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Haematological and biochemical variations among eight sighthound breeds

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Objective The aim of the study was to compare the haematological and biochemical profiles of eight sighthound breeds.

Design Samples were taken from 192 individuals of the sighthound breeds (Whippet, Greyhound, Italian Greyhound, Sloughi, Saluki, Borzoi, Pharaoh Hound and Azawakh). Routine haematological and biochemical examinations were performed and the results were evaluated statistically.

Results There were significant differences in haematology and clinical biochemistry among the sighthound breeds. The most similar laboratory profile to Greyhounds was found in Whippets. Italian Greyhounds had significantly higher alanine aminotransferase activity than other sighthounds, except Pharaoh Hounds.

Conclusion Application of the Greyhound laboratory profile to other sighthounds is not recommended because of the frequent differences in haematological and clinical biochemical reference intervals.

Keywords biochemistry; dogs; haematology; sighthounds

Abbreviations ALP, alkaline phosphatase; ALT, alanine aminotransferase; AST, aspartate aminotransferase; Hb, haemoglobin; Hct, haematocrit; LRI, laboratory reference interval; MCV, mean corpuscular volume; MCH, mean corpuscular haemoglobin; MCHC, mean corpuscular haemoglobin concentration; OSU-RI, reference interval of Ohio State University; PLT, platelet count; RBC, red blood cells; WBC, white blood cells

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Laboratory reference intervals (LRIs) are important for each species for clinicopathological interpretation, but there is also a need for breed-specific LRIs. Haematological and biochemical differences have been described in Bernese Mountain dogs,[1] Alaskan Malamutes, English Setters and Golden Retrievers.[2] One of the most studied breeds has been the Greyhound because of its popularity in trials conducted in North America and the United Kingdom.[3–13] It is well accepted that haematological or biochemical findings in Greyhounds often exceed non-breed-specific LRIs and ignorance of this can lead to mistakes in evaluating their health status. Some authors[13] suggest applying the LRIs of the Greyhound to other sighthounds based on similarities among these breeds.[14] Others have described significant differences in red blood cell (RBC) and eosinophil counts between Greyhounds and the sighthound crossbreed, the Lurcher.[12]

Greyhounds are not common in the Czech Republic or middle Europe and many of them are adopted as retired racers from the UK or Ireland. From 2005 to 2010, only an average of 21 purebred Greyhounds were born in the Czech Republic per year, but more than 180 Whippet puppies. Whippets are also overrepresented at racing circuits, but other breeds such as Borzois, Italian Greyhounds and Pharaoh Hounds are also active racers. The aim of this study was to compare the haematological and biochemical profiles of eight sighthound breeds: Whippet, Greyhound, Italian Greyhound, Sloughi, Saluki, Borzoi, Pharaoh Hound and Azawakh.

Materials and methods

Animals

A total of 219 clinically healthy dogs from the eight breeds were sampled for this prospective study. All dogs included in the study had a traceable origin (adopted Greyhounds) or a Fédération Cynologique Internationale pedigree (others). Answers to a short questionnaire comprising current medications, diet (commercial or home-made (cooked, fresh meat)), dog's level of activity (none/mild or active racer) and origin (Czech Republic or import) were obtained from each owner. The study was approved by the ethics committee of the Veterinary and Pharmaceutical University Brno.

Inclusion and exclusion criteria

Dogs were included in the study if they were not receiving medication, were in good health and had current vaccination status. Pregnant animals and animals with cancer in their history were excluded (1.4% of samples). Any samples with abnormalities that suggested subclinical disease (0.9%) or with outlier values (6.8%) were excluded, as were haemolytic and lipaemic samples or EDTA samples containing clots (3.2%). Outliers were detected in Whippets (n = 5), Greyhounds (n = 3), Borzois (n = 3) and Salukis (n = 2).

Blood collection and sample handling

Blood samples were collected from the vena cephalica antebrachii or vena saphena lateralis into test tubes containing EDTA and clotting-activator (0.5 mL and 3.0 mL, respectively; DISPOLAB s.r.o., Czech Republic). Blood for haematological examination was stored at 4°C until analysis, which was performed as soon as possible within 24 h. Serum was separated after clotting by centrifugation (1000*g*, 15 min) and stored at 4°C until analysis within 48 h.

Haematological and biochemical analyses

Haematological examination (white blood cell (WBC) count, RBC count, platelet (PLT) count, haemoglobin (Hb) concentration,

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haematocrit (Hct), mean corpuscular volume (MCV), mean corpuscular Hb (MCH) and mean corpuscular Hb concentration (MCHC)) was performed with an automated haematological analyser (impedance analyser; Celltac Alpha, Nihon Kohden, Japan). Biochemical analyses (total protein, albumin, urea, creatinine, calcium and phosphorus concentrations and alanine aminotransferase (ALT), aspartate aminotransferase (AST) and alkaline phosphatase (ALP) activities) were performed using a Konelab DCP 20i (Thermo Scientific, Finland) (Table 1).

