Original Article

Epidemiology of characteristics and risk factors for overweight in cats visiting an animal hospital in Bangkok, Thailand

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Abstract

A cross-sectional study aimed to estimate the prevalence and to investigate the characteristics of overweight/obese cats visiting an animal hospital in Bangkok, Thailand. Electronic medical records of feline patient visiting the Small Animal Teaching Hospital, Chulalongkorn University between January 1, 2017 and December 31, 2017 were reviewed. The cat's information included age, breed, sex, neutering status and body condition score. Associated demographic factors and overweight/obesity using idealweight as a reference was performed by logistic regression. The prevalence of feline overweight/obesity was 8.1% (95%CI: 7.4% - 8.9%). From the multivariable logistic regression, age, sex, neutering status, breed and interaction of age and neutering status were significantly associated with being overweight/obese. Male (OR = 2.18, 95%CI: 1.72, 2.78), neutered cats had higher odds of being overweight. Among neutered cats, the odds of being over-weight increased with advancing age. The result of the study indicated that the overweight/obesity problem in cat is not uncommon. The risk factors identified from the study can help veterinarians in managing and preventing the risk of overweight/obesity in cats and educating owners of high-risk cat to aware of overweight/obesity-related disease.

Keywords: characteristics, epidemiology, feline, obesity, overweight

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Introduction

Obesity is a condition of positive energy balance and excessive adipose tissue formation with adverse effects on morbidity and mortality (Crane, 1991). Like humans, obesity in cats is associated with developing lameness (Scarlett and Donoghue, 1998), non-allergic skin disease (Scarlett and Donoghue, 1998), diabetes mellitus (Panciera *et al*., 1990; Lund *et al*., 2005) and lower urinary tract disease (Öhlund *et al*., 2018).

Overweight/obesity, which is classified by body condition score (BCS) greater than 3 (5-scoring system) or 5 (9-scoring system), in cats is not uncommon. Previous studies have reported the prevalences of overweight and obesity are between 7 to 63% in different populations (Colliard *et al*., 2009; Courcier *et al*., 2010). The prevalence of feline obesity is increasing together with the obesity problem in human (Cave *et al*., 2012). Therefore, the trend change of obesity in pets can be a model for obesity in humans (German, 2006). However, information on the prevalence of feline overweight/obesity in Thailand is not available. The knowledge of the prevalence of feline overweight/obesity cannot only alert veterinarians but also cat owners of the importance of the obesity problem in cat population.

Feline obesity has been reported to be related to sex, breed, age, neutering status, and other contextual factors including diet, environment and owner characteristics (Colliard *et al*., 2009; Courcier *et al*., 2010; Bermingham *et al*., 2014). The study of risk factors can be applied to disease prevention. In addition, knowing of risk factors can uncover the underlying causes and be used for further study. However, using risk factors from other studies conducted elsewhere in the world may under-, or over-estimate the true risk factors for overweight/obese cats in Thailand. The objectives of the present study were to estimate the prevalence of feline overweight /obesity, to examine the characteristics and risk factors associated with overweight/obesity in cats visiting an animal hospital in Bangkok, Thailand.

Materials and Methods

Study population: Electronic medical records of all cats visiting the Small Animal Teaching Hospital, Chulalongkorn University, Bangkok, Thailand between January 1, 2017 and December 31, 2017 were reviewed. For repeated records from the same cats, only the first visit of cats during the study period were collected. In each record, information of BCS, breed, age, sex, neutering status and body weight were obtained. Cats in which BCS was not assessed were excluded from the study.

Demographic variables: BCS was evaluated by attending veterinarian using a 5-point scale which was 1 = very underweight, 2 = underweight, 3 = ideal, 4 = overweight, and 5 = obese (Laflamme, 1997). Cats were further divided into three groups based on BSC. The overweight group was defined as cats with BCS of 4 and 5, the ideal-weight group was classified in all cats with a BCS of 3 and underweight group was all cats with a BCS of 1 and 2. Age was recorded in years. Breed was grouped based on frequency distribution as i) Domestic short hair (DSH), ii) mixed breed, iii) Persian, iv) Scottish fold, and v) other pure breeds

Statistical analyses: Descriptive statistics were performed on all variables to describe the distribution of demographic variables. The prevalence of overweight was calculated from number of cats in the overweight group being divided by total number of cats. The correlation between body weight and BCS was evaluated by Spearman's rank correlation analysis. For identification of demographic risk factors, only overweight and ideal weight groups were analyzed. The data was analyzed in 2 stages using SPSS version 22.0 (SPSS Inc., Chicago). In the first stage, univariate logistic regression was performed to screen all explanatory variables and expressed in odds ratio (OR) and 95% confidence interval (95%CI). Evaluation of multicollinearity among explanatory variables was assessed using Chi-square test for categorical variables ($p < 0.05$). In cases of multicollinearity, the variable with higher biological plausibility was retained for multivariable analysis. Age was introduced into the analysis as a categorical variable based on quartile frequency since this categorizing obtained high likelihood in the analysis.

