

The breed-specific vertebral heart score and vertebral left atrial size in toy breed dogs

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Abstract

Vertebral heart score (VHS) and vertebral left atrial size (VLAS) are the objective measures of cardiac and left atrial sizes on thoracic radiographs in dogs. Previous studies have demonstrated that the normal VHS reference ranges can vary among breeds. This retrospective study aimed to evaluate the VHS and VLAS of healthy Maltese, Pomeranian, and Toy Poodle dogs, which were predisposed to cardiac disease. Fifty Maltese, 47 Pomeranian, and 45 Toy Poodles were enrolled. The VHS of Maltese, Pomeranian and Toy Poodles was 9.69 ± 0.51 , 10.69 ± 0.62 , and 9.94 ± 0.60 , respectively. The VHS of Pomeranian and Toy Poodles were significantly higher than the canine reference value of 9.7 vertebrae. The VLAS of Maltese, Pomeranian and Toy Poodles was 2.03 ± 0.17 , 2.17 ± 0.26 , and 2.02 ± 0.15 , respectively. Compared to the reference value of 1.9 vertebrae, the VLAS of Maltese, Pomeranian and Toy Poodles was significantly higher. The VHS and VLAS of Pomeranians were significantly higher than those of Maltese and Toy Poodles. The cardiomegaly or left heart enlargement could be overdiagnosed in healthy Maltese, Pomeranian and Toy Poodles, especially Pomeranians, therefore, the VHS and VLAS values in this study could be used as references.

Keywords: canine, thoracic radiograph, VHS, VLAS

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Introduction

Thoracic radiography is a rapid, cost-effective, easily accessible and widely available initial diagnostic test used to evaluate the cardiac size and silhouette of dogs (Bahr, 2018). Vertebral heart score (VHS) is a common and useful method used to objectively evaluate the cardiac size of dogs (Buchanan and Bücheler, 1995; Lamb *et al.*, 2001). In addition, vertebral left atrial size (VLAS) is an objective radiographic method recently proposed to evaluate the size of the left atrium (LA) of dogs (Hozo *et al.*, 2005; Kim *et al.*, 2017; Malcolm *et al.*, 2018). The mean and standard deviation (SD) values of VHS and VLAS were reported as 9.7 ± 0.5 and 1.9 ± 0.15 vertebrae, respectively (Buchanan and Bücheler, 1995; Vezzosi *et al.*, 2020). VHS and VLAS are used to evaluate dogs with cardiac diseases, including myxomatous mitral valve disease (MMVD) (Malcolm *et al.*, 2018; Poad *et al.*, 2020). A VHS or VLAS of 10.8 and 2.3 vertebrae, respectively, is proposed as a cutoff value with high sensitivity and specificity for predicting echocardiographic left heart enlargement in patients with MMVD (Malcolm *et al.*, 2018; Poad *et al.*, 2020). Therefore, patients with VHS > 10.8 vertebrae or VLAS ≥ 2.3 vertebrae on thoracic radiograph are recommended to undergo echocardiographic examination, which is the gold standard method for cardiac structure and function evaluation.

Several studies have described a breed-specific VHS reference value (Bavegems *et al.*, 2005; Birks *et al.*, 2017; Bodh *et al.*, 2016; Ghadiri *et al.*, 2010; Jepsen-Grant *et al.*, 2013; Kraetschmer *et al.*, 2008; Lamb *et al.*, 2001; Luciani *et al.*, 2019; Marin *et al.*, 2007; Puccinelli *et al.*, 2021; Taylor *et al.*, 2020). In previous studies, the mean VHS value of Miniature Poodles was not significantly different compared to the canine reference value of 9.7 ± 0.5 vertebrae (Azevedo *et al.*, 2016), while that of Pomeranians was significantly higher (Jepsen-Grant *et al.*, 2013). In addition, the mean VHS value for 81 Maltese dogs was 9.53 vertebrae, which was lower than the reference value (Baisan and Vulpe, 2021). Although a previous study evaluated VLAS in a large number of dogs, showing 1.9 vertebrae as median VLAS value, a breed-specific VLAS reference was still not established, except that of Chihuahua, Cavalier King Charles Spaniels and Maltese (Bagardi *et al.*, 2021; Baisan and Vulpe, 2021; Puccinelli *et al.*, 2021; Vezzosi *et al.*, 2020).

