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Research Article

Comparison of M mode echocardiographic ratio indices in two breeds of dog: Effect of variable age and body weight on cardiac indices

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Abstract

The study was conducted at TVCC- RVP IVRI, Izatnagar, Bareilly on 34 dogs of two different breeds, i.e. Spitz and Labrador Retriever. Seventeen healthy dogs of each breed were included and randomly divided into three groups of varying ages containing at least 5 animals in each group. M mode echocardiographic parameters were recorded for each animal for left ventricular cardiac measurements. The raw M mode measurements were divided by weight based aortic root dimension to obtain weighted echocardiographic ratio indices which are assumed to be least affected by body weight and size, and can be used for direct comparison between patient groups. Ratio indices were statistically analyzed to determine the effect of varying age and breed. Weighted left ventricular dimensions were correlated with body weight through Pearson's correlation coefficient to determine the effect of varying body weight over weighted ratio indices. The results signify a non-significant effect of breed, age, and body weight on derived ratio indices and thus can be suggested to be used for direct comparison for cardiac disease diagnosis in dogs despite of wide range of body weight.

Keywords: Dog, M mode echocardiography, Weighted ratio indices

Highlights

- Weighted M mode echocardiographic indices are non-significantly variable between small and medium breed of dog.
- Weighted M mode echocardiographic indices are non-significantly variable between different age groups of dog.
- Weighted M mode echocardiographic indices are weekly correlated with body weight of dogs.
- Weighted echocardiographic indices can be used for direct comparison with clinical cases of any size and weight of dogs.

INTRODUCTION

Echocardiography has gained much importance as routine practice in veterinary medicine for diagnosis and evaluation of cardiac diseases (Reetu *et al*., 2017; Hoque *et al*., 2019). Early haemodynamic alterations in diseases like mitral regurgitation are being evaluated easily through advanced techniques such as tissue Doppler imaging with an efficiency equivalent to gold standards (Kim and Park, 2015). While newly emerged Doppler is used to evaluate cardiac hemodynamic parameters, the quantification of cardiac dimensions still relies on two dimensional and M mode echocardiography (O'Grady *et al*., 1986; Rishniw *et al*., 2021). B mode, M mode and Doppler echocardiography step together for confirmatory diagnosis in any cardiac alteration. However, wide range in echocardiographic measurements of cardiac dimension owing to largely varying body weight among dogs hinders the scope of direct comparison among patient groups for clinical settings (Morrison *et al*., 1992). Existence of

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different breeds among dogs has been emphasized as an important factor responsible for wide echocardiographic reference ranges (Morrison *et al*., 1992; Page *et al.*, 1993). The measurement being used is to be compared with weight based data of echocardiographic measurements established by various authors. Other method has been reported for variable body sizes and weight but almost identical body shape as in dogs of similar somatotype, where M mode measurements can be compared to a provided static length such as withers height or crown rump length instead of conventionally used body weights. In such case also, the measurements have to be compared according to breed or specific somatotype of the dog which need to be established first.

Brown *et al.* (2003) has proposed a method of measurement expressing cardiac dimension in various indices via dividing raw M mode measurements by aortic root dimension for feline, canine and equine. Concepts behind such ratio lie in the assumption that measurement of dimension is greater in large animals and smaller in small animal, however, ratios of any two comparable lengths or area or volume would be similar for two different sized individuals. Ratio indices are such ratios of variable M mode parameter which do not vary according to weight and size of dogs, and a fixed range can be used for any size of dogs (Brown *et al.*, 2003). Their survey study, however required further support work for authenticity as effect of various factors has not been mentioned. With a positive assumption present study was conducted to investigate the effect of factors such as breed of different categories (small and medium), age group and variable body weight which could affect these ratio indices.

