Investigation into Risk Factors for Overweight Status and the Use of Behaviour Change Interventions for Weight Management in Dogs

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Abstract:

The prevalence of overweight dogs is increasing in the UK, compromising their health and welfare and predisposing them to conditions such as arthritis and heart disease.

A scoping review to appraise existing literature on overweight status and obesity in dogs identified three main research areas: risk factors for dogs being overweight or obese (n=10), consequences of dogs being overweight or obese and/or benefits of weight loss (n=27) and methods of weight management in dogs (n=48). There were relatively few studies on risk factors for dogs being overweight, so this area was investigated further. Risk factors for overweight status were compared across three different study populations: Guide Dogs' working dogs, Guide Dogs' breeding stock and pet dogs of the breeds used by Guide Dogs (GD). The results of these studies revealed that most risk factors for overweight status in these breeds were related to owner behaviour, particularly the use of treats. Feeding routines, amount of exercise and monitoring the dog's weight were also associated with the dog's weight status.

Drawing on those findings and behaviour change theories, a behaviour change intervention for new Guide Dog Owners (GDO) was developed. Part of this intervention utilised Protection Motivation Theory, the wish to avoid a negative outcome from a potential threat. A study was conducted to investigate whether the risk of a guide dog becoming overweight could be predicted from its behaviour around food. This work found only a weak correlation between the dog's food interest and its weight status. New GDO were informed of their dog's food interest and given strategies to assist with managing their dog's weight based on previously identified risk factors. These GDO (n=22), along with a control group of GDO (n=36) who received only standard GD weight management advice, were interviewed six months after matching with their guide dog. Comparison of self-reported behaviours between the two groups suggested that the intervention succeeded in changing GDO behaviour around feeding and treating their dog. The follow-up period was too short to allow evaluation of the effect of the intervention on the dog's weight status.

This thesis has identified and synthesised existing evidence around overweight status and obesity in dogs, produced new evidence to show that owner behaviours around feeding, exercise and monitoring their dog's weight are important risk factors for GD breeds being overweight, and investigated the short-term impact of an intervention based around these risk factors. Further work is required to investigate whether similar interventions will be successful in changing owner behaviour and/or improving weight management in pet dogs but the findings of this thesis have highlighted key areas for potential implementation within Guide Dogs and investigation in the wider dog population.

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Abbreviations

BCS - Body Condition Score
BCW - Behaviour Change Wheel
BMI - Body Mass Index
BSH - Brood Stock Holder
BSHA - Breeding Stock Health Advisor
COM-B - Capability, Opportunities Motivations – Behaviour
CT - Computed Tomography
DCWA - Guide Dog's Dog Care and Welfare Advisor
DEXA - Dual-energy X-ray absorptiometry
FE - Female Entire
FN - Female Neutered
FIS - Food Interest Score
***FTO* -** fat mass and obesity-associated gene
GD - Guide Dogs (organisation)
GDO - Guide Dog Owner
GDI-R - Guide Dogs' database
GP - General Practitioner
GSD - German Shepherd Dog(s)
IQR - interquartile range
KMO - Kaiser-Meyer-Olkin test
***MC3R* -** melanocortin receptor 3 gene
***MC4R* -** melanocortin receptor 4 gene
ME - Male Entire
MN - Male Neutered
MRI - Magnetic Resonance Imaging
NBC - Guide Dogs' National Breeding Centre
NRS - Numeric Rating Scale
ORMD - Obesity-Related Metabolic Dysfunction
PBS - Potential Breeding Stock
PCA - Principal Components Analysis
PDO - Pet Dog Owner
***POMC* –** Pro-opiomelanocortin gene
PW - Puppy Walker
RER - Resting Energy Requirement
SCFA - Short Chain Fatty Acids
SHAPE - Size, Health and Physical Evaluation (Body Condition Scoring system)
SVMS - School of Veterinary Medicine and Science, University of Nottingham
VAS - Visual Analogue Scale
WGD - Working Guide Dog

Chapter 1: Introduction

Obesity in dogs has been variously defined as where bodyweight exceeds the optimum bodyweight for that breed or size of dog by more than 15% (Simpson *et al.*, 1993; Laflamme, 2001), 20% (Hand *et al.*, 2000), or 30% (German, 2006). Dogs are considered overweight if their bodyweight is greater than 10% (German, 2016a) or 15% of their optimal bodyweight (German, 2006). The distinction between overweight status and obesity in dogs is therefore not clear-cut, but obesity generally refers to the presence of more excess bodyfat than an overweight condition (Pelosi *et al*., 2013). Obesity can also refer to the social construct of excessive body fat (Moffatt, 2010).

In contrast to dogs, the distinction between overweight status and obesity in humans is clear, with overweight status defined as a Body Mass Index (BMI) of 25-29.9kg/m^2 and obesity as a BMI of $\geq$30kg/m^2. Furthermore, obesity in humans is subdivided into Class I: BMI 30-34.9kg/m^2, with a moderate risk of comorbidities; Class II: BMI 35-39.9 kg/m^2, with a severe risk of comorbidities; and Class III: Morbid obesity (BMI$\geq$40 kg/m^2) with a very severe risk of comorbidities (Swann, 2013; Barnes, 2015). In dogs, the correlation between the amount of excess bodyfat and comorbidities is less clear (Tvarijonaviciute *et al*., 2012).

Most of the dogs in the empirical work described in this thesis were fairly close to their optimum weights, so any dog above its optimum weight will be described as overweight. The terms obese or obesity may still be used on occasion to reflect the terminology used in the literature or to refer to the construct of excessive body fat (Moffatt, 2010).

Overweight dogs are an increasingly common problem in the UK, with a prevalence ranging from 52% (37% overweight, 15% obese) in 2007 (Holmes *et al.*, 2007) to 59% of dogs (Courcier *et al.*, 2010) in studies where trained assessors measured Body Condition Score (BCS). It is difficult to establish the true prevalence of overweight dogs due to variations in the dog populations studied and the subjectivity of some of the methods used to assess body composition (Gosselin *et al.*, 2007). However, the prevalence of overweight dogs is increasing in parallel with the rise in human obesity (Kienzle *et al.*, 1998; Colliard *et al.*, 2006; German, 2006; Nijland *et al.*, 2009).

1.1 Aetiology of overweight status

Overweight status arises from the accumulation of excessive amounts of adipose tissue in the body (Zoran, 2010). This is associated with a positive energy balance, where energy intake exceeds the body's energy requirements for a prolonged period (Laflamme, 2012), but the direction of this association is not clear (Wells and Siervo, 2011). The main determinants of bodyweight are those affecting energy metabolism and energy intake and assimilation (Loftus and Wakshlag, 2015). Energy metabolism comprises resting metabolic rate, active metabolic rate and energy expenditure from activity. Energy intake is determined by eating, which has hormonal and behavioural components, digestion efficiency and dietary factors that affect nutrient assimilation (Loftus

and Wakshlag, 2015). More recent research into overweight status and obesity has found additional factors contributing to weight gain and resistance to weight loss, including genetics and gut microbiota. The latter can influence the amount of energy extracted from the diet in both humans and animals (Kieler *et al*., 2017), due to the fermentation of dietary fibre and starch into large quantities of short-chain fatty acids (SCFA) in some individuals. These SCFA are used as an energy source by the host, making these individuals more resistant to weight loss (Kieler *et al*., 2017; Chun *et al*., 2020).

Dietary components, particularly fat and fibre, influence the composition of the gut microbiota in both dogs and humans (Handl *et al*., 2013; David *et al*., 2014). Changes in diet may therefore affect weight both directly and indirectly via changes in the gut microbiota (Handl *et al*., 2013). Sex, age and breed also affect the gut microbiome, and there is considerable variation between individuals, even within dogs of the same breed, sex and neutering status living in the same colony environment (Handl *et al*., 2013). Research into the systemic effects of gut microbiota is ongoing and it will be interesting to see whether this has any practical implications for weight management in both dogs and humans.

Genetics can affect susceptibility to excessive weight gain in humans and dogs, but environment and behaviour also contribute (Osto and Lutz, 2015). The heritability of human obesity is estimated at 71–81%, but this figure has not yet been determined for dogs (Osto and Lutz, 2015; Wallis and Raffan, 2020). The majority (93–95%) of severe obesity cases in humans are polygenic, involving hundreds or thousands of genetic variants, the majority of which affect appetite (Wallis and Raffan, 2020). In dogs, a deletion in the proopiomelanocortin gene (*POMC*) has been identified in Labrador and flat-coated retrievers, which affects appetite and weight. Increases of 0.5BCS (on a 9-point scale) and 2kg bodyweight were found for each mutant allele (Raffan *et al*., 2016). Mankowska *et al*. (2017a) found that the *POMC* deletion increased bodyweight but not BCS when using a 5-point scale, possibly due to the lower sensitivity of the 5-point scale. Mankowska *et al*. (2017a) also concluded that the mutation had a recessive effect, whereas Wallis and Raffan (2020) proposed an additive effect. Further work is needed to clarify the precise effects of this mutation. Other genes associated with human obesity *e.g.* melanocortin receptors 3 and 4 *(MC3R and MC4R),* fat mass and obesity-associated gene *(FTO)* have been investigated in dogs (Skorczyk *et al*., 2007; Mankowska *et al*., 2017b; Grzemski *et al*., 2019) but no convincing associations with adiposity have yet been identified (Wallis and Raffan, 2020).

1.2 Metabolic effects of overweight status

As well as being a site of fat storage, adipose tissue produces hormones involved in lipid and carbohydrate metabolism, energy regulation, inflammation and the coagulation cascade. These hormones include leptin and adiponectin, which act together to maintain energy homeostasis during feeding and fasting (Clark and Hoenig, 2016). Leptin increases in response to food intake, causing short-term satiety, reducing food intake and increasing energy expenditure (Loftus and Wakshlag, 2015; Clark and Hoenig, 2016). Leptin levels

in dogs increase as body fat increases (Loftus and Wakshlag, 2015; Vitger *et al*., 2017), however higher leptin concentrations in obese humans and dogs do not reduce appetite due to the development of leptin resistance (Wynne *et al*., 2005; Clark and Hoenig, 2016). Leptin also helps to regulate insulin sensitivity and has pro-inflammatory effects (German *et al*., 2010b; Osto and Lutz, 2015; Clark and Hoenig, 2016; Vitger *et al*., 2017) (Section 1.3).

The role of adiponectin in dogs is less clear (Vitger *et al*., 2017). Some studies found increased adiponectin levels after weight loss while others found no effect, likely due to variations in dog populations (client-owned *vs* experimental dogs), breed, reproductive status, environment and type of assay used in the different studies. A systematic review and meta-analysis showed that overall, adiponectin levels were lower in overweight dogs compared to normal weight dogs and increased after weight loss (Munoz-Prieto, 2020). This mirrors the situation in humans, where adiponectin levels decrease with obesity (Iwabu *et al*., 2019). Adiponectin increases insulin sensitivity and has anti-inflammatory effects (Iwabu *et al*., 2019; Munoz-Prieto, 2020).

Being overweight or obese leads to chronic low-grade systemic inflammation, due to the overexpression of inflammatory cytokines such as tumour necrosis factor alpha (TNF- α) and interleukin (IL)-6 (German *et al*., 2010b). This systemic inflammation is thought to contribute to many of the comorbidities associated with being overweight (Ellulu *et al*., 2017), including neoplasia (Glickman *et al.*, 1989; Sonnenschein *et al.*, 1991; Alenza *et al.*, 1998, 2000) and orthopaedic disease (German *et al*., 2010b).

In humans, the combination of obesity, hyperglycaemia, hypertension and dyslipidaemia is known as metabolic syndrome (Huang, 2009). Metabolic syndrome occurs in around 22-28% of overweight and 50-60% of obese individuals (Tvarijonaviciute *et al*., 2012) and predisposes them to cardiovascular disease, type II diabetes and strokes (Verkest, 2014; Ellulu *et al*., 2017). A similar condition (Obesity-Related Metabolic Dysfunction, ORMD) has been identified in around 20% of overweight dogs, with low plasma adiponectin and hyperinsulinaemia (Tvarijonaviciute *et al*., 2012), mild hypertension (Bodey and Michell, 1996) and hyperlipidaemia (Chikamune *et al*., 1995). However, unlike humans, dogs do not develop atherogenic hyperlipidaemia or fasting hyperglycaemia, and type II diabetes, atherosclerosis, coronary heart disease and strokes are rare (Verkest, 2014). Additional studies may help to clarify whether ORMD is associated with poorer health, difficulty in losing weight or a reduced lifespan in dogs (Tvarijonaviciute *et al*., 2012).

1.3 Consequences of being overweight

Excess bodyfat can predispose dogs to disease in two different ways. The first involves the physical or mechanical effects of the excess bodyfat, such as constriction of airways and reduced heat dissipation. The second is due to the chronic inflammatory state induced by excess adipose tissue (German *et al*., 2010b), as discussed in Section 1.2.

The physical effects of excess bodyfat predispose dogs to respiratory conditions such as tracheal collapse (Bach *et al.*, 2007; Fonfara *et al.*, 2011; Manens *et al.*, 2012), urethral sphincter mechanism incompetence (Gregory, 1994) and orthopaedic diseases such as osteoarthritis, although obesity-induced inflammation may also play a role in the latter (German *et al*., 2010b). Overweight dogs are also more likely to suffer from cardiovascular conditions such as left ventricular hypertrophy, hypertension and increased heart rate (Bouthegourd *et al.*, 2009; Pelosi *et al.*, 2013; Mehlmen *et al.*, 2013), mammary tumours (Sonnenschein *et al.*, 1991; Glickman *et al.*, 1995; Alenza *et al.*, 1998, 2000), and reproductive and dermatological disorders (German, 2006). Overweight dogs have a shorter lifespan (Kealy *et al.*, 2002), poorer quality of life (German *et al.*, 2012b) and compromised welfare (Yeates, 2012). Benefits of weight loss in dogs include higher activity levels, improved haircoat, greater vivacity and improvement in musculoskeletal and respiratory conditions (Carciofi *et al.*, 2005). In addition, owners perceived improved quality of life and emotional wellbeing in their dogs and a reduction in pain scores after weight loss (German *et al.*, 2012b).

1.4 Risk factors for being overweight

A number of factors have been identified which can increase a dog's risk of being overweight (Chapter 2). These factors can be divided into three broad categories: (1) dog factors, (2) reproductive management, and (3) dietary/exercise management (human behaviours) (Bland *et al.*, 2009).

1.4.1. Dog factors

The majority of published studies agree that as a dog ages, its risk of being overweight increases (Robertson, 2003; Colliard *et al.*, 2006; Lund *et al.*, 2006). There are a number of possible reasons for this. Owners tend to give their dog more treats as it gets older (Colliard *et al.*, 2006) although the amount of food given decreases (Heuberger and Wakshlag, 2011a). This could result in an increased energy intake, which may be compounded by reduced frequency, intensity and duration of the dog's exercise (Robertson, 2003; Heuberger and Wakshlag, 2011a), necessitated by the onset of diseases which reduce the dog's exercise tolerance such as cardiorespiratory or musculoskeletal diseases (Frye *et al.*, 2016; German, 2016b). In addition, the older the dog is, the more likely it is to be neutered (Robertson, 2003; McGreevy *et al.*, 2005; Trevejo *et al.*, 2011), and neutering is known to predispose to being overweight (Robertson, 2003; McGreevy *et al.*, 2005; Colliard *et al.*, 2006; Lund *et al.*, 2006). McGreevy *et al.* (2005) noted that although the risk of a dog being overweight increased with age, it declined again once the dog reached around ten years of age. This was corroborated by Courcier *et al.* (2010), who found that older dogs tended to fall into either the overweight or underweight categories. Weight loss in older dogs could be due to age-related diseases such as renal failure, or because the lifespan of overweight dogs is reduced compared to normal weight dogs (Kealy *et al.*, 2002; Lawler *et al.*, 2005; McGreevy *et al.*, 2005). Nijland *et al.* (2009) suggested that the reason why dogs tend to gain weight as they age may be related to the length of time they have been with their owners and managed

in a certain way, rather than to their age *per se.* However, they found no relationship between the age of a dog and the amount of excess bodyfat. This may warrant further investigation.

The breed of a dog also appears to influence its risk of becoming overweight, but predisposed breeds vary between countries. Retriever breeds were more likely to be overweight in the UK, France and the USA (Mason, 1970; Colliard *et al.*, 2006; Lund *et al.*, 2006). Cocker Spaniels, Dalmatians, Dachshunds, Rottweilers, Shetland Sheepdogs and cross-breeds were also at increased risk of being overweight in the USA, with Shetland sheepdogs and Dachshunds also prone to obesity (Lund *et al.*, 2006). McGreevy *et al.* (2005) found that certain breeds in Australia, such as gundogs, were prone to becoming overweight after being neutered, but that the reverse was the case for Australian working dogs and terriers, suggesting some interaction between breed and neutering. The differing breed predispositions for overweight status between countries may be due to differences in gene pools, varying breed standards or different uses of dog breeds between countries (Ghirlanda *et al.*, 2013; Pedersen *et al.*, 2013; Parker *et al.*, 2017).

Sallander *et al.* (2010a) suggested that the type of hair coat a dog has may affect its energy requirements. This study was conducted in Sweden, which has a temperate climate in the southern region where the majority of the population live, not dissimilar to the climate in the UK (Visit Sweden, 2020). To the author's knowledge, no UK studies have investigated the effect of a dog's hair coat on its weight status and this could be interesting to explore further. Sallander *et al.* (2010a) also found that dogs with good appetites tended to be overweight, another area which may warrant further research.

The effect of dog sex on its risk of becoming overweight is not entirely clear. McGreevy *et al.* (2005) and Colliard *et al.* (2006) agreed that females were more likely to be overweight than males, and Courcier *et al.* (2010) found that female neutered dogs were at greater risk of being overweight than male neutered dogs. Sallander *et al.* (2010a) found that female dogs were more than twice as likely to be overweight as male dogs, although their study population was 99% entire and included only pure-bred dogs between one and three years of age. In contrast, Robertson (2003) and Bland *et al.* (2009) found no sex difference in the prevalence of overweight status in dogs in Australia, although both these studies relied on the owners' assessment of their dogs' weight (Robertson, 2003) or BCS (Bland *et al.*, 2009). Further studies using reliable outcome measures are needed to clarify the effects of dog sex on weight status and also any interaction with neutering.

1.4.2. Reproductive Management

Previously published studies agree that neutering dogs of either sex increases their risk of becoming overweight (Robertson, 2003; McGreevy *et al.*, 2005; Colliard *et al.*, 2006; Lund *et al.*, 2006). Gonadal hormones such as oestrogens are important for the control of appetite and food intake in both male and female dogs (Miller, 2011). Although weight gain leads to increases in leptin and insulin, these seem less effective in suppressing appetite in neutered

animals. Neutering also decreases activity and metabolic rate, reducing a dog's energy requirement by 20-30% and necessitating a corresponding reduction in the dog's food intake to avoid weight gain (Miller, 2011). However, a study of 1842 rescue dogs in the USA demonstrated a positive correlation between the age of neutering and risk of becoming overweight (Spain *et al.*, 2004). This potential benefit of early neutering warrants further investigation (Root Kustritz, 2007).

1.4.3 Owner behaviour

a. Treats

Studies largely agree that feeding treats and snacks is a risk factor for excessive weight gain (Robertson, 2003; Lund *et al.*, 2006; Bland *et al.*, 2009; Courcier *et al.*, 2010). Kienzle *et al.* (1998) found that owners of overweight dogs fed their dogs more meals and snacks than owners of normal weight dogs, and fed kitchen scraps more frequently in addition to their meals. Owners of overweight dogs were more likely to allow their dogs to be present when the owner was preparing or eating their own food and feed kitchen scraps or titbits at these times (Kienzle *et al.*, 1998).

Heuberger and Wakshlag (2011b) found an association between excessive weight gain and feeding table scraps but not commercial treats, possibly because snacks and table scraps are higher in fat than commercial dog foods or treats (Sallander *et al.*, 2010a, b). However, Lund *et al.* (2006) and Heuberger and Wakshlag (2011b) suggested that feeding frequency, different feeding practices and attitudes towards feeding table scraps may be more important than their composition.

Owners may be unaware of the calorie content of dog treats and give them because they think that they will benefit their dog's health (Rohlf *et al.*, 2012). An average dental treat contains over 100Kcal, which is around 7% of the maintenance energy requirements for a 30kg dog (Lindridge, 2015). Without clear nutritional information on dog treat packaging, owners may not be aware of the significant contribution that dental treats make to their dog's daily calorie allowance and the need to reduce their dog's food to compensate. The provision of nutritional information on dog treats could enable dog owners to make more informed decisions about their use of treats (Morelli *et al.*, 2018).

b. Diet type

The link between diet type and dogs being overweight is controversial. Lund *et al.* (2006) and Heuberger and Wakshlag (2011b) found that feeding table foods increased the risk of excessive weight gain and nutrient deficiencies and Sallander *et al.* (2010a) found that dogs fed a homemade diet or table scraps were twice as likely to be overweight as those fed on commercial food. In contrast, Kienzle *et al.* (1998) and Colliard *et al.* (2006) found no difference in the prevalence of overweight status between dogs fed a homemade diet or table scraps and those fed on commercial food. These inconsistencies may be

due to confounding factors such the country in which the study was conducted and the type of foods included in a homemade diet.

The composition of commercial foods may also influence a dog's weight. Lund *et al.* (2006) found that dogs fed a mainly semi-moist diet were more likely to be overweight, but those fed canned food were more likely to be obese. In contrast, Bland *et al.* (2009) found no association between the weight status of a dog and the type of diet fed. Heuberger and Wakshlag (2011b) found that higher fibre diets reduced the risk of dogs being overweight, probably due to their satiating effects (Jewell *et al.*, 2000; Weber *et al.*, 2007). Furthermore, diets which are high in protein as well as fibre are more satiating than diets containing high fibre or high protein alone and may therefore reduce begging and scavenging, thus reducing the risk of dogs becoming overweight (Weber *et al.*, 2007).

Overall, the evidence suggests that diet type and composition does affect the risk of dogs becoming overweight. Commercial diets high in fibre and protein appear to reduce the risk, whereas a homemade diet and/or table scraps is generally associated with dogs being overweight. It is not clear whether this is solely due to the nutritional composition of the food or is in part due to the owner's lifestyle, attitude towards food and feeding practices.

c. Quantity Fed

Owners may require education around the importance of measuring the quantity of food given, as well as a dog's nutritional requirements (Bland *et al.*, 2009). Three studies have highlighted the challenges of accurately measuring quantities of dog food, which may result in overfeeding. German *et al.* (2011b) found that measuring cups are a very inaccurate method of measuring portions of dry kibbled food, with accuracy ranging from 18% less to 80% more than the desired portion size. Additionally, the scales marked on four out of six measuring cups were inaccurate, and would all have led to overfeeding, by up to 40% in some cases. Similarly, Coe *et al.* (2019) found that the accuracy of dispensing dry dog food ranged from a 48% underestimate to a 152% overestimate depending on the measuring device used. If owners tend to overestimate the amount of kibble they are feeding their dog over a prolonged period of time, then the dog is likely to progressively gain weight.