Based on the results of previous studies, a breed-specific VHS and VLAS of different canine breeds were hypothesized to be present. Thus, establishing and analyzing the breed-specific VHS and VLAS of each breed group will be valuable to prevent misdiagnosing cardiomegaly. In particular, in toy breed groups, such as Maltese, Pomeranian and Toy Poodles, which are breeds prone to MMVD (Kim *et al.*, 2017; Ware, 2014), establishing a reference for breed-specific VHS and VLAS is important to diagnose cardiac diseases. Thus, this study aimed to determine the breed-specific VHS and VLAS reference range for Maltese, Pomeranian and Toy Poodles.

Materials and Methods

Animals: This retrospective and cross-sectional study included Maltese, Pomeranian and Toy Poodle dogs;

both their thoracic radiographs and echocardiography were taken from July 2016 to April 2021 at the Veterinary Teaching Hospital of Kyungpook National University. Toy Poodle dogs were defined as Poodle dogs with a height and thoracic depth of < 25 or < 10 cm on radiographs, respectively. The inclusion criteria were (1) dogs that had undergone an echocardiographic examination within 24 h before the radiograph or within 7 days after the radiograph; (2) no medical history or evidence of cardiac diseases; (3) thoracic radiographs that included ventrodorsal and right lateral projections at the peak inspiration; and (4) echocardiographic examination that included transthoracic two-dimensional, M-mode and Doppler imaging. The exclusion criteria were (1) any dogs with murmurs and obscured cardiac silhouette margins; (2) dogs < 12 months old and had a possible influence of skeletal immaturity on vertebral-based measurements; (3) any patients with vertebral deformities that may have significantly affected their vertebral heart scales based on radiographs; and (4) dogs with cardiostructural heart diseases and cardiac chamber enlargement based on echocardiogram. From the medical records, clinical features including breed, age, gender, body weight and nine-point scale body condition score (BCS) were recorded.

Imaging technique and assessment: All thoracic radiographs were acquired by a digital radiographic system (AccuRay-603R, DK Medical Systems, Seoul, Korea) without general anesthesia or sedation. Digital radiographs were reviewed using a picture-archiving and communication system (INFINITT PACS, INFINITT Healthcare, Seoul, Korea). VHS was measured on right lateral thoracic radiographs previously described by Buchanan and Bücheler (1995). The long axis of the heart was measured from the center of the most ventral aspect of the carina to the most distal contour of the ventral apex of the heart. The maximal short axis of the heart was measured in the central third region of the heart, perpendicular to the long axis. The two lengths were then repositioned over the thoracic vertebrae, starting from the cranial edge of the fourth thoracic vertebra and each length was expressed in vertebral body units to the nearest 0.1 vertebrae. These two parallel linear dimensions were added and used as VHS (Fig. 1).

VLAS was measured on right lateral radiographs previously established by Malcolm *et al.* (Malcolm *et al.*, 2018). A line was drawn and measured from the center of the most ventral aspect of the carina to the most caudal aspect of the LA, where it intersected with the dorsal border of the caudal vena cava. The same line was repositioned over the fourth thoracic vertebrae; this was drawn starting from the cranial edge of the fourth thoracic vertebra, extending caudally just ventral, parallel to the vertebral canal. The length was then expressed in vertebral body units to the nearest 0.1 vertebrae (Fig. 2).

