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FULL PAPER

Measurement of M-mode echocardiographic parameters in healthy adult Van cats

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Abstract

Cardiomyopathies are the most common type of cardiac diseases in cats. Although some normal echocardiographic values for cats have been published, there are variations based on breeds and gender. The objective of this study is to determine normal reference values for M-mode echocardiographic parameters in nonsedated healthy adult Van cats and to compare those values with data reported for nonsedated healthy cats of other breeds. A total of 40 clinically healthy Van cats of both sexes belonging to the Van Cat Research and Application Center of Yuzuncu Yil University were used. Body weight (BW) and 16 M-mode echocardiographic variables were measured in 40 healthy Van cats. The effect of gender and age on each echocardiographic parameter was analyzed and the relationship between BW and each parameter investigated. There was a significant relationship between gender and left atrial dimension during ventricular systole (LAD) and aortic root dimension at end-diastole (AOD) as well as between BW and interventricular septal thickness at end-diastole (IVSd) and end-systole (IVSs), left ventricular internal dimension at end-diastole (LVIDd), left ventricular posterior wall thickness at end-diastole (LVPWd), LAD, AOD, the left ventricular end diastolic volume (EDV) and the stroke volume (SV). A relationship between age and the SV parameter alone was also established. This present study is the first work on cardiac reference values for Van cats highlighting the differences in some M-mode echocardiographic parameters of healthy adult Van cats and other cat breeds, which should be considered when interpreting echocardiographic findings, in order to draw the correct conclusions regarding cardiac health.

Key Words: echocardiography, M-mode echocardiography, reference values, two-dimensional echocardiography, Van Cat.

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Introduction

Reliable normal echocardiogram values are needed for comparison and evaluation of cats suspected of having heart disease. Cardiomyopathies are the most common type of cardiac diseases in cats, while hypertrophic cardiomyopathy (HCM) is the most common myocardial disease in cats, accounting for approximately two thirds of cases[15,16,32]. Although some normal echocardiographic values for cats have been published, there are variations based on both breeds and gender[14,27]. The echocardiographic method is considered superior to electrocardiography and radiography in the diagnosis of dilated and hypertrophic cardiomyopathies and of heart diseases caused in cats particular by hyperthyroidism[25].

The Van cat is a domesticated cat breed that has received great interest in recent years both in Turkey and internationally. Since they have been continuously diminishing, the breed is currently under protection. The cat is a national treasure and enjoys a high status in its native Van province. The cat's main features are a white silky fur and often differently colored eyes. The cat is native to Turkey and has become a status symbol, whereby putting pressure on its population. This has led to calls for protection of the breed.

Echocardiographic studies[14,20,27] on various cat breeds have been carried out and cardiac reference values published. However, no scientific research has yet been conducted in Turkey or abroad on Van cats with the purpose of determining M-mode echocardiographic reference parameters. The present study is the first of this kind.

The determination of reference values for echocardiographic parameters in healthy Van cats would improve the ability to interpret results of echocardiographic examinations in this breed. The purpose of this study was to establish a database (or reference values) for M-mode echocardiographic parameters in nonsedated healthy adult Van cats and compare those values with data reported for nonsedated healthy adult domestic cats of different breeds.

Materials and Methods

Cats: In this study, 40 clinically healthy Van cats from both genders (26 females and 14 males) were used. The study was performed at the Van Cat Research and Application Center of Yuzuncu Yil University. They were between 12 months and 8 years of age (mean, 3.6 years), with body weights ranging from 2.6 to 5.5 kg. The mean body weight was 4.16 kg for males and 3.41 kg for females. The cats were active and have an athletic build. The 40 animals were considered normal in the sense of healthy representative specimen on the basis of the following criteria: cardiovascular physical examinations did not reveal any abnormal findings and none of the cats had a history of illness; a complete echocardiographic examination (2-D, 2-D guided M-mode, Doppler echocardiography) did not show any evidence of heart disease. Echocardiographic investigations were performed to exclude the presence of turbulences in both ventricular outflow tracts, as well as mitral valvular regurgitation. Cardiac auscultation was performed in a quiet room for 5 minutes bilaterally over the apex beat and at the thoracic inlet to ensure absence of heart murmurs and gallop rhythm. No murmurs or gallop rhythm were detected. All cats were examined without sedation or anesthesia.

