In some parts of the world, Greyhounds are used for both racing (English Greyhound) and hunting (Spanish Greyhound or Galgo). Hunting is a popular sport in Spain, where 400,000 Spanish Greyhounds are registered for this purpose. A large part of Spain consists of an open steppe. For hare hunting in such an open area, fast and persistent hunting dogs are needed. These dogs must also be extremely agile to pursue hares, which can make sudden changes in direction. On the dry, uneven terrain of the Spanish plateaus, which are covered with scattered rocks, a high degree of strength is needed to complete the pursuit of a hare. Thus, climate, topography, and demands of hunting have influenced the appearance and abilities of Spanish Greyhounds. This breed has been studied because of hematologic and biochemical differences from other breeds, which include higher RBC counts, PCVs, and hemoglobin concentrations and lower WBC and platelet counts.1,2

Exercise induces changes in several physiologic and laboratory variables in animals, depending on the duration and intensity of the exercise and prior training.3 Transient metabolic changes include alterations in hematologic and acid-base values as well as electrolyte and muscle enzyme concentrations.3–7 Markers of acute inflammation (eg, serum iron and acute-phase proteins, especially CRP) have been used to evaluate changes related to exercise. Serum iron concentrations decrease and acute-phase protein concentrations increase after endurance and high-intensity exercise in sled dogs.8,9

The acute-phase response is characterized by a decreased serum iron concentration.10 Serum iron

**ABBREVIATIONS**

| ALT | Alanine aminotransferase |
| AST | Aspartate aminotransferase |
| CK  | Creatine kinase           |
| CRP | C-reactive protein        |
| LDH | Lactate dehydrogenase     |

**OBJECTIVE**

To investigate effects of exercise on hematologic and biochemical values (especially markers of inflammation and muscle damage) in Spanish Greyhounds used for hunting without previous training.

**ANIMALS**

32 Spanish Greyhounds and 31 dogs of other breeds.

**PROCEDURES**

Hematologic variables and concentrations of C-reactive protein (CRP) and other biochemical markers were compared in samples obtained from Spanish Greyhounds 24 hours after exercise (eg, a hunting race) and 2 months after exercise (ie, at rest) and from non–Spanish Greyhounds at rest. All dogs were healthy. Hematologic and biochemical analyses were performed within 24 hours after samples were obtained, and results were compared by means of a Student t test.

**RESULTS**

CRP concentration and muscle enzyme (creatine kinase, lactate dehydrogenase, and aspartate aminotransferase) activities were significantly higher and serum iron concentration was significantly lower for Spanish Greyhounds after exercise than at rest. The WBC and neutrophil counts were significantly higher after exercise than at rest. Plasma alanine transaminase activity and total protein, calcium, and phosphorus concentrations were significantly higher after exercise than at rest. Spanish Greyhounds at rest had higher RBC counts, PCVs, and hemoglobin concentrations and lower WBC, neutrophil, and lymphocyte counts, compared with values for non–Spanish Greyhounds at rest.

**CONCLUSIONS AND CLINICAL RELEVANCE**

Exercise of Spanish Greyhounds without prior training activated an acute-phase response represented by an increase in serum CRP concentration and decrease in serum albumin and iron concentrations. These changes, along with leukocytosis and neutrophilia, were indicative of a subclinical inflammatory state in Spanish Greyhounds. (Am J Vet Res 2015;76:637–643)
concentrations decrease as a result of an increase in the hepatic synthesis of hepcidin, which decreases serum iron concentrations and limits iron availability to pathogens in cases of infection. A decrease in iron concentration has been described in sled dogs in association with heavy exercise.

The main acute-phase protein in dogs is CRP. The concentration of CRP increases 10- to 100-fold during the acute-phase response to several stimuli, including surgery, infections (eg, ehrlichiosis, parvoviral enteritis, pyometra, and leishmaniasis), acute and chronic inflammation, and exercise. Concentrations of CRP increase rapidly and then decrease even more rapidly. Elevated CRP concentrations are a highly sensitive indicator of many conditions that affect animal health and provide evidence about both clinical and subclinical inflammation. The purpose of the study reported here was to investigate the effect of exercise, such as hunting, on muscle markers of inflammation and damage in Spanish Greyhounds without previous training to determine adaptation to exercise and the intensity of muscle work during exercise.

