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# Characteristics of obese or overweight dogs visiting private Japanese veterinary clinics

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ABSTRACT

**Objective:** To characterize obese or overweight dogs that visited private Japanese veterinary clinics located in humid subtropical climate zones.
**Methods:** Dogs were categorized into four body condition score groups and five body size groups based on their breed. Multilevel logistic regression models were applied to the data. A *Chi*-squared test was used to examine whether the percentage of obese or overweight dogs differed between breeds.
**Results:** There were 15.1% obese dogs and 39.8% overweight dogs. Obese dogs were characterized by increased age and female sex, whereas overweight dogs were characterized by increased age and neuter status ($P < 0.05$). Peak probabilities of dogs being either obese or overweight were between 7 and 9 years of age, with the probabilities then declining as the dogs got older. For example, in toy sized dogs, the probability of dogs being overweight increased from 33.4% to a peak of 55.1% as dog age rose from 1 to 8 years old. Also, in medium, small and toy sized dogs, neutered dogs were more likely to be overweight than intact dogs, whereas neutered small sized dogs were more likely to be obese than intact small sized dogs ($P < 0.05$). Additionally, the percentages of obese or overweight dogs differed between the 10 selected breeds with the highest percentage of obese or overweight dogs.
**Conclusions:** By taking age, body size, sex and neuter status into account, veterinarians can advise owners about maintaining their dogs in ideal body condition.

## 1. Introduction

Numbers of obese and overweight people are increasing in developed countries [1,2]. Also, excessive body weight is a growing problem in dogs [3], and has been implicated in a range of medical concerns such as diabetes mellitus, cardiovascular diseases, dyslipidemia and osteoarticular diseases [4–6]. Dog obesity in developed countries is also a widespread problem. The prevalence (%) of dogs being obese and overweight in the USA, the UK, Australia and China reported was estimated to be 34.1% [5], 59.3% [7], 25.0% [8] and 44.4% [9], respectively.

Factors commonly associated with dogs having excessive body weight are middle age, neutering, female sex, low physical activity and also low human population density [4,5,7,9]. Specific breeds, such as Labrador Retrievers, Beagles and Shetland Sheepdogs, have also been reported as being at highest risk of either obesity or being overweight [5,10]. For example, Cocker Spaniels have been reported as having the highest risk for being overweight, whereas Shetland Sheepdogs were at the highest risk of obesity [5].

Dogs could also be categorized into different size groups based on their breed [4,11], such as large, medium and small size; this would take account of some breed effects. However, no studies in Japan have used medical records in a single model to quantify the characteristic factors (body size, age, sex, neuter status and human population density) associated with

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dogs being either obese or overweight, and the interactions between these factors.

Dogs' veterinary medical records are in a multi-level structure because health related checks, guidance and treatments on an individual dog are all performed in a clinic. The clinic is a variable that includes some unique information, such as a dog's location, the average social and economic status of owners coming with their dogs to the clinic, and veterinary health guidance. Therefore, the objective of the present study was to examine characteristic or risk factors and interactions associated with obese dogs and overweight dogs in Japan by using a mixed-effects model with clinics as a random intercept.

## 2. Materials and methods

### 2.1. Dog database including dog characteristics and body condition score (BCS)

Institutional Animal Care and Use Committee approval at Meiji University (IACUC 15-0013) was obtained for this study. A dog database has been created at Meiji University (Kawasaki, Japan) by cooperating with a veterinary service (Spectrum Lab Japan, Tokyo, Japan). The veterinary service recorded information about individual dog's characteristics (BCS, age, sex, neuter status and breed) when they received serum samples for lipoprotein analysis from veterinarians in private clinics throughout Japan. The veterinarians who submitted the samples were not informed about the specific purposes of the present study. The serum samples were collected from clinically non-diseased dogs that received a health check and from dogs that were being assessed for suspected dyslipidemia. The dogs' health conditions were diagnosed by their veterinarians when the serum samples were taken. The BCS for each dog was evaluated by the dog's veterinarian using a five-point scale system (1: thin, 2: underweight, 3: ideal, 4: overweight and 5: obese). The BCS five-point scale system is widely used in Japan [12], and website information and brochures about the system are widely available to veterinary clinics across Japan, provided by the Pet Food Institute (Washington D.C., USA) and a nutrition company [Hill's-Colgate (Japan) Ltd., Tokyo, Japan].

