Canine obesity in the Netherlands: prevalence, predisposing factors, and the effect of the owner's knowledge and actions

Master Thesis

Michelle Y. J. Bierlee, BSc

Supervised by dr. Ronald J. Corbee

Faculty of Veterinary Medicine – Companion Animal Health, Utrecht University, The Netherlands, dec 2020.

Abstract

Background: Canine obesity is a medical disorder with many negative consequences. It has a prevalence of 34% up to 59% throughout the world and its predisposing factors consist of breed, age, gender and sexual status. Nevertheless, the primary cause of obesity is excessive intake of food energy and reduced physical activity. The causation of canine obesity can therefore almost exclusively be attributed to the husbandry strategies chosen by the owner. To make the right decisions, owners have to be able to assess their dog's body condition and they also have to be aware of the predisposing factors for canine obesity.
Objectives: 1) To see if owners are able to accurately assess the body condition score (BCS) of their dog. 2) To examine if the owner is aware of any predisposing factors for canine obesity, from which source they gained that information, and if they take any action to prevent their dog from becoming overweight. 3) To see if the answers to the questions listed above are associated with an above ideal body condition of their dog. 4) To analyze the prevalence of and predisposing factors for canine overweight in the Netherlands.
Subjects: 119 dogs and their owners from four different, conveniently selected, veterinary practices in the Netherlands. For the multivariate risk factor analysis on predisposing factors, data (BCS and description) of 512 dogs from two other studies on canine obesity in the Netherlands were included.
Methods: The dog's BCS, on a 9-point scale, was assessed by both the owner and the researcher and the level of agreement between the two was analyzed using Cohen's kappa coefficient. A cross-sectional questionnaire study was conducted, for which the researcher asked the owner various questions with the aforementioned objectives in mind. Multivariate binary logistic regression analyses were used to examine the association between the different variables and an above ideal body condition of the dog.
Results: The prevalence of canine overweight was 46.1% and significantly associated risk factors were the gender, age and breed of the dog. There was a minimal level of agreement ($p < 0.001$) between owner and researcher regarding the dog's BCS and weight category, with $\kappa = 0.294$ and $\kappa = 0.246$ respectively. 45.4% (n=54) of owners was aware of one or more of the predisposing factors, the majority of the owners gained their information from experience (n=28), and more exercise (n=69) was most often mentioned as a preventive action. Only underestimation of the BCS of the dog by the owner was associated with significantly higher odds (OR = 3.14, $p = 0.011$) for the dog of becoming an above ideal body condition.
Conclusions: Underestimation of the BCS by the owner was significantly associated with an above ideal body condition of the dog, so veterinarians need to pay more attention to educating the owner about the BCS of their dog and which body condition is a healthy one. Nevertheless, this won't be enough, because it apparently doesn't matter if the owner knows about predisposing factors for canine obesity or says that they take action to prevent their dog from becoming overweight. More needs to be done in researching and addressing owner compliance regarding prevention and reduction of canine overweight, especially because the human-animal relationship and over-humanization of the dog by the owner both play an important role in managing canine obesity.

Keywords: canine, obesity, overweight, BCS, risk factor, owner, perception, knowledge, actions, compliance.

Contents

1. Introduction

Canine obesity is a common medical disorder throughout the world, with 34% up to 59% of dogs being classified as overweight or obese (McGreevy et al., 2005; Colliard et al., 2006; Lund et al., 2006; Holmes et al., 2007; Weeth et al., 2007; Courcier et al., 2010; Mao et al., 2013; Sapowicz et al., 2016). Obesity develops when energy intake exceeds expenditure over an extended period of time (Julianna et al., 2020) and is characterized by an expansion of white adipose tissue (WAT). This expansion of WAT can cause secondary diseases, either through the increased mechanical impact of tissue mass on function or through the effects of a disturbed endocrine function (German et al., 2010). WAT produces pro-inflammatory cytokines and acute phase proteins and both their tissue expression and circulating concentrations are altered by obesity (Trayhurn & Wood, 2004; Manco et al., 2006). This alteration results in a chronic low-grade systemic inflammation, which is thought to be associated with insulin resistance and the metabolic syndrome (Trayhurn & Wood, 2004). Obesity is known to be a risk factor for diseases such as functional impairment of the cardiovascular, respiratory and renal system (Tvarijonaviciute et al., 2013; Tropf et al., 2017), orthopedic diseases (Brown et al., 1996; Kealy et al., 1997), metabolic dysfunction (German et al., 2009; Tvarijonaviciute et al., 2012), diabetes mellitus (German, 2006), tracheal collapse (White & Williams, 1994), certain types of neoplasia (Lund et al., 2006) like mammary carcinoma (Perez-Alenza et al., 2000) and transitional cell carcinoma (Glickman et al., 1989), a decreased immune function (German et al., 2010), ruptured cruciate ligament, pancreatitis, hyperadrenocorticism, hypothyroidism, lower urinary tract disease and oral disease (Lund et al., 2006). Overweight and obese dogs also experience adverse effects on their quality of life (German et al., 2012), an increased anesthetic risk (Clutton, 1988; Petry et al., 2009) and a shorter life span (Kealy et al., 2002; Salt et al., 2019). Risk factors for canine obesity are multifactorial and include predisposing factors inherent to the dog, such as breed, age, gender and sexual status (McGreevy et al., 2005; Colliard et al., 2006; Lund et al., 2006; Holmes et al., 2007; Corbee, 2013; Mao et al., 2013; Julianna et al., 2020). Nevertheless, obesity is primarily the result of excessive intake of food energy and reduced physical activity (Burkholder & Bauer, 1998). A companion dog relies entirely on its owner when it comes to biological needs, such as basic nutrition, proper activities and necessary medical assistance (Julianna et al., 2020). The causation of canine overweight can therefore almost exclusively be attributed to neglectful or erroneous husbandry strategies chosen by the owner (Burkholder & Bauer, 1998; Bland et al., 2009). Subsequently, owner-related factors that influence canine obesity are, among others, feeding and exercise practices and the income, age and BMI of the owner (Kienzle et al., 1998; Colliard et al., 2006; Lund et al., 2006; Holmes et al., 2007; Bland et al., 2009; Nijland et al., 2009; Courcier et al., 2010; Warren et al., 2011; Mao et al., 2013; Julianna et al., 2020). Since canine obesity is multifactorial, the owner not only has to be aware of sufficient feeding and exercise practices, but also of the fact that their dog might be predisposed for becoming overweight. If we take a step back, first the owner has to be able to assess the dog's body condition and health status if we want them to change their husbandry strategies accordingly. The most widely accepted system for quantifying body composition and body fat mass in companion animals is the 9-integer body condition score (BCS), which uses visual assessment and palpation (German, 2006). This system has been shown to correlate well with body fat mass determined by dual-energy X-ray absorptiometry (DEXA) (Mawby et al., 2004). The first objective of this study was to see if owners can accurately assess the BCS of their dog, on a 9-point scale, by examining the level of agreement between the researcher and the owner. Secondly, an interview with open-ended questions was used to examine 1) whether the owner was aware of any predisposing factors for canine obesity, 2) from which source they gained that information, and 3) if they took any action to prevent their dog from becoming overweight. To see if the BCS estimation of the owner and their answers to the open-ended question had any association with their dog's body condition, a multivariate binary logistic regression analysis was used. Lastly, because little research has been done about predisposing factors for canine overweight in the Netherlands, data (BCS and description) of dogs investigated by two other students, was included to perform a multivariate risk factor analysis on breed, age, gender and sexual status, and to examine the prevalence of canine overweight in the Netherlands.

2. Materials & methods

2.1 Data collection

Data (n=119) was collected from dog owners that visited four different, conveniently selected, veterinary practices in the Netherlands between the start of February and the end of April 2016. At first, every dog owner was asked if they were willing to participate. After agreement, the name of the practice, the name, address, zip code, city, email and phone number of the owner (it was also optional to participate anonymously), as well as the name, breed, gender, sexual status, age and weight of the dog were noted by the researcher (Appendix I). The weight of the dogs was measured using the scales from the veterinary practices. Next, the owner was asked to determine, but not yet say out loud, the BCS of their dog, using an adjusted 9-integer BCS card that was presented to them (Appendix II). To prevent the owner from choosing a score they thought was "right", the judgements (too thin, ideal, overweight or obese) and colors of the weight categories were removed from the original BCS card, which was made available by Dr. R.J. Corbee. Thereafter, with consent of the owner and acceptance by the dog, the dog's BCS was also determined by the researcher. The owner had to determine the BCS first, without revealing their result until the researcher had also determined the BCS of the dog, to make sure they wouldn't influence each other's opinions. Lastly, the owner was asked if they knew of any factors that could increase the chance of a dog becoming overweight, where they obtained their information and whether they were taking any actions to prevent their dog from becoming overweight (Appendix III). The questions were asked verbally, the owners did not have access to the questionnaire/possible answers and answers were asked to be as specific as possible. At all times, the researcher made sure to maintain an understanding attitude towards the owner and to never criticize them, because that could compromise their honesty. Furthermore, the owner was asked, after finishing the questionnaire, to participate in a larger trial led by Dr. R.J. Corbee. To increase the sample size for the data used to examine predisposing factors for canine overweight, extra data (n=512) was included from two other studies supervised by Dr. R.J. Corbee and performed by A.N. van der Jagt and N.R. Blees. This data included the breed, gender, sexual status, age, weight and BCS of the dogs.