Materials and Methods

Animals

Analytic variables for Spanish Greyhounds were compared with those of adult dogs that were not Spanish Greyhounds, which consisted of 6 mixed-breed dogs and 25 dogs of various breeds (Epagneul Breton [n = 3], Pointer [3], German Shepherd Dog [3], Labrador Andalusian Podenco [3], Belgian Sheepdog [2], Golden Retriever [2], Border Collie [2], Irish Setter [2], Retriever [2], Neapolitan Mastiff [1], English Cocker Spaniel [1], Siberian Husky [1], and Samoyed [1]). These dogs (17 males and 14 females) had a mean ± SD age of 3.45 ± 1.14 years and mean body weight of 26.1 ± 8.9 kg. The inclusion and exclusion criteria for these dogs were the same as for the Spanish Greyhounds.

Informed consent was obtained from the owners for participation of the dogs. The study protocol was reviewed and approved by the Animal Ethics Committee of the University of Extremadura and was performed in compliance with Spanish (RD1201/2005) and European (ETS No. 170) guidelines for research on animals.

Procedures

The hunting period in Spain is from October to February, and the study was conducted from November 2011 through April 2012. During the study period, Spanish Greyhounds participated in hunting races conducted in accordance with the rules of the Spanish Federation of Galgos. As set forth in the regulations, each competition was held in an open area with level ground, and no aspects of the terrain or vegetation hindered the dogs during a race. On the day of a competition, ambient temperature ranged from 2.7°C to 26.4°C, and relative humidity ranged from 47% to 77%.

Spanish Greyhounds raced in pairs, chasing a hare. These were high-intensity races (racing speed, up to 60 km/h) of short duration. When the duration of a race was < 3 minutes, dogs were permitted a 30-minute break before the subsequent race. If the duration of a race was ≥ 3 minutes, dogs were permitted a break of 60 minutes before the subsequent race. Maximum number of races during the 8 hours of competition was 7 (the number of races depended on the number of hares available for use on a given day). Dogs that competed in ≥ 4 races on a given day were chosen for the study.

Physical activity of the Spanish Greyhounds for the 8 months preceding race day consisted of 1 or 2 walks/d (typical walking speed, 5 to 10 km/h; total walking duration, 1 h/d). All dogs were assessed as healthy on the basis of results of a physical examination performed immediately before (heart rate, 70 to 130 beats/min; respiratory rate, 10 to 40 breaths/min; and rectal temperature, 38° to 39°C) and immediately after (heart rate, 200 to 250 beats/min; respiratory rate, 122 to 175 breaths/min; and rectal temperature, 38.5° to 39.3°C) each race.

Collection of blood samples

One blood sample (7 mL) was collected from a cephalic vein of each of the 32 Spanish Greyhounds within 24 hours after exercise (ie, between 9 AM and 11 AM the morning after the day of hunting races). Blood samples were collected with a 5-mL syringe and 22-gauge needle. Three milliliters of blood was placed in a 3-ml tube that contained potassium EDTA, and the remaining 4 mL of blood was placed in a serum tube and allowed to coagulate.

In April (2 months after the hunting season ended), a 7-mL blood sample was collected from each of the 32 Spanish Greyhounds and processed as described previously. The sample was obtained after each dog had completed its typical daily physical activity (ie, 1 or 2 walks; total walking duration, 1 h/d). These samples were used to establish appropriate reference ranges for Spanish Greyhounds at rest (ie, physiologic changes associated with the exercise during racing had returned to baseline values).

A blood sample (7 mL) was collected from each of the 31 dogs of other breeds selected for having a similar body weight as the Spanish Greyhounds. Samples were obtained after completion of the daily physical activity of these dogs, which was 2 or 3 walks (total walking duration, 45 min/d); thus, these dogs were considered at rest. Samples were obtained between 8 PM and 9 PM over a period of 1 month. Samples were processed as described previously for samples obtained from the Spanish Greyhounds.

