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Hypertension: A Risk Factor Associated with Weight Status in Dogs[1–3]

J. Alberto Montoya,* Penelope J. Morris,[†,4] Immaculada Bautista,* M. Candelaria Juste,* Lourdes Suarez,* Cristina Peña,* Rachel M. Hackett,[†] and John Rawlings[†]

*Veterinary Medicine Service, Faculty of Veterinary Medicine, Las Palmas de Gran Canaria University, Spain and [†]WALTHAM Centre for Pet Nutrition, Waltham-on-the-Wolds, Melton Mowbray, LE14 4RT, UK

EXPANDED EXTRACT

KEY WORDS: • *hypertension* • *obesity* • *blood pressure* • *canine* • *body condition score*

The relation between hypertension and weight status in humans has long been established (1), but because hypertension is uncommon in dogs, and specifically primary (essential) hypertension is rare, similar studies have not been conducted in dogs. With obesity currently estimated to affect 20–40% (2–4) of the canine population, research is required to fully understand the secondary consequences of excess body fat.

Previously, Bodey and Michell (5) conducted a large (1903 dogs) study examining the influence of factors such as sex, neuter status, age, breed, and body condition on canine blood pressure. They concluded that body condition had only a minor effect on blood pressure and that this was most likely related to age, as older animals are most likely to be overweight and to suffer from additional health problems. This study, however, included only 3 classifications of body condition, underweight, ideal, and overweight, as well as including dogs with known pathologies. This group concluded that age, sex, neuter status, breed, and size (small, medium, large, or giant) were significant determinants of blood pressure in dogs.

Experimentally induced canine obesity (6) is known to result in elevated blood pressure measurements, but it is unclear whether this is a result of the high-fat diet fed to induce obesity, the rate of weight gain, or a direct result of excess body fat. The aim of this study, therefore, was to determine the relation between body condition score using a 9-point scale and blood pressure in otherwise healthy dogs.

MATERIALS AND METHODS

Data were collected from 122 Spanish, client-owned, urban household dogs. Dogs were recruited and assessed during routine veterinary visits and were determined to be free of underlying pathologies by physical examination and consultation with the owner. Dog size was defined according to the Kennel Club UK breed classifications, and the population contained 39 small dogs, 44 medium dogs, and 39 large dogs. Eighty-four dogs were from 27 recognized breeds, most commonly Yorkshire Terrier, German Shepherd, Miniature Poodle, Cocker Spaniel, Bulldog, and Canary dogo. Thirty-eight dogs were of mixed breed. All were considered adult for their breed, and ages ranged from 2 to 15 y. Forty-three dogs were male, of which 95% were entire, and 79 dogs were female, of which 86% were entire. Commercially prepared pet food was fed to 97% of the dogs.

Body condition score (BCS) was assessed using a 9-point scale (7). Blood pressure was assessed using the oscillometric method (Memoprint) with an appropriately sized cuff placed around the base of the tail where possible or around a hind limb if the tail site was unavailable. Three measures were taken 10 min apart. Dogs were gently restrained and excluded from analysis if they showed obvious signs of stress. Mean arterial pressure was calculated using the formula:

$$\text{MAP} = [(\text{systolic blood pressure} - \text{diastolic blood pressure})/3] + \text{diastolic blood pressure}.$$

Hypertension was defined according to the criteria of the Veterinary Blood Pressure Society (SBP ≥150 mm Hg and DBP ≥95mm Hg).

Data were assessed for normality of distribution by the Kolmogorov-Smirnov test. Distributions of variables between BCS categories were assessed using 1-way ANOVA. Categorical variables were assessed using the χ^2 test, and the relation between variables was assessed using linear regression and stepwise multiple regression models. All statistical analysis was conducted using SPSS, version 13.0.

RESULTS

Fourteen dogs were determined to have a BCS of 4, 28 had a BCS of 5, 17 had a BCS of 6, 26 had a BCS of 7, 27 had a BCS of 8, and 10 had a BCS of 9. There was no significant difference in the number of neutered and entire dogs in each BCS category ($P = 0.406$), nor were there any differences in the

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[4] To whom correspondence should be addressed. E-mail: penelope.morris@eu.effem.com.