2.2 Data analysis

Descriptive analysis

All data was assimilated in Microsoft Excel and analyzed using the software of RStudio (Version 1.2.5042 ©2009-2020 RStudio, Inc). Weight categories were determined using the assessed BCS's: 1-3 = underweight, 4-5 = ideal, 6-7 = overweight and 8-9 = obese. Age was rounded down to whole years, except for dogs of 9 – 12 months: they were noted as 1 year old. Breeds were classified using the breed groups as defined by the 'Fédération Cynologique Internationale' (FCI) (Appendix IV). One of the female dogs was said to be "neutered" but because a part of the ovary was still inside the abdomen and thereby the influence of hormones was still present, this dog was noted as intact. The answers from the questionnaire and continuous data that was going to be used in the multivariate analysis were categorized. A descriptive analysis was performed on all variables and various tables, contingency tables, box- and line-plots were made to see if the data showed any interesting associations/results.

Level of agreement analysis

To see if the owner was able to make an accurate assessment of their dog's BCS and weight category, the assessment of the owner was compared to the assessment of the researcher. The BCS and weight category of the dog as assessed by the researcher were assumed to be the true values. Firstly, contingency tables between the assessment of the owner and the assessment of the researcher were made to see what percentage of the owners made a correct estimation, what percentage was off by

1 variable-unit and what percentage was off by > 1 variable-unit. Secondly, Cohen's kappa coefficient (κ) was used to measure the level of agreement between the owner and the researcher. The Cohen's kappa measures the inter-rater reliability – the extent to which two raters assign the same scores to the same subject – and it takes random or expected agreement by chance into account. For the BCS, because this is an ordinal variable, the weighted kappa was used, while the unweighted kappa was used for the weight category. For both BCS and weight category, the value of kappa (κ) and its 95% confidence interval (95% CI) was calculated. The levels of agreement between the owner and the researcher were determined by relating the calculated κ-values to a table derived from McHugh (2012) (Table 1).

Table 1 Interpretation of Cohen's kappa

VALUE OF K	LEVEL OF AGREEMENT	% OF DATA THAT ARE RELIABLE
0 - 0.20	None	0 – 4%
0.21 - 0.39	Minimal	4 - 15%
0.40 - 0.59	Weak	15 - 35%
0.60 - 0.79	Moderate	35 - 63%
0.80 - 0.90	Strong	64 - 81%
Above 0.90	Almost Perfect	82 - 100%

(McHugh, 2012)

Risk factor analysis – owner-related factors

The principal aim was to develop a regression model to analyze which of the categorical variables from the questionnaire were significantly associated with the incidence of an above ideal body condition (BCS ≥ 6) versus an ideal body condition (BCS 4-5). The categorization and explanation of the analyzed variables can be found in Table 2. Firstly, dogs with an underweight body condition (BCS < 4, n=5) were excluded from the analysis because it's likely that other factors influence the chance of becoming underweight than the chance of becoming overweight. To assess the possible utility of each of the variables in the multivariate analysis, preliminary univariate analyses (chi-square (χ^2) test) were performed. Because there was only one variable with $p \leq 0.25$ in the univariate χ^2-test, and because a stepwise backward elimination also showed that just using this single variable resulted in the best model of fit (the model with the lowest AIC), a multivariate binary logistic regression analysis was unnecessary. Because the remaining variable showed a $p < 0.05$, it was regarded as having a significant association with the incidence of an above ideal body condition. Per category, the p-values, odds ratios (ORs) and 95% confidence intervals were calculated. The categories with $p < 0.05$ were regarded as having a significant association with the incidence of an above ideal body condition, where an OR < 1 indicated that the category was associated with a reduced chance of becoming an above ideal body condition and an OR > 1 indicated that the category was associated with an increased chance of becoming an above ideal body condition.

Risk factor analysis - predisposing factors

With the analysis of the predisposing factors it was also the aim to develop a regression model to analyze which of the categorical variables were significantly associated with the incidence of an above ideal body condition (BCS ≥ 6) versus an ideal body condition (BCS 4-5). The categorization and explanation of the analyzed variables can be found in Table 3. Again, dogs with an underweight body condition (n=28) were excluded from the analysis. FCI group 10 was also excluded from the analysis because it consisted of only one dog (n=1). Preliminary univariate analyses (chi-square (χ^2) test) were performed on each variable and the variables with $p \leq 0.25$ were used in the multivariate binary logistic regression analysis. The best model of fit was determined using a stepwise backward elimination and all variables with $p < 0.05$ in the multivariate analysis were regarded as having a significant association with the incidence of an above ideal body condition. Again, the p-values, odds ratios and 95% confidence intervals of the significantly associated variables were calculated per category to see which categories were significantly associated with either a reduced or increased chance of becoming an above ideal body condition.

Table 2 Categorization and explanation of the analyzed variables for the owner-related factors

Variable	Category	Explanation
Knowledge of the owner		Answers of the owner to the question: "Do you know any factors that could increase the risk of a dog becoming overweight?"
	No	The owner did not mention any of the predisposing factors: breed, age, gender and sexual status.
	Yes	The owner mention one or more of the predisposing factors: breed, age, gender and sexual status.
Source of knowledge		Answers of the owner to the question: "How did you gain this information?"
	Veterinarian	
	Experience	
	Books	
	Combination	The owner mentioned any combination of veterinarian, experience and books.
	Other	The owner did not mention veterinarian, experience or books but did mention other sources including family/friends, breeder, internet, study, television, study para-veterinarian, and healthcare work.
Actions taken by the owner		Answers of the owner to the question: "How do you prevent your dog from becoming overweight?"
	None	The owner did not mention one of the actions known to be effective: less food, less snacks or more exercise.
	Less food	
	More exercise	
	Less snacks	
	Less food & More exercise	
	Less food & Less snacks	
	More exercise & Less snacks	
	Less food & Less snacks & More exercise	
Estimation of the BCS by the owner	Correct	
	Overestimation	
	Underestimation	

Table 3 Categorization and explanation of the analyzed variables for the predisposing factors

Variable	Category	Explanation
Gender	Female	
	Male	
Sexual status	Intact	
	Neutered	
Age in years	0-1	
	2-4	
	5-7	
	8-10	
	11-16	
Breed (FCI)	0	Crossbreeds or breeds that are not recognized by the FCI
	1	Sheepdogs and Cattledogs (except Swiss Cattledogs)
	2	Pinscher and Schnauzer - Molossoid and Swiss Mountain and Cattledogs
	3	Terriers
	4	Dachshunds
	5	Spitz and primitive types
	6	Scent hounds and related breeds
	7	Pointing Dogs
	8	Retrievers - Flushing Dogs - Water Dogs
	9	Companion and Toy Dogs
	10	Sighthounds

3. Results

3.1 The owner's knowledge, actions and BCS assessment

Dog population

In the non-randomized group of 119 dogs, there was an approximately equal gender distribution of 49.6% (n=59) female and 50.4% (n=60) male dogs. A slight majority of 55.5% (n=66, 34 male and 32 female) of dogs was intact, whereas 44.5% (n=53, 26 male and 27 female) of dogs was neutered. The median age was 5 years old (range 0 - 15) and most dogs (33.6%, n=40) were 2-4 years old. 12.6% (n=15) of dogs was ≤ 1 year old, 21.8% (n=26) was 5-7 years old, 17.6% (n=21) was 8-10 years old and 14.3% (n=17) was 11-15 years old. 16.8% (n=20) of examined dogs were crossbreeds or breeds that are not recognized by the FCI (categorized as group 0), whereas the other 83.2% (n=99) belonged to FCI group 1, 2, 3, 5, 6, 7, 8 or 9. Most represented breed groups were group 8 – Retrievers, Flushing Dogs & Water Dogs – (27.7%, n=33), group 9 - Companion & Toy Dogs – (17.6%, n=21) and group 2 – Pinscher and Schnauzer type, Molossoid type & Swiss Mountain- and Cattledogs – (14.3%, n=17). Of the FCI subgroups, subgroup 8.1 – Retrievers – (25.2%, n=30), subgroup 2.2 – Molossian type – (12.6%, n=15) and subgroup 9.11 – Small Molossian type dogs – (8.4%, n=10) were most represented. Most represented breeds were the Labrador Retriever (17.6%, n=21), French Bulldog (6.7%, n=8) and English Bulldog (5.9%, n=7). In total, the research population consisted of 44 different breeds.

BCS and weight categories

The mean and median BCS of all 119 dogs were 5.79 and 6 respectively (range 3-8). The distribution of the BCS is listed in Figure 1. Most dogs were overweight (49.6%, n=59). 4.2% (n=5) of dogs were underweight, 34.5% (n=41) had an ideal body condition and 11.8% (n=14) were obese. The incidence of an above ideal body condition was 61.3% (n=73).

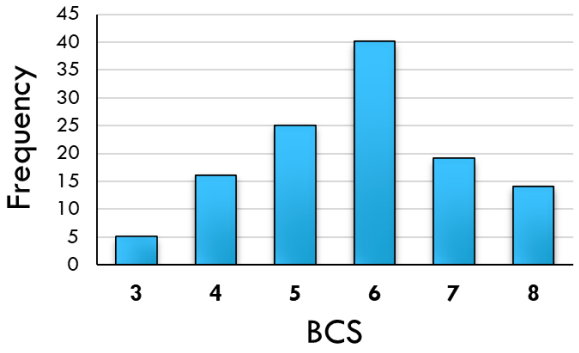

Figure 1 Distribution of body condition scores in the research population of 119 dogs.