Sample processing and analysis

Uncoagulated blood samples were stored at 4°C and transported to the Clinical Pathology Service of the Clinical Veterinary Hospital at Extremadura University for analysis; all uncoagulated blood samples
were analyzed within 24 hours after collection. Within 3 hours after sample collection, serum tubes were centrifuged at 3,000 X g for 10 minutes. Serum was harvested, placed into cryovials, and immediately refrigerated. Samples were then transported back to the Clinical Pathology Service and immediately analyzed.

Hematologic analyses were performed with an automated analyzer, and blood films were stained with a differential stain to enable evaluation of leukocyte morphology and a manual differential leukocyte count. Activity of ALT and concentrations of urea, creatinine, total protein, albumin, calcium, sodium, potassium, phosphorus, chloride, and iron were determined by use of a commercial kit and clinical chemistry analyzer. Serum AST, CK, and LDH activities were determined with a commercial kit. Serum CRP concentrations were determined with a turbidimetric immunoassay for measurement of human CRP concentration that has been validated for the measurement of canine CRP concentration.

Statistical analysis
All variables were normally distributed (Shapiro-Wilk test), and results were expressed as mean ± SD. Groups were compared by use of a Student t test for dependent samples (Spanish Greyhounds after exercise vs at rest) and a Student t test for independent samples (Spanish Greyhounds at rest vs dogs of other breeds at rest). Values of P ≤ 0.05 were considered significant.

Results
Mean values for all hematologic variables were within reference ranges for Spanish Greyhounds at rest and for dogs of other breeds at rest. Segmented neutrophil (P < 0.001) and WBC (P = 0.01) counts were significantly higher for Spanish Greyhounds after exercise than for Spanish Greyhounds at rest (Table 1). For dogs of other breeds at rest, hemoglobin concentration, PCV, and RBC counts were significantly lower, and WBC and lymphocyte counts were significantly (P < 0.001) higher, than values for Spanish Greyhounds at rest. In addition, segmented neutrophil count for dogs of other breeds at rest was significantly (P = 0.01) higher than the value for Spanish Greyhounds at rest.

### Table 1—Mean ± SD values of hematologic data for 32 Spanish Greyhounds after exercise and at rest and for 31 dogs of other breeds at rest.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Spanish Greyhounds</th>
<th>Other dogs at rest</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCV (%)</td>
<td>59.62 ± 12.56</td>
<td>63.06 ± 6.89</td>
</tr>
<tr>
<td>Hemoglobin (g/dL)</td>
<td>18.46 ± 1.57</td>
<td>19.48 ± 2.42</td>
</tr>
<tr>
<td>Mean corpuscular volume (fL)</td>
<td>70.98 ± 10.45</td>
<td>73.87 ± 5.16</td>
</tr>
<tr>
<td>Mean corpuscular hemoglobin concentration (g/dL)</td>
<td>32.28 ± 7.20</td>
<td>31.47 ± 2.48</td>
</tr>
</tbody>
</table>

Cell count

| RBCs (X 10^6 /mL) | 8.57 ± 1.64 |
| WBCs (X 10^3 /mL) | 9.47 ± 2.89* |
| Band cells (X 10^3 /mL) | 0.07 ± 0.16 |
| Segmented neutrophils (X 10^3 /mL) | 6.66 ± 2.71* |
| Eosinophils (X 10^3 /mL) | 0.57 ± 0.40 |
| Lymphocytes (X 10^3 /mL) | 1.73 ± 1.03 |
| Monocytes (X 10^3 /mL) | 0.42 ± 0.34 |
| Platelets (X 10^3 /mL) | 299.93 ± 207.79 |

