Detection of innocent systolic murmurs by auscultation and their relation to hematologic and echocardiographic findings in clinically normal Whippets

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Objective—To determine murmur prevalence by auscultation of 105 apparently healthy Whippets without signs of cardiac disease, to determine the origin of these murmurs, and to evaluate the influence of sex, type of pedigree (ie, bred for showing or racing), and training on these murmurs.

Design—Cross-sectional study.

Animals—105 client-owned Whippets.

Procedures—All dogs were auscultated by the first author and underwent a complete physical and cardiological examination, together with a hematologic assessment. Several RBC variables and echocardiographic variables were compared between dogs with or without a murmur at the level of the aortic valve.

Results—44 of 105 (41.9%) dogs had no murmur. A soft systolic murmur was present with point of maximal intensity at the level of the aortic valve in 50 (47.6%) dogs, at the level of the pulmonic valve in 8 (7.6%) dogs, and at the level of the mitral valve in 3 (2.9%) dogs. No significant differences were found in heart rate, rhythm, murmur presence, point of maximal intensity, and murmur grade between males and females, between dogs with race- and show-type pedigrees, or between dogs in training and not in training. Dogs with a murmur at the level of the aortic valve had a significantly higher aortic and pulmonic blood flow velocity and cardiac output, compared with dogs without a murmur.

Conclusions and Clinical Relevance—Whippets have a high prevalence of soft systolic murmurs in the absence of any structural abnormalities, which fit the description of innocent murmurs. No influence of sex, pedigree type, or training was found on the occurrence of these murmurs in Whippets. (*J Am Vet Med Assoc* 2011;238:468–471)

Auscultation has been an important means to assess heart disease, but the widespread use of Doppler echocardiography in the last 2 decades has considerably diminished its use, causing parallel decreases in skill and confidence in its interpretation. Auscultation, however, remains the primary diagnostic tool for the interpretation of heart murmurs, and it is essential for making decisions about referring patients for echocardiography.[1,2] Congenital or acquired heart disease can contribute to the development of systolic murmurs, but so can physiologic factors.[3] Physiologic murmurs (also referred to as functional or innocent murmurs) are often caused by increased CO or decreased blood viscosity, usually occur early in the systole, and are low in intensity.[2–4] Physiologic murmurs are the loudest at the aortic or pulmonic valve regions and do not radiate extensively.[3,4] In human as well as in veterinary medicine, several articles report the occurrence of systolic murmurs that result from athletic training. Systolic murmurs of low intensity are detected in 30% to 50% of highly trained human athletes and are probably related to the so-called athletic heart syndrome.[5–7] In veterinary medicine, sled dogs and racehorses were reported to have higher prevalence of systolic murmurs due to athletic training.[8–13] Retired racing Greyhounds were also reported to have a higher prevalence of systolic murmurs without any structural abnormalities.[10,13]

Abbreviations

CO	Cardiac output
SV	Stroke volume
VAo	Aortic blood flow velocity
VPulm	Pulmonic blood flow velocity

The purposes of the study reported here were to determine the prevalence of murmurs in Whippets and to characterize them, to determine possible correlations with other Whippet-specific findings, and to evaluate the influence of sex, type of pedigree (ie, bred for showing or racing), and training on the occurrence of these murmurs.

Materials and Methods

Dogs—Privately owned, apparently healthy Whippets without signs of cardiac disease (n = 125) were re-

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cruited through contacts with breeders and owners. All dogs underwent complete physical and cardiological examinations (auscultation, electrocardiography, and echocardiography). Hematologic assessment was also undertaken. The following RBC variables were used for comparison between dogs with or without murmurs at the level of the aortic valve: Hct, hemoglobin concentration, and RBC count. Dogs that were < 10 months of age (n = 11), that had cardiac abnormalities (ie, moderate to severe mitral regurgitation or a ≥ grade 4/6 murmur; 3), or that had incomplete data (6) were excluded from the study.

The study included 105 dogs (51 males and 54 females) that were between 10 and 169 months old (mean ± SD, 59.7 ± 39.3 months; median, 50 months). Dogs weighed between 9.3 kg (20.5 lb) and 17.2 kg (37.9 lb) with a mean body weight of 13.2 ± 2.1 kg (29.1 ± 4.6 lb). Dogs were recruited from race-bred lines (n = 89), show-bred lines (10), or were crosses between race- and show-bred lines (6). Of the 89 dogs with racing pedigrees, 6 dogs were not yet in training, 62 dogs had been in active training for sight hound races for 2 to 78 months (mean, 30.9 ± 22.8 months; median, 24 months), and 21 had been retired and ceased training for 7 to 80 months (mean, 31.9 ± 21.1 months; median, 27 months). The 6 dogs not yet in training were combined with the 21 retired dogs that had ceased training to form the group of 27 dogs with racing pedigrees that were not in training.