To ascertain the influence of gender, age and body weight on echocardiographic measurements, the cats' gender and BW data were compared.

Echocardiography: Echocardiographic examinations were performed using a classic Tera2000 Vet Model Terason Ultrasound System with a 5-MHz tightly curved array transducer. Echocardiographic investigations were carried out in a quiet and dimly lit room after first recording the body weight.

All cats were clipped on the right thoracic wall and positioned in right lateral recumbence according to published standards[41] and manually restrained without sedation on a specially designed table. The transducer was placed through a hole from underneath the table to a right parasternal position in the area of strongest palpable apical beat. Ultrasonic gel was used for coupling the transducer with the skin.

Measurements: All M-mode dimensional measurements were obtained from a right parasternal view. Two-dimensional and M-mode echocardiograms were recorded and analyzed in accordance with recommendations of the American Society of Echocardiography[34,39]. The M-mode echocardiographic evaluation was guided by the simultaneous display of real-time 2-D echocardiographic images. The M-mode cursor was positioned from long axis views. Left ventricular images were obtained by placing the cursor perpendicular to the interventricular septum and the left ventricular posterior wall at the chordae tendinea level. Measurements of the cardiac structures were made on the screen using frozen M-mode images. Ventricular dimensions were always measured apical to the mitral valve at the chordal level. The following M-mode measurements were made: left ventricular internal dimension at end-systole (LVIDs) and end-diastole (LVIDd), left ventricular posterior wall thickness at end-systole (LVPWs) and end-diastole (LVPWd), interventricular septal thickness at end-systole (IVSs) and end-diastole (IVSd), aortic root dimension at end-diastole (AOD), left atrial dimension during ventricular systole (LAD), left atrial to aortic root ratio (LAD/AOD), heart rate (HR) and the mitral valve E point septal separation (EPSS). The LVID, LVPW and IVS parameters were measured in systole (s) and at end-diastole (d).

Aortic root measurements were made on a portion of the sweep with at least one visible valve cusp. The requirement of the American Society of Echocardiography[34] to image two valve cusps could not always be achieved. The aortic root dimension was measured at end-diastole from the outer edge of the anterior wall to the inner edge of the posterior wall. The left atrial systolic dimension included the posterior aortic wall thickness and excluded the left atrial wall thickness, and was measured at maximal aortic root excursion.

Calculations: The percentage fractional shortening (FS %) was derived [by use of the equation (LVIDd-LVIDs/LVIDdX100) and the left atrium-to-aortic root ratio (LAD:AOD)] was calculated by dividing LAD by AOD[6].

The left ventricular end diastolic volume (EDV), the left ventricular end systolic volume (ESV), the stroke volume (SV), and the ejection fraction (EF) were measured automatically by the echocardiography machine using the Teichholz formula.

Statistical analysis: SPSS 13.0 was used for statistical analysis. The General Linear Model (GLM)-Univariate was used to determine the effect of gender, age and body weight on the echocardiographic measurements. In this procedure, gender was adapted as a constant effect, age and BW as a covariate.

Results

The echocardiographic parameters of all cats are compiled in Table 1 specified by gender, age and body weight but without gender separation.

The body weight of male cats was about 22% higher than for female cats, this difference was significant ($p < 0.001$).

The IVS in both diastole and systole were higher in females than in males. Statistical analysis confirmed that there was no gender-related difference. In addition, the IVS in both systole and diastole were not directly related to age. The IVS parameter was statistically significant with respect to BW in diastole and

Table 1. Van Cats Echocardiographic Measurements With Regard to Age, Gender and Body Weight