### Table 2—Mean ± SD values of biochemical data for 32 Spanish Greyhounds after exercise and at rest and for 31 dogs of other breeds at rest.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Spanish Greyhounds</th>
<th>Other dogs at rest</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALT (U/L)</td>
<td>74.30 ± 44.02*</td>
<td>53.17 ± 20.28</td>
</tr>
<tr>
<td>Total protein (g/dL)</td>
<td>5.41 ± 0.85*</td>
<td>5.87 ± 0.86</td>
</tr>
<tr>
<td>Albumin (g/dL)</td>
<td>3.50 ± 0.39*</td>
<td>3.76 ± 0.35</td>
</tr>
<tr>
<td>Urea (mg/dL)</td>
<td>24.42 ± 6.72</td>
<td>30.19 ± 10.72</td>
</tr>
<tr>
<td>Creatinine (mg/dL)</td>
<td>1.12 ± 0.15</td>
<td>0.97 ± 0.19</td>
</tr>
<tr>
<td>Calcium (mg/dL)</td>
<td>10.20 ± 1.06*</td>
<td>9.47 ± 1.34</td>
</tr>
<tr>
<td>Phosphorus (mg/dL)</td>
<td>4.65 ± 0.84*</td>
<td>3.93 ± 0.83</td>
</tr>
<tr>
<td>Sodium (mEq/L)</td>
<td>140.53 ± 23.12</td>
<td>147.91 ± 4.44</td>
</tr>
<tr>
<td>Potassium (mEq/L)</td>
<td>5.00 ± 0.34</td>
<td>5.10 ± 0.40</td>
</tr>
<tr>
<td>Chloride (mmol/L)</td>
<td>113.25 ± 2.22</td>
<td>114.02 ± 3.56</td>
</tr>
</tbody>
</table>

*†Value differs significantly (*P < 0.001; †P = 0.01) from the value for Spanish Greyhounds at rest.
quired unique physiologic adaptations that distinguish hounds as racing sighthounds, these dogs have acquired training at the start of the hunting season. Thus, the purpose of the study reported here was to investigate effects on various markers of muscle inflammation as a result of exercise in dogs that had not been trained (trotting at a speed of 15 to 30 km/h for the months preceding the hunting season, appropriated training). Hare-hunting competitions with Spanish Greyhounds are popular in certain areas of Spain and are regulated by the Spanish Federation of Galgos. During the months preceding the hunting season, appropriate training (trotting at a speed of 15 to 30 km/h for a distance of 10 to 30 km/d) may not be performed. In many cases, dogs compete without adequate training. Thus, the purpose of the study reported here was to investigate effects on various markers of muscle inflammation as a result of exercise in dogs that had not received training at the start of the hunting season.

Owing to the development of Spanish Greyhounds as racing sighthounds, these dogs have acquired unique physiologic adaptations that distinguish them from other breeds, including larger muscle mass than most breeds. These and other adaptations have probably contributed to the unique hematologic and biochemical profile of Spanish Greyhounds, compared with profiles for other breeds. Thus, results obtained for Spanish Greyhounds at rest and after hunting exercise were compared with those obtained for dogs of other breeds at rest.

Table 3—Mean ± SD values of muscle enzyme activities and CRP and iron concentrations for 32 Spanish Greyhounds after exercise and at rest and for 31 dogs of other breeds at rest.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Spanish Greyhounds</th>
<th>Other dogs at rest</th>
</tr>
</thead>
<tbody>
<tr>
<td>CK (U/L)</td>
<td>584.19 ± 695.88*</td>
<td>105.00 ± 29.43</td>
</tr>
<tr>
<td>LDH (U/L)</td>
<td>264.63 ± 151.77*</td>
<td>86.91 ± 32.17</td>
</tr>
<tr>
<td>AST (U/L)</td>
<td>57.66 ± 32.96*</td>
<td>24.22 ± 8.39</td>
</tr>
<tr>
<td>CRP (mg/L)</td>
<td>4.92 ± 2.18†</td>
<td>0.98 ± 0.79</td>
</tr>
<tr>
<td>Iron (µg/dL)</td>
<td>97.81 ± 31.22†</td>
<td>148.57 ± 52.18*</td>
</tr>
</tbody>
</table>

*Value differs significantly (P < 0.001) from the value for other dogs at rest. †Value differs significantly (P < 0.001) from the value for Spanish Greyhounds at rest.

Serum ALT activity and calcium and phosphorus concentrations were significantly higher for Spanish Greyhounds after exercise than for Spanish Greyhounds at rest (Table 2). However, total protein and albumin concentrations were significantly lower after exercise. In addition, serum ALT activity was significantly lower and total protein and urea concentrations significantly higher in dogs of other breeds at rest, compared with results for Spanish Greyhounds at rest. Activity of muscle enzymes (CK, LDH, and AST) was significantly (P < 0.001) higher for Spanish Greyhounds after exercise, compared with activity of those enzymes for dogs of other breeds at rest (Table 3). However, significant differences in muscle enzyme activities were not detected between Spanish Greyhounds at rest and dogs of other breeds at rest.