BCS assessment by the owner

When the BCSs of the dogs were assessed by their owners, the mean and median BCS were 4.89 and 5 respectively and most dogs were an ideal body condition (57.1%, n=68). The majority of the owners underestimated the BCS of their dog (63.9%, n=76), whereas 26.9% (n=32) and 9.2% (n=11) made a correct estimation and overestimation respectively. After the weight categories were determined from the BCSs, a slight majority of the owners made a correct estimation of the weight category (51.3%, n=61). 44.5% (n=53) made an underestimation and 4.2% (n=5) made an overestimation. Most correct estimations were made on dogs with a BCS of 4 (56.2%, n=9) and on dogs in the ideal weight category (75.6%, n=31) (Table 4 & 5). The highest rates of underestimations and overestimations were made on dogs with a BCS of 7 (89.5%, n=17) and 3 (40.0%, n=2) and on dogs in the obese (92.9%, n=13) and underweight (40.0%, n=2) categories respectively. A comparison between the distributions of the BCS assessed by the owner and the researcher is displayed in Figure 2. The same comparison for the assessment of the weight category is shown in Figure 3.

Table 4 Rates of estimation of the dog's BCS by the owner, divided by BCS

	Estimation by the owner		
BCS	Underestimation	Correct	Overestimation
3	20.0% (n=1)	40.0% (n=2)	40.0% (n=2)
4	25.0% (n=4)	56.2% (n=9)	18.8% (n=3)
5	64.0% (n=16)	28.0% (n=7)	8.0% (n=2)
6	62.5% (n=25)	32.5% (n=13)	5.0% (n=2)
7	89.5% (n=17)	5.3% (n=1)	5.3% (n=1)
8	92.9% (n=13)	0.0%	7.1% (n=1)

Table 5 Rates of estimation of the dog's weight category by the owner, divided by weight category

	Estimation by the owner		
Weight category	Underestimation	Correct	Overestimation
Underweight	0.0%	60.0% (n=3)	40.0% (n=2)
Ideal	19.5% (n=8)	75.6% (n=31)	4.9% (n=2)
Overweight	54.2% (n=32)	44.1% (n=26)	1.7% (n=1)
Obese	92.9% (n=13)	7.1% (n=1)	0.0%

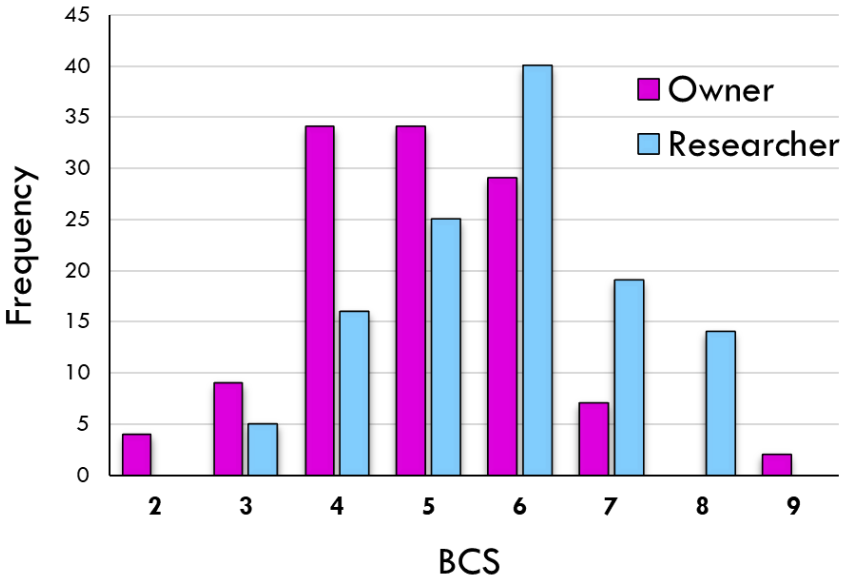

Figure 2 Distribution of the body condition scores as assessed by the owner, compared to the assessment of the researcher

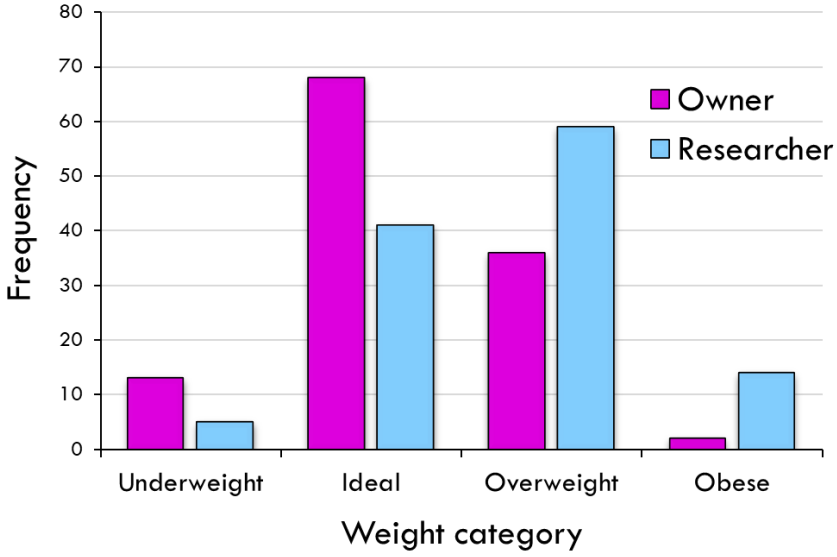

Figure 3 Distribution of the weight categories as assessed by the owner, compared to the assessment of the researcher

Level of agreement between owner and researcher

Using a contingency table it was calculated that the BCS assessment of 26.9% (n=32) of the owners was correct, the assessment of 42.0% (n=50) of the owners was off by 1 BCS-unit and the assessment of 31.3% (n=37) of the owners was off by >1 BCS-units. Using the weighted Cohen's kappa coefficient, it was found that $\kappa = 0.294$ (95% CI 0.207 – 0.381, $p < 0.001$). According to the table derived from McHugh (2012) (Table 1), there was a minimal level of agreement between the owner and the researcher regarding the BCS of the dog. Looking at the assessments of the dog's weight category, 51.3% (n=61) of the owners made a correct assessment, 42.9% (n=51) of the owners' assessments was off by 1 weight category and 5.9% (n=7) of the owners' assessments was off by >1 weight categories. Regarding the weight category of the dog, there was also a minimal level of agreement, $\kappa = 0.246$ (95% CI 0.126 – 0.367, $p < 0.001$), between the owner and the researcher.

Knowledge of the owner

45.4% (n=54) of the owners mentioned breed, age and/or neutering when asked if they knew any factors that could increase the chance of a dog becoming overweight (not one owner mentioned gender) and only when one or more of these three factors were mentioned, the owner was noted as 'having knowledge' about predisposing factors. Of these 54 owners with knowledge, 50.0% (n=27) mentioned only neutering, 27.8% (n=15) mentioned only breed, 3.7% (n=2) mentioned only age, 11.1% (n=5) mentioned neutering & breed and 7.4% (n=4) mentioned neutering & age. The highest rate of dogs with an above ideal body condition was present when the owner didn't mention breed, age and/or neutering as a risk factor (63.1%, n=41). However, when the owner did have knowledge about predisposing factors, 59.3% (n=32) of dogs still had an above ideal body condition.

34.0% (n=18) of owners with a neutered dog and 28.8% (n=19) of owners with an intact dog mentioned neutering as a risk factor. Within the group of neutered dogs there was no difference in the rate of dogs with an above ideal body condition between owners that did or did not mention neutering as a risk factor (72.2%, n=13 and 71.4%, n=25 respectively). The dogs of owners that mentioned age as a risk factor (n=6) had an age of 0-1 (n=1), 5-7 (n=1), 8-10 (n=2) and 11-15 (n=2) years old.

When the owner mentioned breed as a risk factor, dogs had a slightly lower rate of an above ideal body condition (57.1%, n=12) than when the owner didn't (62.2%, n=61). The breeds that were most often mentioned by the owner as having a higher risk of becoming overweight were the Labrador Retriever (n=11) and English Bulldog (n=3). Of the owners that mentioned the Labrador Retriever, 72.7% (n=8) owned a Labrador Retriever themselves. 62.5% (n=5) of Labrador Retrievers (n=21) had an above ideal body condition when the owner mentioned the Labrador Retriever as a high risk breed and 69.2% (n=9) of Labrador Retrievers had an above ideal body condition when the owner did not mention the Labrador Retriever as a high risk breed.

Other risk factors mentioned by the owners were kind and/or amount of food (n=36), too little exercise (n=29), snacks (n=14), metabolism (n=6), illness (n=5), thyroid problems (n=5), diabetes (n=2), gestation (n=2), getting human food (n=2), getting sugary food (n=2), medication (n=1) and stress (n=1). Because these answers/factors are not inherent to the dog, they were not categorized as 'knowledge about predisposing factors for becoming overweight'.

Sources of knowledge

When asked where owners gained their knowledge/information from, 52 of the owners mentioned one or a combination of the following sources: experience (n=28), veterinarian (n=18), books (n=13), family/friends (n=5), breeder (n=3), internet (n=3), study (n=3), television (n=1), study para-veterinarian (n=1) and healthcare work (n=1). When we look at the variables with $n \geq 5$, the lowest rate of dogs with an above ideal body condition was found when the owner gained their information, among others, from family/friends (0.0%), whereas the highest rate was found when the information came, among others, from books (61.5%, n=8). The highest rate of underestimation of the BCS by the owner was found when the owner gained their information, among others, from experience (46.4%, n=13).