Statistical analysis

Statistical analysis was done using MS Excel (Microsoft Corp., Redmond, WA, USA) and Statistica (StatSoft, Tulsa, OK, USA). Outliers were detected by Grubb's test (QuickCalcs, GraphPad Software Inc., CA, USA). In the case of an existing outlier in any parameter, the dog was excluded from the study group. Normality was assessed by the Shapiro-Wilk test and because most of the results had a Gaussian distribution, values in the Tables are showed as mean with standard deviation. Comparisons among breeds and groups were performed by Mann-Whitney U test and the Spearman test was used for correlation studies. The level of significance was set at $P < 0.05$. Results are presented as median or mean values, where specified. Our LRIs were established in 2004 by non-parametric method after exclusion of outliers by Grubb's test, based on a population of 1150 clinically healthy dogs with 1-year negative history of serious illness sampled between 1995 and 2004.

Table 1. List of methods used for clinical biochemistry testing of eight sighthound breeds

Analyte	Method
Total protein	Biuret
Albumin	Bromcresol green
Urea	Enzymatic reaction using urease and glutamate dehydrogenase
Creatinine	Enzymatic reaction using picronic acid
ALT	IFCC method using 2-oxoglutarate
AST	Modified IFCC method using 2-oxoglutarate
ALP	Modified IFCC method using p-nitrophenylphosphate
Calcium total	Arsenaso III
Inorganic phosphorus	Phosphomolybdate

ALP, alkaline phosphatase; ALT, alanine aminotransferase; AST, aspartate aminotransferase; IFCC, International Federation of Clinical Chemistry and Laboratory Medicine.

Results

Participants and lifestyle influence

Of the 219 dogs, 192 met the inclusion criteria. Mean, minimal and maximal values of the individual's age and weight are shown in Table 2. The influence of diet was not assessed because most of the dogs (87 %) were fed only or mainly commercial food. Thus, the rest of the group was too small for a statistical comparison. The effect of activity was evaluated only in Whippets. Significant differences between racers ($n = 15$) and non-racers ($n = 32$) were found in the concentration of creatinine (mean 106.7 vs 93.6 μmol/L, respectively, $P = 0.03$) and phosphorus (mean 1.4 vs 1.2 mmol/L, respectively, $P = 0.01$).

Haematology

No significant differences in haematological profiles were found between Whippets and Greyhounds or between Italian Greyhounds and Pharaoh Hounds (Table 3).

WBC counts were within the LRI in Borzois and Sloughis only (median 11.3 and 9.5×10^9/L, respectively). Between 8.7% and 70.8% of the other dogs had low WBC counts (Figure 1). The highest prevalence of low WBC counts was found in Greyhounds (70.8%; 5.3×10^9/L) and Whippets (57.4%; 5.3×10^9/L).

Increased RBC, Hct and Hb levels above the LRI were noted in all breeds. Increased RBC count was observed mainly in Azawakhs (40%; 8.3×10^{12}/L) and increased Hb concentration was found in 72.3% of Whippets (189 g/L) and approximately 70.0% of Greyhounds and Azawakhs (190 g/L and 195 g/L, respectively; Figure 2). Similar results for the Hct values were noted.

MCV was within the LRI in Sloughis, Azawakhs and Italian Greyhounds. Significantly elevated MCV was found in Whippets and

Table 2. Sex, age and weight of included subjects from eight sighthound breeds

Breed	n	Sex (neutered)		Age (months)			Weight (kg)		
		♀	♂	Min	Mean	Max	Min	Mean	Max
Whippet	47	23 (4)	20 (0)	12	64	144	10.1	13.9	19
Greyhound	27	8 (4)	4 (11)	14	60	105	20.1	30.4	41.5
Italian Greyhound	24	15 (1)	8 (0)	10	38	71	3.7	5.2	7
Borzoi	23	13 (0)	10 (0)	9	30	100	23	30.4	47
Pharaoh Hound	28	17 (1)	9 (1)	14	62.6	144	17.3	22.8	30
Saluki	20	13 (1)	6 (0)	6	66	144	12	21.7	30
Sloughi	13	6 (0)	7 (0)	12	44	130	18	24	30
Azawakh	10	5 (0)	5 (0)	15	60	120	17	19.6	24