		IVSd (mm)			IVSs (mm)		
		Mean ± SE	Range	95% CI	Mean ± SE	Range	95% CI
All Van Cats (n = 40)		3.65 ± 0.09	2.9–5.3	3.48–3.83	5.81 ± 0.12	4.4–7.8	5.56–6.06
Gender			N.S.			N.S.	
	Male	3.58 ± 0.15	2.9–5.3	3.28–3.89	5.78 ± 0.22	4.4–7.8	5.33–6.22
	Female	3.72 ± 0.11	2.9–4.9	3.51–3.94	5.85 ± 0.15	4.7–7.3	5.54–6.16
AGE (years)			N.S.			N.S.	
BW			***			***	

		LVIDd (mm)			LVIDs (mm)		
		Mean ± SE	Range	95% CI	Mean ± SE	Range	95% CI
All Van Cats (n = 40)		14.77 ± 0.29	11.3–19.1	14.18–15.36	7.64 ± 0.26	4.6–11.0	7.11–8.17
Gender			N.S.			N.S.	
	Male	15.04 ± 0.52	11.9–18.9	13.98–16.11	7.59 ± 0.46	5.5–11.0	6.64–8.53
	Female	14.49 ± 0.36	11.3–19.1	13.75–15.23	7.69 ± 0.32	4.6–10.5	7.04–8.35
AGE (years)			N.S.			N.S.	
BW			*			N.S.	

N.S. $P > 0.05$, *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$
IVSd/IVSs = Interventricular septal thickness at end-diastole/end-systole; LVIDd/LVIDs = Left ventricular internal dimension at end-diastole/end-systole.

Table 1 (continued). Van Cats Echocardiographic Measurements With Regard to Age, Gender and Body Weight.

		LVPWd (mm)			LVPWs (mm)		
		Mean ± SE	Range	95% CI	Mean ± SE	Range	95% CI
All Van Cats (n = 40)		3.66 ± 0.13	2.4–6.0	3.40–3.91	5.84 ± 0.21	3.4–9.6	5.41–6.27
Gender			N.S.			N.S.	
	Male	3.70 ± 0.23	2.8–6.0	3.24–4.16	5.93 ± 0.38	3.6–9.6	5.22–6.75
	Female	3.61 ± 0.16	2.4–5.9	3.29–3.93	5.70 ± 0.26	3.4–7.9	5.17–6.23
AGE (years)			N.S.			N.S.	
BW			**			N.S.	

		FS (%)			HR (bpm)		
		Mean ± SE	Range	95% CI	Mean ± SE	Range	95% CI
All Van Cats (n = 40)		48.39 ± 1.34	30–60	45.67–51.12	179.97 ± 5.14	123–223	169.55–190.40
Gender			N.S.			N.S.	
	Male	49.95 ± 2.41	31–59	45.06–54.83	183.55 ± 9.21	127–213	164.87–202.23
	Female	46.84 ± 1.68	30–60	43.44–50.23	176.40 ± 6.41	123–223	163.40–189.39
AGE (years)			N.S.			N.S.	
BW			N.S.			N.S.	

N.S. $P > 0.05$, *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$
LVPWd/LVPWs = Left ventricular posterior wall thickness at end-diastole/end-systole; FS = Fractional shortening; HR = Heart rate.

Table 1 (continued). Van Cats Echocardiographic Measurements With Regard to Age, Gender and Body Weight.

		EF (%)			LAD (mm)		
		Mean ± SE	Range	95% CI	Mean ± SE	Range	95% CI
All Van Cats (n = 40)		82.06 ± 1.34	62.8–91.7	79.33–84.79	9.43 ± 0.21	6.6–12.4	9.01–9.86
Gender			N.S.			*	
	Male	83.36 ± 2.41	63.3–90.9	78.48–88.25	10.06 ± 0.37	6.6–12.4	9.30–10.81
	Female	80.76 ± 1.68	62.8–91.7	77.36–84.15	8.81 ± 0.26	7.4–10.9	8.29–9.34
AGE (years)			N.S.			N.S.	
BW			N.S.			**	
		AOD (mm)			LAD/AOD		
		Mean ± SE	Range	95% CI	Mean ± SE	Range	95% CI
All Van Cats (n = 40)		8.23 ± 0.16	5.2–9.8	7.91–8.55	1.14 ± 0.01	1.0–1.3	1.12–1.17
Gender			*			N.S.	
	Male	8.61 ± 0.28	5.2–9.8	8.04–9.18	1.16 ± 0.02	1.0–1.3	1.12–1.21
	Female	7.85 ± 0.20	6.6–9.2	7.46–8.25	1.13 ± 0.02	1.0–1.3	1.09–1.16
AGE (years)			N.S.			N.S.	
BW			**			N.S.	