Actions taken by the owner

90.8% (n=108) of the owners mentioned less food, less snacks and/or more exercise when asked if they were taking any actions to prevent their dog from becoming overweight. Of these 108 owners 19.4% (n=21) mentioned only more exercise, 15.7% (n=17) mentioned only less food, 3.7% (n=4) mentioned only less snacks, 18.5% (n=20) mentioned less food & more exercise, 16.7% (n=18) mentioned less food & less snacks, 13.9% (n=15) mentioned less snacks & more exercise and 12.0% (n=13) mentioned less food, less snacks & more exercise. Other actions that were mentioned are good quality food (n=14), no human food (n=8), light dogfood or a commercial weight loss diet (n=5), amount of food based on visible body condition ("feeding at sight") (n=5), supplementing food with green beans (n=3), Fresh-Meat food (n=3), determining the body condition by feeling the dog (n=2) and Senior Dog food (n=1).

When the owner mentioned, among others, less food as their action to prevent overweight (n=68), 61.8% (n=42) of dogs had an above ideal body condition, whereas 60.8% (n=31) of dogs had an above ideal body condition when their owner did not mention less food as an action. 66.7% (n=24) of the owners that mentioned kind and/or amount of food (n=36) as a risk factor for overweight also mentioned less food as an action they take to prevent their dog from becoming overweight. Nevertheless, 58.3% (n=14) of dogs from these 24 owners had an above ideal body condition. When we look at these 14 above ideal dogs, 64.3% (n=9) of the owners underestimated the weight category of their dog and 35.7% (n=5) made a correct estimation.

If the owner mentioned, among others, more exercise as their action to prevent overweight (n=29), 72.4% (n=21) of dogs had an above ideal body condition, whereas 57.8% (n=52) of dogs had an above ideal body condition when their owner did not mention more exercise as an action. 75.9% (n=22) of the owners that mentioned exercise (n=29) as a risk factor for overweight also mentioned more exercise as an action to prevent their dog from becoming overweight. Nevertheless, 81.8% (n=18) of dogs from these 22 owners had an above ideal body condition. When we look at these 18 dogs, 61.1% (n=11) of the owners underestimated the weight category and 38.9% (n=7) made a correct estimation.

When the owner mentioned, among others, less snacks as their action to prevent overweight (n=14), 71.4% (n=10) of dogs has an above ideal body condition, whereas 60.0% (n=63) of dogs has an above ideal body condition when their owner did not mention less snacks as an action. 64.3% (n=9) of the owners that mentioned snacks (n=14) as a risk factor for overweight also mentioned less snacks as a preventive action. Nevertheless, 77.8% (n=7) of dogs from these 9 owners had an above ideal body condition. When we look at these 7 dogs, 57.1% (n=4) of the owners underestimated the weight category and 42.9% (n=3) made a correct estimation.

When the owner mentioned, among others, feeding at sight, good quality food, no human food and light dogfood or a commercial weight loss diet as preventive actions, the rate of dogs with an above ideal body condition was 20.0% (n=1), 57.1% (n=8), 62.5% (n=5) and 100% (n=5) respectively. 80.0% (n=4) of owners that mentioned light dogfood or a commercial weight loss diet underestimated the weight category of their dog and 20.0% (n=1) made a correct estimation. When the owner mentioned feeding at sight, 40.0% (n=2) made an underestimation, 40.0% (n=2) made a correct estimation and 20.0% (n=1) made an overestimation of the weight category of their dog.

The effect of the owner-related factors on the body condition of their dog

The univariate binary logistic regression analysis on the effect of 'knowledge of the owner', 'source of knowledge', 'actions taken by the owner' and 'estimation of the BCS by the owner' on the incidence of an above ideal body condition of the dog showed that only the estimation of the BCS by the owner was significantly associated with an above ideal body condition (p = 0.017) (Table 6). Between over- and underestimation of the dog's BCS by the owner, only an underestimation resulted in significantly (p = 0.011) higher odds (OR = 3.14) for the dog of becoming an above ideal body condition than when a correct estimation was made (Table 7).

Table 6 Univariate analysis of the effect of owner-related factors on canine overweight

Variable		NA	N	p-value	OR	OR (95% CI)
Knowledge of the owner		0	114	0.796		
	No		63		-	-
	Yes		51		0.90	0.42 - 1.96
Source of knowledge		65	49	0.593		
	Veterinarian		9		-	-
	Experience		21		0.46	0.06 - 2.53
	Books		4		0.86	0.06 - 22.75
	Combination		11		0.24	0.03 - 1.54
	Other		4		0.29	0.02 - 3.63
Actions taken by the owner		0	114	0.599		
	None		10		-	-
	Less food		17		1.39	0.22 - 8.21
	More exercise		21		0.70	0.12 - 3.36
	Less snacks		4		0.14	0.01 - 1.64
	Less food & More exercise		19		0.48	0.08 - 2.30
	Less food & Less snacks		16		0.71	0.12 - 3.76
	More exercise & Less snacks		14		1.07	0.17 - 6.45
	Less food & Less snacks & More exercise		13		0.96	0.15 - 5.87
Estimation of the BCS by the owner		0	114	**0.017**		
	Correct		30		-	-
	Overestimation		9		0.91	0.19 - 4.13
	Underestimation		75		3.14	1.31 - 7.70

Table 7 The effect of the BCS estimation by the owner on canine overweight

Variable		Estimate	S.E.	p-value	OR	OR (95% CI)
Estimation of the BCS by the owner	Correct	-	-	-	-	-
	Overestimation	-0.08961	0.76415	0.907	0.91	0.19 - 4.13
	Underestimation	1.14513	0.44957	**0.011**	3.14	1.31 - 7.70

3.2 Predisposing factors for canine overweight

BCS and weight categories

The mean and median BCS of all 631 dogs were 5.45 and 5 respectively (range 2-9). The distribution of the BCS is listed in Figure 4. Most dogs had an ideal body condition (49.4%, n=312). 4.4% (n=28) of dogs were underweight, 39.6% (n=250) were overweight and 6.5% (n=41) were obese. The incidence of an above ideal body condition was 46.1% (n=291).

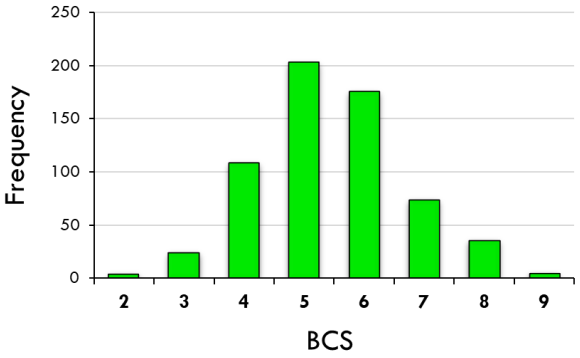

Figure 4 Distribution of body condition scores in the research population of 631 dogs.

Gender

In the non-randomized group of 631 dogs, there was an almost equal gender distribution of 48.3% (n=305) female and 51.7% (n=326) male dogs. A slight majority of 57.8% (n=365, 168 male and 197 female) of dogs was neutered, whereas 42.2% (n=266, 158 male and 108 female) was intact. The highest mean BCS and the highest rates of overweight and an above ideal body condition were found in female neutered dogs (5.59 (2-9), 44.7% (n=88) and 51.8% (n=102) respectively), whereas the highest rate of obesity was found in male neutered dogs (8.3%, n=14) (Table 8).

Age

The median age was 5 years old (range 0 – 16) and most dogs were 2-4 years old (27.1%, n=171). 18.5% (n=117) of dogs was ≤ 1 year old, 24.1% (n=152) was 5-7 years old, 17.9% (n=113) was 8-10 years old and 12.4% (n=78) was 11-16 years old. The mean BCS as well as the rates of overweight and obesity were found to increase with each age category, whereas the rate of an ideal body condition decreased (Figure 5). Using a simple linear regression model, a significant relationship ($p < 0.001$) was found between age and BCS ($R2 = 0.08 \pm 0.013$), with a 0.08-unit increase in BCS for every one-year increase in age.