Table 3. Haematological values of eight sighthound breeds

Breed	WBC ($\times10^9$/L)		RBC ($\times10^{12}$/L)		Hb (g/L)		Hct (%)		MCV (fL)		MCH (pg)		MCHC (g/L)		PLT ($\times10^9$/L)	
	Mean ± SD Range	% ULRI % ALRI	Mean ± SD Range	% ULRI % ALRI	Mean ± SD Range	% ULRI % ALRI	Mean ± SD Range	% ULRI % ALRI	Mean ± SD Range	% ULRI % ALRI	Mean ± SD Range	% ULRI % ALRI	Mean ± SD Range	% ULRI % ALRI	Mean ± SD Range	% ULRI % ALRI
Whippet (n = 47)	5.8 ± 1.5	57.4	7.8 ± 0.8	0	189 ± 18	0	56.1 ± 5.0	0	72.3 ± 3.4	0	24.3 ± 1.5	4.3	337 ± 16	2.1	176 ± 42	73.8
	3.3–10.4	0	5.9–9.9	17	153–228	72.3	44.0–65.6	59.6	65.7–80.1	23.4	21.5–27.4	34	298–364	44.7	82–270	0
Greyhound (n = 27)	5.4 ± 1.8	70.8	7.7 ± 0.5	0	191 ± 15	0	56.2 ± 4.0	0	73.4 ± 1.6	0	24.9 ± 0.8	0	339 ± 12	0	173 ± 49	78.3
	2.7–10.0	0	6.6–8.6	8.3	161–222	70.8	46.8–62.8	58.3	70.3–76.2	20.8	23.6–26.6	45.8	313–359	50	84–285	0
Italian Greyhound (n = 24)	8.1 ± 1.9	8.7	7.6 ± 0.6	0	174 ± 14	0	51.9 ± 4.1	0	68.8 ± 2.2	0	23.1 ± 1.4	0	335 ± 16	0	278 ± 85	17.4
	5.1–12	0	6.4–8.8	4.4	152–198	34.8	44.0–58.0	21.7	65.6–73.8	0	20.0–25.3	4.4	302–361	39.1	129–448	0
Borzoi (n = 23)	11.5 ± 2.3	0	7.7 ± 0.8	0	177 ± 18	0	54.0 ± 5.7	0	70.3 ± 2.4	4.3	23.1 ± 1.2	8.7	327 ± 15	4.3	209 ± 60	35
	6.6–16.5	0	6.0–8.8	13	144–204	43.5	43.6–64.1	43.5	64.6–75.0	0	20.8 + 26.1	4.3	290–347	21.7	72–309	0
Pharaoh Hound (n = 28)	8.8 ± 1.9	11.1	7.5 ± 0.7	0	177 ± 20	0	52.8 ± 4.8	0	70.4 ± 2.8	3.6	23.6 ± 1.8	25	335 ± 20	0	302 ± 153	22.2
	4.8–11.8	0	5.9–9.0	10.7	132–218	42.8	42.2–62.3	32.1	64.0–75.0	0	20.9–27.2	17.8	309–377	42.9	102–726	11.1
Saluki (n = 20)	7.6 ± 1.6	12.5	8.0 ± 0.8	0	185 ± 22	0	55.0 ± 5.7	0	68.9 ± 2.6	6.3	23.2 ± 1.6	18.7	335 ± 15	6.3	211 ± 81	31.3
	4.9–10.2	0	6.1–8.9	37.5	145–211	68.8	44.8–62.3	56.3	63.5–73.4	0	19.6–25.2	6.3	297–355	37.5	84–361	0
Sloughi (n = 13)	9.8 ± 1.7	0	8.1 ± 0.9	0	189 ± 17	0	56.5 ± 4.9	0	70.2 ± 1.9	0	23.5 ± 1.2	7.8	335 ± 15	0	263 ± 92	23.1
	7.1–14.1	0	6.6–9.9	23	165–222	61.5	47.6–64.2	61.5	67.4–73.4	0	21.7–26.2	7.8	306–358	30.7	106–402	0
Azawakh (n = 10)	6.8 ± 1.1	20	8.2 ± 0.9	0	193 ± 16	0	55.6 ± 5.9	0	68.8 ± 2.1	0	23.7 ± 0.9	0	344 ± 7	0	333 ± 107	10
	4.7–8.5	0	6.7–9.4	40	167–217	70	42.4–63.5	60	65.8–71.6	0	22.1–25.0	0	333–355	70	107–500	0
LRI	6.0–17.0		5.5–8.5		120–180		37–55		65–75		22–25		300–340		200–500	

LRI, laboratory reference interval; % ALRI, % of dogs above LRI; % ULRI, % of dogs below LRI; Hb, haemoglobin; Hct, haematocrit; MCH, mean corpuscular haemoglobin; MCHC, mean corpuscular haemoglobin concentration; MCV, mean corpuscular volume; PLT, platelet count; RBC, red blood cell count; WBC, white blood cell count.

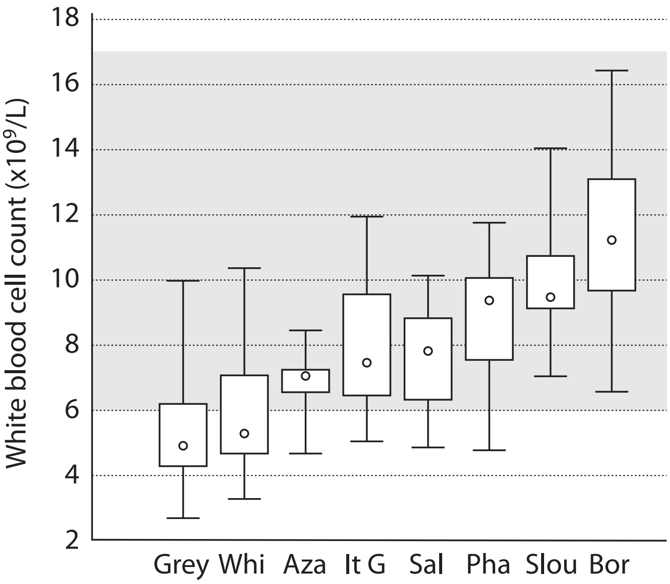

Figure 1. White blood cell count among eight sighthound breeds. Grey area, laboratory reference interval; box, 25–75th percentile; whiskers, minimum–maximum; circle, median. Grey, Greyhound; Whi, Whippet; Aza, Azawakh; It G, Italian Greyhound; Sal, Saluki; Pha, Pharaoh Hound; Slou, Sloughi; Bor, Borzoi.

