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ENERGY METABOLISM AND HEMATOLOGY OF WHITE-TAILED DEER FAWNS

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ABSTRACT: Resting metabolic rates, weight gains and hematologic profiles of six newborn, captive white-tailed deer (*Odocoileus virginianus*) fawns (four females, two males) were determined during the first 3 mo of life. Estimated mean daily weight gain of fawns was 0.2 kg. The regression equation for metabolic rate was: Metabolic rate (kcal/kg$^{0.75}$/day) = 56.1 + 1.3 (age in days), r = 0.65, $P < 0.001$). Regression equations were also used to relate age to red blood cell count (RBC), hemoglobin concentration (Hb), packed cell volume, white blood cell count, mean corpuscular volume, mean corpuscular hemoglobin concentration (MCHC), and mean corpuscular hemoglobin. The age relationships of Hb, MCHC, and smaller RBC's were indicative of an increasing and more efficient oxygen-carrying and exchange capacity to fulfill the increasing metabolic demands for oxygen associated with increasing body size.

Key words: White-tailed deer, heart rate, hematology, metabolic rate, *Odocoileus virginianus*, respiration, weight gain.

INTRODUCTION

Pregnant white-tailed deer (*Odocoileus virginianus*) that are undernourished during winter may produce fawns that weigh half as much as fawns born to well-fed does (Verme, 1977). Fawn mortality and suboptimal growth have also been associated with protein malnutrition in does (Murphy and Coates, 1966). Further study of the relationship between maternal nutritional status and fawn viability requires detailed information about fawn physiology. However, little information of this nature is available. Few studies have examined blood values of newborn fawns (Johnson et al., 1968; Tumbleson et al., 1970; White and Cook, 1974) or energy metabolism of such fawns. The present study describes weight changes, resting metabolism, and hematology of fawns during the first three months of life.

MATERIALS AND METHODS

Six white-tailed deer fawns (four females, two males), born in captivity in early June 1985 at Carlos Avery Game Farm, Forest Lake, Minnesota 55025, USA, were used in this study. Newborn fawns were left with their does for 3 to 5 days, then removed and hand-reared. Fawns were maintained in separate outdoor pens (1.5 × 3.0 m) covered by corrugated steel roofs. During June, July, and August, mean maximum temperatures were 23.9 ± 1.1, 28.6 ± 1.1, and 24.0 ± 0.8 C, respectively, and mean minimum temperatures were 10.8 ± 1.0, 14.7 ± 1.1, and 12.6 ± 0.9 C (National Oceanic and Atmospheric Administration, 1985).

Fawns were bottle-fed a formula consisting of 59.1 ml colostrum, 118.2 ml whole milk, and 59.1 ml evaporated milk, four times per day at a rate of 71.0 ml/kg$^{0.75}$. Fawns were gradually permitted to consume a high protein-high energy (11.1% crude protein, 2,990 kcal digestible energy/kg) commercial pellet ration (E. J. Houle, Inc., Forest Lake, Minnesota 55025, USA) as well, for the remainder of the study. During a pre-study period of 3 wk, 295.7 ml disposable cups, held in place by a tape band around the poll, were used to train fawns to wear a face mask. Cups were placed on fawns two or three times daily for 10 to 25 min periods. Fawns also were regularly held at rest on a technician's lap to habituate them to experimental procedures.

Fawns were weighed to the nearest 0.2 kg on a digital platform balance daily from 3 to 89 days of age. Body weights were calculated as the weight of a technician holding a fawn minus the weight of the technician. Accuracy of measurements was optimized by repeating measurements of weight until fawns were motionless in the arms of the handler and consecutive readings could be duplicated.

Resting metabolic rate (RMR) was determined by indirect calorimetry after fawns were fasted for 12 hr. A face mask was fashioned from a plastic bottle to which a Rudolph valve (Model 1700, Hans Rudolph, Inc., Kansas City, Missouri 64114, USA) was attached. From 31 to 81 days of age, once per week (Thursday, 0700–1000 hours), expired air was collected from each fawn into meteorological balloons (Douglas, 1911) for 5 ± 1 min while the fawn was at rest in a technician's lap. Five ml blood was collected once per week from 3 to 85 days of age by jugular venipuncture into evacuated ethylenediamine tetraacetic acid vials (Vacutainer, Becton Dickinson, Rutherford, New Jersey 07070, USA) which were immediately refrigerated. Hematological analyses [packed cell volume (PCV), hemoglobin concentration (Hb), red blood cell count (RBC), white blood cell count (WBC), mean corpuscular hemoglobin concentration (MCHC), mean corpuscular hemoglobin (MCH), and mean corpuscular volume (MCV)] were conducted within 24 hr as described by DelGiudice et al. (1990).