All echocardiographic examinations were performed using an ultrasonographic machine (Prosound F75, Hitachi Aloka, Tokyo, Japan) equipped with a sector probe (3.0–8.0 MHz) as a part of the inclusion criteria. The left ventricular size that was considered normal had a left ventricular internal

diameter in diastole of < 1.7 , which was normalized for body weight (Keene *et al.*, 2019). The LA size was considered normal when the measured LA-to aorta ratio using Rishniw method was < 1.6 (Keene *et al.*, 2019; Rishniw and Erb, 2000). The right ventricular size was considered normal when the ratio between the right ventricular internal diameter and the left

ventricular internal diameter in diastole on right parasternal short-axis view was ≤ 0.37 (Chetboul *et al.*, 2018). Finally, the right atrial size was considered normal if the right atrium-to-LA ratio was ≤ 1 on the right parasternal long axis, four-chamber view (Chetboul *et al.*, 2018; Serres *et al.*, 2009).

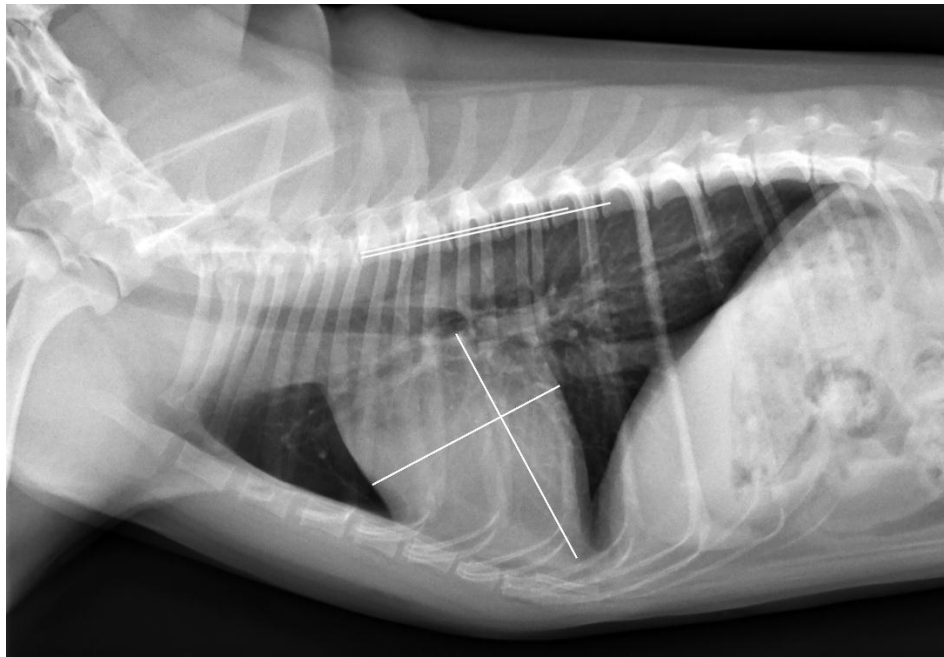


Figure 1 Right lateral radiograph illustrating the measurement of VHS in a Maltese dog. The cardiac long axis is measured from the ventral aspect of the carina to the apex. The short axis is measured at the widest aspect of the heart, perpendicular to the long axis. The long and short axes measurements are then repositioned over the thoracic vertebrae, beginning with the cranial edge of the fourth thoracic vertebra and with each length being expressed in vertebral body units to the nearest 0.1 vertebrae. Two parallel linear dimensions are added and used as VHS.