N.S. $P > 0.05$, *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$
EF = Ejection fraction; LAD = Left atrial dimension; AOD = Aortic root dimension; LAD/AOD = Left atrial to aortic root ratio.

Table 1 (continued). Van Cats Echocardiographic Measurements With Regard to Age, Gender and Body Weight.

		EPSS (mm)			EDV (ml)		
		Mean ± SE	Range	95% CI	Mean ± SE	Range	95% CI
All Van Cats (n = 40)		2.81 ± 0.11	1.7–4.3	2.60–3.03	6.08 ± 0.31	2.9–11.4	5.44–6.72
Gender			N.S.			N.S.	
	Male	2.97 ± 0.19	2.3–3.8	2.58–3.36	6.37 ± 0.56	3.3–11.1	5.23–7.51
	Female	2.66 ± 0.13	1.7–4.3	2.39–2.93	5.79 ± 0.39	2.9–11.4	4.10–6.58
AGE (years)			N.S.			N.S.	
BW			N.S.			*	
		ESV (ml)			SV (ml)		
		Mean ± SE	Range	95% CI	Mean ± SE	Range	95% CI
All Van Cats (n = 40)		1.10 ± 0.11	0.2–2.7	0.88–1.32	4.98 ± 0.27	2.4–10.4	4.44–5.53
Gender			N.S.			N.S.	
	Male	1.10 ± 0.19	0.4–2.7	0.71–1.49	5.28 ± 0.48	2.7–8.5	4.30–6.25
	Female	1.10 ± 0.13	0.2–2.4	0.83–1.37	4.69 ± 0.33	2.4–10.4	4.01–5.37
AGE (years)			N.S.			*	
BW			N.S.			*	

N.S. $P > 0.05$, *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$
EPSS = the mitral valve E point to ventricular septal separation; EDV = Left ventricule end diastolic volume; ESV = Left ventricule end systolic volume; SV = Stroke volume.

systole ($p < 0.001$).

The LVIDd was higher in males than in females. On the other hand, the LVIDs was higher in females than in males. No statistical difference was found between gender and these parameters. In the same way, the LVID in systole and in diastole were not directly related to age. While LVIDd was related to BW ($p < 0.05$), LVIDs was not.

The LVPW in systole and in diastole were higher in males than in females. These differences were, however, not statistically significant with respect to gender. LVPW was also found not to be related to age. The relation of LVPWd and BW was significant ($p < 0.01$), while the relation of LVPWs and BW was not.

FS, HR and EF were higher in males than in females. These differences were not statistically significant ($p > 0.05$) with respect to gender. Statistical analysis confirmed that there was no difference between these parameters and age as well as BW.

The LAD and AOD were higher in males than in females. This difference was significant ($p < 0.05$) with respect to gender. The same parameters were found to have a statistically significant relationship with BW ($p < 0.01$), while they were not related to age. The LAD/AOD ratio was not related to gender, age and BW in a statistically significant way.

EPSS was found to be higher in males than in females, however, no statistical relevance between this parameter and gender, age and BW could be identified ($p > 0.05$).

EDV was higher in males than in females, while ESV was higher in females. These differences proved not to be statistically significant with respect to gender and age. BW and EDV were found to be statistically related ($p < 0.05$); no such relation could be established between ESV and BW.

SV was higher in males than in females. But this difference was not statistically significant ($p > 0.05$) with respect to gender. Age and BW, however, were found to be statistically related to this parameter ($p < 0.05$).

Discussion

We documented a relationship between gender and LAD and AOD measurements, between BW and IVSd, IVSs, LVIDd, LVPWd, LAD, AOD, EDV and SV measurements, and between age and SV. There were no significant differences between other cardiac dimensions and gender, age and body weight.