In the second stage, variables from the univariate analysis with $P \leq 0.2$ and without marked multicollinearity among variables were included in the full multivariable logistic regression for model selection. A backward stepwise variable selection procedure was performed. All possible 2-way interactions were further tested. The Goodness-of-fit test for final multivariable model was assessed by Hosmer-Lemeshow Goodness-of-fit test. The ability of the model to discriminate over-weight cats and ideal-weight cats was tested using a Receiver Operating Characteristic (ROC) and area under the curve (AUC). Models with an AUC value greater than 0.8 or between 0.7 and 0.8 were considered to have good, moderate discriminative capacities, respectively. Accuracy of the final model prediction was evaluated using cross-validation method with random sampling of observed data for model prediction. The results from the model prediction were compared to observed data and the outcome was shown based on percentage of accuracy.

Results

During the study period, the records of 5,439 cats with recorded BCS were included and analyzed. Sixty percent of cats (n = 3,428) were ideal weight, 7 % (n = 381) were overweight (BCS = 4), and 1.1% (n = 60) were obese (BCS = 5), 26.5% (n=1,444) had a BCS of 2, and 2.3% (n = 126) had a BCS of 1 (Fig. 1). The overall prevalence of feline overweight/obesity in the present study was 8.1% (95%CI: 7.4% to 8.9%). Spearman's rank correlation between body weight and BCS was 0.45 ($P<0.001$).

Demographics: The demographics of the cats in the study are presented in Table 1. More than half of the cats was DSH (70.7%). Among pure breed cats, Persian (9.1%) and Scottish Fold (3.7%) were the most frequently seen. There were slightly more males (52%) than females (48%) and 41% of males and 38% of

females were neutered. The median age of cat was 2.0 years (Q_1: 1.0 years, Q_3: 4.0 years) and mostly ≤ 1 year (33.8%).

Univariate analysis: All the variables had $P \leq 0.2$ in univariate analysis (Table 1). No multicollinearity among variables was observed, so these variables were included in the multivariable logistic regression model process.

Multivariable analysis: All variables were significant in the multivariable logistic regression model. The pairwise interaction between age and neutering status was significant and included in the final multivariable logistic regression model (Table 2). The final model fitted well to the data when tested with Hosmer-Lemeshow goodness-of-fit test ($P>0.05$). The area under the ROC curve (AUC) calculated for this model was 0.75 (95%CI:0.72, 0.77, $P<0.05$); therefore, the final model had moderate discrimination capacity. The accuracy of the model prediction was 84% when calculated with cross-validation.