Mean ± SD serum CRP concentration for Spanish Greyhounds at rest was 1.0 ± 1.03 mg/L, whereas the mean CRP concentration for Spanish Greyhounds after exercise was significantly (P < 0.001) higher (4.92 ± 2.18 mg/L). However, there was no significant difference in CRP concentration between Spanish Greyhounds at rest and dogs of other breeds at rest (Table 3). In contrast, the mean serum iron concentration for Spanish Greyhounds was significantly (P < 0.001) lower after exercise (97.81 ± 31.22 µg/dL) than at rest (148.57 ± 52.18 µg/dL). Moreover, the mean serum iron concentration was significantly (P < 0.001) higher for Spanish Greyhounds at rest, compared with the concentration for dogs of other breeds at rest.

**Discussion**

Hare-hunting competitions with Spanish Greyhounds are popular in certain areas of Spain and are regulated by the Spanish Federation of Galgos. During the months preceding the hunting season, appropriate training (trotting at a speed of 15 to 30 km/h for a distance of 10 to 30 km/d) may not be performed. In many cases, dogs compete without adequate training. Thus, the purpose of the study reported here was to investigate effects on various markers of muscle inflammation as a result of exercise in dogs that had not received training at the start of the hunting season.

Owing to the development of Spanish Greyhounds as racing sighthounds, these dogs have acquired unique physiologic adaptations that distinguish them from other breeds, including larger muscle mass than most breeds. These and other adaptations have probably contributed to the unique hematologic and biochemical profile of Spanish Greyhounds, compared with profiles for other breeds. Thus, results obtained for Spanish Greyhounds at rest and after hunting exercise were compared with those obtained for dogs of other breeds at rest.

Spanish Greyhounds at rest had lower mean WBC counts, compared with mean WBC counts for dogs of other breeds at rest. These results are consistent with results of previous studies. Higher WBC (9.47 ± 10^6 WBCs/mL ± 2.89 X 10^6 WBCs/mL) and segmented neutrophil (6.66 ± 10^6 segmented neutrophils/mL ± 2.71 X 10^6 segmented neutrophils/mL) counts were detected for Spanish Greyhounds after hunting exercise, compared with counts for Spanish Greyhounds at rest, as has been described elsewhere. In addition, a nonsignificant higher band cell count was also detected for Spanish Greyhounds after exercise, whereas the lymphocyte count was constant and lymphopenia was not evident (Table 1). For samples obtained 2 months after the hunting season ended, neutrophilia with a higher band cell count and a lymphocyte count within the reference range were consistent with a subclinical inflammatory status but not with a situation of stress.

Hemoglobin concentrations and RBC counts were within reference ranges for Spanish Greyhounds after exercise, which is in contrast to other reports in which investigators described significant increases in these variables immediately after exercise. Discrepancy between results for those reports and results for the study reported here may be attributable to the fact that in the present study, blood samples were collected 24 hours after exercise, when subclinical dehydration caused by exercise had been resolved.

Differences in hematologic values between Spanish Greyhounds and dogs of other breeds include a higher RBC count and hemoglobin concentration for Spanish Greyhounds and dogs of other breeds. These differences, which were also detected in the present study, are attributable to a physiologic adaptation in Spanish Greyhounds that increases oxygen transport to tissues during exercise. Investigators of a previous report described a higher platelet count in Spanish Greyhounds; however, in
the present study, no significant differences were detected between Spanish Greyhounds both at rest and after exercise, compared with values for dogs of other breeds at rest.

Gray vacuolated eosinophils have been described in Greyhounds and may be incorrectly classified by automated analyzers, which results in a lower eosinophil count. We found no significant difference in the mean ± SD eosinophil count between Spanish Greyhounds at rest (0.86 × 10^6 eosinophils/mL ± 0.56 × 10^6 eosinophils/mL) and dogs of other breeds at rest (0.73 × 10^6 eosinophils/mL ± 0.42 × 10^6 eosinophils/mL), possibly because the differential classification of leukocytes was performed manually.