The literature on normal echocardiographic parameters of dog breeds such as Beagle, Doberman Pinscher, Spanish Mastiff, Golden Retriever, English Cocker Spaniel, Greyhound, Irish Wolfhound, Anatolian Karabash, German Shepherd, Mixed and English Bull Terrier is quite comprehensive[3,7,12,17,21,22,24,26,28,29,33,37,40]. The same is not true, however, for publications reporting cardiac reference parameters for cats. While normal echocardiographic parameters have been published for the Sphynx, Maine Coon and Mixed[11,13,14,20,27,31] no such information is available for Van cats.

In research on Maine Coon cats, a strong correlation between echocardiographic parameters such as LVIDd, LAD and AOD and body weight has been found[14] with a significant difference in these parameters between male and female cats ($p < 0.05$). The average LVIDd value for male cats was reported as 19.4 ± 1.8 mm which is considerably higher than for females (17.9 ± 2.2 mm). The average LAD values were also higher for males (14.4 ± 1.4 mm) than females (13.2 ± 1.6 mm). The same tendency was observed for AOD, with 11.7 ± 1.2 mm for male and 10.8 ± 1.1 mm for female cats. The findings of the present study show a significant difference in the LAD and AOD parameters for male and female animals ($p < 0.05$) which are similar to the results reported by Drourr *et al.*[14]. The LAD values for male cats were found to be 10.06 ± 0.37 mm and for female cats 8.81 ± 0.26 mm, while the AOD values were 8.61 ± 0.28 mm and

7.85 ± 0.20 mm respectively. The LVIDd parameter in male Van cats was also higher than in females (15.04 ± 0.52 mm and 14.49 ± 0.36 mm resp.), the difference was, however, of no statistical significance. In addition to the previously reported significant relationship of body weight and LVIDd, LAD and AOD[14], in this study a similarly significant statistical correlation was also found for BW and the parameters IVSd, IVSs, LVPWd, EDV and SV.

It has been reported[14] that a body size comparison of female Main Coon cats with domestic cats yielded no significant difference. It was found, however, that the echocardiographic parameters of female Maine Coons were considerably higher than those previously reported for domestic cats. This was interpreted as a consequence of the breed-specific heart size difference. Breed-specific values for echocardiographic parameters have also been demonstrated in Doberman Pinscher dogs without a documented cause[9]. The authors of the paper suggested the examination of other cat breeds in order to determine whether or not their findings applied to other breeds as well. In this study, we found lower parameter values than those in Main Coon cats.

The LVIDd value (18.5 ± 2.1 mm) for Maine Coon cats was found to be considerably higher than for healthy domestic cats (15.0 ± 2.0 mm); the same tendency was seen in the average LAD value 13.7 ± 1.7 mm versus 11.7 ± 1.7 mm, and in the average AOD value with 11.2 ± 1.3 mm for Maine Coon cats and 9.5 ± 1.4 mm for healthy domestic animals[14]. Drourr *et al*.[14] expressed the opinion that the parameter difference could be the result of different average weights (5.5 ± 1.3 kg for Main Coon and 4.7 ± 1.2 kg for healthy domestic cats).

In this present study, the LVIDd value of 14.77 ± 0.29 mm is close to the value for healthy domestic cats (15.0 ± 2.0 mm) reported in[14], while the average LAD and AOD values, 9.43 ± 0.21 mm and 8.23 ± 0.16 mm respectively, are markedly lower than the data reported for healthy domestic cats (11.7 ± 1.7 mm and 9.5 ± 1.4 mm resp.). For Van cats these parameters are lower with respect to both domestic and Main Coon cats. The reason for this may be their overall lower average weight (3.67 ± 0.66 kg).

In one paper[20], a significant positive correlation ($p < 0.05$) was found between BW and AOD, LAD, IVSs, LVPWd, LVPWs, LVIDd, the right ventricular internal dimension at end-diastole (RVIDd) and the right ventricular internal dimension at end-systole (RVIDs). With respect to positive correlations, in this study a statistically significant relationship was found for BW and LAD, AOD, IVSs and LVPWd, which also corresponds to the findings in[20]. Jacobs and Knight[20] explained the weak correlation between some dimensional measurements and body weight with the heterogenic sample population used in the study, with the variation in the cats' body conformation and the fact that some were outdoor and others indoor cats.