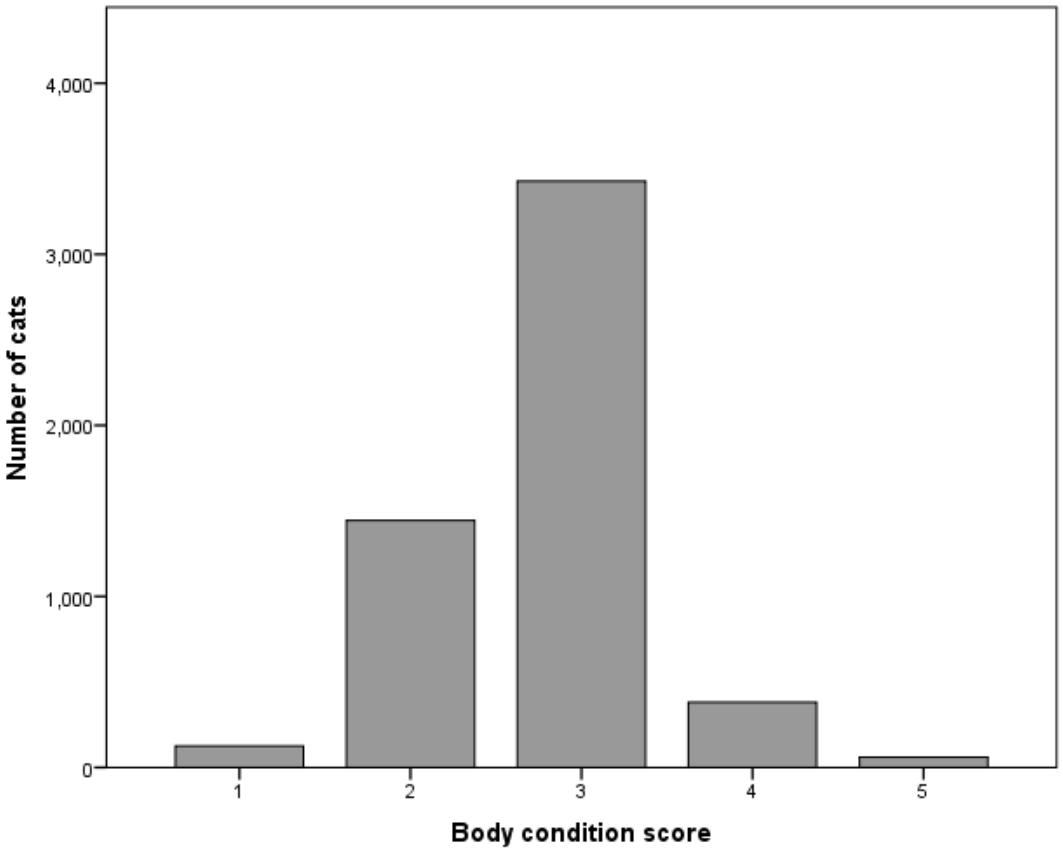

Figure 1 Bar chart of feline body condition scores

Table 1 Distribution of demographic factors and results of univariate logistic regression

Variables	Category	Over-weight	Ideal-weight	OR (95%CI)	*P*-value
Sex	Female	145	1,520	1.00	-
	Male	283	1,638	1.81 (1.46, 2.24)	<0.001
Neutering status	No	114	1,748	1.00	-
	Yes	284	1,082	4.02 (3.19, 5.06)	<0.001
Age	≤ 1 year	63	1,245	1.00	-
	1 - 2 years	81	923	1.73 (1.23, 2.44)	0.002
	2 - 4 years	124	628	3.90 (2.84, 5.36)	<0.001
	> 4 years	170	621	5.41 (3.98, 7.34)	<0.001
Breed	DSH	337	2,351	1.00	-
	Mixed	20	148	0.94 (0.58, 1.52)	0.810
	Persian	16	329	0.34 (0.20, 0.57)	<0.001
	Scottish Fold	14	145	0.67 (0.38, 1.18)	0.167
	Pure breeds	19	181	0.73 (0.45, 1.19)	0.209

Table 2 Results of multivariable logistic regression

Variables	Category	OR (95%CI)	*P*-value
Sex	Female	1.00	-
	Male	2.18 (1.72, 2.78)	<0.001
Neutering status	No	1.00	-
	Yes	7.25 (3.89, 13.48)	<0.001
Age	≤ 1 year	1.00	-
	1 - 2 years	0.81 (0.46, 1.43)	0.469
	2 - 4 years	1.34 (0.81, 2.21)	0.253
	> 4 years	1.38 (0.86, 2.22)	0.187
Breed	DSH	1.00	-
	Mixed	0.82 (0.49, 1.38)	0.164
	Persian	0.32 (0.19, 0.55)	<0.001
	Scottish Fold	0.88 (0.48, 1.61)	0.679
	Pure breeds	0.56 (0.32, 0.97)	0.042
Neutering status x age	Neutered at age 1-2 years	2.08 (0.92, 4.71)	0.080
	Neutered at age 2-4 years	2.96 (1.35, 6.46)	0.007
	Neutered at age > 4 years	7.02 (3.27, 6.46)	<0.001
	Intact at age 1-2 years	0.48 (0.21, 1.09)	0.080
	Intact at age 2-4 years	0.34 (0.15, 0.74)	0.007
	Intact at age > 4 years	0.14 (0.06, 0.31)	<0.001

Discussion

The prevalence of overweight/obesity (BCS = 4 and 5) in the present study was 8.1% which is similar to previous studies (Courcier *et al*., 2012; Rowe *et al*., 2015). In other epidemiologic studies, the prevalence was higher than that of in this study (Lund *et al*., 2005; Colliard *et al*., 2009; Cave *et al*., 2012). The difference in the prevalence can be explained by the different sample populations. In the present study and the study of Courcier and co-workers (Courcier *et al*., 2012), the sample population was cats visiting animal hospital regardless of health status where many of the cats had health problems driving them to emaciation or weight loss condition. Unfortunately, we did not obtain the diagnostic history in the study population. Even though the estimate prevalence was lower than other studies, it is indicated that overweight /obesity was not uncommon in cat population.