Further to the inaccuracies resulting from the use of measuring cups, Murphy *et al.* (2012) found that the size of a dog's feeding bowl affected the amount of food given. Owners dispensed less kibble when measuring the food with a small scoop into a small bowl compared to using a large scoop and/or large bowl. Owners should be therefore be encouraged to use smaller food bowls and ideally weigh out their dog's food on kitchen scales for each meal. If this is too time-consuming, owners could calibrate their own measuring devices by weighing out the required amount of food, pouring it into a small container and marking the level. This process would need to be repeated each time the amount or type of food changed (German *et al.*, 2011b).

Even when owners do accurately measure their dog's food, the feeding recommendations for commercial dog foods are merely guidelines (Hodgkinson *et al.*, 2008). There is a wide variation in energy requirements between adult dogs (Sallander *et al.*, 2010a; Miller, 2011), so the quantity fed needs to be adjusted according to individual requirements (Butterwick and Hawthorne, 1998). If owners are able to either monitor their dog's weight at home, with regular weight checks at the veterinary surgery or are taught to accurately assess their dog's BCS, then they can adjust the amount fed to maintain their dog at its optimum bodyweight and BCS (Hodgkinson *et al.*, 2008).

d. Frequency of feeding

The association between frequency of feeding and dogs being overweight is unclear. Robertson (2003) discovered that dogs fed once daily were more likely to be overweight than those fed more frequently and Colliard *et al.* (2006) reported that dogs fed one or two meals per day were at greater risk of being overweight compared with those fed three or four meals per day. Bland *et al.* (2009) found that normal weight dogs tended to be fed twice daily, compared with overweight dogs which were usually fed either once daily or three or more times a day. Bland *et al.* (2009) suggested that this may be because regular ingestion of small amounts of food increases energy loss through thermogenesis and may also suppress the evolutionary instinct to eat as much as possible when food is available. However, Courcier *et al.* (2010) found no link between dogs being overweight and the frequency of feeding. Further controlled studies are needed to clarify whether there is any association between frequency of feeding and dogs being overweight.

In summary, studies generally agree that feeding additional treats and scraps increases the risk of dogs being overweight. There is conflicting evidence as to whether the type of food and the frequency of feeding are risk factors for dogs being overweight. A lack of nutritional information on dog treats and food packaging and wide individual variations in energy requirements may make it difficult for owners to know how much to feed their dogs. Furthermore, measuring dry food with measuring cups can be highly inaccurate, with frequent overestimations in the amount of food given. Over time this could lead to excessive weight gain in dogs fed dry food by volume.

e. Exercise

Bland *et al.* (2009) found that normal weight dogs were more likely to be exercised at least three times a week compared with once a week for overweight dogs. It is not clear whether dogs become overweight because they are walked less frequently or are walked less frequently because they are overweight (Robertson, 2003; Warren *et al.*, 2011), although some studies suggest a causal relationship between the duration of exercise and overweight status. Courcier *et al.* (2010) found that an extra hour of exercise per week reduced the risk of a dog being overweight by 4% and Robertson (2003) found that for every hour of exercise a dog had per week, the odds of it being overweight decreased by 0.9 times. Conversely, Nijland *et al.* (2009) found that the time spent walking the dog was not related to how overweight the dog or

the owner were. Although there seems to be an association between the weight status of the dog and the duration of its exercise, the nature of the relationship between the two is not yet clear.

The intensity of the dog's exercise may also influence its weight, as higher intensity exercise increases metabolic rate and energy expenditure both during and after exercise (Crane, 1991). Dogs which were restricted to a yard for exercise rather than being walked were more likely to be overweight (Bland *et al.*, 2009), probably due to energy-maximisation *i.e.* conserving energy by reducing activity when food is not available (Norris and Beaver, 1993). Conversely, Robertson (2003) found no difference in weight status between dogs who were walked and those who ran, although intensity of exercise may have been confounded by the age of the dog and the duration and frequency of exercise. Dogs that were only walked were older, exercised less frequently and for a shorter time than dogs which ran; dogs that ran were also more likely to have been swimming (Robertson, 2003). Swimming more than four days a week has been shown to reduce bodyweight in small breed dogs (Nganvongpanit *et al*., 2016) with faster weight loss in dogs that swam daily compared to dogs that swam four times per week.

Although exercise can increase the rate of weight loss in dogs on a calorie-controlled diet (Chauvet *et al*., 2011) and enable the same rate of weight loss with a higher food intake (Wakshlag *et al*., 2012), dietary energy intake has been shown to be more effective than exercise for weight loss in dogs (Chapman *et al*., 2019). Owners did not increase their dog's physical activity by the recommended amount in either study (Wakshlag *et al*., 2012; Chapman *et al*., 2019), therefore it is possible that longer or more intense exercise may have made a greater contribution towards weight loss. Exercise is still beneficial during a weight-loss program as it helps to preserve lean tissue (Bouthegourd *et al*., 2009; Vitger *et al*., 2016) but the optimum amount of exercise required for weight management in dogs has not yet been determined (Vitger *et al*., 2016).

1.4.4 Socio-demographic factors

There are a number of socio-demographic factors that have been reported to affect the risk of dogs being overweight, including the age and BMI of the owner and their bond with their dog. The owner's income, the type of location in which the owner lives and the number of people in the household have also been identified as risk factors for dogs being overweight in some studies.

Older owners are more likely to have overweight dogs (Colliard *et al.*, 2006; Courcier *et al.*, 2010; Heuberger and Wakshlag, 2011a) and younger owners are more likely to have an overweight dog if they are overweight themselves (Heuberger and Wakshlag, 2011a). Kienzle *et al.* (1998) and Nijland *et al.* (2009) agree that overweight owners are more likely to own overweight dogs; furthermore, owners who eat low calorie, nutrient-rich diets tend to have normal weight dogs (Heuberger and Wakshlag, 2011b). This suggests that owners' attitudes and behaviour regarding their own diet and health extends to their pets (Kienzle *et al.*, 1998; Heuberger and Wakshlag, 2011b). Similarly,

Nijland *et al.* (2009) proposed that owners' attitudes and behaviours around dog walking may help to explain the correlation between the weight of the dog and the weight of the owner. In contrast, Stephens *et al.* (2012) found no correlation between owner BMI and the dog's BCS. This may be because the participants in the study by Stephens *et al.* (2012) were recruited from a referral population and largely comprised middle-aged, well-educated and affluent white women, reducing the generalisability of the study. However, Stephens *et al.* (2012) suggested that there may a stronger bond between overweight dog owners and their dogs compared to normal weight owners because overweight owners are more reliant on their dogs for social support and companionship. A stronger bond may be linked to increased treat-giving by the owner (Rohlf *et al.*, 2012), although the direction of the association is not clear. A stronger dog-owner bond may therefore indirectly be linked to excessive weight gain in the dog (Robertson, 2003; Lund *et al.*, 2006; Bland *et al.*, 2009; Courcier *et al.*, 2010). Conversely, a more recent study (Webb *et al.,* 2020) found no association between the strength of the dog-owner bond and the dog's weight, likely because a strong human-animal bond could promote behaviours in some owners which would aid weight management, such as walking or playing with the dog.

Kienzle *et al.* (1998) and Courcier *et al.* (2010) found that owners with lower incomes were more likely to have overweight dogs, and Courcier *et al.* (2010) also found that dogs belonging to owners on a lower income were more likely to be fed scraps. Allied with this, owners of overweight dogs were more concerned about the price of dog food (Kienzle *et al.*, 1998) and special offers Suarez *et al.* (2012), whereas the quality and nutritional content of their dog's food were more important for owners of normal weight dogs (Suarez *et al.*, 2012). Owners of normal weight dogs may be more knowledgeable about maintaining their dog's weight, the risks of being overweight and be able to afford healthier options for their dogs (Courcier *et al.*, 2010).

Owners of overweight dogs bought dog food at the local supermarket more often than owners of normal weight dogs (Kienzle *et al.*, 1998). This may be for reasons of cost and convenience but may also reflect the 'overhumanising' of dogs, where owners wish to buy their pets' food from the same source as they buy their own (Kienzle *et al.*, 1998). Many dog owners use food to show their affection towards their dog, find it hard to resist giving their dog treats or believe that restricting their dog's food will cause it to suffer (Kienzle *et al.*, 1998; White *et al.*, 2007; Bland *et al.*, 2009, 2010; Rohlf *et al.*, 2010). Consciously or unconsciously, these owners prioritise the immediate benefits of feeding their dog over its long-term health (Davis *et al.*, 2004).

The link between the type of location where a dog-owner dyad lives and the risk of a dog being overweight has been investigated in Australia (McGreevy *et al.*, 2005). Dogs living in rural or semi-rural Australia were more likely to be overweight than dogs living in suburban or urban areas. This could be due to greater access to food, especially on farms, or a lack of structured exercise (Bland *et al.*, 2009). Dog owners living in an urban location in flats or apartments may need to need to take their dogs out more frequently to void if

they do not have access to a garden (Degeling *et al.*, 2012; Westgarth *et al.*, 2014). Increased frequency of exercise has been linked with a lower risk of dogs being overweight (Bland *et al.*, 2009), which could help to explain why dogs from an urban environment may have a lower risk of being overweight than those from more rural areas.

The association between the composition of the household in which a dog lives and the dog's weight status is not clear. Bland *et al.* (2009) found that the more people in a household who had a role in caring for the dog, the more likely the dog was to be overweight. This may be due to difficulties in monitoring what the dog is fed in a larger household, especially if there are children present. Conversely, if the children play with the dog, the dog's energy expenditure will increase (Bland *et al.*, 2009), reducing its risk of being overweight. Correspondingly, dogs in single dog households may be at greater risk of weight gain because they have no other dogs to play with (Robertson, 2003).

The effects of the various socio-demographic factors on the risk of a dog being overweight is not always clear. The majority of the published literature suggests that overweight or older owners and owners with a lower income tend to have overweight dogs. The associations between the location in which the dog-owner dyad lives and the composition of the household with the weight status of the dog is less clear and further studies may help to clarify these.

1.5 Assessing weight status

The two most commonly used methods of assessing weight status in companion animals are bodyweight and BCS. Bodyweight is a precise and objective measurement which is more sensitive to weight gain or loss than BCS (Dorsten and Cooper, 2004) and so is useful for monitoring changes over time. If small changes in weight are detected early, interventions can be initiated to maintain the dog at its optimum weight (German *et al.*, 2016a).

BCS is a subjective semi-quantitative method of assessing a dog's weight status using visual and palpable evaluations of body fat at various points on the body (Burkholder, 2000; Witzel *et al.*, 2014; Santarossa *et al.*, 2017). It is commonly used because it is a low-cost, easy and non-invasive method of assessing fat mass (Santarossa *et al.*, 2017) and is useful for comparing an animal's weight status with its optimal weight at a given time-point. There are two main BCS systems used in clinical practice: a validated 9-point system (Laflamme, 1997) which has recently been adopted as standard by the World Small Animal Veterinary Association Global Nutrition Committee (WSAVA, 2013) and a 5-point system, which has not been validated with dual-energy X-ray absorptiometry (DEXA) (Li *et al.*, 2012). A 7-point algorithm-based Size, Health And Physical Evaluation (SHAPE) system has also been developed (German *et al.*, 2006), based on similar visual and palpable characteristics to the 5- and 9–point systems. This correlates as strongly as the 9-point scale with body fat mass determined by DEXA.

Possible locations for palpation and/or visual inspection for assessment of BCS in dogs include the rib cage, pelvic bones, lumbar area, abdomen and waist (Santarossa *et al.*, 2017). Burkholder (2000) noted that BCS protocols based on assessments at multiple locations on an animal correlated better with total body fat compared to systems where assessments were made at only one or two sites. The level of detail in the descriptions provided for differentiating between the various scores is also important in determining the repeatability and reproducibility of a scoring system (Burkholder, 2000). The use of BCS in dogs has been shown to be reliable in trained assessors (Laflamme, 1997; Mawby *et al.*, 2004; German *et al.*, 2006) but owners generally assign a lower BCS to their dogs than veterinary surgeons *i.e.* underestimate the weight of their dogs (Courcier *et al.*, 2011; Eastland-Jones *et al.*, 2014; Gerstner and Liesegang, 2017). The addition of illustrations and silhouettes do not seem to improve owners' recognition that their dog is overweight (Laflamme, 1997; Singh *et al.*, 2002) and may even complicate the assessment of BCS, so written descriptors alone may be preferable (German *et al.*, 2006). Practice in using the relevant BCS protocols is required to make it a reliable assessment (Burkholder, 2000; Blageanu and Vulpe, 2018).

1.6 Weight management

Prevention of excessive weight gain is preferable to having to effect weight loss in dogs which are already overweight (Colliard *et al.*, 2006; Miller, 2011; German, 2016a; Leclerc *et al.*, 2017). For dogs that are overweight, complete weight loss, *i.e.* a return to optimal body condition, is the ideal, especially for younger dogs, where excess bodyfat has only been present for a short time, weight-related diseases are unlikely to have developed and the dogs' remaining lifespan should be long (German, 2016c). Partial weight loss may be more realistic for older dogs or those with comorbidities, aiming for enough weight loss to improve the dog's quality of life, even if the dog does not reach a normal BCS (German, 2016c). An improvement in lameness was seen in overweight dogs with osteoarthritis who lost 11-18% (Impellizeri *et al*., 2000) and 6-9% (Marshall *et al*., 2010; Christmann *et al*., 2018) of their initial bodyweight, even if they did not reach ideal bodyweight. These studies show that a relatively small weight loss can improve a dog's mobility and quality of life (German *et al*., 2012b, 2016b). Further advantages of partial weight loss programs are that most dogs will successfully lose some weight, the program can be relatively short, but owners can extend it if desired, with a new, lower target weight (German, 2016c).

The main components of any weight loss plan are dietary energy restriction, increased energy expenditure (Burkholder and Bauer, 1998; Chauvet *et al.*, 2011; Linder and Mueller, 2014; Murphy, 2016; Bartges *et al*., 2017; Chapman *et al*., 2019) and behaviour modification (Section 1.8). The strategies described below are with the aim of complete weight loss unless otherwise stated.

1.6.1 Energy restriction

The first step of a weight loss consultation is to ascertain the dog's current diet and exercise history. This should include everything the dog is fed, including

supplements, treats and dental chews (Linder, 2020). Owners do not always volunteer this information so direct questions may be necessary (Sallander *et al*., 2010b; Linder, 2020). As well as gathering information about what and how much the dog is fed, this step provides some insight into how the owner and pet interact with food (Michel, 2009).

If current energy intake can be estimated, then calories can be restricted to 80% of present intake to encourage weight loss (Burkholder and Bauer, 1998; Linder, 2020). Alternative methods of calculating energy requirements for weight loss may be used; for example Flanagan *et al*. (2017) used a two-step method to calculate energy requirements for weight loss. The first step was to estimate the dog's ideal bodyweight based on the dog's current BCS. Each unit of BCS above ideal (5/9) equates to 10% excess weight (German *et al*., 2009) so ideal bodyweights for dogs with BCS 7, 8 and 9 were calculated by dividing their current bodyweight by 1.2, 1.3 and 1.4, respectively. The second step is to use the ideal bodyweight to calculate energy requirements for weight loss using the resting energy requirement (RER) for the dog's ideal weight (RER (kcal) = 70 x ideal bodyweight (kg) $^{0.75}$) (Linder, 2020). Flanagan *et al*. (2017) used sex and neutering-specific variations of this equation to calculate the RER as these have been shown to give a more accurate starting energy intake than methods that do not factor in sex and neutering status or that utilise current bodyweight. However, any calculated energy requirements are just a starting point as there is significant individual variation in the energy needed for satisfactory weight loss in dogs (German *et al*., 2007). In the study by German *et al*. (2007), 74% of dogs required at least one adjustment to their weight-loss program to achieve satisfactory progress, highlighting the importance of regular follow-up visits (Saker and Remillard, 2005; Linder, 2020).

1.6.2 Diet type

Therapeutic weight loss diets should be used rather than reducing the amount of a standard maintenance diet and/or feeding a non-therapeutic weight management diet to reduce the risk of vitamin and mineral deficiencies (Toll *et al*., 2010; Gaylord *et al*., 2018). Therapeutic weight loss diets have reduced energy density but increased levels of protein, vitamins and minerals to maintain lean body mass (Bauer, 1998; Burkholder and Bauer, 1998). Quality as well as quantity of protein is important in maintaining lean muscle mass (Floerchinger *et al*., 2015; German, 2016c).

Reduced energy density diets can improve adherence, as it enables owners to give their dog an acceptable volume of food while still reducing calories (Floerchinger *et al*., 2015; Linder and Parker, 2016). The energy density of food can be reduced by expanding kibble with air, adding water (canned food) or fibre to the diet (Linder and Parker, 2016). Adding water to dry food to reduce its energy density does not appear to help with weight management (Alexander *et al*., 2017).

Some studies have shown that high fibre diets increase satiety (Jewell *et al*., 2000; Bosch *et al*., 2009), while others (Butterwick *et al*., 1994) found that fibre

had little or no effect on satiety. These differences may be due to the type of fibre used in the study: Butterwick *et al*. (1994) used five different types of mainly insoluble fibre, Bosch *et al*. (2009) compared diets with low and high levels of fermentable fibre and the fibre type in the study by Jewell *et al*. (2000) was not specified. Diets high in insoluble fibre are typically less energy-dense, while fermentable fibre results in SCFA production and increases satiety (Bosch *et al*., 2009). Higher fibre diets seem to aid weight loss as overweight dogs fed a high fibre, high protein diet lost more weight and more quickly than dogs fed a moderate fibre, high protein diet (German *et al*., 2010a). High protein, high fibre diets are more satiating than diets with only high protein or high fibre and so help to reduce begging and scavenging behaviour. This aids owner adherence to weight-loss programs (Weber *et al*., 2007).

Other dietary ingredients and supplements that may have potential benefits in weight-loss diets include navy and black beans (Forster *et al*., 2016), red ginseng extract (Bae and Oh, 2019), carnitine (Mitsuhashi *et al*., 2013), leucine/pyridoxine supplementation (Murphy *et al*., 2020), diacylglycerol (Umeda *et al*., 2006) and conjugated linoleic acid (Rivera *et al*., 2011). Further studies are required to assess the effectiveness of these substances for weight loss in pet dogs.

1.6.3 Treats and snacks

Non-adherence to feeding guidelines is a problem amongst owners of dogs on a weight-loss plan (German *et al*., 2007). Dog owners commonly feed their dogs treats and ideally these would be stopped (Burkholder and Bauer, 1998). However, many owners use food and treats to show affection for their pet and may be concerned that stopping treats will affect their bond with their dog (Shepherd, 2021). Negotiating the use of treats with an owner can demonstrate that their relationship with their dog is respected and that they can improve their dog's health without depriving it of something they love (Linder and Parker, 2016). Incorporating favourite treats into the weight-loss plan can also help to alleviate owners' concerns about the rigidity and lack of palatability of weight-loss diets and increase adherence (Linder and Parker, 2016). Treats should make up no more than 10% of the daily energy allowance to avoid diluting the essential nutrients provided by the weight-loss diet (Gaylord *et al*., 2018; Shepherd, 2021). Alternatively, vegetables or kibble from the dog's daily ration could be used as treats (Linder, 2020). Advising the owner to only feed the dog treats and snacks from its bowl can also act as a deterrent due to the extra effort involved (Bauer, 1998).

1.6.4 Methods of feeding

Owners should be encouraged to weigh their dog's food out on kitchen scales for every meal to ensure that the correct amount is being fed and to use smaller food bowls (Section 1.4.3c). Food toys and puzzles can be useful to extend mealtimes, thereby improving satiety, reducing overall food-seeking behaviour (German *et al*., 2015a) and increasing activity (Shepherd, 2021).

1.6.5 Exercise

Exercise can be a useful way to strengthen the dog-owner bond without the use of food (Cutt *et al.*, 2008a,b; Roudebush *et al*., 2008; Chauvet *et al.*, 2011; Rohlf *et al.*, 2012; Wakshlag *et al.*, 2012; Westgarth *et al.*, 2014; Linder, 2020). Daily mild to moderate intensity exercise, *e.g.* walking, is recommended for overweight dogs (Bouthegourd *et al*., 2009) and should be introduced slowly (Zenor, 2018). The distance can be gradually increased as the dog's exercise tolerance improves (Linder, 2020). Swimming or physical therapy may be an option for dogs with orthopaedic disease (Nganvongpanit *et al*., 2016; Linder, 2020). The optimum amount of physical activity required for weight management in dogs has not yet been determined (Vitger *et al*., 2016) and many owners find it difficult to increase their dog's exercise due to medical conditions (Vitger *et al*., 2016) or time constraints (Roudebush *et al*., 2008; Bland *et al*., 2010). However, exercise increases the rate of weight loss in dogs on a calorie-controlled diet (Chauvet *et al*., 2011) and allows continued weight loss at a higher energy intake (Wakshlag *et al*., 2012). Exercise also helps to preserve lean tissue during weight loss (Bouthegourd *et al*., 2009; Vitger *et al*., 2016), provides mental stimulation for the dog and may reduce begging (Linder, 2020).

1.6.6 Monitoring weight loss

During the initial weight consultation, a physical examination should be performed and weight, BCS, muscle condition score, morphometric measurements and photographs of the dog recorded (Linder and Parker, 2016). Further tests may be needed if comorbidities are suspected based on the physical examination as these can affect diet selection and exercise recommendations (Linder and Parker, 2016). Recording both weight and BCS is important as BCS is a less sensitive indicator of weight loss than bodyweight. It can take 2-4 months for BCS to change by a single unit on a 5-point scale, whereas bodyweight can drop by 3–4.5% in a month (Dorsten and Cooper, 2004). Monitoring bodyweight allows timely adjustments to be made to the weight-loss plan to ensure a safe but steady rate of weight loss (Burkholder, 2000). Furthermore, owners may not recognise that their pet has lost weight (Towell *et al*., 2015), so demonstrating progress at each visit helps to maintain owner motivation (Burkholder and Toll, 2000; Toll *et al*., 2010; Shepherd, 2021).

Bodyweight and BCS should be assessed every 2–4 weeks (Shepherd, 2021).
The target rate of weight loss is around 1% per week (Flanagan *et al*., 2017; Linder, 2020), although in dogs with comorbidities, a slower weight loss of 0.5% per week may be more realistic. Up to 2% weight loss per week is safe and achievable in colony dogs (Bauer, 1998; Linder, 2020), but the rate of weight loss in pet dogs is significantly slower (Carciofi *et al*., 2005). This may be because of differences in signalment, environment, exercise levels and dietary adherence (German *et al*., 2007; Christmann *et al*., 2015). A faster rate of weight loss may be associated with loss of lean body mass as well as fat (Burkholder and Toll, 2000) and makes rebound weight gain more likely (German *et al*., 2011c; Shepherd, 2021). Severe caloric restriction may also be

counter-productive by decreasing spontaneous activity (Crowell-Davis *et al*., 1995).

If weight loss is satisfactory, then no changes are needed (German *et al*., 2015a), but if weight loss is too slow, or the dog has gained weight, then the suitability of the plan for both dog and owner should be explored (Saker and Remillard, 2005; German *et al*., 2015a). Any barriers to adherence should be discussed, such as children in the household who may not understand that they should no longer give the dog treats, so that Coping Plans (Section 1.8) can be made (Linder and Parker, 2016; Shepherd, 2021). If weight loss is too slow despite good adherence, energy should be restricted by a further by 10–15%; if weight loss is too rapid (rare), energy should be increased by 20% to ensure lean mass is preserved (Shepherd, 2021).