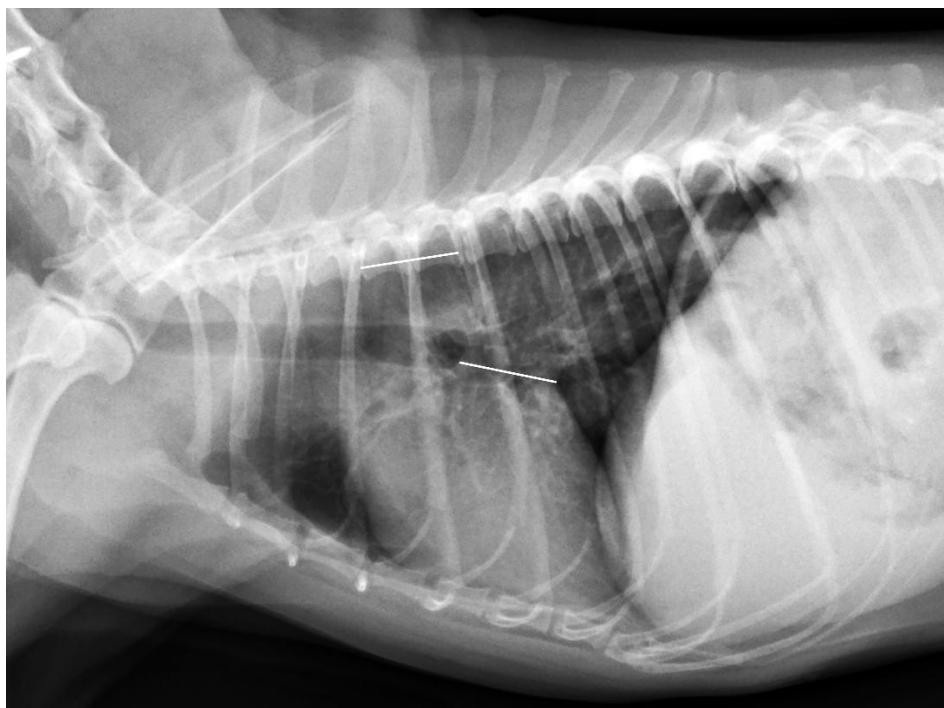


Figure 2 Right thoracic radiograph illustrating the method for the VLAS measurement in a Toy Poodle dog. A line is measured from the center of the most ventral aspect of the carina to the most caudal aspect of the LA where it intersects with the dorsal border of the caudal vena cava. The same line is then drawn starting from the cranial edge of the fourth vertebra and extending caudally just ventral and parallel to the vertebral canal, and its length is expressed in vertebral body units to the nearest 0.1 vertebrae.

Statistical analysis: Statistical tests were selected with the aid of a consulting statistician. Statistical analyses were performed using a commercial software (SPSS 25.0, IBM SPSS statistics, Armonk, NY, USA). All data was examined for normality using the Kolmogorov-Smirnov test and expressed as mean $\pm$ SD. A free application (Reference Values Advisor V2.1) was used for the calculation of the reference intervals for VHS and VLAS of each breed. The standard method for untransformed data and the nonparametric method were used to determine the reference interval of VHS and VLAS, respectively. One sample t-test was used to determine whether the VHS and VLAS of Maltese, Pomeraniannand Toy Poodle dogs differed from the mean reference value proposed by Buchanan and Bücheler, and Vezzosi *et al.* (Buchanan and Bücheler, 1995; Vezzosi *et al.*, 2020). The values from Vezzosi's study expressed as median value and range of 1.9 and 1.3–2.2 vertebrae, respectively (Vezzosi *et al.*, 2020), were thus converted to mean and standard deviation of 1.9 ± 0.15 vertebrae (Hozo *et al.*, 2005). Two sample t-tests were used to compare the VHS and VLAS of the male and female dogs of each breed. The Pearson correlation coefficient was calculated to determine the correlation between VHS and BCS and between VLAS and BCS. Pearson's correlation coefficient was also used to evaluate the correlation between VHS, VLAS, body weight, and age. One-way analysis of variance with Bonferroni post hoc test was used to compare the differences in VHS, while the Kruskal-Wallis test with Bonferroni post hoc test were used to compare the differences in VLAS among the three breeds. A chi-

square test was used to identify significant differences in the percentage of dogs with a VHS of > 10.8 vertebrae and a VLAS ≥ 2.3 in each breed group (Malcolm *et al.*, 2018; Poat *et al.*, 2020). The correlation between VLAS and VHS of each breed was obtained using Pearson correlation. A *P*-value of < 0.05 was considered statistically significant.