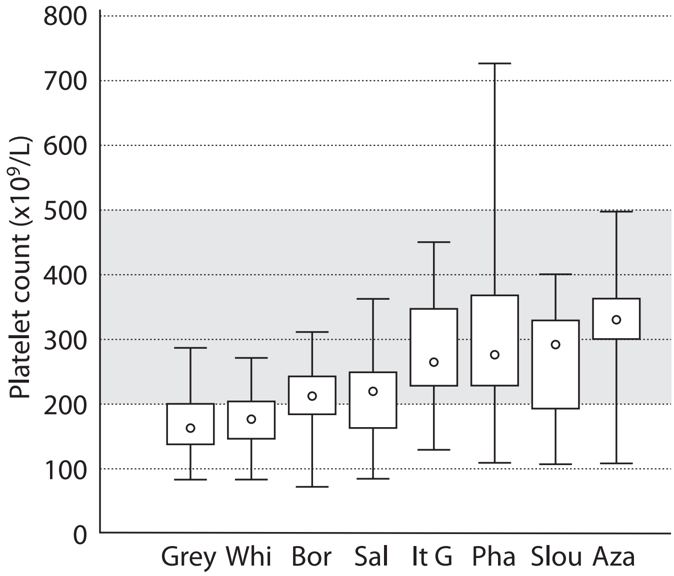

Figure 3. Platelet count among eight sighthound breeds. Grey area, laboratory reference interval; box, 25–75th percentile; whiskers, minimum–maximum; circle, median. Grey, Greyhound; Whi, Whippet; Aza, Azawakh; It G, Italian Greyhound; Sal, Saluki; Pha, Pharaoh Hound; Slou, Sloughi; Bor, Borzoi.

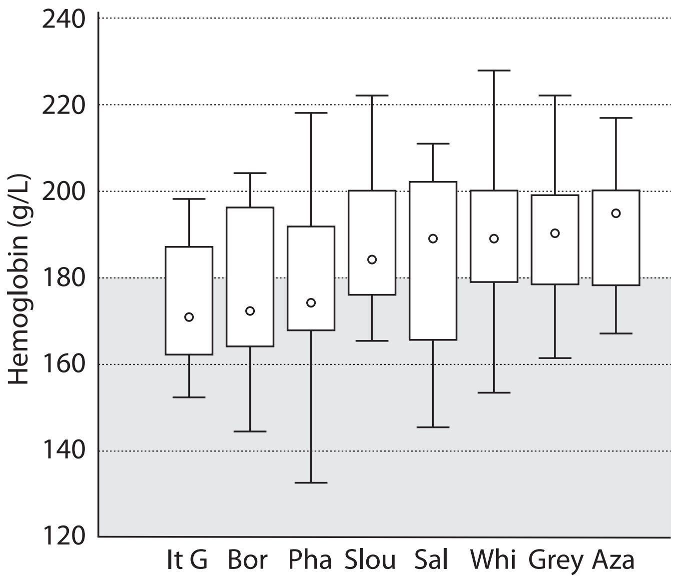

Figure 2. Haemoglobin concentration among eight sighthound breeds. Grey area, laboratory reference interval; box, 25–75th percentile; whiskers, minimum–maximum; circle, median. Grey, Greyhound; Whi, Whippet; Aza, Azawakh; It G, Italian Greyhound; Sal, Saluki; Pha, Pharaoh Hound; Slou, Sloughi; Bor, Borzoi.

Greyhounds. MCH was increased or decreased in some individuals in all breeds except Azawakhs. MCHC was frequently above the LRI in all breeds.

Decreased PLT counts were present in all breeds (Figure 3), but significantly lower in Whippets (176×10^9/L) and Greyhounds (161×10^9/L). The highest PLT count (329×10^9/L) was found in Azawakhs.

Clinical chemistry

No significant differences in clinical chemistry were found between Sloughis and Azawakhs (Table 4). Increased albumin and total protein concentrations occurred in all of the breeds, with the highest protein concentration in Pharaoh Hounds (77.2 g/L) and highest albumin concentration in Salukis (36.9 g/L).

A mild increase in urea was noted in all of the breeds, but always in less than 20.0% of the individuals. Creatinine was significantly highest in Greyhounds (135.0 µmol/L) compared with the other breeds (75.1–103.1 µmol/L, Figure 4). It was within the LRI in Salukis and Italian Greyhounds only.

Regarding liver enzymes, Italian Greyhounds had significantly higher ALT activity (78.4 IU/L, Figure 5) than almost all the other breeds (50–62.6 IU/L), although ALT was increased in all of them. ALP was significantly higher in Pharaoh Hounds (63.7 IU/L) than in most of the other breeds, but within the LRI in all individuals.