Table 8 Average BCS and distribution of weight categories of dogs of different sexes

Gender	Sexual status	Number of Dogs	Mean BCS + range	Under-weight	Ideal	Overweight	Obese
Female	Intact	108	5.35 (2-9)	6.5% (n=7)	46.3% (n=50)	42.6% (n=46)	4.6% (n=5)
Female	Neutered	197	5.59 (2-9)	3.0% (n=6)	45.2% (n=89)	44.7% (n=88)	7.1% (n=14)
Male	Intact	158	5.25 (2-9)	5.1% (n=8)	57.6% (n=91)	32.3% (n=51)	5.1% (n=8)
Male	Neutered	168	5.53 (3-9)	4.2% (n=7)	48.8% (n=82)	38.7% (n=65)	8.3% (n=14)

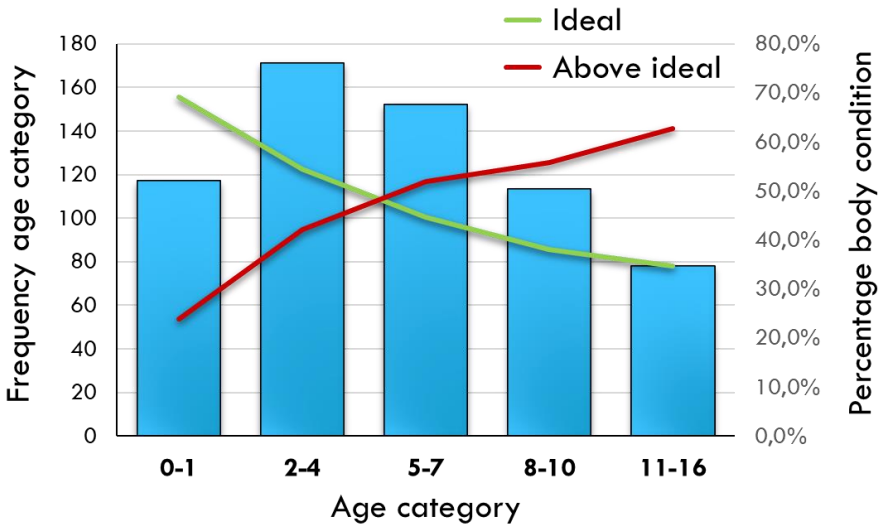

Figure 5 The distribution of age categories and the relationship between age category and an ideal or above ideal body condition in the research population of 631 dogs.

Breed

24.6% (n=155) of examined dogs were crossbreeds or breeds that are not recognized by the FCI, whereas the other 75.4% (n=476) belonged to breed group 1 to 10, recognized by the FCI. Most represented breed groups were group 8 – Retrievers, Flushing Dogs & Water Dogs – (18.5%, n=117), group 9 - Companion & Toy Dogs – (12.4%, n=78) and group 2 - Pinscher and Schnauzer type, Molossoid type & Swiss Mountain- and Cattledogs – (12.0%, n=76). Of FCI subgroups, subgroup 8.1 – Retrievers – (14.7%, n=93), subgroup 1.1 – Sheepdogs – (9.5%, n=60) and subgroup 2.2 – Molossian type – (8.7%, n=55) were most represented. The most represented breeds were the Labrador Retriever (10.9%, n=69), Dachshund (3.5%, n=22), French Bulldog (3.3%, n=21), Jack Russel Terrier (3.3%, n=21) and Border Collie (3.0%, n=19). In total, the research population consisted of 111 different breeds.

The highest mean BCS and rate of obesity were found in FCI group 5 – Spitz and primitive types – (5.79 (4-8) and 14.3% (n=2) respectively), whereas the highest rate of an above ideal body condition was found in group 8 – Retrievers, Flushing Dogs & Water Dogs – (55.6%, n=65) (Table 9). After comparing the FCI subgroups consisting of at least five dogs ($n \geq 5$), the highest rate of an above ideal body condition was found in subgroup 6.1 – Scent hounds – (90.0%, n=9) and the highest rate of obesity was found in subgroup 9.6 – Chihuahueno (Chihuahua) – (27.3%, n=3) (Appendix V). Breeds, consisting of at least five dogs ($n \geq 5$), with the highest rates of an above ideal body condition were the Beagle (100%, n=6), Pug (83.3%, n=5), Boomer (81.8%, n=9), Bull Terrier (80.0%, n=4) and Cavalier King Charles Spaniel (80.0%, n=4). Breeds with the highest rate of obesity were the Pug (33.3%, n=2), Chihuahua (27.3%, n=3) and English Bulldog (25.0%, n=3) (Appendix VI). Most underweight dogs were found in group 1 – Sheepdogs and Cattledogs – (12.3%, n=8), subgroup 2.1 – Pinscher and Schnauzer type – (20.0%, n=2) and the Border Collie (21.1%, n=4).

Researcher

The 631 dogs were examined by one of three researchers (Veterinary Master students), namely A.N. van der Jagt (n=220), M.Y.J. Bierlee (n=122) and N.R. Blees (n=289). The highest mean BCS as well as the highest rates of an above ideal body condition and obesity were found in dogs examined by M.Y.J. Bierlee (5.78 (3-8), 60.7% (n=74) and 11.5% (n=14) respectively) (Table 10). The highest rates of an ideal body condition and underweight were found in dogs examined by N.R. Blees (55.7%, n=161 and 4.8%, n=14 respectively).

Table 9 Average BCS and distribution of weight categories of dogs of different breed groups

FCI*	Number of Dogs	Mean BCS + range	Underweight	Ideal	Overweight	Obese
0**	155	5.38 (2-9)	3.2% (n=5)	54.2% (n=84)	38.1% (n=59)	4.5% (n=7)
1	65	4.91 (2-8)	12.3% (n=8)	60.0% (n=39)	23.1% (n=15)	4.6% (n=3)
2	76	5.74 (3-9)	3.9% (n=3)	46.1% (n=35)	38.2% (n=29)	11.8% (n=9)
3	61	5.56 (3-8)	3.3% (n=2)	54.1% (n=33)	34.4% (n=21)	8.2% (n=5)
4	22	5.32 (4-7)	0.0%	54.5% (n=12)	45.5% (n=10)	0.0%
5	14	5.79 (4-8)	0.0%	50.0% (n=7)	35.7% (n=5)	14.3% (n=2)
6	20	5.40 (4-7)	0.0%	55.0% (n=11)	45.0% (n=9)	0.0%
7	22	5.05 (2-7)	9.1% (n=2)	50.0% (n=11)	40.9% (n=9)	0.0%
8	117	5.46 (3-9)	4.3% (n=5)	40.2% (n=47)	49.6% (n=58)	6.0% (n=7)
9	78	5.77 (3-8)	3.8% (n=3)	41.0% (n=32)	44.9% (n=35)	10.3% (n=8)
10	1	4.00 (4-4)	0.0%	100.0% (n=1)	0.0%	0.0%

* '*Fédération Cynologique Internationale*'
** Crossbreeds and breeds that are not recognized by the FCI

Table 10 Average BCS and distribution of weight categories of dogs examined by different researchers

Researcher	Number of Dogs	Mean BCS + range	Under-weight	Ideal	Overweight	Obese
A.N. van der Jagt	220	5.53 (3-9)	4.1% (n=9)	49.1% (n=108)	40.9% (n=90)	5.9% (n=13)
M.Y.J. Bierlee	122	5.78 (3-8)	4.1% (n=5)	35.2% (n=43)	49.2% (n=60)	11.5% (n=14)
N.R. Blees	289	5.25 (2-9)	4.8% (n=14)	55.7% (n=161)	34.6% (n=100)	4.8% (n=14)

Analysis of predisposing factors

In the univariate binary logistic regression analysis on the effect of gender ($p = 0.053$), sexual status ($p = 0.061$), age ($p < 0.001$) and breed ($p = 0.078$) on the incidence of an above ideal body condition all variables had a p-value ≤ 0.25 (Table 11) and because of that they were all used in the multivariate analysis. The variables gender ($p = 0.021$), age ($p < 0.001$) and breed ($p = 0.011$), but not sexual status ($p = 0.927$), were significantly associated with an above ideal body condition in the multivariate binary logistic regression analysis (Table 12). The best model of fit in the stepwise backward elimination also consisted of these three variables. Being a male dog resulted in lower odds (OR = 0.67) of becoming an above ideal body condition than being a female dog ($p = 0.021$). The odds of becoming an above ideal body condition were found to increase with each age category ($p = 0.003 – p < 0.001$). Lastly, FCI group 8 – Retrievers, Flushing Dogs & Water Dogs – showed higher odds (OR = 2.03, $p = 0.009$) of becoming an above ideal body condition, whereas group 1 – Sheepdogs and Cattledogs – showed, although not significantly, lower odds (OR = 0.52, $p = 0.059$) of becoming an above ideal body condition than the group of crossbreeds and breeds not recognized by the FCI.

Table 11 Univariate analysis of predisposing factors for canine overweight

Variable		NA	N	p-value	OR	OR (95% CI)
Gender		0	602	0.053		
	Female		292		-	-
	Male		310		0.73	0.53-1.00
Sexual status		0	602	0.061		
	Intact		251		-	-
	Neutered		351		1.36	0.99-1.89
Age in years		0	602	**< 0.001**		
	0 - 1		109		-	-
	2 - 4		165		2.24	1.33 - 3.84
	5 - 7		146		3.41	2.01 - 5.91
	8 - 10		106		4.24	2.40 - 7.65
	11 - 16		76		5.25	2.81 - 10.06
Breed (FCI)		0	602	0.078		
	0		150		-	-
	1		57		0.59	0.30 - 1.11
	2		73		1.38	0.79 - 2.43
	3		59		1.00	0.54 - 1.84
	4		22		1.06	0.42 - 2.61
	5		14		1.27	0.42 - 3.89
	6		20		1.04	0.40 - 2.66
	7		20		1.04	0.40 - 2.66
	8		112		1.76	1.08 - 2.90
	9		75		1.71	0.98 - 3.01