All mean values of biochemical variables were within the reference ranges for Spanish Greyhounds and dogs of other breeds, except ALT activity and urea concentration, which were slightly increased in Spanish Greyhounds, as has been described by other authors. Conversely, Spanish Greyhounds had a significantly higher mean ± SD serum ALT activity after exercise (74.30 ± 44.02 U/L) than at rest (53.17 ± 20.28 U/L). Although an increase in ALT activity is considered an indicator of hepatic disease, dogs of the present study did not have clinical signs of hepatic disease. The range for ALT activity is wide in Spanish Greyhounds, as has been described by other authors. Conversely, Spanish Greyhounds had a significantly higher mean ± SD serum ALT activity after exercise (74.30 ± 44.02 U/L) than at rest (53.17 ± 20.28 U/L). Although an increase in ALT activity is considered an indicator of hepatic disease, dogs of the present study did not have clinical signs of hepatic disease. The range for ALT activity is wide in Spanish Greyhounds, making its use as an indicator of hepatic disease unreliable in these dogs. However, the ALT activity results obtained in Spanish Greyhounds of the study reported here are consistent with those reported in another study. There were narrower reference intervals for hepatic enzyme activities in Greyhounds in that other study. In addition, investigators of that study reported a higher ALT activity, compared with values for non–breed-specific reference intervals. On the other hand, ALT is an enzyme that is present in muscle cells of dogs, and muscular dystrophy and subsequent necrosis can increase ALT activity of dogs with no evidence of liver disease. It has been hypothesized that large muscle mass may be a cause of high ALT activity in Greyhounds. Thus, the high ALT activity for the Spanish Greyhounds after exercise in the present study may have been attributable to muscular damage. Moreover, increases in ALT activity in response to exercise have been described.

Acute-phase reactants reduce the circulating albumin concentration because albumin is a negative acute-phase protein. In the present study, the mean ± SD serum albumin concentration of Spanish Greyhounds was lower after exercise (3.50 ± 0.39 g/dL) than at rest (3.76 ± 0.35 g/dL) as a consequence of acute-phase reactants, and this contributed to a lower serum total protein concentration after exercise (Table 2).

Electrolyte concentrations for Spanish Greyhounds after exercise were similar to those measured at rest, except for serum calcium and phosphorus concentrations, which were higher after exercise. In horses, the increase of serum calcium and phosphorus concentrations has been attributed to a long period of inactivity prior to exercise, which causes bone demineralization when animals are subjected to strenuous exercise.

Plasma total protein concentration for Spanish Greyhounds was lower than that for dogs of other breeds at rest. In addition, this concentration was lower in Spanish Greyhounds after exercise than at rest. These lower protein concentrations could have been attributable to an expansion of plasma volume that has been reported in animals undergoing exercise training. Authors of a previous report described a higher creatinine concentration in Greyhounds, although this was not observed in the present study in Spanish Greyhounds. However, a significantly lower mean ± SD serum urea concentration was detected for Spanish Greyhounds after exercise (30.19 ± 10.72 mg/dL), compared with the concentration for dogs of other breeds at rest (41.99 ± 11.38 mg/dL); to our knowledge, no differences in urea concentration have been reported previously.

Analysis of the activity of muscle enzymes, such as CK, LDH, and AST, is extremely useful for the diagnosis of skeletal muscle damage, such as that resulting from rhabdomyolysis, which is a postexercise disorder known to occur in Greyhounds. A lack of suitable training leads to a lack of physical adaptation to strenuous exercise that causes muscle injuries and consequently an increase in muscle enzyme activity, as has been described in sled dogs. Although Greyhounds have slightly higher CK activity than non-Greyhounds because of larger muscle mass, there were no significant differences in muscle enzyme concentrations between Spanish Greyhounds at rest and dogs of other breeds at rest in the present study (Table 3). Higher muscle enzyme (CK, LDH, and AST) activity for Spanish Greyhounds after exercise is consistent with results of other studies.