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distribution of dog sizes between BCS categories ($P = 0.242$). The ratio of male to female dogs was equal in BCS 5, whereas females significantly outnumbered males in all other BCS groups ($P = 0.009$). Dogs with a BCS of 5 were also significantly younger (4 ± 3 y) than dogs with BCSs of 7 (7 ± 3 y; $P = 0.015$), 8 (8 ± 3 y; $P = 0.00$), and 9 (9 ± 1 y; $P = 0.004$). There were no significant differences in age range between any of the other groups.

There were significant correlations between BCS and systolic pressure (**Fig. 1**a, $r = 0.227$, $P = 0.012$), diastolic pressure (Fig. 1b, $r = 0.494$, $P < 0.001$), and MAP (Fig. 1c, $r = 0.461$ $P < 0.001$). There was also a significant correlation between body condition score and the prevalence of hypertension ($r = 0.271$, $P < 0.001$).

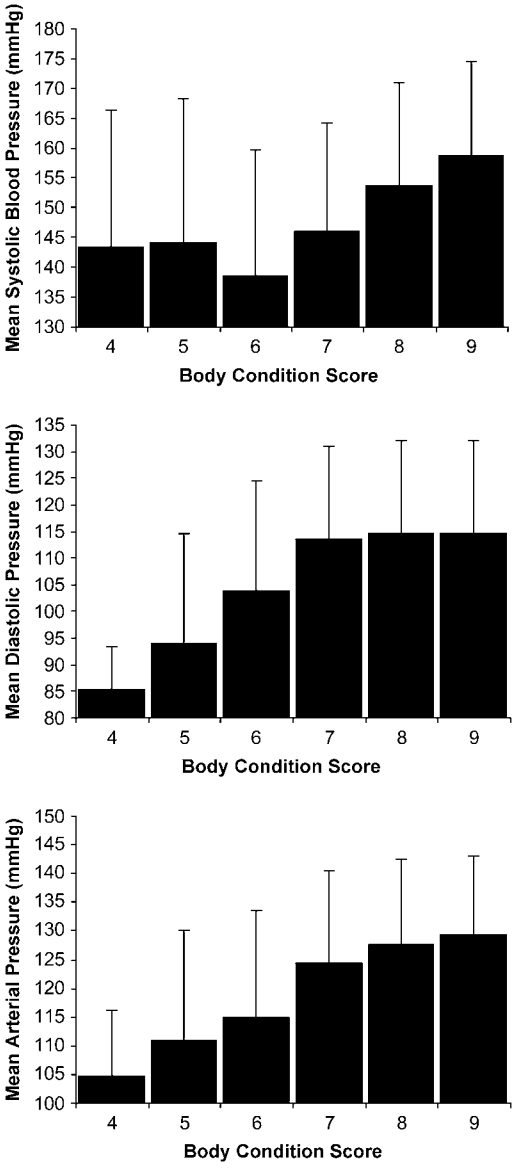

FIGURE 1 Relation between body condition score and blood pressure measures in dogs. Data assessed using linear regression. Correlation between body condition score determined by Laflamme method and systolic blood pressure determined by oscillometry ($r = 0.227$, $P = 0.012$) (*A*). Correlation between diastolic blood pressure and body condition ($r = 0.494$, $P < 0.001$) (*B*). Correlation between body condition score and mean arterial pressure ($r = 0.461$, $P < 0.001$) (*C*). Values are means ± SD.

The association between BCS and systolic blood pressure remained significant when breed ($r = 0.270$, $P = 0.003$), age ($r = 0.199$, $P = 0.029$), sex ($r = 0.238$, $P = 0.009$), and neuter status ($r = 0.228$ $P = 0.012$) were controlled but was not significant when controlling for dog size ($P = 0.088$).