Oxygen (O_2) and carbon dioxide (CO_2) concentrations of expired air were measured with a Scholander (1947) gas analysis apparatus. After warming to 25 C, volume of gas collected was measured with a gas meter (Instrumentation Associates, Inc., New York, New York, USA), then corrected to standard temperature (0 C) and pressure (760 mmHg). Heat production was calculated in kcal/kg$^{0.75}$/day (Gemmil and Brobeck 1968). Data were analyzed using least squares multiple regression procedures (Weisberg 1985; Statistix Statistical software, NH Analytical Software, St. Paul, Minnesota 55117, USA). Differences between means were considered significant at $P = 0.05$. Body weight data were $\log_{10}$-transformed to stabilize the variance before regression analyses.

RESULTS

Fawn weights ($P < 0.001$) and RMR's ($P < 0.001$) were positively correlated with age (Fig. 1). Based on linear transformation of predicted values from the regression equation modeling log body weight and age, average daily weight gain of fawns was calculated as 0.2 kg/day. Red blood cell counts ($P < 0.001$), PCV ($P < 0.001$), and MCHC ($P < 0.001$) of fawns were also positively correlated with age (Fig. 2). Mean corpuscular volume was inversely related ($P < 0.001$) to ages of fawns (Fig. 2). There was no clear relationship between WBC or MCH and age of fawns (Fig. 2).

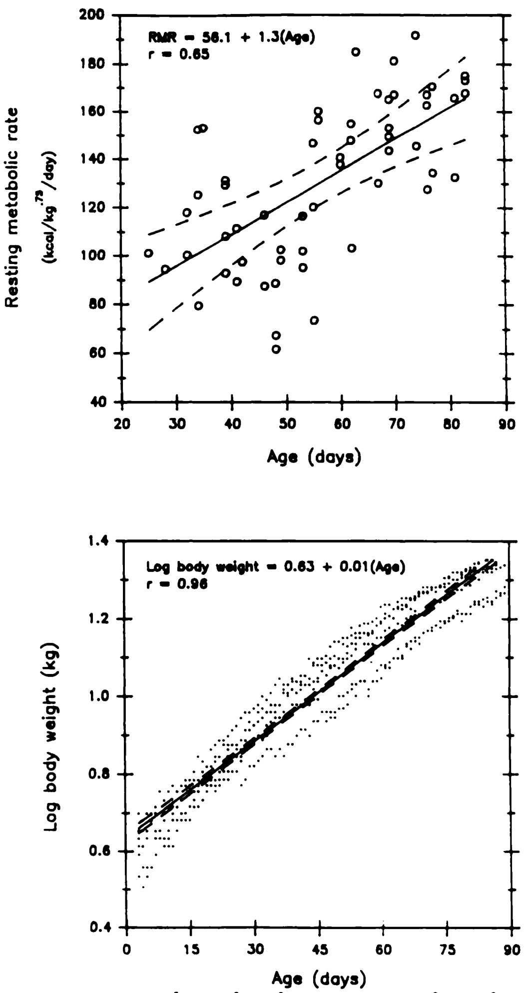

FIGURE 1. Relationships between age and weights (June to August) and resting metabolic rates (July to August) of six captive white-tailed deer fawns, Minnesota, 1985. Dotted lines depict 99% confidence interval.

DISCUSSION

Weight gain and hematology provided data for evaluating the health and performance of the fawns. Elevated WBC counts (20,000/μl) were seen in two fawns at 3 and 10 days of age, respectively; however, daily weight gains of these two fawns (0.07 and 0.10 kg/day) from 3 to 10 days of age were not different from the mean (0.09 kg/day) of other fawns during the same period.