The highest mean ± SD value was detected for serum CK activity (584.19 ± 695.88 U/L), followed by LDH activity (264.63 ± 151.77 U/L) and AST activity (57.66 ± 32.96 U/L). Creatine kinase is primarily found in skeletal muscle, myocardium, and brain tissue, and it is the best indicator of striated muscle damage because most of its activity is in skeletal muscle. Increases in plasma CK activity in dogs are associated with cell-membrane leakage and therefore will be evident in any condition associated with muscular inflammation, necrosis, or degeneration. Creatine kinase has a half-life of only 2 to 3 hours. Thus, high serum CK activity is indicative of recent and active muscle injury. In the present study, blood samples were collected approximately 24 hours after exercise. Thus, if blood samples had been collected sooner after exercise, then it is possible that the CK activity would have been even higher because of muscle damage. Serum LDH activity appears to be increased in humans and horses after strenuous exercise, but results in dogs have been inconsistent. However, serum LDH concentrations were higher in Spanish Greyhounds after exercise. Finally, high serum AST activity is also suggestive of muscle damage, but it is less organ specific than is
CK. Aspartate aminotransferase is also found in the liver, and it has a longer half-life (50 hours) than CK.\textsuperscript{42} Assessment of serum AST activity is useful in conjunction with assessment of CK activity to indicate whether muscle disease is continuing or resolving.\textsuperscript{42}

Exercise caused higher serum CRP concentrations and lower serum iron concentrations in Spanish Greyhounds after exercise, compared with concentrations in those dogs at rest. These findings are consistent with reports\textsuperscript{9,11,12} of similar changes in sled dogs after an endurance race. An increase in serum CRP concentration 24 hours after high-intensity, short-duration exercise (< 1 hour) was also detected in sled dogs, but concentrations remained within the reference range.\textsuperscript{8} Conversely, in the present study, the mean ± SD serum CRP concentration 24 hours after exercise (4.92 ± 2.18 mg/L) exceeded the baseline referent concentration for Spanish Greyhounds at rest (1.00 ± 1.03 mg/L).

Intense exercise causes increases in concentrations of proinflammatory cytokines (interleukin-1, interleukin-6, and tumor necrosis factor-\textalpha) in dogs,\textsuperscript{14} and these cytokines stimulate hepatic synthesis of CRP.\textsuperscript{17} Similarly, cytokines induce iron uptake by macrophages, inhibit iron release, and stimulate hepatic storage of iron in the form of ferritin. In combination, these changes lead to a decrease in the serum iron concentration.\textsuperscript{45} Conversely, regular training causes a decrease in CRP concentration as a result of a reduction in circulating proinflammatory cytokine concentrations.\textsuperscript{46}

In the present study, the CRP concentration in Spanish Greyhounds at rest was used as the baseline referent concentration. The mean ± SD serum CRP concentration for Spanish Greyhounds at rest (1.00 ± 1.03 mg/L) did not differ significantly from the value for dogs of other breeds at rest (0.98 ± 0.79 mg/L). This finding is consistent with results of another study.\textsuperscript{81} Moreover, the CRP concentration for Spanish Greyhounds at rest was within the reference range described for healthy dogs.\textsuperscript{9,10,39}

Mean ± SD serum iron concentration for Spanish Greyhounds at rest (148.57 ± 52.18 µg/dL) was significantly higher than that for dogs of other breeds (114.48 ± 26.33 µg/dL). A greater percentage of transferrin is saturated in Spanish Greyhounds than in other breeds (ie, the amount of iron attached to transferrin is greater; consequently, Spanish Greyhounds have a higher serum iron concentration).\textsuperscript{11}

The lack of adequate training of Spanish Greyhounds used in hare hunting resulted in exercise-induced activation of an acute-phase response indicative of a subclinical inflammatory state. Alterations of various markers of muscle inflammation may be connected to exercise stress. Adequate training would improve the health of Spanish Greyhounds during the hunting season.

Acknowledgments

The authors do not have a financial or personal relationship with other people or organizations that could have inappropriately influenced or biased the content of this report.

Footnotes

\textbf{a.} Mindray, Mindray Medical España SL, Madrid, Spain.

\textbf{b.} Diff-Quik stain set, Siemens Healthcare Diagnostics, Tarrytown, NY.

\textbf{c.} SpinReact, Spinreact SL, Barcelona, Spain.

\textbf{d.} Quantum Saturno 100 Vet, Quantum Vet Diagnostics, Lancaster, England.

\textbf{e.} Human, Diagnostics Worldwide, Wiesbaden, Germany.


References