Table 12 Multivariate analysis of predisposing factors for canine overweight

Variable		Estimate	S.E.	p-value	OR	OR (95% CI)
Gender				**0.021**		
	Female	-	-	-	-	-
	Male	-0.406	0.177	**0.021**	0.67	0.47 - 0.94
Sexual status				0.927		
	Intact	-	-	-	-	-
	Neutered	-0.017	0.188	0.927	0.98	0.68 - 1.42
Age in years				**< 0.001**		
	0 - 1	-	-	-	-	-
	2 - 4	0.847	0.281	**0.003**	2.33	1.35 - 4.09
	5 - 7	1.304	0.295	**< 0.001**	3.68	2.08 - 6.64
	8 - 10	1.636	0.320	**< 0.001**	5.14	2.77 - 9.74
	11 - 16	1.852	0.345	**< 0.001**	6.37	3.28 - 12.72
Breed (FCI)				**0.011**		
	0	-	-	-	-	-
	1	-0.651	0.345	0.059	0.52	0.26 - 1.01
	2	0.408	0.304	0.180	1.50	0.83 - 2.74
	3	-0.279	0.330	0.397	0.76	0.39 - 1.44
	4	0.069	0.484	0.886	1.07	0.41 - 2.77
	5	0.350	0.583	0.548	1.42	0.44 - 4.54
	6	0.088	0.506	0.862	1.09	0.40 - 2.95
	7	-0.230	0.494	0.642	0.79	0.30 - 2.09
	8	0.709	0.270	**0.009**	2.03	1.20 - 3.46
	9	0.378	0.300	0.208	1.46	0.81 - 2.64

4. Discussion

The prevalence of canine overweight in the Netherlands

The incidence of an above ideal body condition in the survey population of 119 dogs was 61.3%, while the combined dataset (n=631) showed an incidence of 46.1%. A large scale study on the prevalence of overweight in the Netherlands has yet to be done, but its prevalence is considered to be similar to that in other countries, where it ranges from 34% up to 59% (McGreevy et al., 2005; Colliard et al., 2006; Lund et al., 2006; Holmes et al., 2007; Weeth et al., 2007; Courcier et al., 2010; Sapowicz et al., 2016). The difference in incidence between the survey population and the combined population could be explained by the fact that there was a significant ($p < 0.001$) association between the researcher and the incidence of an above ideal body condition. The chance of being assessed as an above ideal body condition was higher (OR = 1.79, 95% CI: 1.13-2.85) when the dog was examined by M.Y.J. Bierlee, who was also responsible for examining the survey population. However, the researchers did not examine the same dogs so an analysis of inter-rater reliability could not be made. Research found the correlation between experienced operators in determining the BCS (on a 7-point system) to be excellent (German, 2006).

The difference in incidence of an above ideal body condition between the researchers could be the result of researcher bias, but it could also be that the three different populations of dogs actually showed a different rate of an above ideal body condition. The researchers examined dogs from different veterinary practices from different areas in the country and some factors that are known to influence the chance of a dog becoming overweight are the socioeconomic class of the owner, rural or urban living conditions and the geographic region (McGreevy at al., 2005; Lund et al., 2006; Courcier et al., 2010). It could even be that some veterinary practices put more effort into tackling canine overweight than others. A large-scale study throughout the Netherlands would be necessary to answer these questions.

Predisposing factors for canine overweight

The multivariate analysis showed that gender, age and breed were significantly associated with an above ideal body condition, supporting the findings of previous research as discussed in the introduction. Sexual status, on the other hand, was not significantly associated with an above ideal body condition, while neutering is often found as a risk factor for canine overweight/obesity (McGreevy et al., 2005; Colliard et al., 2006, Lund et al., 2006; Holmes et al., 2007; Weeth et al., 2007; Mao et al., 2013; Sapowicz et al., 2016). Neutering is associated with a lower energy requirement, alterations in feeding behavior and reduced physical activity (German, 2006; Bermingham et al., 2014), most likely due to reduced concentrations of androgens and estrogens. The dog is less likely to show behaviors associated with breeding, like searching for a mate, and it lacks the estrogens that would normally act as a satiety factor in the central nervous system (Crane, 1991). The sample size of the current study was fairly small for a risk factor analysis, which could be one of the reasons why sexual status did not came forward as a significant risk factor. It could also be that the different variables affected each other in the multivariate analysis. Additional univariate and multivariate analysis did show that gender, age and breed were significantly associated with whether or not the dog was neutered (Table 13). McGreevy et al. (2005) also found that breed influences the importance of neutering as a risk factor, where gundogs and non-Australian working dogs had a higher prevalence of overweight after neutering, while Australian working dogs and terriers had a reduction in the prevalence of overweight in association with neutering.

The level of agreement between owner and researcher

There was a minimal level of agreement between the owner and the researcher regarding the dog's BCS and weight category and the majority of owners (44.5%) underestimated their dog's body condition. These results are in accordance with results found in other studies, where the misperception of the owner ranges from 44.1% to 68.0% (Holmes et al., 2007; Courcier et al., 2011; Eastland-Jones et al., 2014), the level of agreement between expert and owner is described as "weak" or "poor" (Colliard et al., 2006; Eastland-Jones et al., 2014) and the majority of the misperceiving owners underestimates the body condition of their dog (Courcier et al., 2011; Eastland-Jones et al., 2014). The amount of disagreement between owner and expert is higher in overweight dogs (White, et al., 2011; Eastland-Jones et al., 2014), which the present study confirmed with a rate of disagreement in dogs with an above ideal body condition of 38.7% and a rate of disagreement of 10.1% in dogs with an ideal or underweight body condition. McGreevy at al. (2005) found that the number of owners that is informed of their dog's body condition by their veterinarian is lower than expected, which could explain why owners were not aware of the condition of their dog and were not skilled enough to make an accurate BCS assessment. Nevertheless, some owners underestimate the body condition of their dog even though the BCS assessment by the veterinarian is stated at the end of the survey (Rohlf et al., 2010). According to White et al (2011), the discrepancies in de BCS values between owners and veterinarians, even when the issue of weight is discussed, could suggest that the owner did not understand the BCS within the context of the animal being healthy or not.

Table 13 Multivariate analysis of the effect of gender, age and breed on the dog's sexual status

Variabele		Estimate	S.E.	p-value	OR	OR (95% CI)
Gender	Female	-	-	-	-	-
	Male	-0.664	0.182	**< 0.001**	0.51	0.36 - 0.73
Age in years	0 - 1	-	-	-	-	-
	2 - 4	1.286	0.275	**< 0.001**	3.62	2.13 - 6.27
	5 - 7	1.934	0.294	**< 0.001**	6.92	3.93 - 12.47
	8 - 10	1.863	0.315	**< 0.001**	6.44	3.51 - 12.10
	11 - 16	1.614	0.338	**< 0.001**	5.02	2.62 - 9.87
Breed (FCI)	0	-	-	-	-	-
	1	-1.097	0.341	**0.001**	0.33	0.17 - 0.65
	2	-0.868	0.319	**0.006**	0.42	0.22 - 0.78
	3	-0.335	0.351	0.340	0.72	0.36 - 1.44
	4	-1.117	0.497	**0.024**	0.33	0.12 - 0.86
	5	-0.936	0.598	0.117	0.39	0.12 - 1.29
	6	-0.298	0.528	0.572	0.74	0.27 - 2.16
	7	-0.890	0.514	0.083	0.41	0.15 - 1.16
	8	-0.801	0.279	**0.004**	0.45	0.26 - 0.77
	9	-0.538	0.320	0.092	0.58	0.31 - 1.10

The knowledge of the owner, its source and the association with canine overweight

Additionally, the source of knowledge was not significantly associated with the incidence of an above ideal body condition of the dog and strikingly only 18 out of 119 owners mentioned the veterinarian as one of their sources of knowledge. Although other studies didn't survey the source of information regarding predisposing factors, Blees (2016) found that 125 of 210 owners in the Netherlands use their veterinarian as a primary source (n=66) or along with other information sources (n=59) regarding the nutrition of their dog and the veterinarian is also the most important source of information on dog nutrition in a study done by Suarez et al. (2012). It looks like predisposing factors for canine overweight is a topic less discussed by the veterinarian than dog nutrition. Regarding the present study we have to take into account that there could be a recall bias. Also, 28 out of 119 owners mentioned experience as one of their sources of knowledge and it could be, hypothetically, that at some point they did gain this information from their veterinarian. When veterinarians don't inform their clients about canine overweight, they might be conserving the lack of information and/or intensifying the reluctance of some owners to admit that there is a problem (McGreevy et al., 2005). In contrast, although veterinarians were the most common source of nutritional information in a study done by Sapowicz et al. (2016), a lack of accurate nutrition knowledge was common among all participants. Just explaining something to the owner doesn't seem to be enough, which is supported by the fact that the knowledge of the owner was not significantly associated with the incidence of an above ideal body condition of their dog. For example, within the group of neutered dogs there was no difference in the rate of dogs with an above ideal body condition between owners that did or did not mention neutering as a risk factor.

This could partly be explained by the fact that, within this group of neutered dogs, the owners of dogs with an above ideal body condition mainly underestimated the weight category of their dogs, whereas the owners of dogs with an ideal or less than ideal body condition mostly made a correct estimation. However, 38.5% (n=5/13) of owners of neutered dogs with an above ideal body condition that did mention neutering as a risk factor made a correct estimation of their dog's above ideal weight category. It has to be taken into account that the owner assessed the BCS of the dog and that the weight categories were not stated on the BCS-card. It could therefore be that they correctly assessed the weight category (derived from the assessed BCS) of their dog but were unaware of the fact that that score meant that their dog was overweight. Although I didn't come across previous research that examined 'the knowledge of the owner regarding predisposing risk factors for canine overweight' as a risk factor, Webb et al. (2020) did find that if the owners states that their dog "easily puts on weight", their dog has a higher risk of becoming overweight. This could imply that the owner uses the dog's known predisposing factors as an excuse for not having to take responsibility for the dog's body condition or maybe they are convinced that they can't do anything about it.