Results

In this study, a total of 142 dogs met the inclusion criteria. The sample population consisted of 50 Maltese, 47 Pomeranian and 45 Toy Poodles. Their sex, age, body weight and BCS are summarized in Table 1 according to breed.

The mean and SD values, reference interval with 90% confidence interval (CI) for lower and upper limits of VHS and VLAS, and the number of dogs with a VHS of > 10.8 or VLAS of ≥ 2.3 are summarized in Table 2. The VHS of Pomeranian and Toy Poodles were significantly higher than the canine reference VHS of 9.7 ($P < 0.001$ and $P = 0.009$, respectively). The VHS of Maltese was not significantly different from the reference VHS of 9.7. The percentage of Pomeranian with a VHS > 10.8 was higher than that of Maltese and Toy Poodles ($P < 0.001$). The VLAS of Maltese, Pomeranian and Toy Poodles was significantly higher than the published mean reference VLAS of 1.9 ($P < 0.001$, < 0.001 and < 0.001 , respectively). The percentage of Pomeranian with a VLAS ≥ 2.3 was higher than that of Maltese and Toy Poodles ($P < 0.001$).

Table 1 Age, body weight, body condition score and sexual status according to breed

Breed	N	Sex (M/F)	Age (years)	Body weight (kg)	BCS	
					N	Mean $\pm$ SD
Maltese	50	27/23	6.2 $\pm$ 3.2 (1.0–12.3)	3.8 $\pm$ 1.2 (1.7–6.5)	48	4.8 $\pm$ 1.1 (3–8)
Pomeranian	47	28/19	5.0 $\pm$ 3.2 (1.0–13.2)	3.4 $\pm$ 1.0 (2.0–6.0)	46	4.7 $\pm$ 1.1 (3–8)
Toy Poodle	45	22/23	7.5 $\pm$ 4.1 (1.0–16.9)	3.9 $\pm$ 1.2 (1.6–6.1)	40	4.3 $\pm$ 1.4 (1–9)

BCS, body condition score; N, number of dogs; M, male; F, female; SD, standard deviation

Table 2 Measurements for the vertebral heart score and vertebral left atrial size of each breed group and comparisons with published mean references

Measurement	Breed	Mean $\pm$ SD (range)	Reference interval (90% CI)	<i>P</i>	VHS > 10.8 or VLAS ≥ 2.3 (%)
VHS	Maltese	9.69 $\pm$ 0.51 (8.7–11.0)	8.7 (8.5–8.9) – 10.7 (10.5–10.9)	0.934 ^a	1 (2.0)
	Pomeranian	10.69 $\pm$ 0.62 (9.2–12.0)	9.4 (9.1–9.6) – 11.9 (11.7–12.2)	$< 0.001^a$	21 (44.7)
	Toy Poodle	9.94 $\pm$ 0.60 (9.0–11.1)	8.7 (8.5–9.0) – 11.16 (10.9–11.4)	0.009 ^a	5 (11.1)
VLAS	Maltese	2.03 $\pm$ 0.17 (1.6–2.4)	1.6 (1.6–1.7) – 2.4 (2.3–2.4)	$< 0.001^b$	4 (8.0)
	Pomeranian	2.17 $\pm$ 0.26 (1.7–2.8)	1.7 (1.7–1.8) – 2.8 (2.6–2.8)	$< 0.001^b$	18 (38.3)
	Toy Poodle	2.02 $\pm$ 0.15 (1.7–2.4)	1.7 (1.7–1.8) – 2.4 (2.3–2.4)	$< 0.001^b$	4 (8.9)

^aComparison between the VHS of each breed and the reference VHS of 9.7 vertebrae

^bComparison between the VLAS of each breed and the reference VLAS of 1.9 vertebrae

CI, confidence interval; SD, standard deviation; VHS, vertebral heart score; VLAS, vertebral left atrial size

