittal T1-weighted magnetic resonance image illustrating the measurements obtained from cervical vertebrae C3 through C7, including (A) vertebral body length (distance between the most dorsocranial and the most dorsocaudal point of the same vertebral body); and (B) vertebral body height (maximum height of the cranial aspect of the vertebral body determined by a line drawn parallel to the cranial vertebral endplate).

Table 1
Body measurements in 15 clinically normal Great Danes and 15 Great Danes with cervical spondylomyelopathy (CSM).

Body measurement (cm)	Normal	CSM-affected	*P* value
Head length	28.63 (27.70, 29.56)	29.20 (28.45, 29.96)	0.3
Head circumference	47.70 (46.16, 49.25)	48.13 (46.88, 49.38)	0.7
Neck length	33.89 (32.26, 35.53)	32.11 (30.78, 33.44)	0.1
Base width	18.69 (17.25, 20.13)	16.76 (15.60, 17.93)	0.05
Withers height	85.16 (82.53, 87.79)	86.76 (84.62, 88.89)	0.4
Back and loin length	72.14 (69.04, 75.23)	73.66 (71.15, 76.18)	0.4

Data are presented as mean (95% confidence interval).

moderate vs. severe). Statistical significance was set at a P value < 0.05. Intra-observer agreement for the vertebral body measurements was calculated using the intraclass correlation (rho, ρ) among the three replicates of measurements that were obtained using a variance components model based on a random effect linear regression analysis. If ρ is close to 1.0, the agreement is excellent, whereas a value of ρ close to 0 indicates lack of agreement. Statistical analyses were performed using Stata version 12.1 (Stata Corporation).

Results

Clinical data

The group of control Great Danes included seven females (six spayed, one intact) and eight males (seven neutered, one intact). Their median age at the time of study enrollment was 2.3 years (range 1.0–6.4 years). The median weight was 52.0 kg (range 40.5–73.0 kg). The group of CSM-affected Great Danes included two spayed females, 12 neutered males and one intact male. Their median age at the time of study enrollment was 4.3 years (range 1.0–7.2 years). The median weight was 56.8 kg (range 42.0–79.3 kg). The median age at the onset of clinical signs in CSM-affected dogs was 1.7 years (range 0.4–4.2 years). Clinical signs had been present for a mean of 1.9 years (range 0–5.0 years) before enrollment in the study. CSM-affected Great Danes were significantly older than control dogs ($P = 0.02$), but there were no significant differences in weight ($P = 0.05$) or sex ratio ($P = 0.1$) between control and CSM-affected Great Danes.

Fourteen out of the 15 CSM-affected dogs had ambulatory tetraparesis with proprioceptive ataxia of all four limbs. One CSM-affected dog had a hypertonic thoracic limb gait, with ambulatory paraparesis and proprioceptive ataxia of the pelvic limbs. All CSM-affected Great Danes had delayed postural reactions involving all four limbs. Mild neck pain was elicited in six CSM-affected dogs at the time of examination.

Forty-four sites of spinal cord compression were identified in the 15 CSM-affected Great Danes, including C4-C5 and C6-C7 (12 dogs each), C5-C6 (10 dogs), C2-C3 (five dogs), C3-C4 (three dogs) and C7-T1 (two dogs). All CSM-affected Great Danes had osseous-associated CSM. On MRI, one clinically normal Great Dane had two sites of spinal cord compression at C4-C5 and C5-C6.

Table 3
P values obtained from the linear regression analysis investigating the association between body measurements and vertebral body dimensions measured on magnetic resonance imaging in 15 Great Danes with cervical spondylomyelopathy.

Body measurement	Vertebral body length	Vertebral body height
Head length	0.5	0.4
Head circumference	0.2	0.3
Neck length	0.9	0.4
Base width	0.3	0.2
Withers height	0.3	0.1
Back and loin length	0.6	0.5

Body measurements

There were no statistically significant differences between control and CSM-affected Great Danes in any body measurements (Table 1). There were no significant associations between gait grading and any body measurements (Table 2). There was no significant association between vertebral body length or vertebral body height for cervical vertebrae C3 through C7 and any body measurements in the CSM-affected dogs (data not shown). Vertebral body lengths and vertebral body heights for all sites were averaged and the linear regression was repeated for all six body measurements with the averaged vertebral body lengths and heights. No statistically significant differences were identified using the averaged vertebral body dimensions (Table 3). Intra-observer agreement was excellent for both vertebral body length (ρ = 0.996) and vertebral body height (ρ = 0.975).