In a study[27] whose purpose was to determine 2-D and M-mode normal reference values for unsedated healthy young adult Sphynx cats, and to compare them with domestic shorthair cats (DSH), the differences only in a few echocardiographic parameters were found. Only the LA dimension measured in 2-D and M-mode, the LAD/AOD ratio, and the LVIDs, measured in M-mode, were found to be significantly higher in Sphynx cats. The same study also compared the values for male and female animals and reported significantly higher LAD and AOD, measured 2-dimensionally, as well as M-mode-measured LAD, AOD, LVIDd and LVPWd in the male specimen. Researchers attributed this difference between male and female animals to the higher body weight of male Sphynx cats. In the present study, LAD and AOD were also found to be higher in males than in females ($p < 0.01$). We also attribute the higher LAD and AOD parameter values found in male cats to their higher body weight.

In other research work[25,30,38] FS's importance for the left ventricular function is highlighted, and it is reported to be a significant parameter for hypertrophic and dilated cardiomyopathy in cats. In other papers[13,35] FS is not found to be related to age, body volume and HR. One FS value was published as 44 ± 13%[35]. In another study, the normal FS value range is given as 29–55%[2]. The FS value range determined in this study is 30–60%. As in previously reported work, we could not find a statistically significant relation between this parameter and gender, age or BW.

The heart rate of Sphynx cats was considerably higher (187 bpm) than in DSH (156 bpm). The researchers in study[27] explain this fact with the young age of the Sphynx cats since young cats have higher HR than adult animals[35]. However, young animals may also be more prone to stress during echocardiographic examination[19]. In the present study, the heart rate of Van cats reached 180 beats/min. The reason for this finding may be the same as in[27], the young age of the animals.

Another important parameter for cardiac function is the left ventricular dimension EF, measured with M-mode echocardiography[1,35]. EF was found not to be correlated with BW, BSA, HR and age[24,35]. In a study on cats[35], the EF was found to be 79 ± 3%; it was higher than values reported for dogs[29]. Some researchers[35] have pointed out that more research is necessary to establish the importance and general validity of EF measurements in cats. It was found that the functional echocardiographic indices EF and FS are not influenced by corporal growth up to the third month of life, and that they are not correlated with it. Instead, it was reported[35] that these indices are valid irrespective of the cats' age and body size. The findings of this present study on Van cats support the literature data; also, we could not find a statistically significant relationship between EF and gender, age or body weight.

It has been reported[27] that the LA dimension may be a good indicator of preload alteration in the beginning development of HCM. HCM, characterized by a slight elevation in the LA size (as well as the consecutive elevation of the LA/AO ratio) should be considered in the cardiac examination of normal Sphynx cats before breeding. In Sphynx cats, a high correlation has been found between BW and some echocardiographic parameters (LA and AOD in 2-D; LA, AOD and LVPWd in M-mode). However, the relationship between the echocardiographic parameters and age was reported to be either weak or non-existent. In the present study, no age relation of statistical significance could be found between age and echocardiographic parameters, with the exception of SV.

In another study on 25 normal healthy cats of different breeds, the aortic root dimension and the left atrial dimension were found to be similar, with an average value of 7.5 ± 1.8 mm. It was reported that the relationship between the LAD and AOD parameters were used as source for the determination of atrial dilatation[31]. In the present study, the measured values for the aortic root and the left atrial dimensions are 8.23 ± 0.16 mm and 9.43 ± 0.21 mm, respectively.

The difference in the 2-D echocardiographic values of standard body weight cats compared with obese cats was reported to be insignificant[23]. Many cardiologists have used reference values for adult cats without taking body weight into consideration[18]. In another study[13] it has been reported that no consistent correlation could be found between cardiac dimensions and body weight. It was further reported in the cited study that, while the relationship between BW and parameters such as LVPW, IVS thickness and AOD was significant, the same could not be said of other echocardiographic parameters. In the present study, and in addition to previously reported results[13], we found a statistically significant relationship between body weight and LVIDd, LAD, EDV and SV.