Calcium concentration was within the LRI only in Pharaoh Hounds, with decreased calcium levels seen in 13.6–47.8% of participants from the other breeds. The phosphorus concentration was different in all breeds except Azawakhs.

Discussion

The number of dogs in this study was too low to determine breed-specific LRIs. Moreover, the number of Azawakhs and Sloughis was so small that their results need to be further confirmed.

The main observations of the clinical haematology profiles of these eight breeds of sighthounds were increased Hb concentration and

Table 4. Serum biochemical profiles of eight sighthound breeds

Breed	TP (g/L)		ALB (g/L)		Urea (mmol/L)		Crea (µmol/L)		ALT (IU/L)		AST (IU/L)		ALP (IU/L)		Ca (mmol/L)		P (mmol/L)	
	Mean ± SD Range	% ULRI % ALRI	Mean ± SD Ranges	% ULRI % ALRI	Mean ± SD Range	% ULRI % ALRI	Mean ± SD Range	% ULRI % ALRI	Mean ± SD Range	% ULRI % ALRI	Mean ± SD Range	% ULRI % ALRI	Mean ± SD Range	% ULRI % ALRI	Mean ± SD Range	% ULRI % ALRI	Mean ± SD Range	% ULRI % ALRI
Whippet	69.9 ± 6.1	0	36.9 ± 3.5	0	6.8 ± 2.0	0	98.3 ± 19.5	0	54.5 ± 15.0	0	42.3 ± 13.5	0	48.2 ± 25.9	0	2.5 ± 0.3	27.7	1.3 ± 0.2	10.2
(n = 47)	55.8–83.4	22.9	30.7–44.7	52	4.2–12.8	17	62.9–151.0	31.3	29.3–98.2	34	19.8–82.0	9.3	1.8–109.6	0	1.7–3.0	0	0.8–1.9	0
Greyhound	69.6 ± 5.8	0	35.9 ± 3.1	0	6.8 ± 1.4	0	137.1 ± 20.5	0	57.2 ± 16.5	0	46.9 ± 14.2	0	57.3 ± 20.4	0	2.5 ± 0.2	18.5	1.3 ± 0.3	12.5
(n = 27)	59.2–79.0	15.4	30.2–42.5	48.2	4.3–9.4	14,8	106.6–173.8	88.9	27.6–92.8	40.7	23.4–85.6	12.5	18.6–100.6	0	2.1–2.8	0	0.8–1.9	0
Italian Greyhound	64.9 ± 6.9	4.4	33.8 ± 1.8	0	6.6 ± 1.4	0	75.9 ± 8.3	0	89.7 ± 45.5	0	38.4 ± 14.5	0	41.9 ± 17.1	0	2.4 ± 0.3	13.6	1.3 ± 0.6	27.3
(n = 24)	54.0–75.9	4.4	30.6–38.4	9.1	4.1–8.7	13,6	61.5–92.8	0	41.9–208.4	61.9	21.6–76.6	15	18.0–76.0	0	1.6–2.8	0	0.3–2.3	9.1
Borzoi (n = 23)	70.6 ± 6.7	0	34.9 ± 3.6	0	6.4 ± 1.6	0	107.2 ± 17.2	0	50.3 ± 9.6	0	43.6 ± 11.1	0	78.0 ± 53.2	0	2.4 ± 0.4	47.8	1.5 ± 0.9	31.8
	58.7–83.7	21.7	29.1–42.6	27.3	4.3–10.2	4,8	83.1–147.7	25	26.3–68.9	13.6	24.0–74.3	8.7	15.6–184.4	0	1.7–3.0	0	0.2–2.8	27.3
Pharaoh Hound	77.2 ± 6.2	0	35.9 ± 3.3	0	6.8 ± 1.6	0	91.5 ± 14.3	0	73.8 ± 32.7	0	39.5 ± 9.8	0	72.1 ± 33.8	0	2.7 ± 0.1	0	1.6 ± 0.4	0
(n = 28)	62.1–89.4	61.5	30.3–41.6	50	4.5–9.9	11,1	65.4–116.8	7.4	37.1–153.3	57.1	23.4–63.5	3.7	21.6–143.7	0	2.3–2.9	0	1.0–2.4	8.3
Saluki (n = 20)	69.0 ± 8.3	0	38.1 ± 3.3	0	5.7 ± 1.4	0	83.2 ± 10.5	0	62.8 ± 21.8	0	42.2 ± 12.9	0	48.9 ± 40.4	0	2.5 ± 0.2	26.7	1.5 ± 0.4	9.1
	55.8–81.9	25	33.3–43.4	70	3.3–8.7	5	69.4–99.7	0	34.7–114.4	45	26.3–68.8	15	19.8–152.1	0	1.9–2.8	0	0.8–1.9	0
Sloughi (n = 13)	67.8 ± 6.4	0	35.7 ± 3.2	0	7.0 ± 1.4	0	92.8 ± 9.3	0	56.7 ± 17.5	0	39.4 ± 10.6	0	52.7 ± 14.0	0	2.5 ± 0.2	15.4	1.5 ± 0.4	7.7
	57.1–77.8	15.4	30.8–42.0	38.5	4.9–9.6	15,4	77.8–114.4	7.7	25.7–83.2	46.2	22.2–58.1	0	32.3–71.9	0	2.1–2.8	0	0.8–2.2	7.7
Azawakh	70.2 ± 6.0	0	35.3 ± 2.4	0	6.4 ± 1.8	0	93.5 ± 18.6	0	55.8 ± 17.4	0	32.3 ± 9.4	0	45.4 ± 13.8	0	2.4 ± 0.2	40	1.5 ± 0.2	0
(n = 10)	59.2–77.8	30	31.6–39.8	30	4.1–9.6	20	58.7–123.2	20	26.9–77.8	50	22.8–53.3	0	27.5–68.3	0	2.1–2.7	0	1.2–1.8	0
LRI	55–75		23–36		3.3–8.3		35–110		6.0–60.0		6.0–60.0		6–180.0		2.3–3.0		1.0–2.1	