The association between BCS and diastolic blood pressure remained significant when breed ($r = 0.499$, $P < 0.001$), age ($r = 0.447$, $P = 0.029$), size ($r = 0.482$, $P < 0.001$), sex ($r = 0.495$, $P < 0.001$), and neuter status ($r = 0.492$, $P < 0.001$) were controlled. Similarly, the relation between MAP and BCS remained significant when all factors (breed, $r = 0.481$, $P < 0.001$; age, $r = 0.415$, $P < 0.001$; size, $r = 0.435$, $P < 0.001$; sex, $r = 0.466$, $P < 0.001$; neuter status, $r = 0.460$, $P < 0.001$) were controlled.

When all factors were inserted into a stepwise multiple regression model, breed, BCS, and size were the major determinants of systolic blood pressure, but this model accounted for only 17.8% of the variance. The factors were also the primary determinants of MAP, accounting for 30.1% of the variance. For diastolic blood pressure, BCS and size were the major determinants, accounting for 28.7% of the variance.

DISCUSSION

The primary aim of this study was to determine the relation between body condition score using a 9-point scale and blood pressure in otherwise healthy dogs. The relation between hypertension and weight status in humans has long been established (1), but as hypertension is uncommon in dogs, and specifically primary (essential) hypertension is rare, similar studies have not been conducted. Although rates of stroke and heart disease are low in dogs, persistent hypertension has consequences for the eyes, heart, brain, and kidneys (8).

Analysis showed that BCS was significantly correlated to systolic, diastolic, and mean arterial pressure, accounting for 5.2, 24.4, and 21.2% of the variability, respectively. These associations remained significant when controlling for breed, age, sex, and neuter status, although the correlation between BCS and systolic blood pressure was not significant when controlled for size. Although the contribution of BCS variance to blood pressure measures is small, the data still suggest that weight status may be an as yet unaccounted for contributor to secondary hypertension.

In addition to storing excess energy, canine adipose tissue secretes several molecules collectively known as adipokines (9). One of these adipokines, angiotensin II, not only influences blood pressure via the kidney but also acts on presynaptic nerve endings to increase sympathetic nervous activity (10). Thus, the excess adipose tissue associated with increasing BCS may explain the increased incidence of hypertension.

Unlike human studies and those previously conducted in a canine population, age was not the primary determinant of blood pressure in the current study. The previous study in dogs (6) that showed age as a primary determinant of blood pressure also included dogs with known pathologies. As the incidence of illness and disease increases with age, this may also explain the previous association. Also, unlike humans, life expectancy in dogs varies with breed and size, with giant breeds having a much shorter life expectancy than small breeds (11). This may explain why breed and size composed part of the multiple regression models along with BCS to describe the variance in systolic, diastolic, and mean arterial blood pressures. In future studies, a measure of age relative to life expectancy should be incorporated into the analysis to fully elucidate the effect of this variable on blood pressure measures.

In addition to life expectancy, blood pressure itself varies with breed and may account for the inclusion of breed and size in the multiple regression model. This variation is thought to have a genetic basis because both racing and show greyhounds (different genetic strains) have high blood pressures (6), suggesting that these do not result from feeding or exercise levels. A larger study needs to be conducted in defined breed groups to further elucidate the role of breed and size.

Exercise level was not recorded as part of this study and may play a large role in BCS and blood pressure. Regular exercise has been shown on numerous occasions to reduce resting blood pressure in humans via a decrease in sympathetic tone. When examined within breed, one group demonstrated that those dogs that exercised heavily had lower resting blood pressures than those that did not (6). A precise level of exercise was not measured, however, and this would be needed to understand the effect of exercise on canine blood pressure and the minimum level needed to reduce hypertension.

Neuter status and sex have previously been shown to affect blood pressure, with entire females having lower blood pressures than entire males and neutered animals being intermediate. The interaction with neuter status and blood pressure will also be affected by age, as most animals are neutered as young adults. Similarly, there is an indication that neuter status impacts on BCS and, thus, may also influence blood pressure measures. Because only 5% of male and 14% of female dogs were neutered there in the current study, there is not enough power to determine whether this was a factor.

The results of this study, however, do indicate that body condition plays a role in the etiology of canine hypertension, although a larger study should be conducted to fully elucidate its role. This suggests that weight status must be considered as a risk factor for secondary hypertension and treatment such as nutritional intervention, increased exercise, and weight loss should all be considered for the overweight dog.

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