As well as monitoring weight loss, the owner's perception of their dog's health, activity levels and wellbeing should be assessed. Quality of life and activity levels tend to increase the more body fat is lost, but ultimately the aim of weight loss is to improve the dog's quality of life rather than have it reach a certain number on the scales or an ideal BCS (German, 2016c).

1.6.7 Success of weight-loss programs in client-owned dogs

Christmann *et al*. (2015) found that 39% of dogs reached their ideal weight during a 6-month study period. Those dogs that reached their ideal weight had a lower starting BCS than those who did not, so a longer study period may have enabled more dogs to achieve this. Consistent with this, German (2015a) found that dogs that reached their target weight remained on their weight-loss program for longer. Furthermore, German *et al*. (2007) found that the median time required for a dog to reach its ideal weight was 9 months and some dogs required over 12 months.

For the first month of a weight-loss program, weight loss may be rapid (1.2% bodyweight/week) but this rate reduced to <0.3% bodyweight/week after 12 months despite a gradual reduction in energy intake of 10–20% (Deagle *et al*., 2015). This may be frustrating for owners, leading to poor adherence and early withdrawal from program. Owner adherence naturally declines over time, with 86% of owners adhering to a weight-loss program for the first 12 weeks but only 27% of dog owners continuing with the program at 48 weeks (German, 2016c). Dogs with more body fat to lose were less likely to complete a weight-loss program (German, 2016c) and dogs who lost weight quickly were more likely to complete the program, probably due to the impact of the rate of progress on owner motivation (German, 2015a, 2016b).

Managing the expectations of owners embarking on a weight-loss program for their dog is important so that they understand the need for long-term change (German, 2016c). Even when the dog has reached its ideal weight, continued food restriction and monitoring are required to prevent rebound weight gain (Laflamme and Kuhlman, 1995; German, 2016c).

1.6.8 Weight maintenance after loss

Energy restriction decreases metabolic rate, so that fewer calories are needed to maintain the dog at its ideal weight (Nagaoka *et al*., 2009; Christmann *et al*., 2015). German *et al*. (2012a) found that 49% of dogs who had reached their optimum weight later regained over 5% of their optimal weight, while 42% maintained and 9% lost more weight. In addition, German *et al*. (2012a) found that dogs were more likely to stay at their ideal weight if they remained on their weight-loss diet rather than changing to a standard maintenance diet after weight loss. This was likely due to the lower energy density of the weight-loss diet; greater satiety, leading to less begging and scavenging of additional food; and possibly miscalculation of the food requirements when switching dogs to the maintenance diet. Although it may be less convenient for owners to purchase their dog's weight-loss diet from the veterinary surgeon (German *et al*., 2012a), it may not be more expensive than the dog's original diet (German *et al*., 2015b). This may encourage owners to continue feeding the weight-loss diet to maintain their dog at its ideal weight (German *et al*., 2012a). If owners can see the improvements in their dog's health, wellbeing and quality of life as a result of its weight loss, this should motivate them to continue with the lifestyle changes to maintain the dog at its new healthier weight (Kushner *et al*., 2006; German *et al*., 2012b; Flanagan *et al*., 2017).

1.7 Role of the veterinary profession

Prevention of excessive weight gain is preferable to having to effect weight loss in dogs who are already overweight (Colliard *et al.*, 2006; Miller, 2011; German, 2016a; Leclerc *et al.*, 2017). Veterinary surgeons are regarded as an important source of information on pet nutrition (Kienzle *et al.*, 1998; Suarez *et al.*, 2012; Kuhl, 2015) and so are well placed to educate owners about the nutritional requirements of their pets and how these will alter with age and growth (Miller, 2011). Veterinary surgeons can help to educate owners on what a healthy bodyweight looks like for a dog, and the optimum weight for their dog (Kipperman and German, 2018). When comparing their own dog to others, owners are likely to be comparing with an overweight norm (Mulrooney, 2019), leading to skewed perceptions of what a healthy weight dog looks like (Bland *et al.*, 2009; Colliard *et al.*, 2006). This may explain why owners tend to underestimate the BCS of their dogs (Sallander *et al.*, 2010a; White *et al.*, 2011). Alternatively, owners may deliberately underscore their dog to avoid feeling guilty about their dog's condition, or may simply ignore the fact that their dog is overweight because they do not want to have to change their routines around feeding and exercise (Bland *et al.*, 2009).

Individuals with strong habitual behaviours, such as those around feeding and exercising their dog, are unlikely to act on new information and may even avoid information that challenges their current behaviour (Verplanken and Wood, 2006). Hence, if veterinary surgeons advise an owner that their dog is overweight, the owner may feel that their identity as a responsible, caring pet owner is being threatened (Furtado, 2021). They may try to explain or justify their dog's weight or disagree with the veterinary assessment (White *et al.*,

2011; Furtado, 2021), implying that they do not believe the dog's weight is a problem (Freeman *et al.*, 2006). Convincing an owner that their dog is overweight can be the hardest part of a weight management programme (Sibley, 1984; PDSA, 2018), but is the first step in addressing the problem as it moves the owner from the Precontemplation to the Contemplation stage of change (Prochaska and DiClemente, 1983) (Section 1.8). To progress beyond the Contemplation stage, owners need to believe that their dog's weight is a problem that needs to be addressed (Brickman *et al.*, 1982). Bland *et al.* (2009) found that 91% of owners were aware of the health risks to dogs of being overweight, but that this was independent of their dog's BCS, suggesting that knowing the risks was insufficient motivation to take remedial action. Furthermore, weight-loss interventions for dogs involving the provision of information designed to alter owner behaviour have largely been unsuccessful (Yaissle *et al.*, 2004; Chauvet *et al.*, 2011).

An Australian study revealed a mismatch between the approaches to weight loss taken by veterinary practices and the preferences of dog owners (Bland *et al.*, 2010). Veterinary practices initially recommended reducing food intake, reducing treats and changing diet; those practices that ran weight-loss clinics (43%) then offered these as a more intensive option. The majority of dog owners surveyed (74%) said that they would consult their vet for weight-loss advice and accepted that dietary modification was important. However, they were reluctant to consider increasing their dog's exercise, eliminating treats, the use of pharmaceutical products or attending weight-loss clinics because of the perceived cost in terms of time, money or the bond with their dog (Carciofi *et al.*, 2005; Bland *et al.*, 2010). Establishing an owner's concerns around the time and financial commitment required and their bond with their dog during a weight-loss program requires good communication between veterinary surgeon and dog owner to enable a mutually acceptable plan to be agreed (White *et al.*, 2011). Owner cooperation is essential for the success of a weight-loss plan, so the proposed changes need to be realistic and achievable for both dog and owner (Brown, 1989; Carciofi *et al.*, 2005; Porsani *et al.*, 2019). Owners need to believe that they are capable of performing the behaviours required to reduce their dog's weight and that these will result in a positive outcome (Prentice-Dunn and Rogers, 1986; Milne *et al*., 2002; Sheeran and Webb, 2016).

1.8 Behaviour Change

There is limited research relating behaviour and behaviour change theories to weight management in dogs (Rohlf *et al.*, 2010; Cairns-Haylor and Fordyce, 2017; Downes *et al.*, 2017; Webb *et al.*, 2018, 2020) and only a small number of cognitive frameworks have been considered to date. The most relevant theories are discussed below:

Social cognitive frameworks

1. **Theory of Planned Behaviour**

Ajzen's Theory of Planned Behaviour (Ajzen, 1991) states that an individual's intention to perform a particular behaviour can be predicted by their beliefs

about the consequences of performing the behaviour (their attitude); their beliefs about how significant others would want them to behave (subjective norms) and their belief about the ease or difficulty of performing the behaviour (perceived behavioural control). For example, Guide Dog Owners (GDO) may be motivated to feed their dog as directed by Guide Dogs (GD) because they believe that GD want them to feed the dog nothing but its daily ration (subjective norm) and that doing this will keep the dog at a healthy weight (attitude). The level of perceived behavioural control is likely to vary between GDO depending on factors such as other people in the household, which may determine how likely the dog is to get treats at home; the level of visual impairment of the GDO, which may affect how likely the dog is to scavenge successfully; the dog's behaviour around food; and GDO emotional attachment to the dog (Downes *et al.*, 2017). A higher level of perceived behavioural control over feeding is associated with improved weight management (Webb *et al.*, 2018).

However, the Theory of Planned Behaviour only relates to a person's *intention* to perform a behaviour, and motivation or intention to change does not always lead to an *actual* change in behaviour (Orbell and Sheeran, 2000). This is particularly true if the current behaviour is habitual or unconscious (Aarts *et al.*, 1997; Ouellette and Wood, 1998; Verplanken and Wood, 2006). In human dietary studies, the Theory of Planned Behaviour (Ajzen, 1991) was shown to account for just 16% of variance in dietary behaviour because eating is largely a habitual behaviour (Barker and Swift, 2009), whereas the Theory of Planned Behaviour is more relevant to conscious, planned behaviours. It is likely that dog owners feeding and treating their dogs is also an unconscious, habitual behaviour and so other models of behaviour need to be considered in conjunction with the Theory of Planned Behaviour.

2. Protection Motivation Theory

Protection Motivation Theory is based on an individual's perception of a potential threat and their desire to avoid a negative outcome (Floyd *et al.*, 2000). Protection motivation is affected by two processes: threat appraisal and coping appraisal. Threat appraisal concerns the level of danger the threat is believed to pose in terms of severity and probability of the event occurring (Webb *et al.*, 2020). For example, an owner who believes that their dog is likely to become overweight if no preventative measures are taken and that this would have a significant negative impact on them is likely to be more motivated to follow weight management recommendations than an owner who is unconcerned about weight gain in their dog and the possible consequences (Milne *et al.,* 2002).

Coping appraisal involves an individual's beliefs about the effectiveness of any preventative measures taken, their ability to perform them (self-efficacy) and the costs of the recommended behaviour (Milne *et al.,* 2002; Webb *et al.*, 2020). Considerations for a dog owner might include how easy it would be to alter their dog's feeding regime and the extra time required to increase its

exercise. If owners feel confident in their ability to carry out the behaviours required to reduce their dog's weight (high self-efficacy), believe that the benefits of doing so outweigh the costs and that these changes will be effective, then motivation to follow the weight management recommendations should be high (Prentice-Dunn and Rogers, 1986; Milne *et al*., 2002; Sheeran and Webb, 2016).

Both the Theory of Planned Behaviour and Protection Motivation Theory are concerned with intention, motivation and goal setting (Milne *et al*., 2002; Webb *et al.*, 2020). However, these intentions need to be translated into behaviours that will move the individual towards their goal (Orbell and Sheeran, 1998). Behaviour change is more likely to occur when the individual is both motivated to act and has plans around how to carry out their desired behaviour (Milne *et al*., 2002).

The development of strategies and plans to enact intentions could involve *Action Planning*, where specific plans are made about exactly how, when and where the intended behaviour will be carried out, or *Implementation Intentions* (Gollwitzer, 1993, 1996; Gollwitzer and Sheeran, 2006). Implementation Intentions have an 'If-Then' structure, with the 'If' specifying particular environmental cues which will 'Then' act as a trigger for the intended action or response (Gollwitzer, 1993). An example of an Action Plan for a dog owner could be to weigh out their dog's food for the week and bag it up immediately after they had fed their dog each Saturday morning, whereas an Implementation Intention might be that if a dog owner was ill and unable to take their dog for a walk, then they would ask their children to play with it in the garden for 20mins instead.

Predetermining responses to specific environmental cues means that the desired behaviour should occur with little conscious thought or effort (Sniehotta *et al.*, 2005), creating 'instant habits' (Gollwitzer, 1999). Implementation Intentions have been successfully used in health-related contexts (Gollwitzer and Oettingen, 2000) because the desired behaviours become automatic responses to the environmental trigger and so are more likely to be maintained as habits (Gollwitzer, 1993, 1996; Orbell *et al.*, 1997).

In addition, *Coping Planning* can be used to reduce the effect of distractions from the desired course of action (Sniehotta *et al.*, 2005). This involves anticipating obstacles and situations where adherence to Action Plans might be difficult and identifying suitable goal-directed responses in advance. Coping Plans can also be formulated using an 'If-then' structure *e.g.* if a dog owner needs to use cheese to give their dog its worming tablets, then they would reduce the size of the dog's meals that day to compensate.

The Transtheoretical Model and Model of Action Phases

The Transtheoretical Model (Prochaska and DiClemente, 1983) relates to intentional behaviour change and decision-making and comprises three

components. Only the Stages of Change component will be discussed here. These stages are:

Precontemplation – the individual is not intending to take action in the next 6 months. This may be because they are unaware of the consequences of their current behaviour, or because they have tried to change without success. They tend to avoid thinking or talking about their problem behaviours and are resistant and unmotivated to change (Velicer *et al.*, 1998; Churchill and Ward, 2016; Bartges *et al.*, 2017).

Contemplation – the individual is starting to consider change and assessing the costs and benefits. If they believe that the goal is highly desirable and achievable, they are likely to take action within the next 6 months. This equates to the Pre-decisional phase of the Model of Action (Gollwitzer and Sheeran, 2006).

Preparation – the individual is intending to take action in the next month. They have a plan of action in place and are ready to embark on a health promotion program. This mirrors the Pre-actional Phase of the Model of Action (Gollwitzer and Sheeran, 2006). Gollwitzer and Sheeran (2006) recognise that new behaviours can easily become part of an individual's routine if they are repeated frequently in stable contexts, but this process may be more difficult if people are unclear about the actions they need to take or the environment in which they will perform them. In these situations, Action Planning can be useful to clarify desired behaviours and the context in which they will be performed.

Action – the individual has successfully and consistently made specific changes to their lifestyle in the last 6 months. They are still at risk of relapse at this stage if presented with distractions and temptations, so learning to be flexible and adapting to threats to progress is important during this phase to ensure that goals are reached (Gollwitzer and Sheeran, 2006).

Maintenance – The new behaviours have been performed for 6 months or more. Only minor changes are required to prevent relapse and the individual is confident they can maintain their new behaviours.

Gollwitzer and Sheeran (2006) have a Post-actional phase as their final phase, where individuals evaluate the degree to which they achieved their goals and the quality of the outcome. This involves comparing their original beliefs about the desirability and feasibility of their goal to their achieved reality. Reflection on successful goal achievement and the outcome meeting or exceeding expectations should encourage maintenance of the new behaviours and help to prevent relapse. For example, owners finding a mutual enjoyment of dog-walking and taking pride in their dog's appearance should maintain motivation to continue (Kushner *et al.*, 2006).

If the owner's current unwanted behaviours around feeding, exercising and treating the dog are habitual, they may be difficult to change (Gollwitzer and Sheeran, 2006). This is because behaviours that are consistently repeated in the same setting eventually become an automatic response to that context (Nilsen

et al., 2012). Furthermore, people who feel under time pressure are more likely to follow established routines because they are efficient and can be carried out with little conscious thought (Betsch *et al*., 1998; Verplanken and Wood, 2006). Good intentions may not be enough to override an owner's automatic, unconscious responses to particular situations *e.g.* measuring out their dog's food with a scoop when it is time to feed the dog. Furthermore, owners may remember their intended behaviours and recognise the opportunity to act, for example remembering that they had planned to play with the dog rather than give it a treat, but may have to overcome an initial reluctance to act (Gollwitzer and Sheeran, 2006). This is common when people decide to start a behaviour that has desirable long-term consequences (*e.g.* weight loss) but less attractive short-term consequences (*e.g.* more time-consuming) (Gollwitzer and Sheeran, 2006).

Habitual behaviours can be disrupted by changing the environment in which those behaviours are carried out (Verplanken and Wood, 2006) *e.g.* putting the kitchen scales next to the kettle each night as a reminder to weigh the dog's food out in the morning. Action Plans including details of exactly how, when and where to implement the new behaviours can also help to link those behaviours to a specific context. For example, an owner might plan to put six pieces of kibble in a bag for use as treats during the day once they had weighed out their dog's food each morning. Although changing habitual behaviours initially require conscious thought, repetition in the same circumstances will cause links to form between the context and the behaviour, which should eventually result in the context (weighing out the dog's breakfast) triggering the new behaviour (bagging up extra kibble for treats) directly without the need for conscious decisions (Gollwitzer and Sheeran, 2006). Although it may initially take time and effort to perform the desired behaviour rather than default to old habits, eventually the new behaviours should become routine (Verplanken and Wood, 2006).

Potential problems and barriers can also be identified and Coping Plans in the form of Implementation Intentions (If-then plans) drawn up (Gollwitzer, 1999). An example of an 'If-then' plan for a GDO could be 'If I want to reward my dog for exceptional work, then I will give them extra fuss when we get home' or 'If I am unable to take my dog for a free run, then I will play with it indoors' (Webb *et al.*, 2018). Setting Implementation Intentions in advance means that when the specified situation arises, the predetermined desirable behaviour should be automatically triggered without the need for conscious thought (Gollwitzer and Sheeran, 2006).

A combination of Protection Motivation Theory and Implementation Intentions has been shown to be successful in encouraging behaviour changes to improve health (Milne *et al*., 2002).

The Behaviour Change Wheel

The many different models of behaviour change and frameworks for behaviour change interventions have been systematically reviewed, analysed and simplified into a Behaviour Change Wheel (BCW) (Michie *et al*., 2011). The BCW has the COM-B system of behaviour at its centre and states that an individual's Behaviour (B) is influenced by their Capability (C), Opportunities (O) and Motivations (M) to perform that behaviour. Capability comprises an individual's psychological and physical ability to perform the behaviour and encompasses knowledge and skills. Opportunities are physical or social factors that prompt or enable the behaviour. Motivation consists of the thought processes that stimulate and direct behaviour and includes both conscious decision-making (reflective behaviours) and habitual and emotional responses (automatic behaviours) (Michie *et al*., 2011).

Behaviour change interventions

Behaviour change interventions can be designed using a pragmatic approach or based on theories or models of behaviour (Michie *et al.*, 2011). In a systematic review and meta-analysis of 14 studies on behaviour change interventions designed to help dog owners manage their dog's weight, there was no statistically significant difference in effect sizes between the studies that reported using theories and those that did not (Krasuska and Webb, 2018). However, only two of the 14 studies reported using theory to design their interventions which may skew the results. Furthermore, Michie and Prestwich (2010) found that many interventions which are reportedly based on theory are often minimally or not at all, making it difficult to distinguish clearly between studies based on theory and those that are not.

Based on the COM-B model of behaviour, interventions can be designed to target any of the six components of the behavioural system (physical capability, psychological capability, reflective motivation, automatic motivation, physical opportunity and social opportunity) (Michie *et al*., 2011). Different types of intervention can be used to target different aspects of behaviours, for example educational interventions address psychological capability and reflective motivation, while persuasion targets reflective and automatic motivation (Michie *et al*., 2011).

Human behaviour is just one level of a hierarchy of processes known as Dilts' Logical Levels (Dilts, 1990). Dilts' Logical Levels provides a broader perspective on changing owner behaviours related to managing weight in their dogs and is described below.

1.9 Dilts' Logical Levels

Dilts' Logical Levels (Dilts, 1990) states that there are six different dimensions within an individual or group which influence relationships and interactions, one of which is human behaviour (Table 1.1). The purpose of each level is to

synthesise, organise and direct the interactions on the levels below it.

Table 1.1: Dilts' Logical Levels. Adapted from Dilts (2014).

Level	Content	Question addressed
Life purpose	Vision & Purpose	For Whom? For What?
Identity	Permission & Motivation	Who?
Beliefs and values	Values and Meanings	Why?
Capabilities and skills	Strategies and Plans	How?
Behaviour	Actions & Reactions	What?
Environment	Constraints & Opportunities	Where? When?

The most basic level of influence on individuals' relationships and interactions is the external Environment or the context in which people exist. The next level is Behaviour, the activities and interactions that occur in response to that environment. Each subsequent level is an amalgamation of the components of the level below it until the highest level of influence, Life Purpose, is reached. This concerns how an individual relates to the larger systems of which they are a part *e.g.* family and friendship groups. For an individual to be happy and fulfilled, all these dimensions of their lives need to be aligned (Dilts, 2014).

Making changes on a higher level will bring about changes in the levels beneath it to bring them into line with the higher-level change. Making changes at a lower level *could* (but not necessarily would) effect change on a higher level. The higher the level on which change is brought about, the greater the impact of that change (Dilts, 1990). This means that behaviour change interventions are more likely to be successful if they are targeted at levels above behaviour, namely Skills and Capabilities, Values and Beliefs or even Identity.

Identity

Identity essentially 'refers to who or what one is' (Gecas and Burke, 1995) and can be defined on three different levels: personal identity, social identity and collective identity (Sanders, 2000).

Collective identity refers to the way in which individuals are perceived as representatives of identifiable groups *e.g.* dog owners, visually impaired people.

Social identity is the way in which an individual is viewed by those with whom they interact and the basis for how that individual is treated during social interactions (Sanders, 2000). Social identity is therefore attributed by others, rather than assumed by the individual themselves (Hogan and Cheek, 1983).

Personal identity comprises a set of attributes unique to an individual and is how that individual might label themselves (Strauss, 1997). Dilts (1990) and Hitlin (2003) claim that personal identity is based on an individual's values and Hitlin (2003) highlights the many similarities between the two: both personal

identity and values involve beliefs, both are cross-situational and both encourage an individual to behave in a way that should lead towards their desired outcome.

Beliefs

Dilts (1990) defines beliefs as an individual's strongly held generalisations about cause and meaning in the world around them, their behaviour, their capabilities and their identities. Beliefs substitute for knowledge in situations where reality cannot be known (*e.g.* whether God exists) and because they cannot be proven or disproved by evidence or logic, they are very difficult to change by rational thinking or argument. One person is unable to change the beliefs of another, it is only possible for an individual to change their own beliefs. In addition, the beliefs that have the greatest effect on an individual are usually those that the individual is least aware of (Dilts, 1990).

Beliefs are often formed during childhood based on one or more meaningful experiences and may involve unconscious role modelling of significant others. For example, if parents use food as a reward for good behaviour, then their children are likely to grow into adults who believe that good behaviour should be rewarded with food (Puhl and Schwartz, 2003).

Beliefs are connected to an individual's value systems in that a belief is the relationship between cause, effect and values (Dilts, 1990).

Values

Values have variously been defined as beliefs associated with emotion (Maio and Olson, 1998; Sullivan *et al.*, 2002), what is important in life (Schwartz, 2012) or goals and ideals that motivate action (Bardi and Schwarz, 2003; Hitlin, 2003). People choose to behave in ways which express one or more of these values or move them closer to their goals (Bardi and Schwarz, 2003) as this evokes positive emotions (Sullivan *et al.*, 2002). Each individual has a number of values prioritised in order of importance (Verplanken and Holland, 2002). The behaviours associated with one particular value may either conflict or align with the pursuit of other values (Bardi and Schwarz, 2003) and it is the relative importance of the different values which will drive behaviour (Schwartz and Bilsky, 1987).