The correlation between bodyweight and BCS in the present study was lower (r = 0.45) compared to a previous study (Teng *et al*., 2017). The poor correlation suggests that the interobserver variation of assessment the BCS was high. We did not perform the agreement among veterinarians in the hospital. Even though this was poor correlation, the positive correlation direction indicated that body weight was in agreement with BCS.

In the logistic regression analysis, we used the ideal weight cats as a reference group which has been used in one previous study (Teng *et al*., 2017) but not in other studies (Colliard *et al*., 2009; Laurence *et al*., 2009; Öhlund *et al*., 2018). The reason for using ideal weight cats to be a reference is that cats with BCS 1 or 2 may be interfered with by health-related diseases rather than overweight cats. Furthermore, evaluation of the risk of being overweight compared to the risk of ideal-weight and under-weight combined may bias the estimates (Teng *et al*., 2017). Therefore, including these cats in the comparison group may bias the association.

Male cats have higher odds of being overweight compared to female cats and this has been found in previous studies (Lund *et al*., 2005; Teng *et al*., 2017; Öhlund *et al*., 2018). It has been proposed that female cats have a higher maintenance energy requirement per kilogram in body weight than males (Bermingham *et al*., 2010). Therefore, males are consuming excess energy and thus becoming more overweight more easily than female cats. In addition, this may be explained by the perception of veterinarians. Male cats are generally larger in body size and higher in body weight then knowing the weight of the cats may influence the assessment of their BCS (Hendriks *et al*., 1997; Kienzle and Moik, 2011).

Neutered cats had 2.5 times higher odds of being overweight. Most of the previous studies have consistently shown that neutering increases the odds of overweight in cats (Lund *et al*., 2005; Colliard *et al*., 2009; Courcier *et al*., 2010). The increase in weight after neutering can be caused by increased daily food intake as suggested by several experimental studies, a decrease in metabolic rate, and decreased activity level predisposing neutered cats to be overweight (Fettman *et al*., 1997; Donoghue and Scarlett, 1998; Hoenig and Ferguson, 2002).

Age appeared to be an important factor for overweight and obesity, which seemed to be increasing with advancing age, similar to other studies (Courcier *et al*., 2010; Courcier *et al*., 2012; Teng *et al*., 2017). In the multivariable model, we found an interaction between neutering status and age of cat. Among neutered cats, the odds of being overweight increased with advancing age whereas in intact cat the odds of being overweight decreased. This observation has not been previously reported. This can be explained by the distribution of cats in the study population in which, with advancing age, the proportion of neutered cats is higher. The increase in the proportion of neutered cats in advancing age results in increased risk of overweight.

Dealing with breed introducing into the model was difficult because of the low numbers of certain breeds of cats. However, the result of the present study was similar to previous studies in which DSH cats tend to have higher BCS (Colliard *et al*., 2009; Öhlund *et al*., 2018). This was not surprising because DSH was the majority breed cat in this study (70.7%).

The present study had several limitations. First, the study population was only from a single animal hospital in Bangkok area which may not be representative of cats in Bangkok or in Thailand. Second, the present study analyzed all cats visiting the hospital where, in general, both diseased and healthy cats were enrolled resulting in a low prevalence of feline obesity. Lastly, we did not include contextual factor including owner's information and diet which in a previous study were associated with being overweight or obesity in cat. Therefore, the association of owner characteristics and contextual factor and over-weight cats should be further analyzed.

Conclusion

The prevalence of overweight and obesity in cats in Thailand is marked. This should alert Thai veterinarians as well as the owners of the importance of being overweight/obese in cat. As neutering and males are associated with increased risk of overweight, veterinarian should educate the owners of overweight cats to be aware of obesity -related conditions.

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Conflict of interest: The authors declare no conflict of interest in the study.

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