The VHS and VLAS was not significantly different between male and female Maltese ($P = 0.230$ and 0.857 , respectively), Pomeranian ($P = 0.405$ and 0.116 , respectively), and Toy Poodles ($P = 0.891$ and 0.294 , respectively). No significant correlation was noted between the age and VHS and VLAS of Maltese ($P = 0.890$ and 0.688 , respectively), Pomeranian ($P = 0.168$ and 0.853 , respectively) and Toy Poodles ($P = 0.424$ and 0.214 , respectively). A significant correlation of the body weight and BCS with VHS in Toy Poodles was identified ($r = 0.357$, $P = 0.016$ and $r = 0.432$, $P = 0.005$, respectively). In Pomeranian, VHS significantly correlated with BCS ($r = 0.410$, $P = 0.005$) but not with body weight ($P = 0.363$). No significant correlation was noted in the body weight and BCS with VHS in Maltese ($P = 0.638$ and 0.247 , respectively). No significant correlation was noted in the body weight and BCS with

VLAS in Maltese ($P = 0.899$ and 0.646 , respectively), Pomeranian ($P = 0.764$ and 0.769 , respectively), and Toy Poodles ($P = 0.996$ and 0.199 , respectively).

The correlation between the VHS and VLAS in each breed group was analyzed and a positive linear correlation was found between the VHS and VLAS in Pomeranian ($r = 0.473$ and $P = 0.001$). Moreover, no correlation was noted between the VHS and VLAS in Maltese and Toy Poodles ($P = 0.425$, and 0.093 , respectively).

The differences in VHS and VLAS among the breed groups were analyzed. Pomeranians had a significantly higher VHS than Maltese and Toy Poodles ($P < 0.001$ and < 0.001 , respectively; Fig. 3A). The VLAS in Pomeranian was also significantly higher than that in Maltese and Toy Poodles ($P = 0.028$ and 0.007 , respectively; Fig. 3B).

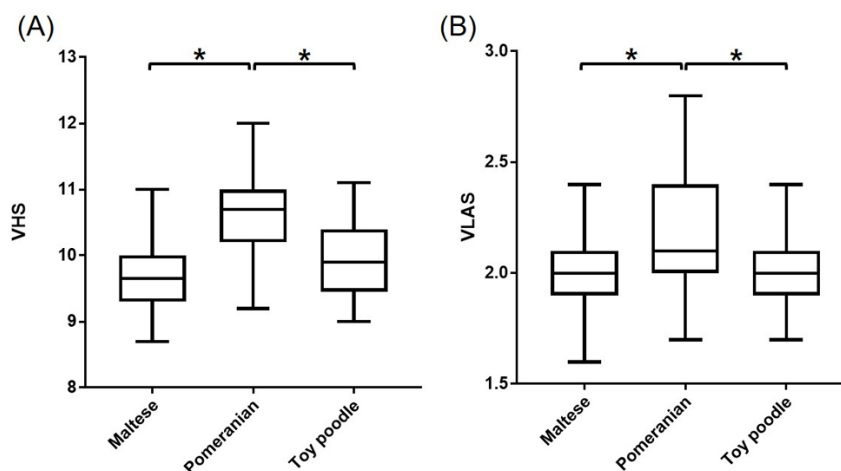


Figure 3 Graph representations of the vertebral heart score (VHS, A) and vertebral left atrial size (VLAS, B) among the breed groups. All data presents the median values with interquartile range, with extreme values represented by whiskers. The VHS and VLAS of Pomeranian are significantly higher than those of Maltese and Toy Poodles. * $P < 0.01$