Behavioural norms are another potential reason why an individual's behaviour may not always be consistent with their values (Bardi and Schwarz, 2003). Behavioural norms can be regarded as social norms because they either relate to social values and the expectations of other people, or collective values and the membership of groups (Schwartz and Bilsky, 1987; Reynolds *et al.*, 2015). Compliance with behavioural norms is therefore important for successful social interactions (Schwartz and Bilsky, 1987). The stronger the normative pressure to act in a certain way, the more a person is likely to conform to those norms, even if it conflicts with their personal values (Bardi and Schwarz, 2003). If the approval of others or group membership is important to an individual, these social norms can become internalised, so that they become part of an

individual's personal or collective identity (Reynolds *et al.*, 2015). In this case, collective identity and personal identity become congruent, leading to a change in an individual's behaviour to align with the normative behaviour of the group (Reynolds *et al.*, 2015).

Skills and Capabilities

Skills and Capabilities bridge the gap between Behaviours and Beliefs. They comprise the plans and strategies used by individuals to determine behaviours, in contrast to habitual behaviours which are automatic responses to external stimuli. Skills and Capabilities include learning, decision-making and monitoring the effectiveness of behaviours, as well as memory and imagination (Dilts, 1990).

Links between Identity, Values and Behaviour

Dilts (1990) and Hitlin (2003) claim that personal identity and values are linked by authenticity, the alignment of an individual's personal identity and their values manifested in their behaviour. Gecas (2000) and Verplanken and Holland (2002) agree that it is not values themselves that drive behaviours, but a combination of values and identities.

Dilts (1990) recommends that the first step for successful behaviour change in an individual is to find the values they are operating from while Reynolds *et al.* (2015) go further by suggesting that Identity should be the basis for behaviour change. Dilts (1990) also points out that an individual's beliefs around their self-efficacy may need to be addressed before change can occur; if a person believes that they can change their behaviour, then they will, because belief activates capabilities and behaviours (Bandura, 1982; Dilts, 1990). Individuals with low self-efficacy may be reluctant to change their behaviour because of feelings of hopelessness (they do not believe the outcome is possible), helplessness (they believe the outcome is possible but they are not capable of effecting change) and worthlessness (they do not believe the outcome is deserved) (Dilts, 1990). These first two aspects of self-efficacy may be relevant in the context of weight management in dogs.

1.10 Aims of the thesis

The aims of this thesis were firstly to investigate risk factors for dogs being overweight or obese and secondly to utilise these data to design and evaluate an intervention which incorporated behaviour change theory to assist owners in managing their dog's weight.

These aims were achieved by firstly investigating the current literature on overweight status and obesity in dogs in order to identify gaps in existing knowledge (Chapter 2). Risk factors for dogs being overweight were then explored in three different populations of dogs, Working Guide Dogs (WGD) (Chapter 3), GD Breeding Stock (Chapter 4) and pet dogs of GD-type breeds and their crosses (Chapter 5). Chapters 2-5 were exploratory studies so hypotheses were not appropriate, but the findings of these studies were used to develop

hypotheses and intervention materials for the subsequent chapters of this thesis.

Part of the planned behaviour change intervention (Chapter 7) was to tell new GDO of their dog's risk of becoming overweight to see whether this knowledge increased their adherence to weight management guidelines. Previous studies (Sallander *et al.*, 2010a; Raffan *et al.*, 2015; Luno *et al.*, 2018) found correlations between a dog's interest in food and its weight status, so a Food Interest questionnaire for dogs was developed and validated in Chapter 6. The hypothesis for this study was that a dog's interest in food could be used to predict its risk of becoming overweight. The Food Interest questionnaire was then administered to Puppy Walkers (PW) of a cohort of WGD in training and the questionnaire responses used to classify each puppy as a high or low Food Interest Score (FIS) dog. This information was communicated to the new GDO when these dogs qualified as WGD as part of the behaviour change intervention (Chapter 7). The other components of the behaviour change intervention were recommendations about feeding and treating the dog based on owner behaviours identified as risk factors for overweight status in previously published literature (Chapter 2), surveys of GDO (Chapter 3), BSH (Chapter 4) and Pet Dog Owners (PDO) (Chapter 5) (Figure 1.1). The hypothesis for Chapter 7 was that the behaviour change intervention would modify GDO behaviour around feeding, treating and exercising their dog.

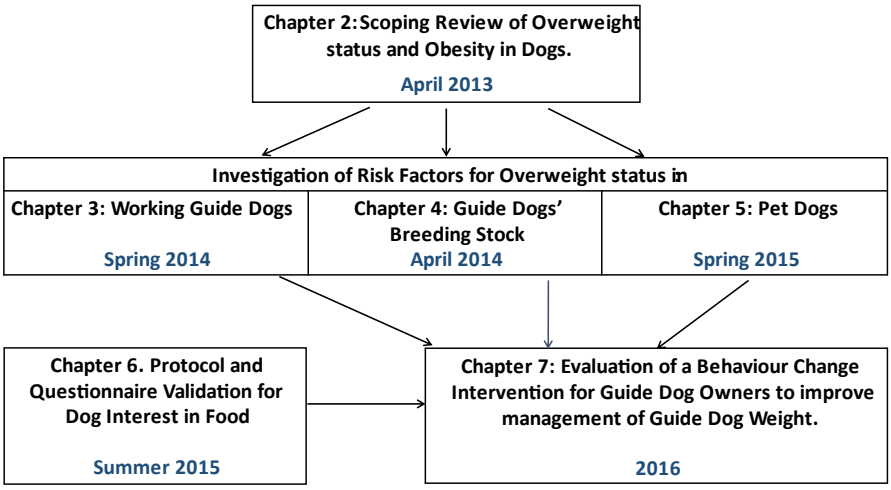


Figure 1.1: Thesis structure and dates when the empirical work for each chapter was conducted.

Ethical approval for these studies was granted by the Ethics Committee at the School of Veterinary Medicine and Science, University of Nottingham (SVMS) and Guide Dogs.

Chapter 2: A Scoping Review of Overweight status and Obesity in Dogs.

2.1 Introduction

2.1.1 Rationale

Overweight dogs are an increasingly common problem in the UK, with an estimated prevalence of between 52% and 59% (Holmes *et al.*, 2007; Courcier *et al.*, 2010).

The aim of this scoping review was to investigate the current literature on overweight status and obesity in dogs in order to identify gaps in existing knowledge.

2.1.2 Objectives

1. To identify the published, peer-reviewed literature on overweight status and obesity in dogs through a systematic search of databases.
2. To categorise areas of existing research on overweight status and obesity in dogs and identify areas where evidence is limited.
3. To evaluate the quality of existing evidence in one research area of interest.
4. To summarise the existing evidence on overweight status and obesity in dogs in the research area of interest.

2.2 Materials and Methods

2.2.1 Protocol and registration

This review follows the Joanna Briggs Institute Methodology for scoping reviews and has not been registered to an existing protocol.

2.2.2 Database selection and search terms

Three online databases, CAB Abstracts (1910 – 2013), Medline (In-Process & Non-Indexed Citations 1948 to present) and ISI Web of Science (v5.11) were searched for publications on canine overweight status and obesity (Grindlay *et al.*, 2012). The searches were carried out between 01.04.13 and 10.04.13 using the OvidSP platform and the following search terms:

(dog OR dogs OR canids OR canine OR canines OR hound OR hounds) AND (obese OR obesity OR body fat OR fatness OR adiposity OR overweight OR over weight OR grossness OR heaviness).

The initial Web of Science strategy produced a large number of publications (n>2000) and was therefore refined to restrict the search to Veterinary Sciences only.

2.2.3 Study selection

The results of each search were visually scanned by title to assess their relevance. Publications from each database that were not clinical studies relating to overweight status or obesity in dogs or where the full text was not

available in English were immediately rejected (Step 1) (Figure 2.1). If the relevance of the article was unclear from the title, the abstract was also examined against the inclusion and exclusion criteria (Table 2.1) (Step 2) (Figure 2.1).

Table 2.1: Inclusion and exclusion criteria for a scoping review of overweight status and obesity in dogs.

Criteria	Inclusion	Exclusion
Population	Client-owned dogs	Experimentally induced overweight status or obesity and/or laboratory dogs
Study design[1]	Cohort, case-control or cross-sectional studies. Studies where n ≥ 10	Case series, case reports, randomised controlled trials. Studies where n<10 (Sallander *et al.*, 2010a)
Variables investigated	Dog characteristics and behaviour Dog owner characteristics and behaviour Public perceptions of dog weight Association between being overweight or obese and disease processes Medical methods of weight control, including dietary or exercise modification Drugs licensed in UK to assist weight loss in dogs	Association between being overweight or obese and laboratory findings Effects of weight loss/gain on laboratory findings Surgical means of mediating weight loss Drugs *not* licensed in UK to assist weight loss in dogs
Outcome variable	Methods of assessing dog body composition commonly used in small animal practice (Santarossa *et al.*, 2017): Bodyweight Body Condition Score (BCS) Morphometric measurements	Methods of assessing dog body composition *not* commonly used in small animal practice due to cost, ease of use, invasiveness and/or accuracy (Payan-Carreira *et al.*, 2016; Santarossa *et al.*, 2017): Dual X-ray absorbtiometry (DEXA) Computed Tomography (CT) Magnetic Resonance Imaging (MRI) Deuterium oxide dilution Bioelectrical impedance analysis
Geographical location	Worldwide	
Language	Available in English	Not available in English

Publication type	Peer-reviewed original research studies	Conference proceedings (Kreulen *et al.*, 1998) Expanded abstracts Review articles Textbooks/book chapters Opinion pieces, editorials, letters
Availability of paper[2]	Full text available free of charge through the University of Nottingham	Full text *not* available free of charge through the University of Nottingham or abstract only available.

[1]In order to determine study design, definitions from Mann (2003), Pearce (2012) and Sargeant *et al*. (2017) were used.
[2] A study was included if full text could be obtained from any of the University of Nottingham libraries or e-libraries, through University of Nottingham journal subscriptions or free online Open Access.

The publications which met the inclusion criteria were downloaded into separate Microsoft Excel (2013) (Microsoft Corp., Redmond, Washington) spreadsheets and sorted into alphabetical order by title. The spreadsheets from each database were then combined and any duplicates discarded (Step 3) (Figure 2.1).

The final list of included publications was then sorted into common themes with a miscellaneous category for studies that did not fit into any of the main areas of research.

2.2.4 Data items

Study and participant information and study results of included publications from one of the themes were extracted and presented. Information collected from each publication included study date, design and population, sample size, number of overweight dogs in the sample, method of assessment of weight status, which potential risk factors for overweight status were measured and funding sources.

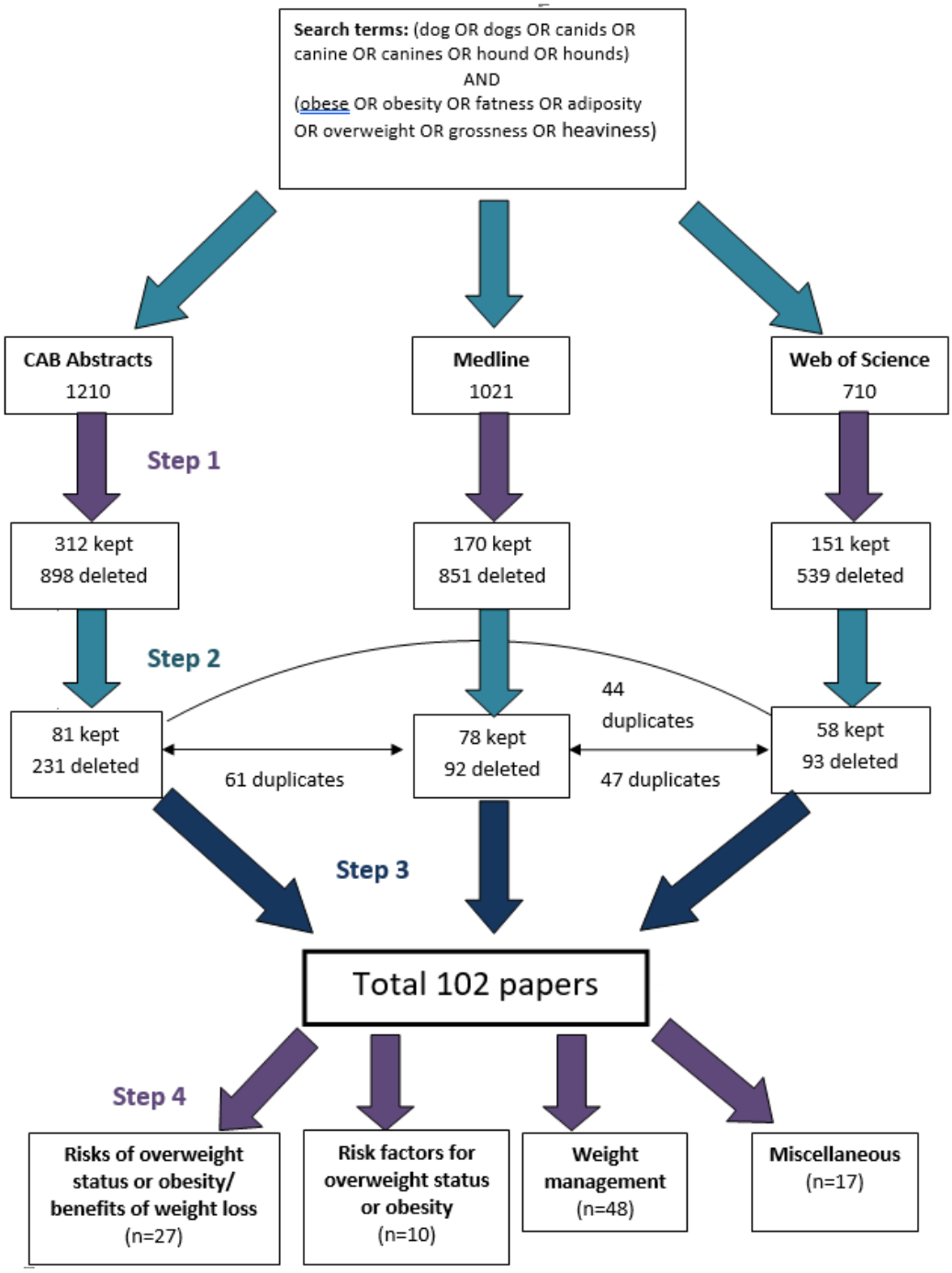


Figure 2.1: Numbers of studies screened, assessed for eligibility, and included in a scoping review of overweight status and obesity in dogs

2.2.5 Synthesis of results

Summary measures used by each publication were recorded and an evidence summary presented for each study. Meta-analysis of the results was not an objective of this review.

2.3 Results

2.3.1 Study selection

Review of the publications identified three main categories of research area (Figure 2.1):

- Risk factors for overweight status and obesity
- Risks of being overweight or obese and/or benefits of weight loss
- Weight management

2.3.2 Synthesis of results

There were ten publications relating to risk factors for overweight status or obesity in dogs. The summary measures and an evidence summary for each of these publications are presented below (Tables 2.2, 2.3 and 2.4)

Table 2.2: Study characteristics of ten publications on risk factors for being overweight or obese identified in a scoping review of overweight status and obesity in dogs carried out in April 2013

Author	Date of data collection	Country	Source of funding	Study design	Sampling method	Method of weight assessment	Who assessed weight	Total study population	Number (%) of overweight dogs	Management/risk factors measured
Robertson (2003)	1996	Australia	No funding declared	XS	Random telephone survey of households in metropolitan Perth	Weight (kg) Owner opinion of whether dog is underweight, correct weight or overweight	Owner	860 dogs 657 households	25.2% overweight or obese (95% CI 22.3 – 28.1%)	Dog breed, age, sex, neutering status. Number of dogs in household. Whether dog is mainly indoors or outdoors, heartworm prophylaxis, frequency of worming. Feeding frequency, diet type. Treats/snacks fed, other sources of food, supplements given. Exercise type, frequency, intensity and duration
McGreevy *et al.* (2005)	Start date not clear. End date Dec 17th, 2000	Australia	No funding declared	XS	SA practices recruited via Hill's Pet Nutrition database (n=178). Additional 31 practices selected by RSPCA. VS asked to complete questionnaire for every eligible dog examined in a 1-month period.	BCS (5-point scale)	VS	2661 dogs	892 (33.5%) overweight, 201 (7.6%) obese	Dog breed, age, sex, neutering status. Practice location (urban, suburban or rural) Whether owner informed of their dog's BCS.
Colliard *et al.* (2006)	February – May 2003	France	Waltham Centre for Pet Nutrition	XS	All dog owners attending the vaccination department at the	Weight (kg) BCS (5-point scale)	VS	681 dogs	33.8% (95% CI 30 – 37.6%)	Dog breed, age, sex, neutering status. Owner age, working status, lifestyle.

Author	Date of data collection	Country	Source of funding	Study design	Sampling method	Method of weight assessment	Who assessed weight	Total study population	Number (%) of overweight dogs	Management/risk factors measured
					National Veterinary School at Alfort				overweight (BCS 4) 5% (95% CI 3.2 – 6.8%) obese (BCS 5)	Type of house (apartment, house; garden or balcony) Feeding frequency, diet type. Treats/snacks or table scraps fed Owner opinion of dog's weight on a 5-point scale using verbal descriptors followed by images. Owner estimation of dog's bodyweight
Lund *et al.* (2006)	Jan 16th 1995 – Jan 13th 1996	USA	Hill's Pet Nutrition	XS	Practices recruited via PMS newsletter. Data collected on all dogs examined during specified data collection periods.	BCS (5-point scale)	VS	21,754 dogs	29.0% overweight, 5.1% obese	Dog breed, age, sex, neutering status. Any health problems. Geographic region of USA Diet type. Treats and table scraps.
Bland *et al.* (2009)	July – August 2007	Victoria, Australia	No funding declared	XS	Convenience sample of owners recruited via street handouts, veterinary practices, pet shops, dog day care and training centres etc	BCS (modified 5-point scale) Owner opinion of whether dog overweight or not	Owner	302 dogs 219 households	168 (76.7%) households had normal weight dogs 51 (23.3%) households had overweight dogs	Dog breed, age, sex, neutering status. Owner sex, age, number of people in household. Location (urban or rural) Feeding frequency, diet type, how amount to feed is decided. Treat frequency. Exercise frequency.

Author	Date of data collection	Country	Source of funding	Study design	Sampling method	Method of weight assessment	Who assessed weight	Total study population	Number (%) of overweight dogs	Management/risk factors measured
										Knowledge and monitoring of dogs' weight (kg). Owner opinion of whether dog is overweight. Awareness of health risks of being overweight. Attitudes to weight management
Nijland *et al.* (2009)	Not reported	The Netherla-nds	None	XS	Owners approached in waiting room of three different veterinary practices. Questionnaire completed by owner	Weight Estimated percentage overweight	VS	47 dogs	Not reported	Dog age, sex. How long dog BIOP. Owner sex, age, level of education. Owner physical activity levels. Owner weight change since dog acquired, current weight, height and BMI. Time spent dog walking per day
Courcier *et al.* (2010)	July 2007	Glasgow area, UK	PFMA Hill's Pet Nutrition Ltd	XS	Owners approached in waiting room of five different veterinary practices during normal consulting hours.	BCS (7-point scale)	VS or VSt	696 dogs	271 (38.9%) overweight, 142 (20.4%) obese	Dog breed, age, sex, neutering status. How long dog BIOP. Frequency of scavenging. Owner sex, age, income, opinion of their own weight status.

Author	Date of data collection	Country	Source of funding	Study design	Sampling method	Method of weight assessment	Who assessed weight	Total study population	Number (%) of overweight dogs	Management/risk factors measured
			BSAVA Petsavers		Questionnaire completed by VS or VSt.					Presence of other dogs in household. Feeding frequency, diet type, how current feeding routine/ amount to feed was established. Treat/snack frequency, table scrap frequency, supplements given. Exercise duration. Knowledge of dogs' weight. Owner opinion of dog's weight. Awareness of health risks of being overweight. Attitudes to weight management
Heuberger and Wakshlag (2010b)	Not reported	USA	Not reported	XS	Convenience sample recruited via word of mouth and advertisements	BCS (5-point scale)	Owner	61 dogs	13 (21.3%) overweight or obese	Dog age, sex, neutering status. Dog's weight (kg). Owner sex, age, race, BMI. Frequency and duration of exercise. Amount and type of food given, table food quantity and frequency, frequency of treats. Nutrient densities of table foods. General activity level, time spent outside.

Author	Date of data collection	Country	Source of funding	Study design	Sampling method	Method of weight assessment	Who assessed weight	Total study population	Number (%) of overweight dogs	Management/risk factors measured
										General health. Whether vet has ever told owner their dog is overweight.
Sallander *et al.* (2010a)	1999	Sweden	Foundation for Research (Agria Insurance Company)	XS	Random sample of dogs. Combined mail and telephone questionnaire mailed to owners who agreed to participate.	Weight BCS (5-point scale)	Owner	460 dogs	73 (15.9%) overweight or obese	Dog breed, age, sex, neutering status. Dog's appetite and weight (kg). Feeding patterns. Amount, type and frequency of commercial foods, table foods, homemade diets, supplements and treats. Energy density of foods, ME intake, energy density of food, proportion of energy from protein, fat and NFE. General activity level, play with other dogs. Exercise frequency, duration, type and daily/seasonal variations.
Warren *et al.* (2011)	Not reported	USA	Nestle Purina Pet Care Internal University	XS	Obesity clinic sample: Part of weight-loss protocol at Cornell University Companion Animal Hospital	Weight BCS (9-point scale)	Not clear	Obesity clinic sample: 38 dogs Community Sample: 39 dogs Total: 77 dogs	Obesity clinic sample: 38 (100%) obese (BCS 7 – 9) Community Sample: 16	Daily step count (walks and other physical activities)

Author	Date of data collection	Country	Source of funding	Study design	Sampling method	Method of weight assessment	Who assessed weight	Total study population	Number (%) of overweight dogs	Management/risk factors measured
			grant		Community Sample: local newspaper and flyer advertisements in similar area of Upstate New York				(41.0%) overweight (BCS 6) 9 (23.1%) obese (BCS 7-9)	

XS=Cross-sectional, SA=Small animal, RSPCA=Royal Society for the Prevention of Cruelty to Animals, VS=Veterinary Surgeon, BCS=Body Condition Score, PMS=Practice Management System, BIOP=Been In Owner's Possession, BMI=Body Mass Index, PFMA=Pet Food Manufacturers' Association, BSAVA=British Small Animal Veterinary Association, VSt=Veterinary Student, ME=Metabolisable Energy, NFE=Nitrogen Free Extract.