### 2.2. Data and exclusion criteria

The database comprised data of 9 120 dogs from 116 breeds, collected from 1 198 veterinary clinics between 2006 and 2013, amounting to 10.9% of the 11 032 small animal clinics in Japan [12]. The samples were submitted from all the 47 prefecture regions, which are mostly located in humid subtropical climate zones. The proportions of the samples in Northern Japan, East Japan (including Tokyo), West Japan and Kyushu were 9.6%, 56.7%, 28.1% and 5.6%, respectively. Additionally, the proportions of the samples submitted in January to March, April to June, July to September and October to December were 20.9%, 29.5%, 24.9% and 24.7%, respectively.

Records of second or later visits were not used in the present study (2 170 records). Records of dogs having diabetes mellitus, hypothyroidism or hyperadrenocorticism health problems, which would influence body condition, were excluded from the dataset (563 records) if the veterinarians had made a diagnosis of endocrine diseases from blood and urinary tests, on the basis of clinical signs such as polydipsia and polyuria. Also, the records of dogs with BCS 1 were excluded (12 records) because those dogs were few and were suspected of having a health problem. With the exception of the above exclusion criteria, all the other cases submitted by the clinics were included in the present study.

Two datasets were created in the present study. Dataset 1 (including BCS 2, 3, 4 and 5 dogs) contained the records of 5 605 dogs in 108 breeds from 1 094 clinics, and was used to investigate characteristic factors associated with obese dogs. In Dataset 2 (including only dogs of BCS 2, 3 and 4), dogs with BCS 5 were excluded (844 records) because this dataset was used to examine factors only related to overweight dogs with BCS 4. Hence, Dataset 2 included the records of 4 761 dogs in 103 breeds from 1 020 clinics.

### 2.3. Categories and definitions

Obese and overweight dogs were defined as dogs having BCS 5 and BCS 4, respectively. Additionally, dogs were classified into two sex groups (male dogs or female dogs) and also two neuter status groups (intact dogs or neutered dogs). The dogs in the 103 breeds were grouped into six body size categories (breed body size) based on their breed [6]: giant (*e.g.* Saint Bernard), large (*e.g.* Labrador Retriever), medium (*e.g.* Beagle, Pembroke Welsh Corgi), small (*e.g.* Miniature Schnauzer, Shetland Sheepdog), toy (*e.g.* Chihuahua, Miniature Dachshund, Pomeranian, Shih Tzu, Yorkshire Terrier) and unknown. In the present study, giant sized dogs (23 records) were included in the large sized dog group because there were relatively few samples. Finally, the unknown group consisted of mixed breed dogs. In addition, human population density (people per $km^2$) values were based on the population density of the city where each clinic was located, and were obtained from the Statistics Bureau in the Ministry of Internal Affairs and Communications, Japan [13].

### 2.4. Statistical analysis

All statistical analyses were performed using SAS software (SAS Institute Inc., Cary, USA). Two-level analysis was applied, using a clinic at level 2 and an individual dog at level 1, to take account of the hierarchical structure of the individual dogs within a clinic. A two-level mixed-effects logistic regression model, using the GLIMMIX procedure with logit link function, was performed to determine risk factors for obese or overweight dogs. Also, ILINK (inverse link function) was used to convert the logit to a probability [14]. Pairwise multiple comparisons were performed using the Tukey–Kramer test.

Outcome variables in Models 1 and 2, respectively, were whether or not dogs were obese (1 or 0; reference category = dogs with BCS 2 – 4), and whether or not dogs were overweight (1 or 0; reference category = dogs with BCS 2 and 3). Age, sex, neuter status, breed body size groups and human population density were included in both Models as possible factors (explanatory variables). Quadratic expressions of continuous variables (*e.g.* age) and all possible Two-way interactions between explanatory variables were also examined in both Models, and were then removed from the Models if they were not significant ($P > 0.10$). The years when BCS was evaluated were taken as a fixed effect in the Models, even though in preliminary analysis the year was not associated with the probability of dogs being obese or overweight ($P \geq 0.11$). Additionally, both Models included the clinic as a random intercept. To assess the variations in the probability of dogs being obese or overweight that could be explained by the clinic,