Discussion

The study of toy breed-specific VHS and VLAS was lacking although its breed-specific variation has increasingly been proved (Bagardi *et al.*, 2021; Baisan and Vulpe, 2021; Bavegems *et al.*, 2005; Birks *et al.*, 2017; Bodh *et al.*, 2016; Ghadiri *et al.*, 2010; Jepsen-Grant *et al.*, 2013; Kraetschmer *et al.*, 2008; Lamb *et al.*, 2001; Luciani *et al.*, 2019; Marin *et al.*, 2007; Puccinelli *et al.*, 2021; Taylor *et al.*, 2020; Vezzosi *et al.*, 2020). This study proposed the reference intervals of VHS and VLAS in a larger number of Pomeranian and Toy Poodles than previous studies (Azevedo *et al.*, 2016; Fonseca Pinto and Masao, 2004; Jepsen-Grant *et al.*, 2013). In addition, Toy Poodles in this study had smaller body height (Fonseca Pinto and Masao, 2004) and body weight (Azevedo *et al.*, 2016) than Poodles in previous studies. The VHS and VLAS of Pomeranian and Toy Poodles were significantly higher than previously published general canine VHS and VLAS reference values. The VLAS of Maltese was significantly higher than the previously published VLAS reference value of 1.9. Among these breeds, Pomeranian showed an especially higher VHS and VLAS and a higher percentage of dogs with VHS >10.8 , and VLAS ≥ 2.3 than Maltese and Toy Poodles. These findings indicate

that healthy Maltese, Pomeranian and Toy Poodles could be overinterpreted with having cardiomegaly or left heart enlargement on thoracic radiographs, especially Pomeranian. Therefore, breed-specific VHS and VLAS for these breeds should be considered.

Multiple possible factors affecting breed-specific VHS and VLAS have been proposed and include different heart-to-body size ratios, variations of vertebral body length and chest conformation (Bodh *et al.*, 2016; Ghadiri *et al.*, 2010; Jepsen-Grant *et al.*, 2013; Parker and Kilroy-Glynn, 2012; Vezzosi *et al.*, 2020). Smaller dogs have a larger heart-to-body size ratio than larger dogs (Parker and Kilroy-Glynn, 2012). No study evaluating breed specific vertebral body length was noted. In addition, no significant correlation was noted between the chest conformation and VHS in different canine breeds (Bodh *et al.*, 2016; Ghadiri *et al.*, 2010). However, limited chest types were included in previous studies regarded as its limitation (Bodh *et al.*, 2016; Ghadiri *et al.*, 2010). Thus, the higher VHS and VLAS in toy breed dogs of this study than the reference values could be due to these factors. Therefore, further studies are necessary to investigate the correlation between the VHS and VLAS of each breed with vertebral body length, chest conformation, and heart-to-body size ratio.

The VHS of 10.69 ± 0.62 vertebrae in Pomeranian of this study was similar to 10.5 ± 0.9 of 18 Pomeranians in a previous study (Jepsen-Grant *et al.*, 2013). The breed-specific VHS of Toy Poodles in this study was 9.94 ± 0.60 vertebrae. This result was inconsistent with the VHS of previous studies showing 9.72 ± 0.73 vertebrae for 40 Poodle dogs < 11 kg (Azevedo *et al.*, 2016) and 10.12 ± 0.51 vertebrae for 30 Poodle dogs (Fonseca Pinto and Masao, 2004). This may be due to the different body sizes of Poodle dogs included in this study. As a result of restricting the height and thoracic depth of Toy Poodle dogs in this study, the maximum body weight of Toy Poodles was 6.1 kg. The VHS of Poodles in this study was considered to be higher than in the previous study because smaller dogs have a larger heart-to-body size ratio than larger dog (Parker and Kilroy-Glynn, 2012). A larger number of Pomeranian and only Toy Poodles of strict standards were included in this study compared to previous studies of Pomeranian (Jepsen-Grant *et al.*, 2013) and Poodles (Azevedo *et al.*, 2016; Fonseca Pinto and Masao, 2004), therefore, the reference value of this study could be better in Pomeranian and Toy Poodles.