Table 2.3. Data extraction-Participant characteristics from ten publications on risk factors for being overweight or obese identified in a scoping review of overweight status and obesity in dogs carried out in April 2013

Study	Practice/ geographical information	Reported response rates	Dog Age (years)	Dog Breed	Dog sex/neutering status	Specific demographic information and exclusions
Robertson (2003)	Metropolitan Perth, Australia	2326 households contacted 131 (5.6%) declined to take part 2195 households (94.4%) interviewed. Of these, 657 households (30%) owned one or more dogs	Not reported	Pure breed dogs: 458 (54.4%) Cross breeds: 384 (45.6%)	Males: 416 (49.4%) Females: 426 (50.6%) Entire: 297 (35.3%) Neutered: 545 (64.7%)	None reported
McGreevy *et al.* (2005)	209 (estimated 11.6%) SA Veterinary Practices in Australia	1700 practices approached, 178 (10.5%) agreed to help. A further 31 practices suggested by local RSPCA. 52 (24.9%) of the 209 practices responded, data from 48 practices used in analysis	Dogs ≥ 1 year old	Australian working Dog: 375 (14·7%) Gundog: 324 (12·7%) Hound: 127 (5·0%) Non-sporting: 236 (9·3%) Terrier: 436 (17·1%) Toy: 423 (16·6%) Unspecified: 148 (5·8%) Utility 238 (9·3%) Working dog (other): 242 (9·5%)	ME: 407 (15.8%) FE: 190 (7.5%) MN: 749 (29.4%) FN: 1120 (43.9%) Male, NR: 16 (0.6%) F, NR: 14 (0.5%) Sex NR: 53 (2.1%)	Dogs ≥ 1 year old Excluded if pregnant, seriously ill, had a health condition likely to affect their weight, already on a weight-loss program, euthanasia cases. Underweight dogs (BCS 1 or 2) excluded from analysis
Colliard *et al.* (2006)	Vaccination department at the National Veterinary School, Alfort	681 potential respondents, 616 completed questionnaires (response rate 90.5%)	<1year: 16.6% 1 – 2 years: 6.5% 10 years: 5.3% >10 years:17.5%	Pure breed dogs: 67% Most common: Yorkshire Terrier 14% Poodle 12% Retriever 9% Bichon 8%	ME: 45.5% FE: 31.5% MN: 7.1% FN: 15.7%	Excluded if respondent: Not dog's owner On second visit during survey period Deaf

Study	Practice/ geographical information	Reported response rates	Dog Age (years)	Dog Breed	Dog sex/neutering status	Specific demographic information and exclusions
				Rottweiler 6% German Shepherd 4%		
Lund *et al.* (2006)	Exclusively SA private first opinion veterinary practices using a specific PMS	63 practices approached, 52 completed all four data collection periods.	Not reported	Mixed breed dogs: 5719 (46.0%) Most common pure breed dogs: Labrador Retriever: 1738 (14.0%) Cocker Spaniel: 1123 (9.0%) Golden Retriever: 1075 (8.6%) German Shepherd: 651 (5.2%) Shih Tzu: 527 (4.2%) Poodle: 497 (4.0%)	ME: 3806 (17.5%) FE: 2838 (13.1%) MN: 5954 (27.4%) FN: 9115 (42.0%)	Dogs >1 year of age
Bland *et al.* (2009)	Convenience sample of owners recruited from veterinary practices, pet shops, dog day care and training centres etc	550 questionnaires distributed, 219 returned (response rate 39.8%)	Not reported	Normal weight dogs: 71.6% pedigrees Overweight dogs: 74.5% pedigrees	ME: 34 (11.3%) FE: 20 (6.6%) MN: 125 (41.4%) FN: 123(40.7%)	None reported

Study	Practice/ geographical information	Reported response rates	Dog Age (years)	Dog Breed	Dog sex/neutering status	Specific demographic information and exclusions
Nijland *et al.* (2009)	Three veterinary practices in different areas of Amsterdam	135 owners approached, 14 declined, 38 excluded. 83 responses (RR 61.5%): 47 dog owners and 36 cat owners	Mean 6.9, SD 3.9 years	Not reported	Male: 20 (42.6%) Female: 27 (57.4%)	Dogs >1year old and BIOP > 1 year. Not suffering from any health condition likely to affect their weight. Excluded if respondent: Not dog's owner Under 21 years of age Suffering from health condition likely to affect their weight.
Courcier *et al.* (2010)	Glasgow area. One charitable first opinion practice, four private first opinion practices	Number of owners approached not reported. 829 questionnaires completed, data from 696 dogs (84.0%) used in analysis	1-2 years: 149 (21.4%) 3-8years: 278 (39.9%) ≥9 years: 269 (38.6%)	Pure breed dogs: 63% Most common: Yorkshire Terrier 11% Labrador Retriever 8.4% German Shepherd 8.1%	ME:251 (36%) FE: 144 (21%) MN: 119 (17%) FN: 178 (26%) NR: 4 (0.6%)	Dogs ≥ 1 year old Each dog included only once Only one dog per household included
Heuberger and Wakshlag (2010b)	Continental USA	Not reported	Mean 5.7 +/- 4.2 years, range <1 – 16years	Not reported	Males: 31 (50.8%) Females: 30 (49.2%) Entire: 9 (14.8%) Neutered: 52 (85.2%)	Excluded if respondent: Not dog's owner Under 18 years of age Fed multiple pets simultaneously.
Sallander *et al.* (2010a)	Dogs registered with the largest animal insurance company in Sweden	680 dogs randomly selected	1-3 years old	124 different breeds. Four most common: Dachshund	Male: 248 (54%) Female: 212 (46%)	Pure bred dogs, 1-3 years old. One dog excluded from analysis for unrealistic responses.

Study	Practice/ geographical information	Reported response rates	Dog Age (years)	Dog Breed	Dog sex/neutering status	Specific demographic information and exclusions
	(Agria Insurance Company)	608 owners (89.4%) agreed to take part 461 owners (67.8%) completed questionnaires		German Shepherd Golden Retriever Labrador Retriever	99% of dogs entire	
Warren *et al.* (2011)	Obesity clinic sample: Obesity clinic at Cornell University Companion Animal Hospital, New York. Community sample: Similar community in upstate New York	Not reported	Obesity clinic sample: Mean 6.1 years, SEM 0.7 Community group: Mean 5.3 years, SEM 0.4	Not reported	ME: 2 (4·3%) FE: 0 (0%) MN: 31 (45·2%) FN: 44 (49·5%)	Medium to large dogs (> 35cm shoulder height and >10kg) Obesity clinic sample: BCS 7-9

SA=Small Animal, RSPCA=Royal Society for the Prevention of Cruelty to Animals, ME=Male Entire, FE=Female Entire, MN=Male Neutered, FN=Female Neutered, NR=Not Reported, BCS=Body Condition Score, PMS=Practice Management System, RR=Response Rate, BIOP=Been In Owner's Possession, SD=Standard Deviation, SEM=Standard Error of the Mean.

2.3.2 Synthesis of results

Table 2.4: Statistically significant results from ten publications on risk factors for being overweight or obese in dogs identified in a scoping review of overweight status and obesity in dogs carried out in April 2013

Variable	Author	Study design	Risk factor identified (multivariable analysis) and measures of association
Dog Breed	McGreevy *et al.* (2005)	Cross-sectional	Compared to the Australian working dog, other breeds are *less* likely to be overweight: Gundog: OR=5·60* Hound: OR=5·54* Non-sporting: OR=4·54* Terrier: OR=2·34* Toy: OR=5·39* Unspecified: OR=2·69* Utility: OR=1·52* Working dog (other): OR=7·58*
	Colliard *et al.* (2006)	Cross-sectional	Retrievers more likely to be overweight than other breeds of dog when stratified for dog's age (OR=2.47, 95% CI 1.30 – 4.71)
	Lund *et al.* (2006)	Cross-sectional	Breeds more likely to be overweight: Cocker Spaniel (OR=1.9), Dachshund (OR=1.6), Dalmatian (OR=1.6), **Labrador Retriever (OR=1.6)**, Rottweiler (OR=1.6), **Golden Retriever (OR=1.5)**, Shetland Sheepdog (OR=1.4), and Mixed-breed dogs (OR=1.1). Breeds more likely to be obese: (Shetland Sheepdog (OR=1.9), Dachshund (OR=1.7), **Golden Retriever (OR=1.6)**
Dog Sex	McGreevy *et al.* (2005)	Cross-sectional	Females more likely to be overweight than males (OR=1.23, p=0.010), although there was a significant interaction with breed (p= 0.007)
	Colliard *et al.* (2006)	Cross-sectional	Females more likely to be overweight than males (OR=1.54, 95% CI 1.11 – 2.14)
	Sallander *et al.* (2010a)	Cross-sectional	Females more likely to be overweight than males (OR=2.17, 95% CI 1.30 – 3.70, p=0.003)
Dog neutering status	McGreevy *et al.* (2005)	Cross-sectional	Neutered dogs more likely to be overweight or obese, but significant interaction with breed (p=0.011).

Variable	Author	Study design	Risk factor identified (multivariable analysis) and measures of association
			Australian working dogs more likely to be overweight after neutering, but the converse was true for other working dogs.
	Robertson (2003)	Cross-sectional	Neutered dogs more likely to be overweight (OR=2.8, 95% CI 1.9 – 4.0, p<0.001)
	Colliard *et al.* (2006)	Cross-sectional	Neutered dogs more likely to be overweight (OR=2.23, 95% CI 1.52 – 3.30)
	Lund *et al.* (2006)	Cross-sectional	Neutered dogs more likely to be overweight (OR=1.5) or obese (OR=1.3)
Sex and neutering status	Courcier *et al.* (2010)	Cross-sectional	Female neutered dogs more likely to be obese (RRR 2.14, 95% CI 1.25 – 3.67, p= 0.006) or overweight (RRR 1.63, 95% CI 1.04 – 2.57, p= 0.035) than male entire dogs
Age of dog	Robertson (2003)	Cross-sectional	Increased risk of being overweight for each year of a dog's life (OR=1.1, 95% CI 1.0 – 1.1, p<0.001)
	McGreevy *et al.* (2005)	Cross-sectional	Increasing risk of being overweight with increasing age until about 10 years of age (OR 0.64*), then risk decreases (OR 1.02*)
	Colliard *et al.* (2006)	Cross-sectional	Increased risk of being overweight with increasing age. Compared to dogs <1 year old: Dogs 2-3 years: OR=2.81, 95% CI 1.34 – 5.88 Dogs 4-7 years: OR=6.47, 95% CI 3.16 – 13.67 Dogs 8-12 years: OR=7.58, 95% CI 3.63 – 15.83 Dogs >12 years: OR=11.75, 95% CI 4.48 – 30.83
	Lund *et al.* (2006)	Cross-sectional	Increased risk of overweight status (OR=1.1) and obesity (OR=1.1) with increasing age. Prevalence of overweight status or obesity highest (>40%) in dogs between 6–10 years old.
	Courcier *et al.* (2010)	Cross-sectional	Increased risk of being overweight for each year of a dog's life (RRR 1.09, 95% CI 1.04 – 1.14, p=0.001.
Length of time dog been in owner's possession.	Nijland *et al.* (2009)	Cross-sectional	Positive correlation between the percentage a dog is overweight and the length of time dog been in owner's possession.

Variable	Author	Study design	Risk factor identified (multivariable analysis) and measures of association
Other dogs in household	Robertson (2003)	Cross-sectional	Dogs from a single-dog household more likely to be overweight (OR=1.6, 95% CI 1.1-2.2, p<0.01)
Number of people in household	Bland *et al.* (2009)	Cross-sectional	Greater number of people in households where dog(s) considered overweight compared to households where dog(s) thought to be normal weight (KW, Chi; χ^2=6.28; 2.2 (s=0.79) v 2.5 (s=1.66); d.f.=2, p <0.05).
Geographical area	McGreevy *et al.* (2005)	Cross-sectional	Dogs more likely to be overweight if they live in a rural (OR=0.83*) or semi-rural (OR=0.91*) area compared to an urban area. Significant interaction between breed and geographical area (p=0.016)
	Lund *et al.* (2006)	Cross-sectional	Overweight dogs more likely to live in the Pacific (OR=1.4), South Central (OR=1.3), East North Central (OR=1.2) or Northeast (OR=1.2) regions of the United States Obese dogs more likely to live in the Pacific (OR=1.7) or Northeast (OR=1.3) regions of the United States
Age of owner	Colliard *et al.* (2006)	Cross-sectional	Retired owners more likely to own an overweight dog than owners of working age (OR=2.98, 95% CI 1.24 – 7.18)
	Courcier *et al.* (2010)	Cross-sectional	Increasing age of owner associated with excessive weight gain in dogs. Compared to owners 18 – 35 years of age: Age 36 – 50 years: RRR 1.16, 95% CI 0.63 – 2.14, p= 0.625 Age 51 – 65 years: RRR 3.18, 95% CI 1.68 – 6, p<0.001 Age >65years: RRR 3.96, 95% CI 1.85 – 8.5, p<0.001.
Owner Income	Courcier *et al.* (2010)	Cross-sectional	Higher income owners less likely to have overweight or obese dogs. Compared to owners with an income of <£10,000: Owners with an income of £10,000-£20,000: RRR 1.29, 95% CI 0.69 – 2.39, p= 0.423 for obesity, RRR 2.14, 95% CI 1.26 – 3.64, p= 0.005 for overweight status. Owners with an income of £20,000-£40,000: RRR 0.41, 95% CI 0.22 – 0.76, p= 0.005 for obesity, RRR 0.87, 95% CI 0.54 – 1.4, p= 0.559 for overweight status. Owners with an income of >£40,000: RRR 0.35, 95% CI 0.14 – 0.84, p= 0.019 for obesity, RRR 1.49, 95% CI 0.86 – 2.58, p= 0.158 for overweight status.

Variable	Author	Study design	Risk factor identified (multivariable analysis) and measures of association
Owner BMI	Nijland *et al.* (2009)	Cross-sectional	Overweight dogs more likely to have overweight owners (r=0.31, p=0.03)
Owner diet	Heuberger and Wakshlag (2010b)	Cross-sectional	Owners who ate lower calorie, nutrient dense diets had normal-weight dogs (P<0.05)
Frequency of feeding	Robertson (2003)	Cross-sectional	Dogs considered overweight more likely to be fed once daily (OR=1.4, 95% CI 1.0 – 1.9, p<0.05)
	Bland *et al.* (2009)	Cross-sectional	Dogs considered normal weight fed twice daily, dogs considered overweight were fed once or more than three times a day (Chi; χ^2=6.30; d.f.=1; P < 0.05)
Frequency of feeding snacks/treats	Robertson (2003)	Cross-sectional	Dogs fed snacks more likely to be overweight than dogs not fed snacks (OR=1.5, 95% CI 1.0 – 2.0, p<0.05)
	Bland *et al.* (2009)	Cross-sectional	Dogs considered normal weight given treats less frequently than dogs considered overweight (Chi; χ^2=31.81; d.f.=6; P < 0.001)
	Courcier *et al.* (2010)	Cross-sectional	Dogs fed snacks/treats more likely to be overweight than dogs never fed snacks/treats: Monthly: RRR 3.38, 95% CI 1.64 – 6.97, p= 0.001 Weekly: RRR 2.16, 95% CI 1.03 – 4.51, p= 0.041 Daily: RRR 2.57, 95% CI 1.11 – 5.98, p= 0.028
Feeding of table scraps	Courcier *et al.* (2010)	Cross-sectional	Dogs fed table scraps every month more likely to be overweight than dogs never fed table scraps (RRR 2.43, 95% CI 1.26 – 4.66, p= 0.008)
	Heuberger and Wakshlag (2010b)	Cross-sectional	Dogs fed table foods on a regular basis more likely to be overweight than dogs not fed table foods (p< 0.02)
	Sallander *et al.* (2010a)	Cross-sectional	Dogs fed table scraps or home-made diets more likely to be overweight than dogs not fed these foods (OR 2.06, 95% CI 0.97 – 4.35, p=0.050)

Variable	Author	Study design	Risk factor identified (multivariable analysis) and measures of association
Diet type	Lund *et al.* (2006)	Cross-sectional	Dogs fed mainly semi-moist foods more likely to be overweight (OR=1.5) Dogs fed mainly 'other' types of food (meat or other food products, commercial treats, table scraps) (OR=2.3), homemade diets (OR=1.9) or canned food (OR=1.4) more likely to be obese.
Calorie intake	Heuberger and Wakshlag (2010b)	Cross-sectional	Normal-weight dogs have a higher calorie intake (102kCals per metabolic bodyweight (range: 43–172, SD=37)) than overweight dogs (81kCals per metabolic bodyweight (range: 45–120, SD= 26)) (P<0.04)
Composition of diet	Heuberger and Wakshlag (2010b)	Cross-sectional	Normal-weight dogs receive significantly more crude fibre from their dog food compared to overweight dogs, regardless of the number of treats given (p<0.001). Normal-weight dogs have diets with greater micronutrient densities than overweight dogs (p <0.03)
Dog's appetite	Sallander *et al.* (2010a)	Cross-sectional	Dogs with a good/very good appetite more likely to be overweight than dogs with a bad/very bad appetite (OR 3.42, 95% CI 1.19 – 9.80, p=0.022)
Duration of exercise	Robertson (2003)	Cross-sectional	Risk of excessive weight gain reduced with each hour of weekly exercise (OR=0.9, 95% CI 0.8–0.9, p<0.001)
	Warren *et al.* (2011)	Cross-sectional	Dogs with a lower BCS had a higher average daily step count (Spearman's Rho=-0.52, p<0.0001)
Frequency/type of exercise	Bland *et al.* (2009)	Cross-sectional	Dogs considered normal weight more likely to be exercised at least 3 times per week compared to once a week for dogs considered overweight (Chi; χ^2=9.9; d.f.=1; P < 0.01). Dog(s) considered normal weight more likely to be walked and dogs considered overweight more likely to be confined to a yard for exercise rather than walked (Chi; χ^2=18.4; d.f.=1; P < 0.001).
Concurrent disease	Lund *et al.* (2006)	Cross-sectional	Overweight dogs more likely to be diagnosed with hyperadrenocorticism (OR=2.4), ruptured cruciate ligament (OR=1.7), hypothyroidism (OR=1.4), lower urinary tract disease (OR=1.3), or oral disease (OR=1.1).

Variable	Author	Study design	Risk factor identified (multivariable analysis) and measures of association
			Obese dogs more likely to be diagnosed with hypothyroidism (OR=2.8), diabetes mellitus (OR=2.6), pancreatitis (OR=2.2), ruptured cruciate ligament (OR=2.1), or neoplasia (OR=1.4).

BMI=Body Mass Index, OR=Odds Ratio, CI=Confidence Interval, RRR=Relative Risk Ratio, KW=Kruskal-Wallis, d.f.=degrees of freedom, r=Pearson correlation coefficient

*A negative regression coefficient (0<OR<1) means that the variable is associated with an increased prevalence of overweight status. A positive regression coefficient (OR>1) shows that the variable is associated with a reduced risk of excess weight.

2.4 Discussion

The three online databases (CAB Abstracts (1910 – 2013), Medline (In-Process & Non-Indexed Citations 1948 to present) and ISI Web of Science (v5.11)) were selected to search as they provide good coverage of veterinary journals (Grindlay *et al.*, 2012).

The number of eligible studies investigating risk factors for overweight status and obesity was small considering its high prevalence in dogs and its negative effects on dog welfare and quality of life (German *et al.*, 2012b; Yeates, 2012). Clarification of risk factors for overweight status is important so that dog owners can be given evidence-based advice on modifying these risk factors where possible to prevent or treat excessive weight gain in their dog. This area was therefore investigated in more detail (Tables 2.2, 2.3 and 2.4).

2.4.1 Study characteristics

All of the studies identified in the scoping review were cross sectional studies, which limits their ability to determine causality (Kleinbaum *et al.*, 1982). Cross sectional studies are relatively poor-quality studies in the hierarchy of evidence, with a high risk of bias (Kleinbaum *et al.*, 1982; Burns *et al.*, 2011).

A number of studies were convenience samples of dog owners (Colliard *et al.*, 2006; Nijland *et al.*, 2009; Heuberger and Wakshlag, 2010b; Warren *et al.*, 2011), which may have biased the samples towards owners with a particular interest in dog health. McGreevy *et al.* (2005) and Lund *et al.* (2006) used a convenience sample of veterinary practices, where the veterinary surgeons were required to complete questionnaires (McGreevy *et al.*, 2005) or assign diagnostic codes (Lund *et al.*, 2006) during consultations. The time required for this may have deterred some veterinary practices and/or veterinary surgeons from participating and therefore the data collected may have been from veterinary practices and/or veterinary surgeons who were already proactive in addressing the issue of overweight dogs. Collection of data from veterinary practice records would also have limited the participants to the 82– 90% of dog owners who are registered with a veterinary practice, who tend to be employed and on a higher income (Animal Medicines Australia, 2019; PDSA, 2019; Bir *et al.*, 2020).

A five-point BCS was commonly used as a method of weight assessment (McGreevy *et al.*, 2005; Colliard *et al.*, 2006; Lund *et al.*, 2006; Bland *et al.*, 2009; Heuberger and Wakshlag, 2010b; Sallander *et al.*, 2010a) but the details of the scales differed between studies. Heuberger and Wakshlag (2010b) used written descriptors, McGreevy *et al.* (2005) used images, while Bland *et al.* (2009) used photographs but omitted BCS1. Colliard *et al.* (2006) and Sallander *et al.* (2010a) used a combination of written descriptors and images, while Lund *et al.* (2006) provided a training video to participating practices but no details of the criteria for each BCS were provided. Other studies used a seven-point (Courcier *et al.*, 2010) or nine-point (Warren *et al.*, 2011) BCS scale or an estimation of the percentage the dog was overweight (Nijland *et al.*, 2009). This

lack of consistency in assessing the weight status of the dogs could make meta-analysis difficult.

In addition, four of the studies (Robertson, 2003; Bland *et al.*, 2009; Heuberger and Wakshlag, 2010b; Sallander *et al.*, 2010a) used owner assessment of their dog's weight status and/or owner-reported weights as the outcome variable. These are subject to bias as owners tend to underestimate their dog's BCS, even with the use of a BCS chart (German *et al.*, 2006; Eastland-Jones *et al.*, 2014; Kobayashi *et al.*, 2014). The studies by McGreevy *et al.* (2005), Colliard *et al.* (2006), Lund *et al.* (2006) and Courcier *et al.* (2010) used veterinary professionals or trained veterinary students to assess BCS, so the BCS assigned should be more reliable (Laflamme, 1997; Mawby *et al.*, 2004). Warren *et al.* (2011) stated that BCS were assessed by a single investigator but do not give any details about the training or experience of this assessor (Kobayashi *et al.*, 2014).

Some studies (Lund *et al.*, 2006; Courcier *et al.*, 2010) differentiated between overweight and obese dogs, while other studies simply classified dogs as overweight or normal weight (Robertson, 2003; Colliard *et al.*, 2006; Bland *et al.*, 2009; Heuberger and Wakshlag, 2010b; Sallander *et al.*, 2010a). This lack of consistency makes comparisons between studies difficult as risk factors associated with obesity sometimes differ from those associated with being overweight (Lund *et al.*, 2006; Courcier *et al.*, 2010).

2.4.2 Summary of evidence

The existing literature shows that there are many factors which can impact on the weight of a dog. These can be considered within three broad categories: genetic predisposition, reproductive status (which are both dog-related) and diet and exercise, which are largely determined by the dog owner/carer (Bland *et al.*, 2009).