Auscultation and echocardiography—All Whippets were auscultated while quietly standing on an examination table by the first author (VCB) using a pediatric stethoscope.[a] Heart rate, rhythm, and presence of cardiac murmurs were evaluated as well as the timing of murmurs in relationship to the cardiac cycle and point of maximal intensity. Systolic murmurs were graded as follows: grade 1/6, faintest murmur detectable and heard only with particular effort; grade 2/6, faint murmur clearly heard after a few seconds of auscultation by an experienced examiner; grade 3/6, moderately loud and easily heard murmur; grade 4/6, loud murmur that does not produce a palpable thrill; grade 5/6, very loud murmur that produces a thrill but is inaudible with removal of the stethoscope from the chest wall; and grade 6/6, very loud murmur that produces a thrill and is audible even after removal of the stethoscope from the chest.[3,14]

Echocardiographic variables were obtained as described previously.[15] The unsedated Whippets were consecutively positioned in right and left lateral recumbency (the former for right parasternal M-mode and 2-D measurements and the Doppler study of the pulmonic valve and the latter for the Doppler study of the aortic, mitral, and tricuspid valves). All echocardiographic studies were performed by the first author (VCB) using an ultrasound unit[b] with a 5-MHz mechanical sector transducer with color and spectral Doppler capabilities. All echocardiographic measurements were made in accordance with the guidelines of the American Society of Echocardiography by use of the leading-edge to leading-edge method of measurement. For all M-mode and 2-D measurements, a lead II ECG was recorded simultaneously and 3 representative cycles were measured and averaged with the respective heart rate. The following variables were used for comparison between dogs with or without murmurs at the level of the aortic valve: interventricular septum thickness in diastole and systole, left ventricular internal diameter in diastole and systole, left ventricular wall thickness in diastole and systole, fractional shortening, aortic root diameter, left atrial diameter, VAo, VPulm, CO, and SV.

Statistical analysis—An ANOVA was used to compare sex, pedigree type, and the effect of training in dogs with racing pedigrees with respect to heart rate. The Fisher exact test was used to compare sex, pedigree type, and the effect of training in dogs with racing pedigrees with respect to rhythm, murmur presence, and point of maximal intensity. The Wilcoxon rank sum test was used to compare sex, pedigree type, and the effect of training in dogs with racing pedigrees with respect to the murmur grade. An ANOVA was used to compare dogs with or without murmurs at the level of the aortic valve with respect to RBC and echocardiographic variables. Unless otherwise stated, results are expressed as mean ± SD values. Values of $P < 0.05$ were considered significant.

Results

Auscultatory findings—Eighty-three of 105 (79%) dogs had a respiratory sinus arrhythmia with a heart rate of 89 ± 17 beats/min, whereas 22 (21%) dogs had a regular rhythm with a heart rate of 116 ± 17 beats/min. No cardiac arrhythmias were detected during auscultation. Forty-four of 105 (41.9%) dogs had no murmur. Fifty of 105 (47.6%) dogs had a systolic murmur with point of maximal intensity at the level of the aortic valve, which was a grade 1/6 murmur in 29 (27.6%) dogs, a grade 2/6 murmur in 17 (16.2%) dogs, and a grade 3/6 murmur in 4 (3.8%) dogs. Eight of 105 (7.6%) dogs had a systolic murmur with point of maximal intensity at the level of the pulmonic valve, which was a grade 1/6 murmur in 4 (3.8%) dogs and a grade 2/6 murmur in the other 4 (3.8%) dogs. Three of 105 (2.9%) dogs had a systolic murmur with point of maximal intensity at the level of the mitral valve, which was a grade 1/6 murmur in 1 (1%) dog and a grade 2/6 murmur in the other 2 (1.9%) dogs. No diastolic or continuous murmurs were detected.

Comparison between male and female dogs—No significant differences were found between males and females with respect to heart rate ($P = 0.73$), rhythm ($P = 0.63$), murmur presence ($P = 0.84$), point of maximal intensity ($P = 0.87$), and murmur grade ($P = 0.71$).