Actions the owners say they take to prevent overweight and the association with canine overweight

Also, the actions taken by the owner, like less food, less snacks and more exercise, were not significantly associated with the incidence of an above ideal body condition of the dog. This is not entirely in accordance with other literature where food type, feeding frequency, frequency of snacks/treats, activity control, hours of weekly exercise and the intensity of physical activity were found as owner-related risk factors that are significantly associated, either positively or negatively, with canine overweight (Lund et al., 2006; Courcier et al., 2010; Mao et al., 2013; Morrison et al., 2013; Julianna et al., 2020). The main difference is that these studies tried to measure the variables, like feeding behavior and physical activity, as objectively as possible. The present study, however, asked the open-ended question "if the owner took any actions to prevent their dog from becoming overweight", without asking about specific topics. The answers to this question are more a representation of what the owner knows could help to prevent overweight or what they think I would like to hear from them, but they are not a representation of what the owner actually does. When the owner says they do something, but there is no effect to show for it, it could mean one of two things: either the owner doesn't really do the thing they say they'll do or they actually try to do the thing, but it's not effective. It is known that there can be a huge discrepancy between what owners claim to have done and what they actually did ("Veterinary medicines and owner compliance", 2006). It could be that some owners don't take action against canine overweight, because they don't consider their dog to be overweight even when they are able to correctly assess its body condition (Bland et al., 2009). Besides that, some owners don't effectively address the problem, even though they do recognize their dog to be overweight (Rohlf et al., 2010), probably because they don't acknowledge canine overweight/obesity to be a problem (White et al., 2011). Dogs of owners who do not consider obesity to be a disease are more likely to be obese (Muñoz-Prieto et al., 2018). This is a central issue in the fight against canine overweight, because the human-animal interaction plays a large role in the body condition of pets (Linder & Mueller, 2014), so "*owners need to believe that their dogs are overweight and that this has important health implications*" (Rohlf et al., 2010) to make any treatment regime successful. White et al. (2011) included some open-ended questions in their study about veterinarian and owner perception of canine obesity to see if they could explain *how* owners account for the weight of their dog and might find reasons why the owner doesn't take action to prevent canine overweight. They found that owners use personal narratives to explain their dog's current condition, like "I know he's overweight, but when you look into those big brown eyes you have to give him a biscuit… we're two of a kind!" after noting that their dog is "spoilt". It is possible that these owners are overfeeding and/or over-humanizing the dog, where food is used as an expression of affection.

A study done by Kienzle et al. (1998) supports the hypothesis that humanizing the dog has an effect on its body condition, because they found that "*owners of obese dogs speak more to their pets, are more likely to allow their pets to sleep with them, and spend more time watching their pets eat*". Even if the owner knows that their dog is overweight and acknowledges that it's a problem, if they have a strong emotional relationship with it they may be less inclined to withhold food or treats, because a high level of attachment with their dog could be associated with emotional dependency (Linder & Mueller, 2014). If both the dog and owner are overweight or obese, the situation may actually be perceived as positive, or at least less negative, because sharing specific negative circumstances brings less sense of responsibility, shame and guilt (Favaro & Adamelli, 2014). There is in fact a significant relationship between canine overweight and the BMI of the owner (Holmes et al., 2007; Nijland et al., 2009). Because of this emotional human-animal bond it can be hard as a veterinarian to discuss canine overweight and there are indeed clinicians that are reluctant to discuss pet obesity and the associated health problems, in particular when the owner is also overweight (Larsen & Villaverde, 2016). But even though it may seem difficult at times, remember the words of Seneca, an ancient Roman philosopher: "We do not confront adversities because they are difficult, instead they are difficult when we do not confront them" (Favaro & Adamelli, 2014).

Recommendations

Further recommendations would be to do a large-scale study on canine obesity in the Netherlands, because the sample size of the current study was too small to make convincing statements. Especially with regards to the impact of the knowledge, actions and compliance of the owner on the body condition of their dog and any success of a weight loss program, a lot of additional research can be done. It would be advisable to conduct a study where the difference between what a pet owner knows, what they say and what they actually do is examined. Also, it would be wise to examine why the owner doesn't act on the veterinarian's recommendations and which approaches in trying to convince the owner of the importance of a health body condition, preventing overweight and a weight loss program in the case of canine overweight/obesity, actually works. Veterinarians need to be more aware of the importance of the human-animal bond and their own perseverance in the fight against canine obesity and with the right knowledge they could be more confident in convincing the owner of the importance of maintaining a lean, and thus healthier, dog.

5. Conclusion

The present study confirms that canine overweight is also a major problem in the Netherlands, with a prevalence of 46.1%. Risk factors for an above ideal body condition were gender, age and breed, but not sexual status. Possibly because gender, age and breed also had a significant association with whether or not the dog was neutered. The level of agreement between owner and researcher regarding the BCS and weight category of the dog was minimal and underestimation of the dog's BCS by their owner had a significant association with canine overweight. This might mean that veterinarians need to pay more attention to educating the owner about the BCS of their dog and about which body condition is a healthy one. The 'knowledge of the owner regarding predisposing factor', 'source of knowledge', and 'actions taken by the owner to prevent canine overweight' were not associated with the body condition of the dog, which could mean that it doesn't matter for the dog's BCS if the owner knows about the dog's predisposing factors for canine overweight or the owner tells the veterinarian that they take action to prevent it. Also, a strikingly low number of owners (15.0%) gained their information about predisposing factors from their veterinarian. Much more needs to be done to research, prevent and reduce canine obesity, especially because the human-animal relationship, over-humanizing the dog and owner compliance all play an important role in managing canine overweight and obesity.

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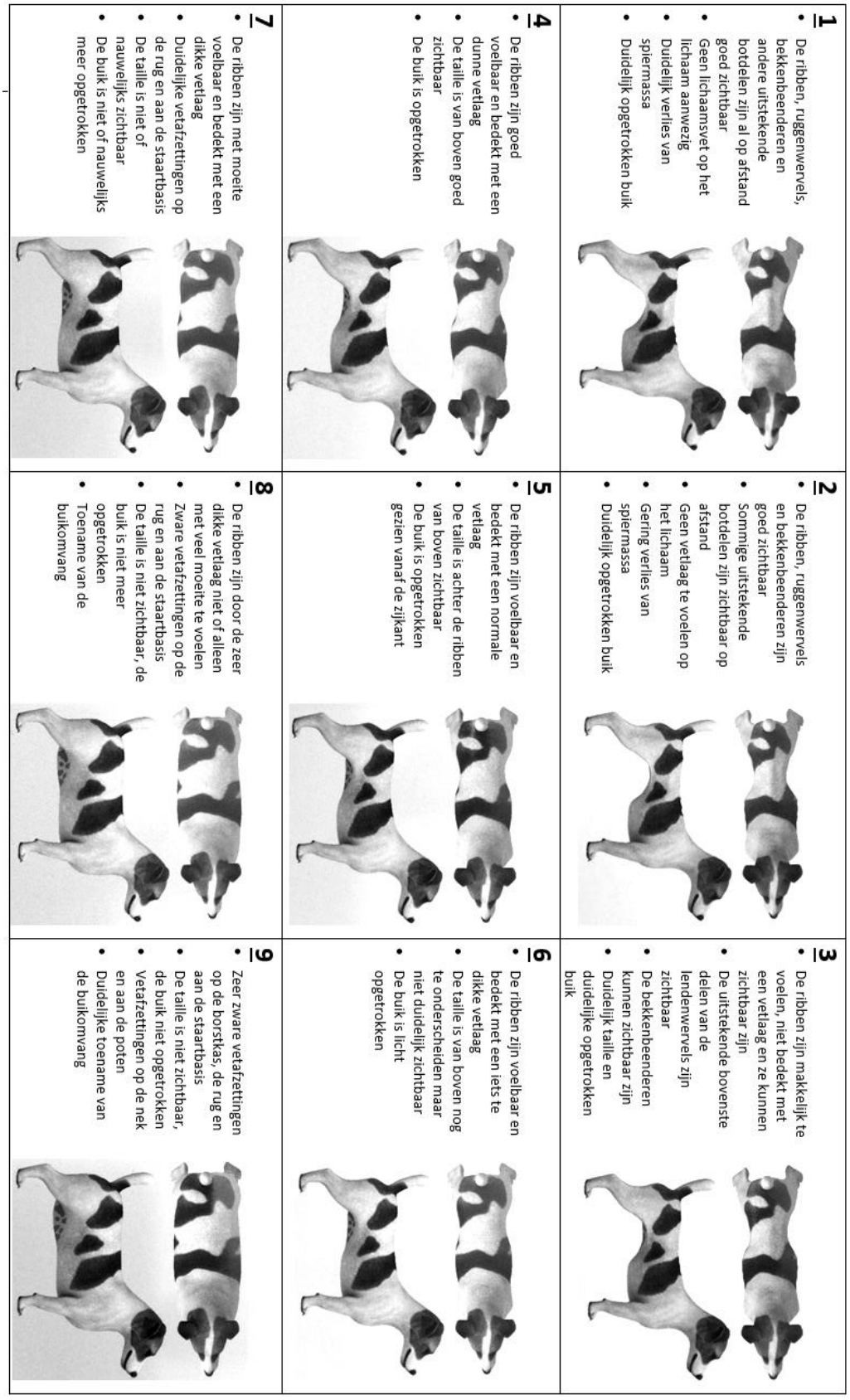
Appendix I Survey – information owner and dog

Practice:	
Data owner	
Name:	
Address:	
Zip code:	
City:	
Email:	
Phone number:	
Data animal	
Name:	
Breed:	
Gender:	☐ Male, intact ☐ Male, neutered ☐ Female, intact ☐ Female, neutered
Age:	
Weight (kg):	

Appendix II Adjusted 9-integer BCS card (in Dutch)



Appendix III Survey – questionnaire

Body Condition Score

Owner: Researcher:

Questions

Do you know any factors that could increase the risk of a dog becoming overweight?