LRI, laboratory reference interval; % ALRI, % of dogs above LRI; % ULRI, % of dogs below LRI; ALB, albumin; ALT, alanine aminotransferase; AST, aspartate aminotransferase; ALP, alkaline phosphatase; Crea, serum creatinine; Ca, total calcium; P, phosphorus; TP, total protein.

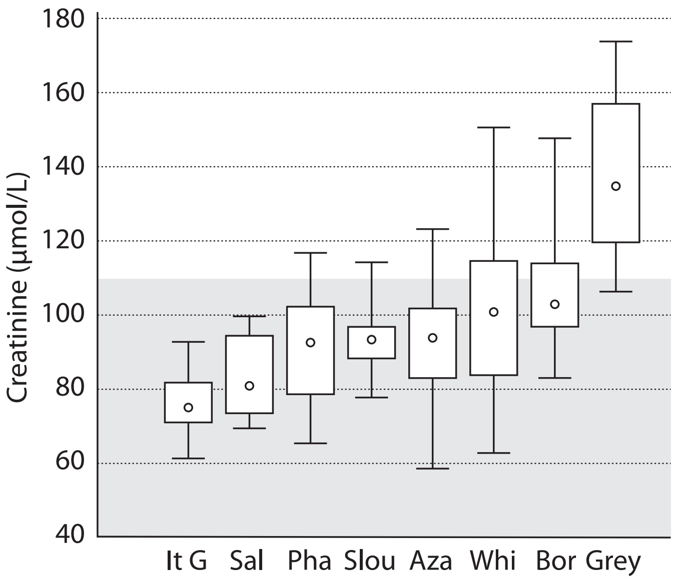

Figure 4. Creatinine concentration among eight sighthound breeds. Grey area, laboratory reference interval; box, 25–75th percentile; whiskers, minimum–maximum; circle, median. Grey, Greyhound; Whi, Whippet; Aza, Azawakh; It G, Italian Greyhound; Sal, Saluki; Pha, Pharaoh Hound; Slou, Sloughi; Bor, Borzoi.

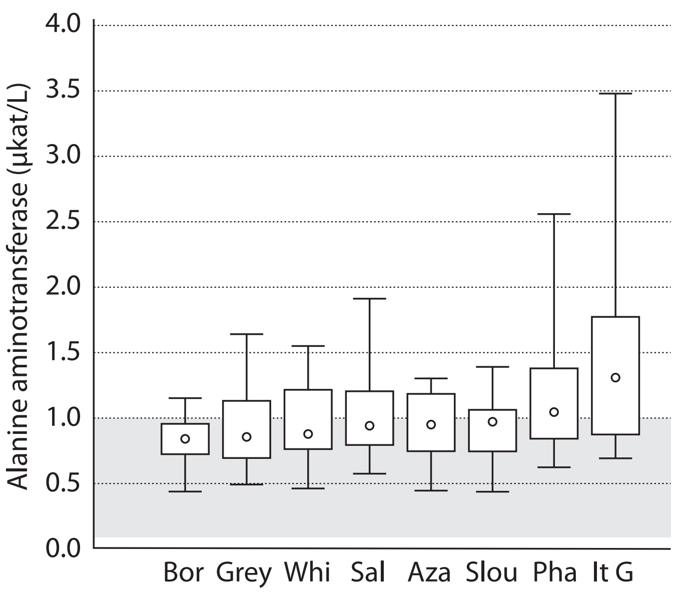

Figure 5. Alanine aminotransferase activity among eight sighthound breeds. Grey area, laboratory reference interval; box, 25–75th percentile; whiskers, minimum–maximum; circle, median. Grey, Greyhound; Whi, Whippet; Aza, Azawakh; It G, Italian Greyhound; Sal, Saluki; Pha, Pharaoh Hound; Slou, Sloughi; Bor, Borzoi.

slightly decreased PLT count. Leucopenia was only frequently observed in Greyhounds and Whippets.