Discussion

In this study, we obtained six body measurements to compare the body conformation of clinically normal and CSM-affected Great Danes. No significant differences were identified between control and CSM-affected dogs. In addition, no significant associations were identified in the CSM-affected dogs between body measurements and the severity of neurological signs or body measurements and vertebral body dimensions obtained on MRI.

Body conformation has been proposed as a predisposing factor for canine CSM (Wright et al., 1973). Wright et al. (1973) suggested that the combination of large head, long neck and rapid growth in Great Danes may cause an imbalance of forces acting on the cervical vertebral column and change the shape of the cervical vertebrae, eventually causing clinical CSM. However, no comparison between the body conformation of clinically normal and CSM-affected Great Danes was available, and no kinematic or biomechanical investigations were performed. Another study proposed that breed conformation, head weight and posture, and neck length and shape are important etiologic factors in canine CSM, but provided only limited data to support this statement (Lewis, 1992).

Table 2
Association between body measurements and severity of neurological signs in 15 Great Danes with cervical spondylomyelopathy.

Severity of signs	Head length	Head circumference	Neck length	Base width	Withers height	Back/loin length
Mild ($n = 4$) (cm)	29.7 (28.1, 31.2)	48.8 (46.4, 51.1)	33.5 (30.4, 36.6)	17.2 (15.1, 19.4)	87.1 (82.6, 91.5)	75.5 (72.1, 78.9)
Moderate ($n = 4$) (cm)	30.8 (29.0, 32.5)	49.5 (46.8, 52.2)	32.3 (28.8, 35.8)	15.6 (13.1, 18.0)	90.0 (85.0, 95.1)	74.0 (70.1, 77.9)
Severe ($n = 7$) (cm)	28.8 (27.6, 30.0)	48.1 (46.2, 49.9)	31.7 (29.4, 34.1)	17.6 (15.9, 19.2)	85.9 (82.4, 89.3)	73.8 (71.1, 76.4)
Mild vs. moderate (*P* value)	0.4	0.7	0.6	0.3	0.4	0.6
Mild vs. severe (*P* value)	0.4	0.7	0.4	0.8	0.7	0.5
Moderate vs. severe (*P* value)	0.07	0.4	0.8	0.2	0.2	0.9

The gait grading in the CSM-affected Great Danes yielded the following results: grade 1 ($n = 1$); grade 2 ($n = 3$); grade 3 ($n = 1$); grade 4 ($n = 3$); grade 5 ($n = 1$); grade 6 ($n = 6$). Dogs with gait grades of 1 and 2 were categorized as mild, those with grades of 3 and 4 were considered to be moderate and those with grades of 5 and 6 were categorized as severe. Data for each body measurement category are presented as mean (95% confidence interval).

A study comparing body measurements between CSM-affected and unaffected Doberman Pinschers found no differences (Burbidge et al., 1994); moreover, radiographic abnormalities were also independent of any of the body dimensions measured, including neck length and head size (Burbidge et al., 1994). The results of our study do not support the hypothesis that body conformation related to head size, neck length, and body height and length, play a role in the development of CSM in Great Danes.

Nevertheless, the high prevalence of CSM in some dog breeds, particularly Doberman pinschers and Great Danes, but also Bernese Mountain dogs, Bull Mastiffs, Weimaraners and Rottweilers suggests a breed predisposition of this disease that, even if not related to breed conformation, may have a genetic origin (Trotter et al., 1976; Raffe and Knecht, 1978; Lewis, 1992; Burbidge et al., 1994; Eagleson et al., 2009; da Costa, 2010; da Costa et al., 2012; Lewis et al., 2013). No genetic studies have been performed in CSM-affected Great Danes.

Limitations of this study include the small sample size and the higher proportion of males and older dogs in the CSM-affected group compared with the control group. This may have hindered the ability to identify significant differences between groups secondary to a lack of power and due to bias for sex and age. Another limitation is that the investigator who obtained the body measurements was not blinded to the clinical status of the dog.

Conclusions

The results of this study do not support the hypothesis that differences in body conformation related to head size, neck length, and body height and length, play a role in the pathogenesis of CSM in Great Danes.

Conflict of interest statement

None of the authors has any financial or personal relationship that could inappropriately influence or bias the content of the paper.

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