In a study on 79 healthy and DCM (dilated cardiomyopathy) cats[36] plasma taurin concentrations were determined and M-mode echocardiographic measurements taken in order to examine the relationship between body weight and LVIDd, LVIDs, LVPWd, LVPWs, IVSs, AOD and LAD. Only a weak correlation could be established. No relationship was found between BW and other dimensional values (RVIDd, IVSd and EPSS) and calculated indices (FS %, LA/AO ratio). In this study on Van cats we found the following statistically significant BW relationships: with LVIDd ($p < 0.05$), with LVPWd, LAD and AOD ($p < 0.01$), with IVSd and IVSs ($p < 0.001$). No statistical significance could be found between body weight and LVIDs, LVPWs, LAD/AOD, FS and EPSS.

It has repeatedly been reported that cardiac dimension in dogs correlate with body weight[7,21,24]. In cats, however, the relationship is weak. The following reference value ranges have been reported: LVIDd 11–16 mm, LVIDs 6–10 mm, IVSd 2.5–5 mm, IVSs 5–9 mm, LVPWd 2.5–5 mm, LVPWs 4–9 mm, LAD 8.5–12.5 mm, AOD 6.5–11 mm, LAD/AOD 0.8–1.3 and FS 29–55%[4,5]. In this present study, a statistically significant relationship has been found between body weight and the following cardiac parameters: IVSd, IVSs, LVIDd, LVPWd, LAD, AOD, EDV and SV. They are all within the reported reference value range.

However, the results of the study on adult Sphynx cats[27] harmonize better with the findings in two other papers[8,20] which established a direct correlation between BW and echocardiographic values. In the present study, we found a direct and significant relationship between BW and many parameters (IVSd, IVSs, LVIDd, LVPWd, LAD, AOD, EDV and SV), but not with all those reported in the cited studies.

In a study on Domestic shorthair, British shorthair and Abyssinian cats from birth to three months old carried out with the purpose of establishing M-mode echocardiographic reference values[35], a significant relationship was reported between body weight and age and the parameters LVIDd, LVIDs, IVSs, IVSd, LVPWd, LVPWs, LAD and AOD. However, no correlation of importance could be found between BW and age and the parameters FS, EF and the LAD/AOD ratio. In this study we found a significant correlation between body weight and IVSd, IVSs, LVIDd, LVPWd, LAD, AOD, EDV and SV, while age was significantly correlated only to SV.

In a study on EDV, ESV and SV, involving 25 cats[10], the EDV value was found to be 6.2 ± 2.08 ml; that is slightly more than the volume we found for Van cats (6.08 ± 0.31 ml). The ESV value in that study (1.7 ± 0.69 ml) was considerably higher than the present study value of 1.10 ± 0.11 ml, while SV value (4.98 ± 0.27 ml) found in the present study was higher than the corresponding value (4.5 ± 1.59 ml).

In recent years, Van cats have enjoyed increasing popularity both in Turkey and abroad leading to a decrease in cat populations and the introduction of protective measures. Despite their prominence, no study has as yet been carried out to establish cardiac reference values. In general, cardiomyopathies are the most common type of cardiac disease seen in cat. HCM is constituting the most common myocardial disease and diagnosed in approximately two thirds of the cases. Together with appropriate treatment measures taken in the light of the normal range, cardiac reference values will benefit cardiac health in Van cats that may have this disease, as well as aiding in the diagnosis of HCM.

In conclusison, in this study, we have established differences between healthy adult Van cats and other cat breeds, and between certain M-mode echocardiographic parameters. We have also determined values for EF, EPSS, EDV, ESV and SV which have not been considered in detail in previous work. The results of this study will aid in the interpretation of echocardiographic findings and in the distinction between healthy and unhealthy Van cats. After having established, for the first time, M-mode echocardiographic reference values for this indigenous cat, we plan to continue our research on Van cats to measure Doppler parameters of transmitral flow and pulmonary venous flow.

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