MATERIALS AND METHODS

The study was carried out in Referral Veterinary Polyclinics-Teaching Veterinary Clinical Complex, IVRI, Bareilly. Thirty-four healthy dogs of small sized breed, i.e., Spitz (17) and medium sized breed, i.e., Labrador retriever (17) were selected for the study. These dogs were subjected to routine electrocardiography and chest radiography to ascertain the healthy cardiac condition. M mode echocardiography was performed in all the dogs to evaluate left ventricular and aortic dimensions. Dogs of each breed were categorized into three groups according to age with at least 5 animals in each group. Recorded echocardiographic parameters of cardiac dimensions were used to evaluate weighted M mode ratio indices by dividing left ventricular parameters with weight bases aortic root dimension (Ao_w) as described by Brown *et al.* (2003). Weight based aortic root dimension was calculated by formula $Ao_w = kW^{1/3}$, where k is a constant = 0.010, and W is weight of the animal. The following weighted/indexed parameters were calculated:

i. wLVIDd = Index left ventricular internal dimension, diastole
ii. wLVIDs = Index of left ventricular internal dimension, systole
iii. wIVSd = Index of inter-ventricular septal thickness, diastole
iv. wIVSs = Index of inter-ventricular septal thickness, systole
v. wLVWd = Index of left ventricular wall thickness, diastole
vi. wLVWs = Index of left ventricular wall thickness, systole
vii. wLVODd = Index of left ventricular outer dimension, diastole
viii. wLVODs = Index of left ventricular outer dimension, systole
ix. wWTd = Index of combined septal and left ventricular wall thickness, diastole
x. wWTs = Index of combined septal and left ventricular wall thickness, systole
xi. wΔA = Index of change in left ventricular internal area i.e., short-axis stroke area
xii. wWAd = Index of left ventricular short-axis myocardial wall area, diastole
xiii. wWAs = Index of left ventricular short-axis myocardial wall area, systole
xiv. FWTd (cm) = Fractional LV myocardial wall thickness, diastole

xv. FWTs (cm) = Fractional LV myocardial wall thickness, systole
xvi. FΔA = Fractional change in LV internal area
xvii. FWAd (cm^2) = Fractional LV myocardial wall area (short axis), systole
xviii. FWAs (cm^2) = Fractional change in LV myocardial wall area (short axis), diastole

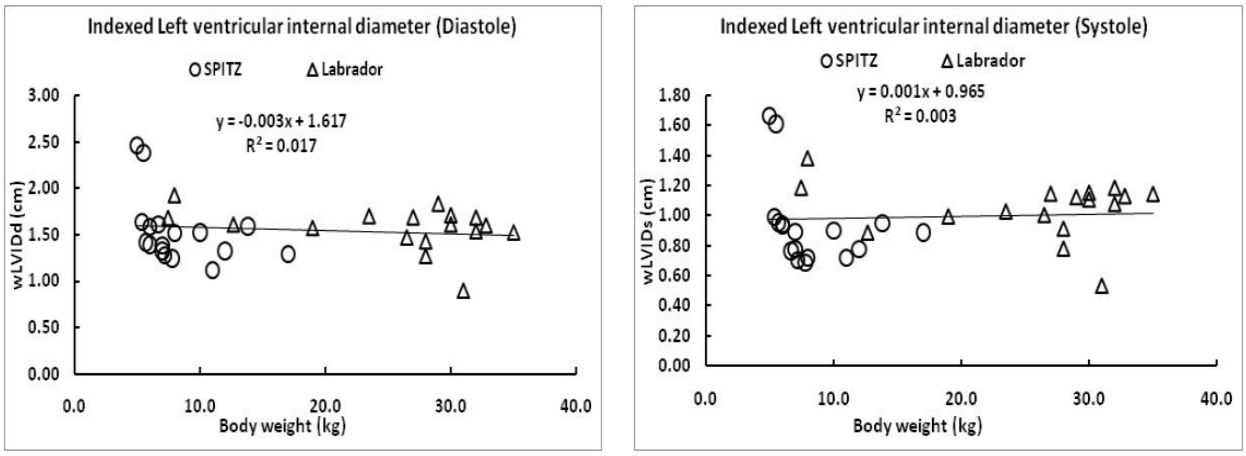
Calculated parameters were analyzed through ANOVA to determine the variance between different age groups and breeds. Weighted left ventricular dimensions were also correlated with body weight through Pearson's correlation coefficient to determine the effect of varying body weight over weighted ratio indices.