Comparison between dogs with racing pedigrees (in training and not in training) and show pedigrees—No significant differences were found between dogs with racing or show pedigrees with respect to heart rate ($P = 0.29$), rhythm ($P = 1.00$), murmur presence ($P = 0.51$), point of maximal intensity ($P = 0.59$), and murmur grade ($P = 0.39$). Also, no significant differences were found between dogs in training and not in training from race-bred lines with respect to heart rate ($P = 0.27$), rhythm ($P = 0.78$), murmur presence ($P = 0.65$), point of maximal intensity ($P = 0.17$), and murmur grade ($P = 0.60$).

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Table 1—Mean ± SD values of several variables in 94 Whippets with or without a systolic murmur at the level of the aortic valve.

Variable	Dogs with a murmur at the level of the aortic valve (n = 50)[a]	Dogs without a murmur (n = 44)[b]	*P* value
Hct (%)	46.4 ± 4.1	45.5 ± 4.0	0.29
Hb (mmol/L)	10.4 ± 1.0	10.2 ± 0.9	0.29
RBC ($\times 10^{12}$ cells/L)	6.9 ± 0.7	6.7 ± 0.6	0.23
IVSd (mm)	9.6 ± 1.3	9.1 ± 1.1	0.062
LVDd (mm)	37.4 ± 3.8	36.9 ± 3.8	0.59
LVWd (mm)	8.8 ± 1.1	8.8 ± 1.1	0.70
IVSs (mm)	12.3 ± 1.6	11.8 ± 1.5	0.16
LVDs (mm)	27.1 ± 3.6	26.6 ± 3.7	0.47
LVWs (mm)	12.4 ± 1.5	12.5 ± 1.6	0.71
FS (%)	27.5 ± 5.2	28.0 ± 5.3	0.60
Ao (mm)	18.9 ± 1.7	19.1 ± 1.7	0.70
LA (mm)	26.4 ± 3.2	26.4 ± 3.1	1.00
VAo (m/s)	1.47 ± 0.24	1.29 ± 0.23	< 0.001*
VPulm (m/s)	1.19 ± 0.21	1.08 ± 0.24	0.013*
CO (L/min)	5.06 ± 1.26	4.39 ± 1.34	0.023*
SV (mL/beat)	51.1 ± 10.5	47.0 ± 12.0	0.11

*Significant ($P < 0.05$) difference in variable between groups.

Ao = Aortic root diameter (2-D). FS = Fractional shortening. Hb = Hemoglobin concentration. IVSd = Interventricular septum thickness in diastole. IVSs = Interventricular septum thickness in systole. LA = Left atrial diameter (2-D). LVDd = Left ventricular internal diameter in diastole. LVDs = Left ventricular internal diameter in systole. LVWd = Left ventricular wall thickness in diastole. LVWs = Left ventricular wall thickness in systole. RBC = RBC count.

[a]Values for CO and SV missing for 7 dogs. [b]Values for CO and SV missing for 6 dogs.

Comparison of RBC and echocardiographic variables between dogs with or without a murmur at the level of the aortic valve—Eleven dogs had a murmur with the point of maximal intensity at the level of the pulmonic (8 dogs) or mitral (3 dogs) valve; these dogs were excluded for this comparison. Forty-four of the remaining 94 (46.8%) dogs had no detectable murmur. Fifty of 94 (53.2%) dogs had a systolic murmur with point of maximal intensity at the level of the aortic valve.

The values of Hct, hemoglobin concentration, RBC count, interventricular septum thickness in diastole and systole, left ventricular internal diameter in diastole and systole, left ventricular wall thickness in diastole and systole, fractional shortening, aortic root diameter, left atrial diameter, VAo, VPulm, CO, and SV were compared between dogs with or without a murmur at the level of the aortic valve (**Table 1**). Dogs with a murmur at the level of the aortic valve had a significantly higher VAo, VPulm, and CO ($P < 0.001$, $P = 0.013$, and $P = 0.023$, respectively), compared with dogs without a murmur. The VAo was 1.47 ± 0.24 m/s for dogs with a murmur and 1.29 ± 0.23 m/s for dogs without a murmur. The VPulm was 1.19 ± 0.21 m/s for dogs with a murmur and 1.08 ± 0.24 m/s for dogs without a murmur. The CO was 5.06 ± 1.26 L/min for dogs with a murmur and 4.39 ± 1.34 L/min for dogs without a murmur.

Discussion

In this study, a systolic murmur was found in 61 of 105 (58.1%) Whippets, which was aortic in origin in 50 (47.6%) Whippets. No significant differences were found between male or female dogs, between dogs of race- or show-bred lines, and between race-bred dogs in training or not in training with respect to heart rate, rhythm, murmur presence, point of maximal intensity, and murmur grade.