Dog-related factors

a. Dog characteristics

Studies by McGreevy *et al.* (2005), Colliard *et al.* (2006) and Lund *et al.* (2006) all show breed variations in the prevalence of overweight status and obesity. Retrievers were shown to be at particular risk in the studies by Colliard *et al.* (2006) and Lund *et al.* (2006), whereas gundogs (including retrievers) were less likely to be overweight than Australian working dogs in the study by McGreevy *et al.* (2005). This may be because Colliard *et al.* (2006) and Lund *et al.* (2006) analysed the predisposition of individual breeds to being overweight, whereas McGreevy *et al.* (2005) used Australian Kennel Club breed groups. It is also possible that differences in lifestyle and dog breeds between Australia, France and the USA may contribute to this discrepancy (Ghirlanda *et al.*, 2013; Pedersen *et al.*, 2013; Parker *et al.*, 2017).

All of the studies that investigated the effect of sex and reproductive status on the weight of a dog (Robertson, 2003; McGreevy *et al.*, 2005; Colliard *et al.*,

2006; Lund *et al.*, 2006; Courcier *et al.*, 2010; Sallander *et al.*, 2010a) found that female dogs and/or neutered dogs were at increased risk of being overweight. Similarly, Robertson (2003), McGreevy *et al.* (2005), Colliard *et al.* (2006), Lund *et al.* (2006) and Courcier *et al.* (2010) all found that the risk of being overweight increased with age, although McGreevy *et al.* (2005) and Lund *et al.* (2006) noted that the risk of being overweight reduced once a dog reached 10 years old. This may be because dogs lose weight after this age due to degenerative processes associated with old age such as renal failure (Nijland *et al.*, 2009) or because leaner dogs tend to live longer (Lawler *et al.* 2005; McGreevy *et al.*, 2005).

b. Dog Behaviour

Dogs with a good appetite were more likely to be overweight than dogs with a poor appetite (Sallander *et al.*, 2010a). This is likely due to a higher calorie (energy) intake compared to energy expenditure in these dogs (Degeling *et al.*, 2012).

Owner related factors

a. Owner Characteristics

Colliard *et al.* (2006) and Courcier *et al.* (2010) found that the prevalence of overweight dogs increased with increasing owner age. Both these studies were carried out in a limited geographical area (the National Veterinary School at Alfort and the Glasgow area, respectively) so the findings may be biased by the demographics of owners in that area (Colliard *et al.*, 2006). In contrast, Bland *et al.* (2009) and Nijland *et al.* (2009) found that owner age did not affect the weight status of a dog. The participants in the study by Nijland *et al.* (2009) were from areas of different socioeconomic status in Amsterdam while those of Bland *et al.* (2009) were from a wider geographical area (Victoria, Australia). Both McGreevy *et al.* (2005) and Lund *et al.* (2006) found that the geographical area and type of environment (urban or rural) where a dog resides affects its weight status, therefore the results of the study by Bland *et al.* (2009) are more likely to be generalisable. However further work is needed to clarify this.

b. Owner behaviour

Robertson (2003) and Bland *et al.* (2009) agree that dogs fed once daily were more likely to be overweight. However, Bland *et al.* (2009) also found that dogs fed more than three times a day were more likely to be overweight. Similarly, dogs fed treats more frequently were more likely to be overweight (Bland *et al.*, 2009). This is probably due to calorie (energy) intake being greater than energy expenditure in these dogs (Degeling *et al.*, 2012).

Regardless of frequency, the feeding of treat/snacks *per se* is associated with dogs being overweight (Robertson, 2003; Courcier *et al.*, 2010). The feeding of table foods and scraps is also associated with dogs being overweight (Courcier *et al.*, 2010; Heuberger and Wakshlag, 2010b; Sallander *et al.*, 2010a). Table foods generally have a higher fat content than commercial foods, making them more energy-dense (Lund *et al.*, 2006; Sallander *et al.*, 2010a, b). Unless owners

are aware of this and either use less energy-dense table foods or reduce the dog's calorie intake from the other components of its diet, energy intake is likely to exceed energy expenditure, resulting in weight gain (Sallander *et al.*, 2010a).

Robertson (2003), Bland *et al.* (2009) and Warren *et al.* (2011) all found an association between exercise and overweight status, with increasing duration, intensity and frequency of exercise associated with a reduced risk of excessive weight gain. Dogs left to self-exercise in a yard or garden were more likely to be overweight (Bland *et al.*, 2009), highlighting the importance of owners taking their dogs out for walks or other forms of exercise such as running or swimming (Sallander *et al.*, 2010a).

2.4.3 Limitations

The database search was conducted in April 2013; more studies fitting the inclusion and exclusion criteria are likely to have been published since then. The identification of publications for inclusion was carried out by the author alone, leading to potential bias in study selection. The database search should be rerun to include more recent publications and study selection carried out by two independent researchers.

2.4.4 Conclusions

For future studies, bias could be reduced by recruiting larger numbers of dog owners who are representative of the dog-owning population over a large geographical area, including rural, suburban and urban environments. Ideally, the study design would provide a higher quality of evidence, such as Randomised Controlled Trials (RCTs), cohort studies or even case control studies. A consistent method should be used to assess the weight status of a dog, such as a standardised 9-point BCS system, and for each study, the BCS should be assigned by a small number of trained veterinary professionals to eliminate inter-rater differences (Laflamme, 1997; Mawby *et al*., 2004; Elliott, 2006). Statistical analysis based on the raw BCS, rather than composite measures, would allow direct comparison between studies.

Most of the papers identified in this scoping review evaluated risk factors for dogs being overweight relating to the dog, owner characteristics and behaviour and the environment in which the dog and owner lived. This suggests that at the time the systematic review was conducted, these demographic, environmental and behavioural factors were believed to be the main influences on the weight of a dog. Although the studies that fell into the weight management category were not appraised in detail, the majority investigated diet composition and feeding practices (Yamka *et al.*, 2007; Fritsch *et al.*, 2010; German *et al.*, 2010a; German *et al.*, 2011a; Murphy *et al.*, 2012), exercise (Chauvet *et al.*, 2011; Rohrer *et al.*, 2011) or the use of BCS (Dorsten and Cooper, 2004; German and Morgan, 2008). This supports the assertions of Brickman *et al.* (1982) and Dilts (1990) that what individuals or organisations believe is the cause of a problem determines where they will look for a solution. This will be discussed further in Section 8.4.

The following chapters of this thesis investigated risk factors for overweight status in two sub-populations of dogs belonging to GD and a convenience sample of pet dogs. The common risk factors were then used as the basis for an intervention designed to assist with weight management in WGD.

Introduction to Chapters 3, 4 and 5: Guide Dog Owners, Brood Stock Holders and Pet Dog Owners Surveys

The scoping review described in Chapter 2 identified risk factors for dogs being overweight, including aspects relating to both the dog, the owner and the owner's management of the dog. There are a number of confounding factors and limitations in the studies identified in the scoping review, including dog age, neutering status and owner age (Colliard *et al.*, 2006), breed (Sallander *et al.*, 2010a) and size of dog (Warren *et al.*, 2011) and data collection from a limited geographical area (Nijland *et al.*, 2009; Courcier *et al.*, 2010). In addition, several of the studies relied on owners' evaluation of their dog's BCS (Bland *et al.*, 2009; Heuberger and Wakshlag, 2010b; Sallander *et al.*, 2010a) or assessment of their dog's weight (Robertson, 2003; Bland *et al.*, 2009). Studies have shown that owners tend to underestimate the BCS of their dogs (Singh *et al.*, 2002; Colliard *et al.*, 2006; Courcier *et al.*, 2011), even with the use of a BCS chart (Eastland-Jones *et al.*, 2014), so these outcome measures may not be reliable.

The studies conducted for this thesis mainly used dogs belonging to GD as this helped to address a number of these limitations. All dogs belonging to GD have their weights and BCS regularly assessed and recorded by a veterinary surgeon or member of GD dog care staff. GD use a limited number of medium-sized breeds (Labradors, Golden Retrievers, Flat Coat Retrievers, German Shepherds, Standard Poodles) and crosses of these breeds, reducing the variation in the weight of the dogs in the study population. Within breeds, the size of a dog can vary considerably (Salt *et al.*, 2017), but GD breed the majority of their own dogs (Cole *et al*., 2004) so most of the dogs come from a small gene pool. This means that variations in size and weight between dogs of the same breed are likely to be smaller (Salt *et al.*, 2017).

Guide Dogs have a standard management system for their dogs, with all puppies bred by GD initially managed in a similar way. They are cared for by PW from 7-8 weeks old until they are selected for training as working dogs or Potential Breeding Stock (PBS) at around 12-14 months of age. During this time the dog's weight is monitored and their food adjusted to maintain the dog at a healthy weight. Puppies that are overweight at 7 months old are likely to become overweight adults (Leclerc *et al.*, 2017) so ensuring that growing GD puppies are kept at a healthy weight minimises the effects of weight gain early in life on adult weight and BCS.

WGD and GD breeding stock are two distinct populations of dogs. WGD are all neutered and are located throughout the UK. GD breeding stock are all entire and live within an hour's drive of the GD National Breeding Centre (NBC) near Leamington Spa.

GD educate all GDO and Brood Stock Holders (BSH) on feeding their dogs, instructing each owner/carer about the amount that their dog is to be fed. GD also recommend that any treats given should be taken from the dog's daily ration. This contrasts with the variable sources of information used by UK dog

owners, with only 37% of dog owners asking their veterinary surgeon for nutritional advice (Kuhl, 2015).

GDO and BSH are advised by GD on levels of exercise for their dogs and the importance of keeping their dog at a healthy weight. Information sources for pet dog owners on their dog's exercise requirements are variable, with only 26% of dog owners discussing this with their veterinary surgeon (Kuhl, 2015). Similar numbers of dog owners reported that they did not seek information on exercising their dog (20%), or asked friends, family and colleagues (20%) (Kuhl, 2015).

All WGD are owned by their visually impaired owners (GDO) whereas GD breeding stock remain the property of GD, although they live as pets in the BSH home. The difference between ownership (GDO) and fostering of the dog (BSH), along with the different reasons for GDO and BSH acquiring their dogs, may result in differences in the relationship between the two different groups of owners/carers and their dogs. However, to the author's knowledge, there is no published literature investigating the relationship between dogs and people who foster them.

A number of studies compare the relationship of a GDO and a PDO with their dogs (Lane *et al.*, 1998; Whitmarsh, 2005; Kwong and Bartholomew, 2011; Mariti *et al.*, 2013; Glenk *et al.*, 2019). These show many similarities between the two groups of owners: pet dogs and WGD provide their owners with companionship, social and emotional support and are often regarded as members of the family. Both are a source of non-judgemental affection and comfort and can improve the owner's quality of life (Lane *et al.*, 1998; Whitmarsh, 2005; Mariti *et al.*, 2013; Glenk *et al.*, 2019). However, the assistance role of the WGD necessitates a bond of mutual trust between the dog and the GDO (Mariti *et al.*, 2013), which may lead to a stronger bond between the GDO and their dog compared to a pet dog and its owner (Whitmarsh, 2005; Kwong and Bartholomew, 2011).

There are a limited number of studies investigating the effects of the human animal bond on the weight status of the dog (Kienzle *et al.*, 1998; McCune *et al.*, 2014; German, 2015). A recent study by Webb *et al.* (2020) found no association between the strength of the dog-owner bond and the dog's weight status, probably because a strong human-animal bond may promote behaviours which could assist (*e.g.* walking the dog) or hinder (*e.g.* giving the dog treats) successful weight management.

All of the studies identified in the scoping review (Chapter 2) used pet dogs as their study population, so it was important to compare risk factors for overweight status and obesity in pet dogs to those of WGD and GD breeding stock to investigate whether risk factors identified in previously published literature were relevant to these populations of dogs. To reduce any potential confounding effects of breed and size of dog, the PDO survey was limited to owners of pet dogs of GD-type breeds and their crosses.

The main aim of the Chapters 3-5 of this thesis was to investigate the risk factors for dogs being overweight in populations of working WGD (Chapter 3), GD Breeding Stock (Chapter 4) and pet dogs of GD-type breeds and their crosses (Chapter 5). This would enable comparison of risk factors for overweight status in dogs across three different types of dog-owner relationship. Risk factors that were common to all groups of dog owners/carers could then be used as a basis for designing a weight management intervention which would be evaluated in Chapter 7.

Chapter 3: Investigation of Risk Factors for Overweight status in Working Guide Dogs

WGD are owned by their visually impaired owners, for whom their dog is a mobility aid, giving them greater independence and increasing their social contact (Lane *et al.*, 1998; Moxon *et al.*, 2016; Glenk *et al.*, 2019). Many GDO also consider their WGD as a valued member of the family (Lane *et al.*, 1998; Glenk *et al.*, 2019) and more of a friend or companion than a working dog (Lane *et al.*, 1998; Audrestch *et al.*, 2015). The close emotional bond that GDO have with their dog means that caring for their dog's health and welfare is more than just a desire to keep the dog fit for work (Lane *et al.*, 1998). The reciprocal reliance of the GDO and the WGD on each other (Mariti *et al.*, 2013) may lead to a stronger bond between the GDO and their dog than that of a pet dog owner and their dog (Whitmarsh, 2005; Kwong and Bartholomew, 2011).

Investigating GDO self-reported behaviour around feeding and exercising their dogs should give valuable insights into the approach to weight management taken by dog owners who have a strong bond with their dog, are aware of the importance of keeping their dog at a healthy weight and have been given strategies to achieve this. In addition, there are specific features of WGD as a study population which help to address some of the limitations and confounding factors seen in other studies (Chapter 2):

- All WGD are neutered.

- WGD are usually matched with a visually impaired person at around 2 years old, when they should be fully grown (Helmink *et al.*, 2000; Salt *et al.*, 2017). They are retired at around 10 years old or sooner if their health starts to decline (Caron-Lormier *et al.*, 2016), so any changes in the dogs' weight status during their working life should be attributable to changes in body fat rather than aging or disease (McGreevy *et al.*, 2005).

- All Guide Dogs' working stock have an optimum weight set by the regional Dog Care and Welfare Advisor (DCWA) just before they qualify as WGD. The dogs are around 18 months to 2 years of age at qualification and therefore fully grown (Helmink *et al.*, 2000; German *et al.*, 2017a,b; Salt *et al.*, 2017). Optimum weights are based on the weight of the dog when its BCS is 5; if a dog was above or below BCS 5 at the time of qualification, then its daily ration would be adjusted accordingly and the dog's weight and BCS monitored until it reached BCS 5. The dog's weight at that point would be recorded as its optimum weight. Bodyweight is a more sensitive measure of weight change than BCS (Dorsten and Cooper, 2004), enabling any deviations from optimum to be detected and addressed early. Bodyweight should be used in conjunction with BCS to assess the weight status of a dog (Burkholder, 2000) as BCS allows variability in the conformation of the dog to be accounted for (Courcier *et al*., 2010; Smith *et al.*, 2018).

- WGD also have their BCS assessed and recorded by either a DCWA (n=23), a Guide Dog Mobility Instructor or a veterinary surgeon at least twice a year.

- Working Guide Dogs have a veterinary examination, including weighing and BCS, every 6 months. This means that each dog's weight and BCS should be regularly monitored and recorded. If a GDO judges from the fit of the harness that the dog's weight is changing, then they are advised to get their dog's weight checked more frequently, with some dogs being weighed every week.

The main aim of this chapter was to investigate the risk factors for overweight status in a sample of WGD with a view to establishing links between dog and owner characteristics and behaviours and the weight status of the dog. The second aim of this chapter was to gather data to inform the development of an online questionnaire for BSH (Chapter 4).

The following objectives were set for the GDO study: (1) to develop an interview schedule to investigate GDO lifestyles, care and management of their dogs and the dog's behaviour around food; (2) to conduct telephone interviews with a sample of GDO volunteers; (3) to interrogate the resulting data to look for links between the weight status of the dog and a) its feeding and exercise management and general care, b) the dog's behaviour around food and c) dog and GDO characteristics; and (4) to generate data which would enable comparisons between the findings of the GDO survey and those of the BSH (Chapter 4) and PDO (Chapter 5) surveys to determine similarities and differences in risk factors for dogs being overweight between these three groups of dog owners/carers.

3.1 Materials and Methods

3.1.1 Recruitment of participants

GDO were recruited via the GDO magazine and email in January 2014. The study was described as 'health-related research' and did not mention dog weight to try to avoid bias in the GDO who volunteered to take part. A formal sample size calculation was not performed as a maximum of 50 interviews was thought to be feasible in the time available (Ragin and Becker, 1992). The list of potential participants was closed after 8 weeks and volunteers were then contacted in an accessible format (*e.g.* Braille, audio) to provide more information about of the study and assure confidentiality and anonymity.

Volunteers were then telephoned by the author to introduce herself as a veterinary surgeon working at SVMS who was conducting research into feeding and exercise of WGD. GDO were given the opportunity to ask questions about the study and then verbal consent obtained to contact them again for the interview to give them time to consider their participation in the interim.

3.1.2 Development of interview schedule

An interview schedule was developed to survey GDO about the feeding and exercise management of their WGD (Table 3.1). The questions for the interview were informed by previous studies on risk factors for overweight status in dogs (Chapter 2). Additional questions suggested by GD Research Staff were also included. The interview schedule was designed to be semi-structured, with prompt questions which could be used if necessary. It was piloted on four pet-owning members of staff and PhD students at SVMS and the introductory script and questions modified after each pilot interview in response to the feedback given. No changes were suggested after the fourth interview therefore no further piloting was carried out (Table 3.1).

Table 3.1: Semi-structured telephone interview schedule on dog feeding and exercise management administered to 50 Guide Dog Owners.

Topics	Information requested	Examples of prompt questions
Dog details	Name, sex, breed, age of dog Length of time dog been with owner	
GDO interaction with dog	Description of a typical day, including grooming, tooth brushing, other routine care Use of rewards and treats, including type, frequency, situation	Could you describe a typical day for you and your dog? Does this differ between weekdays and weekends? How do you reward your dog for good behaviour?
Feeding	Current food Frequency of feeding Determination and measurement of amount fed Routine at feeding time Dietary supplements	How do you decide how much to feed your dog? How do you measure the amount of food to give? Do you keep your dog company while it eats?
Dog's interest in food	Dog's behaviour while GDO is preparing food/eating GDO interaction with dog while they are preparing food/eating Begging Scavenging	Do you allow your dog in the kitchen while you are preparing food for yourself? What does your dog do while you are eating? What would your dog do if you accidentally spilled a large

	Coprophagia Vignette to assess dog's food drive	quantity of their food on the floor?
Dog exercise	Length and frequency of working walks Other exercise away from home Activity levels of dog at home	Does your dog play with other dogs/toys during a free run? Does your dog play with toys at home?
Dog health	Long term health problems	
Dog weight	Dog's current and optimum weight GDO opinion of dog's weight Monitoring of dog's weight Awareness of BCS system	How would you describe your dog's weight? How might you tell if your dog's weight had changed? Have you heard of Body Condition Scoring in dogs?
GDO lifestyle	GDO diet and exercise	Could you describe your own diet in terms of how healthy it is? How much exercise do you do apart from walking with your guide dog?
GDO demographics	Other pets in the household Previous guide dogs Location, number of people in household, working status, age Height and weight to enable GDO BMI to be calculated	How many guide dogs have you had before your current dog? How would you describe the place where you live *e.g.* village, city centre? Would you mind telling me your height and weight?
Additional comments	Any other relevant information	

GDO=Guide Dog Owners, BCS=Body Condition Scoring, BMI=Body Mass Index

The final version of the questionnaire is included in Appendix 1.

3.1.3 Conducting the interviews

GDO were telephoned at a prearranged time from a speakerphone and the interviews recorded on two separate Dictaphones. At the beginning of each telephone call, the GDO were informed that the interviews were being recorded, confidentiality and anonymity were assured and participants were asked whether they had any questions before the interview commenced. Agreement to proceed with the interview was recorded as informed consent.

Notes were taken during each interview and answers to closed questions recorded on a data collection form. At the end of the interview the participants were asked whether they had any other comments relevant to the survey and given the option to receive a summary of the findings. The interview recordings from each Dictaphone were transferred to a password-protected computer as soon as practical after the interview. Backup copies were also made and stored securely.

3.1.4 Data cleaning

Responses to the closed questions were collated into Microsoft Excel 2013 (Microsoft Corp., Redmond, Washington) for cleaning. Any failed partnerships that a GDO had had in the past were counted as a previous WGD.

The amount of working exercise the dog did in a day was usually expressed in terms of time, but where it was given as a distance, this was converted to an approximate time by assuming a walking speed of 3mph (Clark-Carter *et al.*, 1986). If the response was given as a range, then the mean value was taken (*e.g.* 1/2–4 hours was converted to 2 ¼ hours). If the respondent stated the maximum or minimum amount of exercise the dog had in a typical day, then the figure they gave as the maximum or minimum was used *e.g.* 'at least 45 minutes' was converted to 45 minutes. The length of time spent working was then grouped into three categories: <1hour, 1-2 hours or >2-4 hours per day. The frequency of free runs (off-lead exercise) was grouped into five categories: Never/rarely, weekly, 2-3/week, 4-6week and daily. Where owners said that their dog's exercise was too variable to quantify, this was recorded as missing data.

The National Health Service (NHS) BMI Healthy weight calculator (www.nhs.uk/Tools/Pages/Healthyweightcalculator.aspx) was used to calculate the BMI of the GDO who disclosed both their weight and their height. Imperial or metric units or a combination of the two can be used in this BMI calculator, enabling the measurements given by the GDO to be input directly, without the need for conversion.

The GD database (GDI-R) was searched to find the current BCS, weight and optimum weight of the dogs in the survey to compare with the weight and opinion of the dog's weight given by the GDO. Where these data were missing, the Canine Research Associate at GD was contacted to ask whether recent weights and BCS were available.

3.1.5 Statistical analysis

Descriptive statistics were calculated in Microsoft Excel 2013 (Microsoft Corp., Redmond, Washington) before the data were imported into SPSS v.25 (SPSS Inc., Chicago, IL, USA) for further statistical analysis. Kolmogorov–Smirnov tests for normality (Nijland et al., 2009) were performed on all continuous outcome variables and parametric or non-parametric tests used as appropriate. Cases were excluded pairwise to deal with missing data. Results were regarded as statistically significant if $p<0.05$ unless otherwise stated.

1. Selection of an appropriate outcome variable.

The intention in the current study was to use the dogs' BCS at the time of questionnaire completion as the outcome variable. However, due to findings discussed below, (Section 3.2.13a), alternative outcome variables were needed. The weight of the dog as reported by the GDO and the percentage difference between the dog's actual weight and its optimum weight (Nijland *et al.*, 2009; German *et al.*, 2012a) were used as outcome variables. The percentage weight difference of the dog from its optimum weight was calculated for each dog using the formula:

$$\text{Percentage weight difference} = \frac{\text{actual weight of dog} - \text{optimum weight of dog}}{\text{Optimum weight of dog}} \times 100$$

The most recent weight and optimum weight recorded on GDI-R before the interview took place were used for this calculation.

The GDO-reported weight of their dog was used as a second outcome variable to enable direct comparison of risk factors for dogs being overweight between this study and the PDO survey (Chapter 5).

2. Associations between dog and GDO characteristics and behaviour and the weight status of the dog

The same 3-step process was repeated for both outcome (dependant) variables:

Step 1. Univariate analysis

Univariate analysis of the data was performed using linear regression as both outcome variables were continuous. Each of the predictor (independent) variables were compared to the outcome variables one by one and retained if $p<0.2$ (Dohoo *et al.*, 2003; Rolph *et al.*, 2014). Multiple comparisons were not corrected for in order to obtain a fuller model of potential associations (Perry *et al.*, 2020).