RESULTS

Body weight of Spitz breed dogs included in the study was non-significantly variable in all three age groups with a mean ± SD of 8.3±3.37 kg. However, Labrador retrievers had significantly high ($p<0.05$) body weight as compared to the Spitz in each age groups with a mean ± SD of 25.41±8.54. Mean ± SD of age was 5.84±0.74 years, 8.7±2.9 years and 9.77±4.08 years in group A1, A2, and A3, respectively, while 0.6±0.33 years, 4.14±1.44 years and 9.13±1.18 years in B1, B2 and B3, respectively were recorded. Mean ±SD values of all the weight indexed parameters calculated for left ventricle dimensions are found non-significantly variable between different age groups in two breeds (i.e. between A1, A2, and A3 of Spitz breed and B1, B2 and B3 of Labrador retriever breed) as well as between the breeds (Table 1). The present study found weak correlation of various ratio indices for left ventricular dimensions with varying body weight of dogs as well, i.e., R2 = 0.017 and 0.003 for wLVIDd and wLVIDs, respectively (Fig. 1), R2 = 0.151 and 0.161 for wIVSd and wIVSs, respectively (Fig. 2), R2 = 0.105 and 0.188 for wLVPWd and wLVPWs, respectively

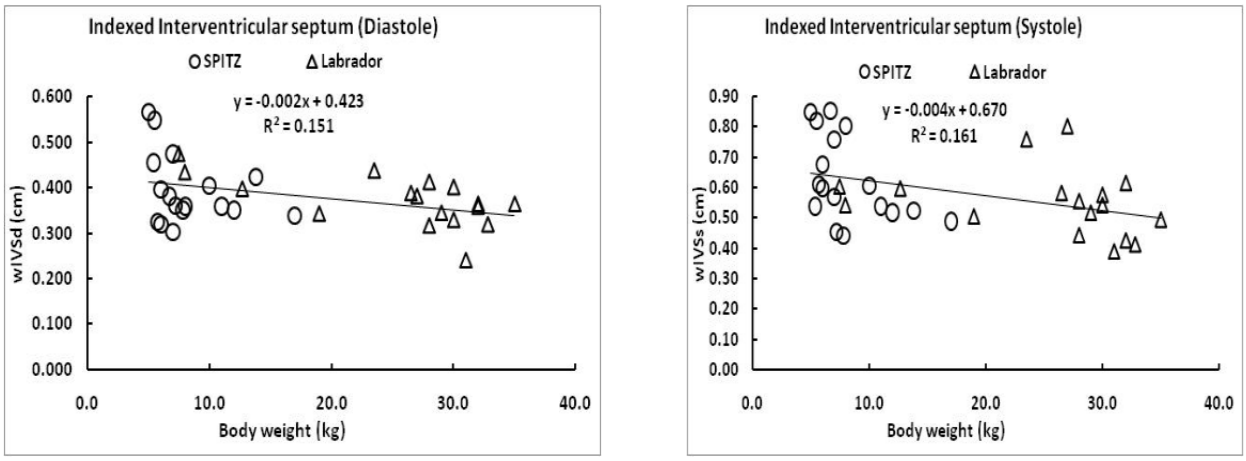
Table 1. Breed and group wise comparison of M mode- Indexed parameters in Spitz and Labrador retriever