The similar haematological profiles of Whippets and Greyhounds is in accordance with previous genetic studies that have confirmed a close relationship between the breeds.[15] Higher Hct, RBC, MCV, MCHC, and lower WBC and PLT values than the LRIs have been previously described for Greyhounds.[4,10,11,16,17]

Although increased Hb concentration and MCHC were reliable findings in all of the breeds, lower WBC count was not so frequently observed and some breeds had a WBC count within the LRI. Contrary to previous studies,[4,13,16] we found MCH values higher than the LRI in 45.8% of Greyhounds and 32.6% of Whippets, which is not surprising, because of the method of calculating the MCH as haemoglobin divided by red blood cell count. The reason for an increased MCV is usually assumed to be increased erythropoiesis because of the shorter life-span of RBC in Greyhounds.[7]

One study has shown significantly higher Hct and Hb concentrations in Salukis (n = 26) than in Whippets (n = 18).[14] In our study, the 47 Whippets had higher average Hct and Hb levels and lower RBC counts than the 20 Salukis, but these results were not significantly different.

Salukis had a very similar haematological profile to that of Sloughis and Azawakhs, both of which had the highest mean RBC counts of all the studied breeds.

The reason for the higher Hb, Hct or RBC count in sighthounds is unknown, but assumed to be a breed adaptation for athletic performance in the sense of increased total oxygen-carrying capacity.[17,18] However, Hb concentration does not depend on the athletic performance of an individual as it is present in sighthounds kept as pets for their entire lives.

All of the breeds except Borzois and Sloughis had individuals with a WBC count lower than the LRI, especially Greyhounds (70.8%) and Whippets (57.4%). Borzois had the highest mean WBC count, but no individuals belonging to this breed exceeded the LRI. The results of blood smears for differential WBC count and cell morphology were not included in this study. The smears were often performed after transportation of the blood sample, which had a negative effect on cell morphology, and as most of the dogs were leucopenic, the number of WBC found in a monolayer was frequently fewer than 100, resulting in potentially inaccurate results and thus not included for analysis. However, eosinophils with an abnormal colour, 'grey eosinophils', were found in Greyhounds, Whippets, Italian Greyhounds and Borzois.

For evaluation of the PLT count, the negative influence of blood storage was first excluded. PLT counts in samples analysed less or more than 6 h after collection showed no significant differences in any of the breeds (data not shown). Azawakhs displayed the highest mean PLT count of all the breeds, with only 10.0% of individuals with values lower than the LRI. Decreased PLT count has been described as a regular finding in Greyhounds[3,4,11] and was also frequently observed in other sighthound breeds in our study (10.0–73.8%). Some authors suggest that decreased PLT counts are explained by the bipotential stem cell theory (haematopoietic competition between the erythroid and megakaryocytic lines), given that a correlation between PLT and Hb or Hct has been previously observed.[3] In our study, there was a significant negative correlation between PLT count and Hb ($r = -0.48$, $P < 0.05$) concentration in Greyhounds only and no correlation between PLT count and Hct, Hb or RBC count in any of the other breeds (data not shown). Azawakhs had the highest mean Hb, RBC count and PLT count of all the studied breeds. We cannot exclude increased frequency of PLT clumps in Greyhounds, but the influence of clumping on PLT count in the Greyhound seems doubtful.[19] The production of PLTs is regulated by the whole PLT mass, so increased PLT volume could be an explanation of a mild decrease in the count. However, mean PLT volume was higher, although not significantly, in Greyhounds[3] and the presence of macrothrombocytes has not been described in any studies in which blood smear evaluation was performed.[4,11]

One of the major differences in clinical chemistry between Greyhounds and other breeds is the serum creatinine concentration.[4,5,17] Greyhounds have a significantly higher level of this parameter than all the other studied breeds, with an elevation above the LRI in almost 90% of Greyhounds. Almost 30% of the Greyhounds in the present study showed values above the breed's LRI of the Ohio State University (OSU-RI: maximum value 173.8 μmol/L),[13] but all of them had a creatinine level within the LRI published by Dunlop et al.[10] Most of the Greyhounds in our study were adopted from Ireland or the UK, which could explain the good agreement with the latter study.[10] The three main theories of the high creatinine concentrations in Greyhounds include extensive muscle metabolism, increased dietary creatinine intake and an altered glomerular filtration rate,[5] although alteration in glomerular filtration rate has been excluded by others.[20] To date, the most likely explanation is massive muscle mass.[13] We found a significantly higher concentration of creatinine in active racing Whippets sampled at rest than in non-racing Whippets. However, there was no correlation between body weight and creatinine concentration in female and male Whippets or Greyhounds (data not shown). More correctly, the correlation of lean muscle mass with creatinine concentration should be calculated; however, none of the sampled Whippets or Greyhounds was obese and no significant difference in body weight was found between racing and non-racing Whippets. The upper limit of the Greyhound's creatinine OSU-RI[13] included all the Whippets in this study (31.9% of them were above the LRI), but approximately 20.0% of them had lower values. The second highest creatinine concentration was observed in Borzois, where 25.0% of the dogs exceeded the LRI but were within the Greyhound's OSU-RI.[13] The only breeds with creatinine concentrations within the LRI in all individuals were the Saluki and Italian Greyhound.