- ☐ No
- ☐ Yes, namely:
  - Neutering
  - Age
  - Breed:
    - _____
    - _____
    - _____
    - _____
    - _____

How did you gain this information?

- ☐ The veterinarian
- ☐ The breeder
- ☐ Internet, do you know wherefrom?:_____
- ☐ TV, do you know wherefrom?: _____
- ☐ Family, friends or acquaintances
- ☐ Commercials, do you know wherefrom?: _____
- ☐ Other, namely: _____

How do you prevent your dog from becoming overweight?

- ☐ Less food
- ☐ Less snacks
- ☐ More exercise
- ☐ Other, namely:
  - _____
  - _____
  - _____
  - _____
  - _____

Appendix IV Fédération Cynologique Internationale breed (sub)groups

From: http://www.fci.be/en/Nomenclature/

Group 1	**Sheepdogs and Cattledogs (except Swiss Cattledogs)**
Section 1	Sheepdogs
Section 2	Cattledogs (except Swiss Cattledogs)
Group 2	**Pinscher and Schnauzer - Molossoid and Swiss Mountain and Cattledogs**
Section 1	Pinscher and Schnauzer type
Section 2	Molossian type
Section 3	Swiss Mountain- and Cattledogs
Group 3	**Terriers**
Section 1	Large and medium sized Terriers
Section 2	Small sized Terriers
Section 3	Bull type Terriers
Section 4	Toy Terriers
Group 4	**Dachshunds**
Group 5	**Spitz and primitive types**
Section 1	Nordic Sledge Dogs
Section 2	Nordic Hunting Dogs
Section 3	Nordic Watchdogs and Herders
Section 4	European Spitz
Section 5	Asian Spitz and related breeds
Section 6	Primitive type
Section 7	Primitive type - Hunting Dogs
Group 6	**Scent hounds and related breeds**
Section 1	Scent hounds
Section 2	Leash (scent) Hounds
Section 3	Related breeds
Group 7	**Pointing Dogs**
Section 1	Continental Pointing Dogs
Section 2	British and Irish Pointers and Setters
Group 8	**Retrievers - Flushing Dogs - Water Dogs**
Section 1	Retrievers
Section 2	Flushing Dogs
Section 3	Water Dogs
Group 9	**Companion and Toy Dogs**
Section 1	Bichons and related breeds
Section 2	Poodle
Section 3	Small Belgian Dogs
Section 4	Hairless Dogs
Section 5	Tibetan breeds
Section 6	Chihuahueno
Section 7	English Toy Spaniels
Section 8	Japan Chin and Pekingese
Section 9	Continental Toy Spaniel and others
Section 10	Kromfohrländer
Section 11	Small Molossian type Dogs
Group 10	**Sighthounds**
Section 1	Long-haired or fringed Sighthounds
Section 2	Rough-haired Sighthounds
Section 3	Short-haired Sighthounds

Appendix V BCS and weight categories of different FCI subgroups

Average BCS and distribution of weight categories of dogs of different FCI subgroups

FCI*	Number of Dogs	Mean BCS + range	Underweight	Ideal	Overweight	Obese
1.1	60	4.82 (2-8)	13.3%	61.7%	21.7%	3.3%
1.2	5	6.00 (5-8)	0.0%	40.0%	40.0%	20.0%
2.1	10	5.10 (3-7)	20.0%	30.0%	50.0%	0.0%
2.2	55	5.93 (4-9)	0.0%	47.3%	38.2%	14.5%
2.3	11	5.36 (3-8)	9.1%	54.5%	27.3%	9.1%
3.1	7	5.86 (5-8)	0.0%	57.1%	28.6%	14.3%
3.2	23	5.91 (4-8)	0.0%	47.8%	34.8%	17.4%
3.3	29	5.28 (3-7)	6.9%	55.2%	37.9%	0.0%
3.4	2	4.50 (4-5)	0.0%	100.0%	0.0%	0.0%
4	22	5.32 (4-7)	0.0%	54.5%	45.5%	0.0%
5.1	5	5.80 (4-8)	0.0%	40.0%	40.0%	20.0%
5.4	4	6.75 (5-8)	0.0%	25.0%	50.0%	25.0%
5.5	4	5.00 (4-6)	0.0%	75.0%	25.0%	0.0%
5.7	1	5.00 (5-5)	0.0%	100.0%	0.0%	0.0%
6.1	10	6.20 (5-7)	0.0%	10.0%	90.0%	0.0%
6.3	10	4.60 (4-5)	0.0%	100.0%	0.0%	0.0%
7.1	20	5.00 (2-7)	10.0%	50.0%	40.0%	0.0%
7.2	2	5.50 (5-6)	0.0%	50.0%	50.0%	0.0%
8.1	93	5.51 (3-9)	3.2%	40.9%	50.5%	5.4%
8.2	20	5.50 (3-8)	10.0%	25.0%	55.0%	10.0%
8.3	4	4.25 (4-5)	0.0%	100.0%	0.0%	0.0%
9.1	17	5.88 (4-8)	0.0%	41.2%	47.1%	11.8%
9.11	27	5.70 (3-8)	3.7%	44.4%	40.7%	11.1%
9.2	3	4.00 (3-5)	33.3%	66.7%	0.0%	0.0%
9.4	1	6.00 (6-6)	0.0%	0.0%	100.0%	0.0%
9.5	14	5.93 (5-7)	0.0%	35.7%	64.3%	0.0%
9.6	11	5.73 (3-8)	9.1%	45.5%	18.2%	27.3%
9.7	5	6.40 (5-7)	0.0%	20.0%	80.0%	0.0%
10.3	1	4.00 (4-4)	0.0%	100.0%	0.0%	0.0%

* *'Fédération Cynologique Internationale'*

Appendix VI BCS and weight categories of different breeds

Average BCS and distribution of weight categories of dogs of different breeds (n ≥ 5)

Breed	Number of Dogs	Mean BCS + range	Under-weight	Ideal	Over-weight	Obese
Beagle	6	6.33 (6-7)	0.0%	0.0%	100.0%	0.0%
Pug	6	6.50 (5-8)	0.0%	16.7%	50.0%	33.3%
Boomer	11	6.45 (5-8)	0.0%	18.2%	72.7%	9.1%
Bull Terrier	5	6.20 (5-7)	0.0%	20.0%	80.0%	0.0%
Cavalier King Charles Spaniel	5	6.40 (5-7)	0.0%	2.0%	80.0%	0.0%
English Bulldog	12	6.42 (5-8)	0.0%	33.3%	41.7%	25.0%
English Cocker Spaniel	6	5.50 (3-8)	16.7%	16.7%	50.0%	16.7%
Shih Tzu	11	5.91 (5-7)	0.0%	36.4%	63.6%	0.0%
Frisian pointing dog	5	5.40 (4-6)	0.0%	40.0%	60.0%	0.0%
Labrador Retriever	69	5.57 (3-9)	2.9%	37.7%	53.6%	5.8%
Maltese	14	6.00 (4-8)	0.0%	42.9%	42.9%	14.3%
Rottweiler	11	6.09 (5-8)	0.0%	45.5%	45.5%	9.1%
Jack Russel Terrier	21	5.95 (4-8)	0.0%	47.6%	33.3%	19.0%
Golden Retriever	16	5.50 (4-8)	0.0%	50.0%	43.8%	6.2%
Crossbreed	112	5.43 (2-9)	2.7%	51.8%	41.1%	4.5%
Dachshund	22	5.32 (4-7)	0.0%	54.5%	45.5%	0.0%
Chihuahua	11	5.73 (3-8)	9.1%	45.5%	18.2%	27.3%
French Bulldog	21	5.48 (3-8)	4.8%	52.4%	38.1%	4.8%
Boxer	8	5.62 (4-9)	0.0%	62.5%	25.0%	12.5%
English Springer Spaniel	6	4.67 (3-6)	16.7%	50.0%	33.3%	0.0%
American Staffordshire Terrier	10	5.20 (3-7)	10.0%	60.0%	30.0%	0.0%
Staffordshire Bull Terrier	14	5.00 (3-6)	7.1%	64.3%	28.6%	0.0%
German Shepherd Dog	18	4.83 (3-6)	16.7%	55.6%	27.8%	0.0%
Bernese Mountain Dog	9	5.11 (4-7)	0.0%	77.8%	22.2%	0.0%
Labradoodle	6	4.67 (4-6)	0.0%	83.3%	16.7%	0.0%
Border Collie	19	4.58 (2-8)	21.1%	63.2%	10.5%	5.3%
American Bulldog	7	4.71 (3-6)	14.3%	71.4%	14.3%	0.0%
Rhodesian Ridgeback	7	4.57 (4-5)	0.0%	100.0%	0.0%	0.0%

* '*Fédération Cynologique Internationale*'