The prevalence of systolic murmurs in Whippets is lower than reported for retired racing Greyhounds (67%)[13] but higher than reported for highly trained sled dogs (39.6% to 45%).[8,16] In human medicine, systolic murmurs are reported for 30% to 50% of highly trained athletes.[5–7] In racehorses, the prevalence of functional systolic murmurs was reported to be 53% to 57.7%.[9,14,17] In horses, the increase in the prevalence of murmurs associated with training is most often attributed to murmurs of atrioventricular valve regurgitation.[9,11,12,14,17,18] In our study, only 3 dogs had a systolic murmur at the level of the mitral valve, which was a grade 1/6 murmur in 1 dog that was 10 months old and a grade 2/6 murmur in 2 dogs that were 107 and 169 months old, respectively. No dog had a systolic murmur at the level of the tricuspid valve.

Several studies[8,11,12] report a positive influence of training on the prevalence of murmurs in dogs as well as in horses. In our study, no significant difference in murmur presence was found between race-bred dogs in training and not in training. This could be the result of the age difference between the groups. The group of race-bred dogs not in training consisted of the youngest dogs (mean age, 14.8 ± 6.8 months; median age, 12 months) that did not start training yet, together with the oldest dogs (mean age, 112.0 ± 31.3 months; median age, 99 months) that ceased training. The group of race-bred dogs in training consisted of dogs that were 46.6 ± 23.5 months old (median, 39.5 months old). To be able to study the influence of training on the occurrence of murmurs in these Whippets, it would have been better to compare 2 groups of comparable age. This was not possible with the available population of dogs in our study because most of the dogs had racing pedigrees and were actively trained.

In this study, the Whippets with a murmur at the level of the aortic valve had a significantly higher VAo, VPulm, and CO, compared with that of Whippets without a murmur. This is in agreement with the study on retired racing Greyhounds, where a mildly but significantly higher VAo in dogs with a left basilar systolic murmur was found.[13] Several articles in human medicine also describe higher aortic flow volume and velocity across a normal aortic valve in children or adults with so-called innocent murmurs, compared with that of a control group.[5,7,19–21] Murmurs are generally produced by turbulence due to an increase in blood velocity, which may be caused by a narrowing of the outflow tract, an increase in SV passing through this outflow tract, or both.[21] The occurrence of turbulence in a vessel with a uniform diameter can be explained by the Reynolds number, which can be defined as $Re = (D \times V \times \rho)/\eta$, where D = diameter of the blood vessel, V = the mean flow velocity, ρ = blood density, and η = blood viscosity.[22–25] The lower limit for the critical Reynolds number, above which murmurs can occur, is 2,300.[22,25,26] Blood viscosity correlates well with the Hct.[27] However,

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no significant difference in aortic root diameter nor Hct was found between the Whippets with or without a murmur at the level of the aortic valve, so this could not explain the occurrence of turbulence in these dogs. This also means that the increased flow velocity was not due to absolute stenosis at the level of the aortic valve. Turbulent flow patterns can occur in clinically normal humans and animals under some circumstances, such as during states of high CO or with rapid blood flow in large vessels.[22,24,25] On echocardiographic examination, dogs with innocent murmurs have normal cardiac structure and function, and Doppler echocardiographic studies reveal normal flow dynamics, except for slightly increased flow velocities.[22]

So-called innocent or physiologic murmurs are described as soft systolic murmurs (most often grade 1/6 to 3/6 murmurs), never associated with a thrill. In human as well as in veterinary medicine, innocent murmurs are most often early to midsystolic and best heard over the left heart base.[1–4,19–22,28,29] Most of the murmurs observed in this study had a point of maximal intensity over the left heart base with low intensities. This fits with the previously described innocent murmurs in dogs.[3,4,8,13,22,30–32] Our findings suggest that the increased aortic and pulmonic blood flow velocities are a key determinant for the innocent murmurs in Whippets.

The results of this study suggest that Whippets have a high prevalence of soft systolic murmurs in the absence of any structural abnormalities, most likely due to an increase in VAo. These murmurs fit the description of innocent murmurs. No influence of sex, pedigree type, or training was found in this study.

a. Littmann Classic II pediatric stethoscope, 3M Health Care, Saint Paul, Minn.
b. Vingmed CFM 800 unit, GE Medical Systems, Horten, Norway.

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