Step 2. Multivariable Analysis

Weight status is complex and can be influenced by a large number of factors (Osto and Lutz, 2015), so multivariable analysis was performed. This helps to address potential confounding factors by investigating the effect of each

variable while holding the others constant (Perry *et al.*, 2020). To minimise multicollinearity (Dohoo *et al.*, 2003), the significant predictors from step 1 were divided into three groups: dog characteristics or behaviours, owner characteristics or behaviours and 'other' variables, *e.g.* location (urban, suburban or rural) which did not fit clearly into either of the other categories. Because the variables in the dog and owner groups had already been checked for multicollinearity in Chapter 4, this was not repeated for this dataset.

Step 3. Model building

All predictors significantly associated with the dependant variable ($p<0.2$) (Dohoo *et al.* 2003) went forward into a linear regression model. Both a forwards regression and backwards elimination process were performed (Courcier *et al.*, 2011) and the significant variables ($p<0.05$) in the resulting models were checked for interaction. Each interaction was added to the relevant model and retained if statistically significant ($p<0.05$).

The residuals from each model were checked for homoscedasticity (*i.e.* that the variance around the regression line was the same for all values of the predictor variable) by plotting the standardised residuals against the standardised predicted values and visually assessing the scatter plot (Dohoo *et al.* 2003).

3.1.6 Qualitative analysis

Selection of interviews

A maximum variation sampling strategy was used to select nine interviews for thematic analysis (Baker and Edwards, 2012; Palinkas *et al.*, 2015). Interviews were selected to include GDO of different ages, sex, BMI (normal weight, overweight or obese), working status and number of previous WGDs. Other considerations were the location (rural, suburban or urban), the number of people and other pets in the household, dog characteristics including age, breed, sex and the GDO's opinion of the dog's weight (underweight, normal weight or overweight).

Thematic analysis

The nine selected interviews were professionally transcribed and thematic analysis carried out by a third-year undergraduate veterinary student. The transcripts were imported into NVivo (NVivo, 2012) for coding (the identification of codes or features of interest in the data). An inductive (data-driven) approach was used, with codes being identified, defined and patterns in the data noted, enabling the data to be condensed into broader categories (subthemes and themes) (Braun and Clarke, 2006) (Table 3.12). Sections of the transcripts were collaboratively coded with another undergraduate student who was also researching canine weight management to ensure coder reliability (Crittenden and Hill, 1971).

3.2 Results

3.2.1 Sample size

Approximately 4,800 GDO should have received the GDO magazine and/or email invitation to participate in the study. When the list of potential participants was closed, 84 GDO had volunteered, giving a response rate of around 2%. Of these 84 volunteers, 50 (60%) were interviewed, a sample of around 1% of all UK GDO.

3.2.2 Guide Dog Owner demographics

The majority of GDO interviewed (n= 39/50, 78%) were between 45 and 75 years old and two thirds of them (n=33/50, 66%) were female. Thirty-nine (78%) of the GDO interviewed had had a WGD previously. The number of previous WGD ranged from one to seven (Table 3.2), with a median of 1.5 and an interquartile range (IQR) of 1-4.5. Five (10%) of the first-time GDO had had pet dogs previously, but four (8%) had never owned a dog before. Two first-time GDO (4%) did not specify whether they had owned a pet dog previously.

Table 3.2: Demographics of 50 Guide Dog Owner participants in a telephone survey about feeding and exercising their guide dogs

Demographic question	Response: Number (%) of participants
GDO Sex	Male: 17 (34%) Female: 33 (66%)
GDO Age (years)	Under 25: 0 (0%) 25-34: 3 (6%) 35-44: 3 (6%) 45-54: 7 (14%) 55-64: 21 (42%) 65-74: 11 (22%) 75-84: 4 (8%) Over 85: 1 (2%)
GDO Working status	Full-time employment: 8 (16%) Part-time employment: 10 (20%) Retired: 23 (46%) Full-time carer: 2 (4%) Voluntary work: 2 (4%) Not working: 5 (10%)
Number of people in household	1: 17 (34%) 2: 25 (50%) 3: 2 (4%) 4: 6 (12%)
Number of children under 18 years old in household	None reported: 46 (92%) 1: 1 (2%) 2: 3 (6%)
Age of youngest child (years)	Not applicable: 46 (92%) 4: 1 (2%) 5: 1 (2%) 9: 1 (2%)

	16: 1 (2%)
Location	Urban: 7 (14%) Suburban: 35 (70%) Rural: 7 (14%) Other: 1 (2%)
Other pets in household (more than one response permitted)	None: 38 (76%) Cat(s): 8 (16%) WGD: 1 (2%) Retired guide dogs: 4 (8%) Chickens: 1 (2%)
Number of WGD held previously	None: 11 (22%) 1: 3 (6%) 2: 6 (12%) 3: 8 (16%) 4: 9 (18%) 5: 8 (16%) 6: 4 (8%) 7: 1 (2%)

GDO=Guide Dog Owner, WGD=Working Guide Dog

Twenty-six (52%) of the GDO had a healthy BMI (18.5–25kg/m^2), 18 (36%) were overweight (BMI 25–30kg/m^2) and four (8%) were obese (BMI>30kg/m^2). Two female GDO declined to disclose their weight.

3.2.3 Dog details

Over half of the WGD in the survey were Labrador-Golden Retriever crosses (n=27, 54%), with Labradors being the most common pure breed (n=11, 22%) (Table 3.3).

Table 3.3: Demographics of 50 guide dogs whose owners completed a telephone survey about feeding and exercise management of their dogs.

Dog details	Response: Number (%) of dogs
Sex	Male: 27 (54%) Female: 23 (46%)
Age (years)	Median: 6 years Interquartile range: 3.75–7.75 Range: 2–11
Breed	Labrador: 11 (22%) Golden Retriever: 4 (8%) German Shepherd: 4 (8%) Labrador x Golden Retriever: 10 (20%)* Golden Retriever x Labrador: 17 (34%)* Golden Retriever x German Shepherd: 2 (4%) Irish Water Spaniel x Labrador: 1 (2%) Curly Coated Retriever x Labrador: 1 (2%)
Length of time dog been with owner (years)	Median: 4 years Interquartile range: 1.75–5.5 Range: < 0.5–10

* These two groups were combined for statistical analysis

3.2.4 Care of the Guide Dog

The majority of the GDO (n=44, 88%) said that they groomed their dog at least once a week with only 5 (10%) of GDO stating that they never or only occasionally groomed their dog. In contrast, the majority of GDO (n=41, 82%) said that they never or only occasionally brushed their dog's teeth, and only seven GDO (14%) said that they brushed their dog's teeth at least once a week (Table 3.4).

Table 3.4: Guide Dog Owner-reported frequency of grooming their dogs and brushing their dogs' teeth in a telephone interview about care of their dogs.

Frequency	Number of GDO grooming (%)	Number of GDO brushing teeth (%)
Daily	11 (22%)	2 (4%)
Every 2-3days	25 (50%)	4 (8%)
Weekly	8 (16%)	1 (2%)
Fortnightly*	1 (2%)	1 (2%)
As necessary	3 (6%)	4 (8%)
Rarely/Never*	2 (4%)	37 (74%)
No response	-	1 (2%)
Total	**50**	**50**

GDO=Guide Dog Owner
*Combined for statistical analysis

3.2.5 Exercise

The majority of dogs (n=30/50, 60%) were worked for an average of 1-2 hours/day. Eleven dogs were worked for 45 minutes per day or less, while five dogs were worked for at least 3 hours per day.
Most dogs (n=35/50, 70%) got a free run between once and three times a week, with only three dogs getting a free run less than once a week (Table 3.5).

Table 3.5: Guide Dog Owner-reported frequency of free runs in a telephone survey about feeding and exercising their dogs

Frequency of free run	Number (%) of dogs
Daily*	10 (20%)
Between 4 and 6 per week*	2 (4%)
2-3 per week	17 (34%)
Once a week	15 (30%)
Rarely/never	3 (6%)
Variable/missing data	3 (6%)
Total	**50 (100%)**

*Combined for statistical analysis.

3.2.6 Feeding

The majority of the WGD were fed twice a day (n=40, 80%). One dog (2%) was fed three times a day; eight dogs (16%) were fed once a day in the evening and one dog (2%) once a day in the morning.

All of the WGD were fed on dry food, although one GDO reported alternating a week of the dry food provided by GD with a week of meat and biscuits. Four dogs (8%) were on a weight management diet.

3.2.7 Treats

For many GDO (n=37/50, 74%), treats were used to train their dog or reward them for good behaviour. Over half the GDO (n=27/50, 54%) gave their dog a treat as part of their daily routine *e.g.* before bed, while the owner was eating (Table 3.6).

Table 3.6: Guide Dog Owner-reported use of dog treats and rewards during a telephone interview about feeding and exercising their dogs (n=50). Multiple responses were possible therefore the percentages may exceed 100%.

Question	Response	Number of respondents (%)
How do you reward your dog for good behaviour?	Praise	42 (84%)
	Fuss/cuddles	32 (64%)
	Dog treats *e.g.* bought from a shop, table scraps	21 (42%)
	Play/toys	10 (20%)
In what situations do you give your dog treats?	Training and rewards	37 (74%)
	Part of daily routine	27 (54%)
	When leaving the dog on its own	0 (0%)
What type of treat do you give to your dog?	Shop bought treats *e.g.* Bonios	37 (74%)
	Fruit or vegetables	16 (32%)
	Dental chews *e.g.* Dentistix	13 (26%)
	Food taken from daily allowance	10 (20%)
	Bones from butcher	9 (18%)
	Another type of treat	6 (12%)

3.2.8 Guide Dog behaviour around food

Only three respondents (6%) admitted that their dog begged, compared to 36 (72%) who said that their dog did not. Six GDO (12%) said that their dog would beg from other people while five of the respondents (10%) were unsure whether their dog begged or not.

Of the 31 (62%) GDO who said that their dog scavenged, 12 (24%) said that this only happened occasionally and four (8%) stated that it only occurred when the dog was free-running. One of these owners said that she muzzled her dog while she was free-running to prevent her from scavenging.

In four of the 19 dogs (8%) who exhibited coprophagia, it was only reported to be an occasional problem (Table 3.7).

Table 3.7: The number (%) of dogs reported to scavenge and exhibit coprophagia in a telephone survey of 50 Guide Dog Owners

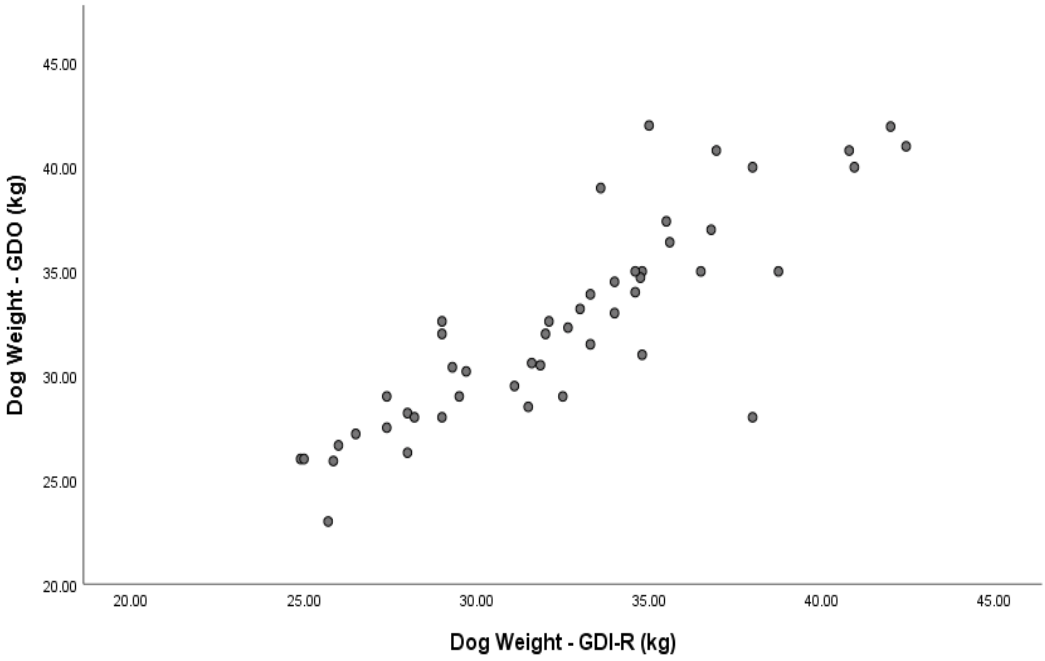
		Scavenging			
		Yes	**No**	**Not sure**	**Total**
Coprophagia	**Yes**	12 (24%)	7 (14%)	0	19 (38%)
	No	17 (34%)	9 (18%)	2 (4%)	28 (56%)
	Not sure	2 (4%)	1 (2%)	0	3 (6%)
	Total	31 (62%)	17 (34%)	2 (4%)	50 (100%)

3.2.9 Dog health conditions

Twenty-six of the GDO (52%) did not consider their dogs to suffer from any long-term health conditions, although six of these 26 owners mentioned that their dogs had occasional gastroenteritis, sometimes associated with scavenging. Some chronic conditions associated with overweight status were reported, such as skin disease (n=6, 12%), anal gland problems (n=5, 10%) and signs of osteoarthritis (n=3, 6%).

3.2.10 Dog weight

All GDO except one (n=49/50, 98%) gave a weight for their dog. The mean reported weight of the dogs was 32.5+/-4.9kg. There was a strong correlation between the GDO-reported weight for their dog and the most recent weight recorded on GDI-R ($r=0.86$, $p<0.001$) (Figure 3.1).



GDI-R=Guide Dogs' database, GDO=Guide Dog Owner

Figure 3.1: The correlation between dog weights recorded by Guide Dogs and Guide Dog Owner (GDO)-reported weights from telephone interviews with 50 GDO about feeding and exercising their dog.

Mann Whitney tests showed that male dogs (mean weight 34.9+/-0.79kg, 95% CI 33.3–36.5kg) were heavier than bitches (mean weight 29.5+/-0.89kg, 95% CI 27.7–31.4kg) (*U*=149.5, p=0.010). There was no difference in bodyweight between Labradors and Labrador Retriever crosses (p=0.501) but there were not enough dogs of the other breeds and crosses in the sample for statistical analysis.

The median percentage weight difference was 0% (IQR: 3.8–6.9). There were no differences in percentage weight difference between sexes or between Labradors and Labrador Retriever crosses (p=0.699). There were not enough dogs of the other breeds and crosses in the sample for statistical analysis.

3.2.11 Guide Dog Owner perception of their dog's weight

The majority of GDO (n=41/49, 84%) thought that their dogs were the correct weight, while five (10%) thought their dogs were overweight and four (8%) thought their dogs were underweight. There was a moderate correlation between the GDO's opinion of the dog's weight and the dog's percentage weight difference (Spearman's rho=0.34, p=0.016).

All five of the dogs that were considered overweight by their owners scavenged, but none of them were reported to beg and only two were coprophagic. Three of these owners believed that their dogs' weight gain could be due to a reduction in their exercise, while one GDO said that he had not been as strict with treats as he should have been. The other GDO had reduced the amount of food his GD was getting as he thought she was gaining weight.

Owners who thought that their dogs were underweight had a variety of explanations for this. One of these GDO was concerned about her WGD developing a particular health condition and had made a conscious effort to keep her dog's weight down. The second GDO tried to keep her dog slightly under the weight recommended by GD to give 'room to manoeuvre'. The third GDO reported struggling to keep weight on her dog, especially in the summer when the dog's exercise increased. The final GDO who believed her dog was underweight said that the vet and GD thought that the dog was the correct weight. This WGD had a BCS of 5/9 (normal).

When asked how they monitored their dog's weight, 35 (70%) of the GDO interviewed said that they had their dog weighed at the vets, 30 (60%) said that they could tell from feeling their dog and 17 (34%) said that they could tell by the fit of the harness.

The majority (n=37/50, 74%) of GDO had never heard of the term 'Body Condition Scoring', although three (6%) remembered it when prompted. Only nine of the GDO interviewed (18%) recognised the term with no prompting.

3.2.12 Guide Dog records and potential outcome variables

When GDI-R was searched for the weights and BCS of the WGD in the survey, 13 of the 50 dogs (26%) in the survey had no BCS recorded, and for another 12 (24%) dogs, the BCS was over 12 months old. This meant that 25 (50%) of the GD in the survey had no BCS recorded in the previous year in the GD database. Weights for the WGD were recorded more consistently, with only nine dogs (18%) having no weight recorded in the last 12 months.

The Canine Research Associate at GD provided current BCS and weights for 21 and eight dogs respectively from other GD records. In total, current BCS were available for 46/50 dogs (92%) and current weights for 49/50 dogs (98%). The median BCS was 5 (IQR: 5–6) and the mean weight from GDI-R was 32.7+/-4.6kg.

Both actual and optimum weights were obtained for 49/50 dogs (98%) enabling a percentage weight difference to be calculated. The median percentage weight difference was 0% (IQR: -3.6-6.5%).

3.2.13 Statistical analysis

Significance was set at $p<0.05$ for all statistical tests unless otherwise stated.

1. Selection of an appropriate outcome variable.

a. The dogs' BCS as recorded on GDI-R as an outcome variable

When the percentage weight difference of each dog was compared to its most recent BCS, a marked discrepancy was noted, with the majority of dogs assigned a BCS of 4 (underweight) being above their optimum weight (Figure 3.2). The correlation between the percentage weight difference of each dog and its most recent BCS was not significant (Spearman's rho=0.17, p=0.231).

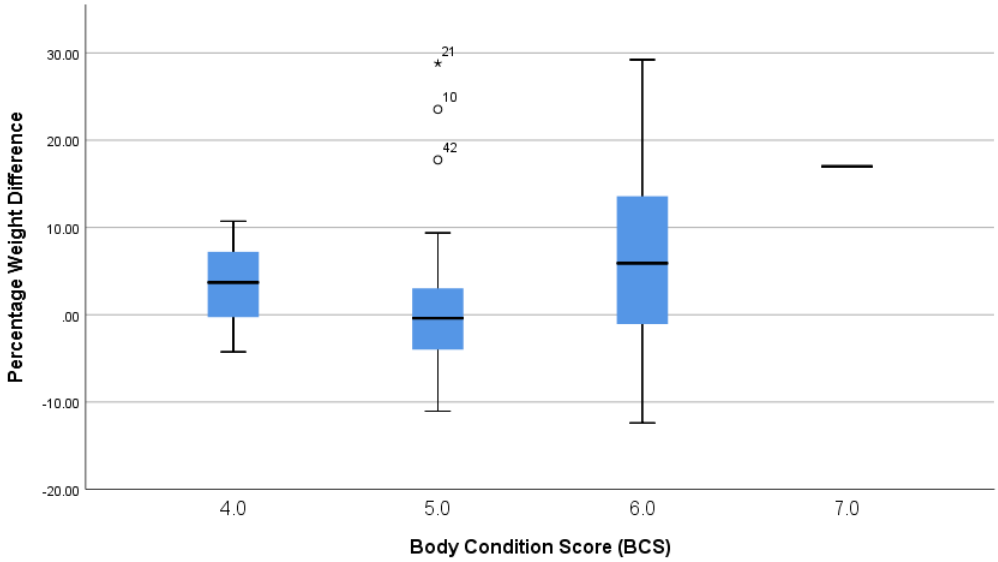


Figure 3.2: Comparison of the Body Condition Score (BCS) of 50 guide dogs extracted from Guide Dogs' database and the percentage weight difference of the dog from its optimum weight.

The inconsistencies between the BCS assigned and the percentage weight difference, along with the lack of recent BCS recorded in GDI-R for the WGD in the study meant that BCS was rejected as a reliable outcome measure. No further statistical analyses were performed on these data and alternative methods of assessing the weight status of the WGD were used.

b. The Percentage Weight Difference of the dog from their optimum weight as an outcome variable.

Optimum weights for WGD are set by the regional DCWA (n=23). The small number of people involved in setting optimum weights should increase inter-rater reliability and make these more reliable than BCS assigned by a larger number of people with various job roles (Laflamme, 1997; Mawby *et al*., 2004; Elliott, 2006). Although the use of the percentage weight difference is not without its limitations (Section 3.3.3), it was considered a more reliable indicator of a dog's weight status than its BCS as recorded on GDI-R.

c. The dog's weight as reported by the Guide Dog Owner as the outcome variable

Owner-reported weights have previously been used as outcome variables in studies investigating risk factors for overweight status in dogs (Robertson, 2003; Spain *et al.*, 2004; Bland *et al.*, 2009; Sallander *et al.*, 2010a; Heuberger and Wakshlag, 2010b). GDO-reported weights were used as an outcome variable in this study to enable direct comparison of overweight status risk factors with the PDO survey (Chapter 5).

Statistical Analysis

Step 1. Univariate analysis

There were a number of independent variables that were significantly associated ($p<0.2$) with the percentage weight difference (Table 3.8).

Step 2. Avoiding Multicollinearity

There were no dog-related variables significantly associated with the percentage weight difference of the dog ($p<0.2$). However, there were a number of variables associated with the percentage weight difference which related to the owner or neither dog or owner (Table 3.8).

Table 3.8: Variables significantly associated (p<0.2) with the percentage weight difference of the dog from its optimum weight in a telephone survey of 50 Guide Dog Owners.

Independent Variable	Responses	P value	Difference/ Unstandardised B	95% Confidence Interval for B	
				Lower bound	Upper bound
GDO behaviour					
GDO monitors dog's weight by feel	No Yes	 0.021	 -6.276	 -11.581	 -0.971
GDO rewards dog with treats	No Yes	 0.047	 5.408	 0.064	 10.751
GDO gives dog treats as a reward	No Yes	 0.055	 5.905	 -0.123	 11.933
GDO uses food taken from daily ration as treats	No Yes	 0.104	 5.597	 -1.197	 12.391
GDO monitors dog's weight by fit of harness	No Yes	 0.158	 -4.051	 -9.736	 1.633
GDO gives dog treats as part of daily routine	No Yes	 0.161	 -0.204	 -9.228	 1.581
Duration of the dog's working exercise per day	<1 hour 1 – 2 hours >2 - 4 hrs	 0.484 <0.001	 1.910 19.354	 -3.552 10.840	 7.372 27.868
Frequency of free runs	Never/rarely Weekly 2–3/week 4/week–Daily	 0.601 0.696 0.069	 2.999 2.229 10.836	 -8.493 -9.204 -0.894	 14.492 13.661 22.566
GDO characteristics					
GDO is male	No Yes	 0.161	 4.028	 -1.658	 9.714
Other Variables					
Number of people in the household	1 2 3 4	 0.458 0.633 0.105	 -2.251 -3.409 -7.454	 -8.311 -17.700 -16.533	 3.810 10.882 1.624

GDO=Guide Dog Owner

The individual variables significantly associated with the percentage weight difference were taken forwards into the modelling process.