Resting metabolic rates of fawns, on a metabolic weight basis, increased during

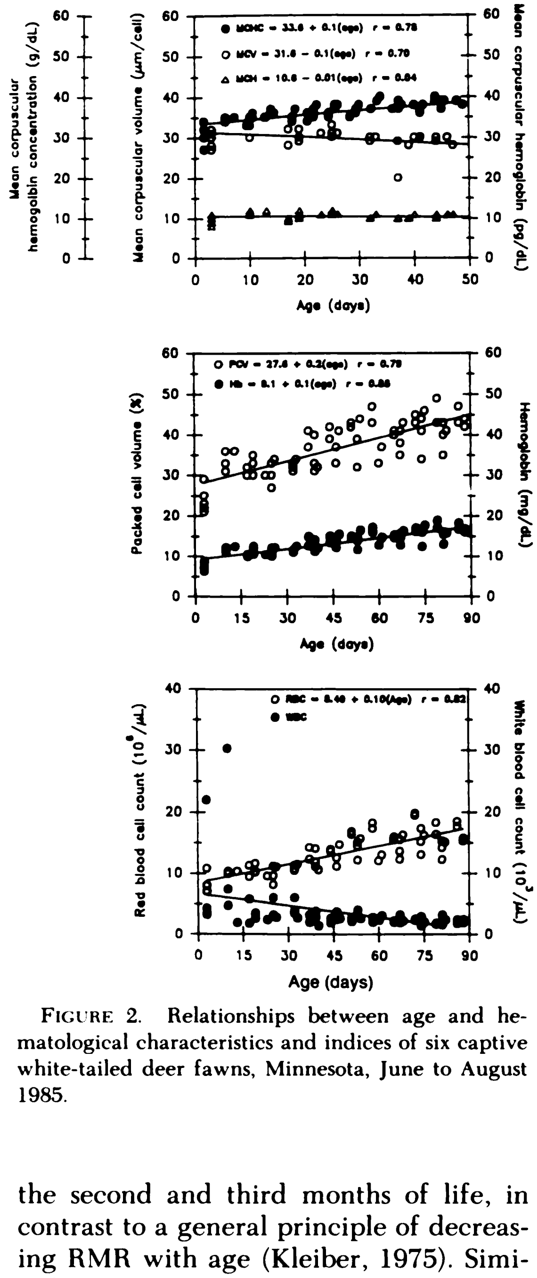

FIGURE 2. Relationships between age and hematological characteristics and indices of six captive white-tailed deer fawns, Minnesota, June to August 1985.

the second and third months of life, in contrast to a general principle of decreasing RMR with age (Kleiber, 1975). Similarly, Robbins et al. (1979) found that RMR's of elk calves rose from 137 to 161 kcal/kg$^{0.75}$/day as calves aged from 2 to 3 mo. Mean RMR's of 121 and 173 kcal/kg$^{0.75}$/day were reported for white-tailed deer and mule deer fawns, respectively (Thompson et al., 1973; Kautz, 1978). Silver et al. (1959) measured a mean basal RMR of 69.1 kcal/kg$^{0.75}$/day in 1.5- to 2-yr-old white-tailed deer.

A shortcoming of measuring RMR using a face mask might be the increase in energy expenditure when animals actively object to restraint or to wearing the device. After 1 mo of training, fawns accepted the mask, remaining still in the handler's lap, and excitement-induced panting was minimal during collection of expired air.

Of particular interest were measurements of various hematologic variables which may be altered by nutrition or infectious disease (Benjamin, 1981; Seal et al., 1981; Bubenik and Brownlee, 1987; DelGiudice et al., 1987). The positive slopes of the regression equations used to model RBC, Hb, PCV, and MCHC data and the negative slope of the regression analysis of MCV values indicated that during the early months of life, the blood of fawns is characterized by decreasing size, but increasing numbers of red cells, with increasing Hb concentrations. Amount of Hb per red cell (MCH) remained stable. These data are consistent with those presented by Tumbleson et al. (1970) for white-tailed deer fawns during the first 10 weeks of life. However, regression equations in the present study describe the relationship between age and each of the characteristics in greater statistical detail.

The steady increases in weights and weight-specific RMR in fawns contributed to an increasing total daily metabolic requirement (kcal/day). It follows that the concurrent increase in RBC, Hb, and MCHC, and decrease in MCV as fawns aged and grew, served to maximize the O_2-carrying capacity of the blood to accommodate the elevated O_2 requirements. The increased number of smaller erythrocytes also maximizes surface area, thus contributing to a more efficient exchange of O_2 and CO_2.

These data clearly demonstrate a relationship between age and growth, energy requirements, and hematology in white-tailed deer fawns. It is conceivable that alterations of "normal" hematology in growing fawns that reflect differences in maternal nutrition, or disease or nutritional deficiencies in the fawn, may compromise its ability to fulfill its increasing energy demands and may influence its endurance. Implications exist with regard to fawn vulnerability to predation and require further study.

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