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Serum biochemical, blood gas and antioxidant status in search and rescue dogs before and after simulated fieldwork

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ABSTRACT

The aim of the study was to assess the physiological and antioxidant status before and after a 4 h search and rescue field exercise, with handlers, under warm-weather conditions performing activities compared to a control group of similarly trained dogs at rest.

Serum chemistry demonstrated a decrease in serum sodium (Na) and potassium (K) in both exercising and control groups, however only Na was decreased significantly ($P < 0.05$) after exercise and hematocrits (HCTs) remained unchanged. The exercise group demonstrated significantly decreased serum phosphorus (P) and magnesium (Mg) compared to pre-exercise values, as did the control group ($P < 0.025$). There was also a significant increase in creatinine kinase concentrations in the exercise groups ($P < 0.025$). Serum non-esterified fatty acids were increased only in the exercise group after exercise, suggesting fat mobilization to produce energy. The mean total serum antioxidant potential in searching dogs was no different from the pre- and post-exercise values in the control dogs. Serum vitamin E concentrations did not differ between the two groups, with a decreasing trend in both groups. There was a modest decrease in serum uric acid in the control group, while there was a significant rise after exercise in the searching group ($P < 0.01$). Multiple changes in serum chemistry, HCTs and blood gases were documented in this study, and were similar to those observed after other endurance activities. The lack of hemoconcentration in this field search exercise suggested that even in extreme environmental conditions (heat and humidity), dogs with access to water do not experience significant dehydration or diminished antioxidant status.

Introduction

The canine athlete performs a wide range of athletic pursuits, and dogs of varying ages, breeds, sexes, and training backgrounds execute an incredible variety of tasks for variable durations and under a variety of conditions. Data on normal and abnormal hematological, biochemical and blood gas values for these athletes are needed to establish reference ranges that could be used to assess health status and physical stress, thereby improving and individually tailoring conditioning and nutrition programs.

Currently, field studies of dogs performing specific activities and reported in the veterinary literature include investigations of sled dogs (Hinchcliff et al., 1993, 1997, 2000; Querengaesser et al., 1994; Burr et al., 1997; Baskin et al., 2000; Piercy et al., 2000, 2001a, 2001b; Dunlap et al., 2006; McKenzie et al., 2007; Angle et al., 2009; Wakshlag et al., 2010) and Greyhounds (Lassen et al., 1986; Snow et al., 1988; Ilkiw et al., 1989; Rose and Bloomberg, 1989; Nold et al., 1991; Pieschl et al., 1992). These two groups represent large, accessible populations of canine athletes that are often relatively uniform in age and genetic background, and the studies demonstrate that important changes do occur in the exercising canine. However, they represent only the opposite extremes of exercise demands, with sled dogs being extreme endurance athletes and Greyhounds purely sprint athletes.

Racing Greyhounds undergo significant changes in hematological and biochemical values after racing (Lassen et al., 1986; Snow et al., 1988; Ilkiw et al., 1989), suggesting energy production through anaerobic glycolysis, increases in circulating glucose concentrations, metabolic acidosis, and other changes related to hemoconcentration and exercise-induced hemodynamic changes (Snow et al., 1988; Ilkiw et al., 1989; Rose and Bloomberg, 1989).

At the other end of the athletic spectrum, sled dogs exhibit changes related to prolonged exercise, including increased blood volume resulting in decreased packed cell volume due to hemodilution

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(Querengaesser et al., 1994; Burr et al., 1997). This change does not result in a decrease in total erythrocyte number, but rather reduces cardiac load due to diminished blood viscosity. Other characteristic changes include increased serum creatinine kinase (CK) and aspartate aminotransferase (AST) concentrations associated with muscle damage during the events (Hinchcliff et al., 1993; Querengaesser et al., 1994; McKenzie et al., 2007). It has also been observed that serum sodium (Na) and potassium (K) concentrations decrease due to a decrease in total body cation content in the absence of a significant change in total body water content (Hinchcliff et al., 1997).

Data have also been reported from popular canine athletic events, such as field trials, hunting and agility (Matwichuk et al., 1999; Davenport et al., 2001; Steiss et al., 2004; Rovira et al., 2007a; Steiss and Wright, 2008; Pasquini et al., 2010). Dogs performing such intermediate activities also undergo changes in hematological and biochemical parameters. Labrador retrievers that completed field trials had modest hemoconcentration, lactic acidosis, respiratory alkalosis, hypocapnia and hyperthermia (Matwichuk et al., 1999; Steiss et al., 2004; Steiss and Wright, 2008). Changes observed in hunting Pointers after a 40 min period of exercise included increased serum triglycerides, AST, osmolality, serum urea nitrogen, hematocrit (HCT) and thyroxin, and decreased serum K and chloride (Cl) concentrations. Changes were variable based on environmental and conditioning status (Davenport et al., 2001). Similar to Greyhounds, agility dogs demonstrated significant increases in HCT consistent with splenic contraction; elevated serum triglycerides which were probably associated with lipolysis; and elevated post-exercise lactate concentrations with increased serum lactate dehydrogenase activity associated with anaerobic pathway utilization (Rovira et al., 2007a; Baltzer et al., 2012).