Parameters	Breed								Between breeds		
	Spitz			p-value	Labrador			p-value	Spitz	Labrador	p-value
	A_1	A_2	A_3		B_1	B_2	B_3		A	B	
wLVIDd (cm)	1.80±0.57	1.45±0.17	1.41±0.18	0.13	1.70±0.14	1.60±0.19	1.42±0.30	0.16	1.54±0.36	1.58±0.23	0.71
wLVIDs (cm)	0.91±0.39	0.76±0.11	0.85±0.10	0.061	1.10±0.19	1.05±0.15	0.98±0.26	0.67	0.93±0.29	1.05±0.19	0.18
wIVSDd (cm)	0.41±0.13	0.37±0.03	0.40±0.05	0.77	0.41±0.05	0.37±0.03	0.36±0.06	0.062	0.39±0.08	0.37±0.06	0.33
wIVSs (cm)	0.69±0.13	0.61±0.20	0.59±0.10	0.063	0.60±0.10	0.56±0.13	0.49±0.08	0.24	0.63±0.14	0.55±0.11	0.10
wLVPWd (cm)	0.46±0.19	0.35±0.03	0.36±0.08	0.30	0.36±0.06	0.33±0.05	0.31±0.06	0.34	0.38±0.12	0.34±0.05	0.15
wLVPWs (cm)	0.60±0.17	0.57±0.08	0.51±0.10	0.45	0.52±0.07	0.50±0.06	0.42±0.08	0.09	0.55±0.12	0.48±0.08	0.06
wLVODd (cm)	2.66±0.90	2.17±0.22	2.16±0.29	0.21	2.48±0.17	2.30±0.24	2.07±0.40	0.10	2.31±0.55	2.28±0.31	0.84
wLVODs (cm)	2.50±0.70	1.94±0.16	1.95±0.22	0.06	2.22±0.18	2.12±0.29	1.89±0.40	0.23	2.11±0.46	2.08±0.30	0.85
wWTd (cm)	0.87±0.33	0.72±0.05	0.75±0.13	0.46	0.78±0.10	0.70±0.08	0.64±0.10	0.08	0.78±0.19	0.71±0.10	0.20
wWTs (cm)	1.29±0.31	1.18±0.16	1.09±0.19	0.17	1.12±0.14	1.07±0.18	0.91±0.15	0.12	1.18±0.22	1.04±0.17	0.06
WΔA	1.89±1.16	1.54±0.41	1.29±0.37	0.26	1.67±0.20	1.45±0.36	1.08±0.33	0.058	1.54±0.71	1.41±0.38	0.49
wWAd (cm^2)	4.25±2.90	2.62±0.46	2.73±0.74	0.22	3.28±0.52	2.74±0.51	2.30±0.70	0.06	3.15±1.70	2.77±0.67	0.40
wWAs (cm^2)	5.04±2.65	3.20±0.60	3.09±0.78	0.06	3.72±0.59	3.43±0.96	2.67±0.88	0.16	3.7±1.70	3.29±0.90	0.39
FWTd (cm)	0.32±0.01	0.33±0.02	0.35±0.02	0.10	0.32±0.03	0.31±0.02	0.31±0.02	0.76	0.34±0.02	0.31±0.02	0.062
FWTs (cm)	0.52±0.02	0.61±0.05	0.56±0.05	0.40	0.51±0.06	0.50±0.04	0.49±0.06	0.82	0.56±0.05	0.5±0.05	0.057
FΔA	0.55±0.04	0.72±0.06	0.63±0.05	0.06	0.58±0.09	0.56±0.05	0.53±0.08	0.52	0.63±0.08	0.56±0.07	0.06
FWAd (cm^2)	0.54±0.02	0.55±0.02	0.57±0.03	0.09	0.53±0.04	0.52±0.03	0.53±0.03	0.76	0.56±0.03	0.52±0.03	0.061
FWAs (cm^2)	0.77±0.02	0.84±0.05	0.80±0.04	0.43	0.75±0.07	0.75±0.04	0.73±0.06	0.81	0.81±0.05	0.75±0.05	0.061