The breed-specific VHS of Maltese in this study was 9.69 ± 0.51 vertebrae and showed no significant difference with the published reference value of 9.7. However, a previous study showed that the VHS value of 81 Maltese is 9.5 ± 0.46 vertebrae, lower than the 9.7 ± 0.5 vertebrae initially proposed (Baisan and Vulpe, 2021). The mean values of VHS in Maltese between the previous (Baisan and Vulpe, 2021) and current studies showed a significant difference ($P = 0.009$). This could be due to differences in body size between the previous and current studies (9 ± 6 and 3.8 ± 1.2 kg in body weight, respectively). A further study for VHS in Maltese will be needed. The mean VLAS value of Maltese dogs in this study was 2.03 vertebrae, similar to the median VLAS value of 81 Maltese dogs in the previous study (Baisan and Vulpe, 2021).

Previous studies reported a significant correlation between BCS and VHS in several breeds including Lhasa Apsos and Norwich Terrier (Jepsen-Grant *et al.*, 2013; Vezzosi *et al.*, 2020). This was due to possible variations in the amount of pericardial fat in different breeds (Taylor *et al.*, 2020). Thus, Norwich Terriers may have more deposited epicardial fat than others (Taylor *et al.*, 2020). However, no correlation was reported between the VHS and BCS or between the VHS and body weight of other canine breeds (Bodh *et al.*, 2016; Jepsen-Grant *et al.*, 2013; Puccinelli *et al.*, 2021). In this study, significant correlations were noted between body weight and BCS with VHS in Toy Poodles and between BCS with VHS in Pomeranian. These two breeds may have more deposited epicardial fat than others and a strict limitation of the body size in Toy Poodles leads to a significant correlation of body weight and BCS with VHS. In addition, no correlation was noted between body weight and BCS with VLAS in all three breed dogs. This could be due to the difference in the distribution of pericardial fat (Bertaso *et al.*, 2013) or due to the lesser effect of pericardial fat compared to VHS. Further studies are needed to demonstrate these hypotheses.

In this study, the VHS of toy breed dogs was not influenced by sex. The correlation of VHS with sex is

controversial. Correlation was noted between VHS and sex in a few studies (Birks *et al.*, 2017; Lamb *et al.*, 2001), however, the VHS of many canine breeds was not influenced by sex (Bavegems *et al.*, 2005; Buchanan and Bücheler, 1995; Jepsen-Grant *et al.*, 2013; Luciani *et al.*, 2019; Puccinelli *et al.*, 2021; Taylor *et al.*, 2020). A previous study demonstrated that sexual size dimorphism becomes smaller with decreasing body size and the smallest breeds are nearly monomorphic (Frynta *et al.*, 2012). In this study, the reason why VHS was not affected by sex may be due to the absence of significant differences in the morphotype of female and male toy breed dogs. In addition, in this study, the VHS of toy breed dogs was also not influenced by age. In humans, epicardial fat deposition has been shown to increase with ageing, and a previous study suggested that a similar finding could occur in dogs (Birks *et al.*, 2017; Silaghi *et al.*, 2008). Further studies are needed to investigate the correlation of VHS or epicardial fat deposition with age.

A limitation of this study was that some BCS records were missing due to the retrospective nature of the current study. The size and morphotype of each breed were homogenous and will have little effect on reference range determination. Another limitation was that the sample size was small because healthy dogs, for which echocardiography was not performed, were excluded from this study. However, the Maltese, Pomeranian and Toy Poodle dogs in this study had homogenous size and morphotypes. Thus, it is less likely to lead to a difference in the reference range for each breed group, even if the sample population were increased.

In conclusion, the breed-specific VHS and VLAS references for healthy Maltese, Pomeranian and Toy Poodles were presented in this study. The VHS of Pomeranian and Toy Poodles and the VLAS of Maltese, Pomeranian and Toy Poodles were significantly higher than published reference values. In addition, the VHS and VLAS of Pomeranian were significantly higher than those of Maltese and Toy Poodles. These findings indicate that healthy Maltese, Pomeranian and Toy Poodles could be overinterpreted with having cardiomegaly or left heart enlargement on thoracic radiographs, especially Pomeranians. Therefore, the breed-specific VHS and VLAS values in this study should be considered as references for these breeds.

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