Scent detection dogs are invaluable partners in a myriad of fields including wildlife conservation, cancer detection, explosives detection, national security, and locating survivors, victims, and minute amounts of human remains (Komar, 1999; Lasseter et al., 2003; Jones et al., 2004; Oesterhelweg et al., 2008; Kerley, 2010; Cornu et al., 2011; Jones, 2011; Sonoda et al., 2011; Ehmann et al., 2012; Migala and Brown, 2012). Search and rescue dogs have been lauded for their prominent and integral roles in response teams involved in national and international disasters (Duhaime et al., 1998; Nolen, 2011; Gordon, 2012). Published data from field studies investigating the physiological changes associated with canine search and rescue activity are scant (Mazin et al., 2001; Ahrens et al., 2005), although hematological and biochemical effects were observed after a 20 min field exercise search and rescue in one study (Rovira et al., 2008).

The aim of our study was to assess the physiological and antioxidant status before and after a 4 h search and rescue exercise with handlers in Disaster City, College Station, Texas, during warm weather typical of the region. This information in working search and rescue dogs could help to evaluate the effectiveness of current field management procedures and aid in the development of more effective training, conditioning and monitoring programs for search and rescue dogs.

Materials and methods

Dogs

All procedures performed were approved by the Cornell University Institutional Animal Care and Use Committee (2013-0043).

Nineteen dogs between the ages of 2 and 9 years (median, 3 years), including two intact and nine castrated males, and one intact and seven spayed females, were recruited for this simulated search. There were 12 Labrador retrievers, two Golden retrievers, one German shepherd, and four Belgian Malinois. All search and rescue dogs were part of the Texas Task Force One search and rescue team certified for deployment for the state of Texas. The dogs in Texas Task Force One were all Federal Emergency Management Agency certified on either human scent or human remains, having passed a field search activity test and certification examination.

All of the dogs were fed the same diet (Annamaet Extra) commencing 4 weeks before the simulated search, to remove dietary variability. The last meal before exercise was fed the evening before the exercise period. Conditioning of the dogs was variable among handlers, who typically trained the dogs two to four times a week with minimally 26 days of at least 4 h of training with the Texas Task Force One Team, primarily at Disaster City.

Exercise

One group of nine dogs and one group of 10 dogs were scheduled to report on two separate Saturdays in the fall of 2013 for a simulated 4 h search at a designated search and rescue facility (Disaster City, College Station, Texas). On each of the 2 days, 3 of 9 or 10 dogs that arrived at the facility were assigned to the control group and did not perform any exercise.

The exercise period for each group (day 1, $n = 6$; day 2 $n = 7$) consisted of eight different stations of search and rescue related activities (Fig. 1). The eight stations consisted of two rubble piles, two building searches, one train wreck, one barrel search station, one agility command station and one directional station. Handlers accompanied their dogs at each station providing directional guidance; if the dog found the target in less than the 20 min time period, the handler continued the search with directional guidance across the obstacles in the station to continue the search activities. Each handler utilized different verbal, whistle or hand directional commands, depending on the dog's responsiveness and training cues. Each dog was rewarded with a toy at the completion of the task and then encouraged to continue the search at the station with all dogs finding their target at each station. Immediately before and after each session, rectal temperatures were measured as a precautionary measure for overheating.

The dogs performed 20 min of search related activities at each station before resting for 10 min, then moved on to the next station; thus, each station lasted approximately 30 min and a total of 4 h of work was performed. During the 10 min break period, all dogs were offered ad libitum bottled water that was kept in a large cooler filled with ice. Water was poured into a bowl in 0.5 L increments; if an entire 0.5 L was consumed, another 0.5 L was provided. No dog consumed more than 1 L of water at any one rest period and all dogs drank without encouragement. The dogs were allowed to stand, sit or lie in a shaded area before the next period of exercise. To allow complete rest during the rest time, handlers did not provide any directional cues, praise, or extensive handling. The dogs were encouraged to be inactive during this time.

The control dogs had initial blood collections performed with the exercising dogs and were then taken to an adjacent but separate building with an awning. Since six handlers had two dogs but could only work one dog at a time, the non-working dog was designated as control and was scheduled to work in the afternoon rather than the morning when the trial was initiated. All control dogs were housed with ad libitum water in appropriate sized travel kennels under the shade of the awning and were checked every hour. At each check, the control dogs were relaxed and showed no signs of anticipation. They could not see the simulated search area.

Blood collection

All dogs had been fasted for at least 8 h before blood collection since they received their last meal the evening before the exercise. Blood collection occurred between 08.00 and 09.00 h before exercise, and again 10–15 min after exercise ended. Cephalic venepuncture was performed using a 20-gauge needle and 10 mL of blood

Fig. 1. Aerial map of Disaster City, College Station, Texas, showing the eight stations for canine work. Station 1, Rubble 1; Station 2, Building 129; Station 3, Agility; Station 4, Agility and Rubble 2; Station 5, Field walking; Station 6, Directionals; Station 7, Train wreck; Station 8, Barrel searches.