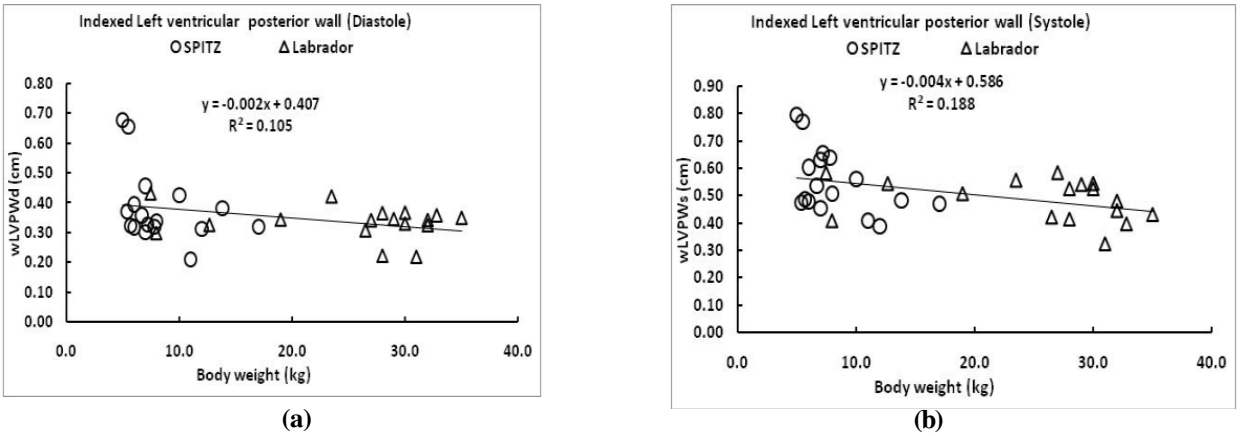
(a) (b)

Fig. 1. Regression line for weighted left ventricular internal diameter against body weight, a) Line for wLVID at diastole, b) Line for wLVID at systole



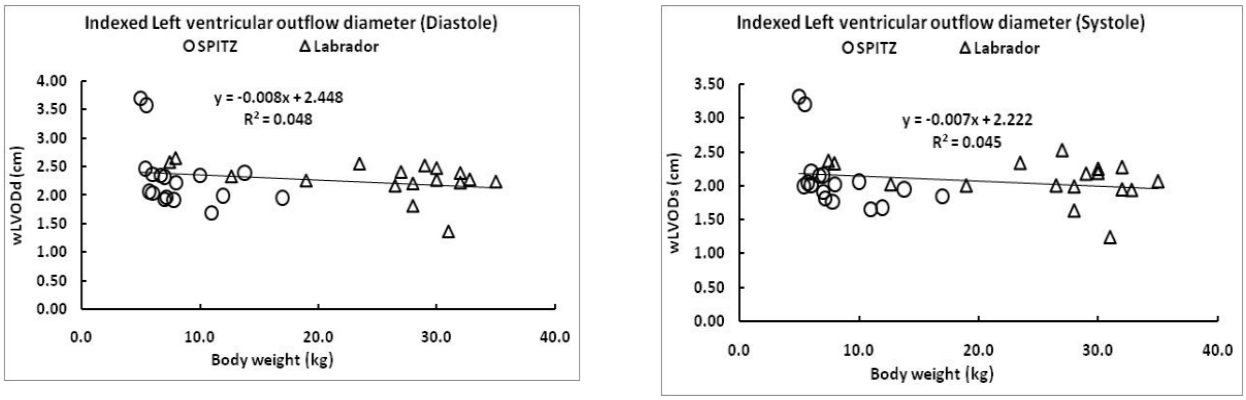
(a) (b)

Fig. 2. Regression line for weighted inter-ventricular septal thickness against body weight, a) Line for wIVS at diastole, b) Line for wIVS at systole



(a) (b)

Fig. 3. Regression line for weighted left ventricular posterior wall thickness against body weight, a) Line for wLVPW at diastole, b) Line for wLVPW at systole



(a) **(b)**

Fig. 4. Regression line for weighted left ventricular outflow diameter against body weight, a) Line for wLVOD at diastole, b) Line for wLVOD at Systole

(Fig. 3), R2 = 0.048 and 0.045 for wLVODd and wLVODs, respectively (Fig. 4). The recorded values were under normal physiological ranges as according to weight based derived reference ranges established by various authors earlier.