A decreased concentration of total protein has been previously reported in Greyhounds.[14,17] We did not find hypoproteinemia in any of the study dogs, but increased total protein level was present in 4.4–61.5% of them. The mean total protein concentration in Greyhounds was higher than that previously published and similar to the other sighthound breeds, except Pharaoh Hounds, which had a significantly higher total protein level with a mean value above the LRI. The reason for the discrepancy with other studies in total protein concentration remains unclear given that the principle of measurement should be similar in all these studies. Concentration of albumin was higher than the LRI in 12.5–70% of dogs. Extensive research in Greyhounds has shown that a decrease in globulin is associated with a decrease in the α and β globulin fractions. The reason for this is unknown, but the effect of training or an adaptation mechanism of lower serum viscosity because of higher Hct and higher viscosity of whole blood is hypothesised.[6] The albumin concentration in the Greyhounds (mean 35.9 g/L) was similar to or slightly higher than previously published results.[14,17] The reason for increased albumin concentration in sighthounds is also unclear. Dehydration, which seems to be the most probable cause, has been excluded because the same results are found for repeated samples from the same individuals.[4] Owners of all breeds in our study made the subjective observation of decreased water intake or intake of liquids only in food. Most of the owners had more than one dog and measurement of water intake for each individual was not possible. More research into the sensitivity or density of osmoreceptors in sighthounds is needed.

The ALT level was higher than the LRI in 40.7% of the Greyhounds and 34.0% of the Whippets, but always less than twice the upper LRI limit; most dogs were between 1- and 1.5-fold of the upper LRI limit. AST was elevated in 12.0% of the Greyhounds and 9.3% of the Whippets, but was always less than 1.5-fold of the upper LRI limit. Both these findings are similar to the difference between the Greyhound OSU-RI and the non-breed-specific OSU-RI,[13] even though the absolute values were higher for the sighthounds in our study as well as in our non-breed-specific LRIs. Significantly higher ALT activity was found in Italian Greyhounds compared with almost all the other studied breeds. ALT values were above the LRI in more than 61% of the Italian Greyhounds, whereas AST activity increased only mildly in 15% of the dogs. An increased ALT in Greyhounds is thought to be related to muscle dystrophy and necrosis,[13] but seems unlikely for Italian Greyhounds that have a very small muscle mass. Other explanations are connected to hepatic disease and although all dogs were considered clinically healthy, we were unable to exclude subclinical hepatic disease because ultrasonography or more invasive (e.g. biopsy) interventions were not performed. Breed predisposition for inherited hepatic disease was considered in this context (relatively high prevalence and some clinically healthy individuals with very high ALT, >600% of the LRI upper limit, were excluded as outliers), but without success from available sources.[21] ALP activity was significantly higher in Pharaoh Hounds than in Whippets, Italian Greyhounds, Salukis and Azawakhs. Greyhounds had lower ALP activity too, but this was not significant (P = 0.13). All the Pharaoh Hounds sampled for the study were more than 14 months old and we did not consider higher ALP activity as clinically relevant because the concentrations were within the reference range.

Total calcium was within the LRI in all Pharaoh Hounds. Greyhounds had 18.6% of individuals with slightly decreased calcium level, mean values being close to those previously published. The other sighthound breeds had similar calcium concentrations as the Greyhounds, with decreased concentrations observed in 13.6–47.8 % of the dogs. Calcium levels lower than 2 mmol/L were frequently linked to lower phosphorus levels, so vitamin D deficiency was put on the list of differential diagnoses. However, only a few of the dogs were fed homemade food and laboratory error cannot be excluded. Decreased phosphorus was noticed in less than 13% of Greyhounds and Whippets and in each case the decrease was less than 30.0% of the lower LRI interval, similar to the OSU-RI.[13] Similar findings were observed in Borzois, where a decrease in phosphorus was present in 31.8% of them and always linked to decreased calcium. Surprisingly, 27.3% of Italian Greyhounds had lower phosphorus concentrations. Causes of decreased phosphorus concentration include decreased dietary intake, laboratory error, reduced renal reabsorption and others. However, the Italian Greyhounds were often stressed at blood collection and so phosphorus translocation because of hyperventilation leading to respiratory alkalosis seems probable in these individuals. By contrast, increased phosphorus concentration was noted in 27.3% of the Borzois. All of these dogs came from the same owner and the effect of a home-cooked diet in these individuals seems high. Mild increase in phosphorus was also noticed in Italian Greyhounds, Pharaoh Hounds and Sloughis, but only occasionally.

The most important breed-specific differences in clinical chemistry were elevated albumin concentration and ALT activity (mainly in Italian Greyhounds). Creatinine concentration was above the LRI, particularly in Greyhounds.

Conclusions

Many breed-specific, clinically relevant alterations in the different sighthound breeds were found, with significant similarity between the whole biochemical and haematological profiles not confirmed in any breed. Our results indicate that breed-specific-reference intervals are needed for more sighthound breeds than just Greyhounds. Application of the Greyhound LRIs to all sighthound breeds can lead to misinterpretations. However, it should be noted that the results of this study could be affected by the relatively low number of participants.

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