DISCUSSION

Echocardiographic dimensions of canine heart show obvious variation in body weight and size, varying greatly in different breeds and categories of dogs. Since the past, various studies have endeavoured towards the establishment of echocardiographic reference ranges for dogs (Gugjoo *et al.*, 2014 a,b,c; Bodh *et al*., 2016; 2019). Many authors have established reference values for various left ventricular cardiac dimensions in different breeds of dogs (Gooding *et al.*, 1982; O'Grady *et al.*, 1986); meanwhile, some have reported a significant variation in these values (Morrison *et al.*, 1992). Range values for various breeds including Cocker Spaniel (Gooding *et al.*, 1982), Pembroke Welsh Corgi, Miniature Poodle, Afghan Hound and Golden Retriever (Morrison *et al.*, 1992), Beagle (Crippa *et al.*, 1992), Greyhound (Page *et al.*, 1993), Spanish mastiff (Bayon *et al.*, 1994), Bull Terrior (O'Leary *et al.*, 2003), Karabash (Kayar and Uysal, 2004), German Shepherd (Kayar *et al.*, 2006; de Oliveira *et al*., 2014), Whippets (Bavegems *et al.*, 2007), Spitz (Bodh *et al.*, 2016, 2019; Reetu *et al.*, 2019), dogue de Bodeaux dogs (Locatelli *et al.*, 2011), Indonesian mongrel dogs (Noviana *et al.*, 2011), Yorkshire Terrier (Castro *et al.*, 2011), Border Collies (Jacobson *et al.*, 2013), Labrador retriever (Gugjoo *et al.*, 2014a,b,c; Bodh *et al.*, 2016, 2019) and Indian Mongrel (Singh *et al.*, 2018) has been reported. Reference ranges observed to vary greatly between the breeds and within same breed owing to different body size, weight and confirmation. Strong correlation has been reported between left ventricular dimension and body surface area of dogs (Morrison *et al*., 1992; Page *et al.*,1993). However, the method used for the quantification and interpretation of M-mode echocardiographic measurements in which each cardiac dimension is expressed as an index derived by dividing the raw measurement by the aortic root dimension can be used over a wide range of dog sizes. As the present study results indicated the non-significant variation of ratio indices parameters in two different categories of dogs, in addition, measurements of these parameters didn't differ significantly according to the age and body weight of dogs. This can draw an inference of the non-significant effect of breed, age and body weight on these ratio indices. Previous studies of normal and abnormal echocardiographic measurements for

dogs have relied on linear regressions of M-mode dimensions against body weight or surface area, which often fails to meet the statistical prerequisites that data be distributed normally about the linear model prediction and that the variance not change appreciably with the independent variable. There is an advantage of comparing linear M mode echocardiographic measurements to a static length, i.e., either the measured withers height or crown rump length instead of conventionally used body weight. The observation they concluded on the basis of their study on a wide range of body sizes with nearly identical shapes for which dogs of specific somatotype were selected (i.e., Greyhounds, Whippets and Italian Greyhounds). The ratio index method rather facilitates direct comparison among individuals instead comparison with body weight or static lengths; hence a direct diagnosis for diseased could be reached.

The quantitative indices thus obtained can be considered valid for dogs and suggested to be used as reference values for them over a wide range of body weights and varying ages of small and medium breeds.

M mode echocardiographic parameters of dogs revealed a non-significant effect on breed, age, and body weight on derived ratio indices; thus, can be suggested to be used for direct comparison for cardiac disease diagnosis in dogs despite of wide range of body weight.

Conflict of interest: Authors have no conflict of interest in this study.

Author's contribution: R: Clinical examination, echocardiography, recording and analysis of data, writing of the manuscript; MH: Research design, supervision, echocardiography and writing; ACS: Echocardiography; NKV, KE, PP: Clinical examination of dogs and collection of data.

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