Step 3. Model building

The forwards and backwards modelling processes resulted in the same final model. There were four predictors for the percentage weight difference of the dogs in the models: whether treats were taken from the dog's daily ration; the

duration of the dog's working exercise per day; the number of people in the household and whether the GDO monitored the dog's weight by feel (Table 3.9). The adjusted R^2 for the models was 0.43 and the Durbin-Watson statistic was 1.99, showing that no autocorrelation was detected in the sample. No significant interactions ($p<0.05$) were found and a homoscedasticity plot showed that residuals for the model outputs had an approximately normal distribution.

Table 3.9. Multivariable model for the percentage weight difference of working guide dogs from their optimum weight in a telephone survey of 50 Guide Dog Owners.

Predictor	Responses	P value	Unstandardised B / Difference	95% Confidence Interval for B	
				Lower bound	Upper bound
Constant		0.427	-3.319	-11.698	5.061
GDO uses food taken from daily ration as treats	No Yes	0.010	7.379	1.853	12.906
GDO monitors dog's weight by feel	No Yes	0.029	-5.293	-10.024	-0.561
Duration of the dog's working exercise per day	<1 hour 1–2 hours >2-4 hrs	0.098 0.006	5.227 14.955	-1.022 4.696	11.477 25.214
Number of people in the household	1 2 3 4	0.167 0.734 0.106	-4.280 -2.863 -8.992	-10.441 -19.890 -20.005	1.882 14.164 2.021

GDO=Guide Dog Owner

c. The dog's weight as reported by the GDO as the outcome variable

Step 1. Univariate analysis

There were a number of independent variables that were significantly associated ($p<0.2$) with the weight of the dog as reported by the GDO (Table 3.10).

Step 2. Avoiding Multicollinearity

There were independent variables significantly associated with the GDO-reported weight of the dog ($P<0.2$) which related to dog characteristics, GDO behaviour and which did not relate exclusively to either dog or owner *e.g.* whether the GDO had previously had a WGD (Table 3.10).

Table 3.10: Variables significantly associated with the Guide Dog Owner (GDO)-reported weight of the dog in a telephone survey of 50 GDO.

Predictor		p value	Unstandardised B	95% Confidence Interval for B	
				Lower Bound	Upper Bound
Dog characteristics					
Dog is male	No Yes	<0.001	5.358	2.979	7.737
GDO characteristics and behaviours					
GDO is male	No Yes	0.006	3.937	1.168	6.705
GDO monitors dog's weight by feel	No Yes	0.035	-2.986	-5.751	-0.221
GDO gives dog treats other than shop-bought treats, fruit or vegetables or food from their daily ration	No Yes	0.087	-3.674	-7.902	0.554
GDO gives dog treats as part of their daily routine	No Yes	0.160	-0.204	-4.774	0.809
GDO monitors dog's weight by weighing dog at veterinary surgery	No Yes	0.192	-2.002	-5.047	1.043
GDO rewards dog with fuss/cuddles	No Yes	0.199	-1.957	-4.984	1.069
Other variables					
GDO has had WGD previously	No Yes	0.084	2.912	-0.411	6.234

GDO=Guide Dog Owner, WGD=Working Guide Dog

The individual variables significantly associated with the percentage weight difference were taken forwards into the modelling process.

Step 3. Model building

The backwards modelling process showed that the GDO-reported weight of the dog could be predicted by the dog's sex, the GDO sex, whether the GDO monitored the dog's weight by weighing the dog at the veterinary surgery and whether the GDO had had WGD in the past (Table 3.11). The forwards modelling process produced a model comprising only the dog's sex and the GDO sex but the adjusted R^2 (0.37) was lower than that of the backwards model

(0.44). The backwards model was chosen as it explained more of the variance in the data than the forwards model. The Durbin-Watson statistic for the backwards model was 2.21 showing that no autocorrelation was detected in the sample. No significant interactions ($p<0.05$) were found and a homoscedasticity plot showed that residuals for the model outputs had an approximately normal distribution.

Table 3.11: Multivariable (backwards) model for the Guide Dog Owner (GDO)-reported weight of their dog in a telephone survey of 50 GDO

Predictor		P value	Unstandardised B coefficient	95% Confidence Interval for B	
				Lower Bound	Upper Bound
Constant		<0.001	28.096	25.284	30.908
Dog is male	No Yes	<0.001	4.834	2.639	7.030
GDO has had WGD previously	No Yes	0.016	3.607	0.703	6.512
GDO monitors dog's weight by weighing dog at veterinary surgery	No Yes	0.045	-2.654	-5.252	-0.057
GDO is male	No Yes	0.049	2.380	0.008	4.753

GDO = Guide Dog Owner, WGD = Working Guide Dog

3.2.14 Thematic analysis

Thematic analysis of a purposive sample of nine GDO interviews revealed three main themes: empowerment of the GDO to manage their dog's weight; barriers to maintaining their dog at a healthy weight; and lifestyle and routine (Table 3.12). These will be discussed further in Section 8.4.2.

Table 3.12: Thematic analysis of nine guide dog owner interview transcripts on feeding and exercising their dog

Code/Node	Description	Sub themes	Main themes	Example quotes
Positive opinions of Guide Dogs	Positive comments made about Guide Dogs and the ways in which they have assisted individual GDO	Support provided by Guide Dogs to GDO	**Empowerment**	'I've got nothing but praise for the Guide Dog Association and the freedom the

Code/Node	Description	Sub themes	Main themes	Example quotes
Training provided by Guide Dogs	Positive and negative views towards the training provided by Guide Dogs			dogs have given me' 'I was okay once I got taught the techniques, and all the obedience and bits and bobs, and I understood why you were doing the different obedience, and why you should keep up training' 'I've always tried to make sure that she's in good condition and she's okay. I wouldn't give her a lot of stuff because we were told not to, so I just play by the rules' 'Guide Dogs are very strict in their guidance' 'I don't always listen to what Guide Dog people tell me' 'I'm conscious that dogs of that sort of breed often have trouble with their hindquarters and things, so they get arthritis and stuff. So any
Advice from Guide Dogs	Regular advice given to the GDO on feeding, exercise, grooming and management of the dog			
Past experience with dogs and dog training	How previously owning a guide dog or past experience of dog training has helped with their current dog			
Problems with Guide Dogs	Any problems arising between GDO and Guide Dogs. GDO sometimes feel as though 'too much' guidance is given which frustrates them			
Awareness of weight-related issues	Any reference to obesity and the risks to a dog of being overweight	GDO awareness of the risks to a dog of being overweight and what they can do to prevent this		
Healthy treats and snacks	Healthier options used by GDO to treat their dog			
Negative opinions towards treat giving	Why some GDO do not give treats in			

Code/Node	Description	Sub themes	Main themes	Example quotes
	certain circumstances			elements of being overweight would make that worse'
Weight monitoring and control	How GDO assess the weight of their dog and opinions on monitoring the dog's weight			'she just gets weighed every six months when she goes to the vets'
Knowledge of Body Condition Scoring	GDO knowledge of BCS and how they perform this with limited visual input			'by feeling her ribs. Putting the harness on her and things like that, I can feel. And when grooming her, I can feel how she's going. If there's any excess flesh over her ribs'
Veterinary support	Frequency of visits to the vets and the role of the veterinary practice in supporting guide dogs and their owners			'my vets… have been brilliant'
Frequency of feeding	How often GDO feed their dogs and why	GDO knowledge of the importance of feeding their dog correctly.		
Food measured out by the GDO	Any reference to how the GDO measures out the dog's food *e.g.* with a tin, weighing scales, by handfuls			'I use a measuring tin'
Treat frequency	How often GDO give their dogs treats and whether this differs depending on whether they			'I count them out very carefully actually. She gets ten gravy bones a day, split in half'
				'I got into the habit of counting them out, and when they're gone,

Code/Node	Description	Sub themes	Main themes	Example quotes
	are working or not			they're gone, she knows that'
Reward for good behaviour	The importance of the dog being well trained and obedient to work safely.			'I never give a treat when working a dog'
Supplements	Reference to GDO giving their dog supplements to complement their diet or aid with any health issues			'Mainly praise actually, verbal praise. Very occasionally treats, not often'
Control over what the dog does when outside the house	GDO feel that they do not have full control because they cannot see exactly what the dog is doing/eating and have no control over members of the public feeding their dogs.	Visual impairment can interfere with training and controlling the dog's actions	**Barriers**	'if it's in front of him, of course I can't see it, but then I can feel him snap down'
GDO feel restricted by their visual impairment	Occasions when GDO have felt restricted because of their visual impairment and how they are hindered from doing certain activities			'I can't always tell. Unless someone with a pair of eyes tells me he's eating something'
Temperament of guide dog	Commonly-mentioned			'when I go to the greengrocers, the shopkeeper gives her a carrot and two biscuits, although they're just fat and I ask them not to, still they do it'

Code/Node	Description	Sub themes	Main themes	Example quotes
	guide dog characteristics	Guide dog characteristics and behaviour		'she scavenges anything and everything, she's terrible!'
Breed specifics	Any quotes related to specific dog breeds			
Dog excitement over food	How excited dogs get over food and treats			
Coprophagia	Reference to whether dogs eat either their own faeces, or faeces from other dogs or other animals			
Health status of the dog and illness contributing to weight gain	Reference to past illnesses that may account for weight gain or any current health issues	Factors that may hinder weight loss/contribute to weight gain in a guide dog		
GDO exercise	GDO comments on their own fitness and activity levels with and without their dog	GDOs are either healthy and active or want to improve their lifestyle	**Lifestyle and Routine**	'we eat very healthy, my partner's an excellent cook and we eat a lot of fresh food, vegetables, meat, fruit'
GDO diet	How healthy the GDO diet is and how important diet is to them			
Grooming and general care	Frequency of grooming and GDO opinions on dog grooming and brushing teeth	GDOs take great pride in their dogs and look after them accordingly		

Code/Node	Description	Sub themes	Main themes	Example quotes
Free run and exercise	Frequency and duration of the dog's daily work and any exercise apart from work			
Social interactions	The guide dog being used for more than just the journey to work			
Human animal bond	The relationship between the GDO and their dog and their dependence on each other			'as I say, we bonded very quickly. So yes, so quite like my shadow' 'The thought of her retiring, I do find that upsetting. She comes to me for everything'
GDO holds dog in high regard	GDO have high regard for their dog and what they do for them			
Dog discipline	Guide dogs are well trained and obedient.	GDOs understand that for the dog to work at its best, they must have strict routine and discipline		'He's obviously been trained by a very strict person so he wouldn't dream of giving his paw. So I don't encourage him to at all' 'Does Piper beg at all?' 'No. No, I won't allow it' 'We whistle three times and she knows that's her cue to eat'
Strict GDO	GDO are firm with their dogs			
Discipline during feeding time	GDO routine when feeding their dogs *e.g.* whistle-feeding			
Set routines	How GDO reward their dogs for good behaviour whether they are working or not.			

Code/Node	Description	Sub themes	Main themes	Example quotes
Spending (toileting) routine	Any mention of regular spending routines.			'Her toileting is after breakfast she's let out, and then mid-morning, and then obviously after dinner, and then at night time between nine thirty and ten o'clock she goes out'

GDO=Guide Dog Owner, WGD=Working Guide Dog, BCS=Body Condition Scoring

3.3 Discussion

The main findings of this study were that the predictors for the GDO-reported weight of the dog were the sex of the dog, the sex of the GDO, whether the GDO had had WGDs previously and whether the GDO monitored the dog's weight by weighing it at the veterinary surgery. When the percentage weight difference of the dog was used as the outcome variable, effectively eliminating the effect of the dog's sex, the main predictors for the weight status of the dog were the duration of the dog's working exercise per day, whether the GDO took the dog's treats from its daily ration, monitored the dog's weight by feel and the number of people in the household. Most of the explanatory variables associated with the percentage weight difference of the dog in the final model were related to the GDO behaviour around feeding, exercising and monitoring their dog's weight. This was also highlighted in the thematic analysis where empowerment, barriers to managing their dog's weight and routine emerged as the main themes. These findings mirror those of Courcier *et al.* (2010) and highlight that the owners' management of their dog has a much greater impact on the dog's weight than dog behaviours such as scavenging and coprophagia.

3.3.1 Discussion of main findings

Dog Sex

Analysis of the GDO-reported weight of the dogs showed that male dogs weighed more than bitches. This may reflect the fact that male dogs are generally larger and heavier than bitches (Mankowska *et al.*, 2017a; Smith *et al.*, 2018) rather than that the male dogs were overweight. This is substantiated in the model using the percentage weight difference of the dog, which accounts for sex differences in size, as the outcome variable, as the final model did not include the sex of the dog. The variation in weight between dogs of different sexes was demonstrated by Helmink *et al.* (2000), who found that adult bodyweights in German Shepherd (GSD) and Labrador retriever guide dogs in

the USA were 4.7±0.2 kg higher for males than for females. A similar median weight difference (5.4kg) was found between sexes in the current study, although the study by Helmink *et al.* (2000) involved only GSD and Labradors, whereas the current study also included Golden Retrievers and crosses of these breeds. Helmink *et al.* (2000) also found that the mean mature weights of their GSD were 29.1kg for males and 24.4kg for females, compared to 40.8kg for a male GSD and 28.5-35.0kg for females in the current study. This suggests that GSD guide dogs in the USA have a considerably lower bodyweight than their UK counterparts and so comparisons should be made with caution.

Dog sex was not included in the final model using the percentage weight difference as the outcome variable, in accordance with the findings of Robertson (2003) and Bland *et al.* (2009). Neither Robertson (2003) or Bland *et al.* (2009) found any sex difference in prevalence of overweight dogs in Australia, although both these studies relied on the owners' assessment of their dogs' weight (Robertson, 2003) or BCS (Bland *et al.*, 2009). In contrast, Sallander *et al.* (2010a) found that female dogs were more than twice as likely to be overweight as male dogs in a study population that was 99% entire. Possible explanations for this difference are that the outcome variable used in the study by Sallander *et al.* (2010a) was whether the owner considered the dog to be overweight or not and so could have been subject to owner underestimation (German *et al.*, 2006; Eastland-Jones *et al.*, 2014; Kobayashi *et al.*, 2014) or social desirability bias (Fisher, 1993). In addition, the study was carried out in Sweden on an insured population of pure-bred dogs between 1 and 3 years old, so cultural and sociodemographic factors as well as breed and age differences from the dogs in the current study may explain the discrepancy in results. In other previously published studies where female dogs were more likely to be overweight than males (McGreevy *et al.*, 2005; Colliard *et al.*, 2006), neutering may have been a confounding factor, although the proportion of neutered dogs of each sex was markedly different in the two studies (Male Neutered (MN): 30% v 7.1%; Male Entire (ME): 16.3% v 45.5%; Female Neutered (FN): 44.9% v 15.7%; and Female Entire (FE) 7.6% v 31.5% respectively). The association between dog sex and weight status will be examined further in the Guide Dogs' Breeding Stock (Chapter 4) and Pet Dogs (Chapter 5) surveys.

Sex of GDO

Male GDO had dogs with a higher GDO-reported bodyweight than female GDO, although GDO sex was not associated with a higher percentage weight difference (p=0.161). It is possible that male GDO are paired with bigger dogs rather than tending to have dogs that are overweight, as dog height is one of many factors considered when matching a potential GDO with a WGD (Guide Dogs, personal communication). The lack of association between GDO sex and percentage weight difference is supported by previous studies where the sex of the owner (n=696) had no effect on the weight status of their dog (Courcier *et al.*, 2010). Nijland *et al.* (2009) also found no association between the sex of the owner and the weight status of the dog, although this study only involved 47 dogs-owner dyads. Male GDO rated the independence provided by a WGD

more highly than female GDO in a study by Whitmarsh (2005) and may therefore be more motivated to keep their dogs at a healthy weight. However, human studies have shown that men feel less well informed than women about healthy eating, consider healthy eating less important, and are more likely to ignore food and health advice, especially if they are older or from a lower social class (Buttriss, 1997). It would be useful to investigate whether this attitude of men towards healthy eating extends to GDO and their dogs, in which case a larger representative sample of GDO may reveal an association between the weight status of the dog and the sex of the GDO.

Guide Dog Owner use of treats

GDO who reported that they took their dog's treats from their daily ration had dogs with a higher percentage weight difference than GDO who did not. Similarly, GDO who reported giving treats as part of their daily routine had dogs of a lower bodyweight or percentage weight difference than those who did not. Munoz-Prieto *et al.* (2018) agreed that dogs were more likely to be overweight if they did not receive treats and Perry *et al.* (2020) found that dogs receiving <10% of their calorie requirements from treats were not at increased risk of being overweight. Treats given regularly may be accounted for when calculating the dog's daily food ration so these dogs would not be consuming excess calories to cause weight gain (Webb *et al.*, 2020). Furthermore, Raffan *et al.* (2015) found that owners of overweight dogs were more likely to restrict their dog's food intake, hence GDO with overweight dogs may give fewer treats in an attempt to reduce their dog's weight. GDO with overweight dogs may also have been advised by GD to reduce or eliminate treats completely (Guide Dogs, 2014). One GDO in this study stated that he had reduced the amount of food his WGD was getting as he thought she was gaining weight (Section 3.2.11) but comparison of GD weight records and further interviews with GDO around their use of treats would be needed to confirm this.

GDO responses may also be subject to social desirability and recall bias and owners of overweight dogs may either have deliberately underreported their use of treats or underestimated how many treats they gave their dog in a day. Most studies looking at the association between weight status and treat-giving found that dogs fed additional snacks and treats were more likely to be overweight than dogs who were not (Robertson, 2003; Courcier *et al.*, 2010). However, treats were not defined in the studies by Kienzle *et al.* (1998), Robertson (2003), Bland *et al.* (2009) and Courcier *et al.* (2010). Heuberger and Wakshlag (2011b) found that feeding treats which were high in fibre reduced a dog's risk of being overweight, demonstrating that the nutritional content of the treat may determine its effect on the dog's weight (Webb *et al.*, 2020). Providing nutritional information for dog treats could enable dog owners to make more informed decisions about their use (Morelli *et al.*, 2018), especially if this information was given in the context of example nutrient requirements of different sized dogs.

There may also be other factors related to treat-feeding and the weight of the dog that were not explored in this survey. Interviewing GDO about their use of

treats and comparing their responses with their dog's weight status may help to clarify these.

Duration of working exercise

There was a positive correlation between the length of time the dogs worked on a typical day and the percentage weight difference, with dogs that were worked for longer being further above their optimum weight. This contradicts the findings of Robertson (2003) and Warren *et al.* (2011), who both found that a longer duration of exercise reduced the risk of being overweight. However, the dogs in the studies by Robertson (2003) and Warren *et al.* (2011) were pet dogs and so exercise was probably not a stressful experience for them. In contrast, the WGD were working during their walks, which may cause the dog stress (Craigon *et al.*, 2017). In rats, moderate and low levels of stress increase food intake (Ullman, 1951, 1952; Sterritt, 1962; Rowland and Antelman, 1976; Levine and Morley, 1981; Dess, 1992) even when the animals are not hungry and have no metabolic need for calories (Rutters *et al.*, 2008; Foster *et al.*, 2009; Dallman, 2010) and there is limited empirical evidence that stress-induced eating occurs in dogs (Hennessy *et al.*, 2002, 2003; Kato *et al.*, 2012; Luno *et al.*, 2018). If WGD experience chronic low-level stress while working, then dogs which spend longer working might consume more food and gain weight if energy intake exceeds expenditure. Reducing these dogs' food in an attempt to reduce their weight may add to the dog's stress by removing one of their coping mechanisms and therefore be detrimental to their welfare (McMillan, 2013). If the source of the dog's stress (its workload) cannot be removed or reduced, then other ways of helping the dog to cope, such as non-working exercise, may help (McMillan, 2013). In this study, dogs that were free-run more frequently tended to be above their optimum weight, although they may not be representative of the general WGD population. GDO may also have allowed their WGD to free-run more frequently to promote weight loss if the dog was overweight. Potential links between weight status, appetite, stress levels and the amount of working exercise and free runs that WGD receive warrant further investigation (McMillan, 2013).

Monitoring the weight of the dog

In the univariate analysis, GDO who monitored their dog's weight by feel or by weighing them at the veterinary surgery had dogs with a lower bodyweight than GDO who did not, although only weighing the dog at the veterinary surgery remained in the final model. Similarly, GDO who monitored their dog's weight by feel or by the fit of the harness had dogs with a lower percentage weight difference than GDO who did not, although only monitoring the dog's weight by feel remained in the final model.

Many GDO referred to feeling the dog as they groomed them or when they examined them after a walk. The majority of the GDO (n=44, 88%) groomed their dog at least weekly, therefore most GDO probably assessed their dog's weight either consciously or subconsciously every week. Such regular monitoring of the dogs' weight should allow early detection of any changes,

enabling measures to be put in place to maintain the dog at its optimum weight before significant weight gain occurs (German, 2016a).

To the author's knowledge, there are no published studies investigating whether dog owners who monitor their dogs' weight regularly are less likely to have overweight dogs, although regular monitoring of a dog's weight during a weight-loss program improves adherence and weight-loss success (Bauer, 1998; Remillard, 2001; Brooks *et al.*, 2014; Candellone *et al.*, 2017).

Previous Guide Dogs

GDO who had owned one or more WGD prior to their current dog had dogs of a higher bodyweight than GDO who were first-time WGD owners. GDO advice on weight management has changed over time (Jill Tromans, Guide Dogs, personal communication) but if GDO had developed strong habitual behaviours around feeding and exercising their dog, these may be difficult to change (Gollwitzer and Sheeran, 2006; Verplanken and Wood, 2006). Individuals tend to follow established routines because they are efficient and can be carried out with little conscious thought (Betsch *et al*., 1998; Verplanken and Wood, 2006), so GDO may ignore updated guidance and might even avoid information that challenges their current behaviour (Verplanken and Wood, 2006). Furthermore, owners' personal attitudes and behaviours around diet and exercise often extend to their pets (Kienzle *et al.*, 1998; Nijland *et al.*, 2009; Jung *et al.*, 2017). As attitudes tend to be stable over time (Prislin, 1996), the attitudes and behaviours that GDO developed with their first WGD could persist with subsequent dogs.

Number of people in the household

Dogs living in a household with a larger number of people had a lower percentage weight difference. Larger households provide increased opportunities for the dog to play, leading to increased energy expenditure and therefore reducing the risk of being overweight (Robertson, 2003). Positive interactions with people may also help to reduce a dog's stress levels and therefore stress eating (Hennessy *et al.*, 2002, 2003; Luno *et al.*, 2018). In contrast, Bland *et al.* (2009) and Munoz-Prieto *et al.* (2018) found that dogs considered normal weight were more likely to live in a house with fewer people. Bland *et al.* (2009) suggest that this is because it is more difficult to manage a dog's food intake in larger households, especially those with children, because children are likely to discard food or feed the dog from the table. There were too few households with children in the current study to investigate whether the number of children or the age of the youngest child was significantly associated with the weight status of the dog.

Households where other dogs are present may also provide increased opportunities for the dog to play, increasing energy expenditure and reducing the risk of it being overweight (Robertson, 2003). In the current study, other pets in the household were not significantly associated with the dogs' weight status.

3.3.2 Methodology

GD recommend that telephone interviews are used to survey GDO to enable a consistent method of data collection from GDO with differing degrees of visual impairment and variable use of technology (David Grice, personal communication). This restricted the sample to GDO who had access to a telephone (Sturges and Hanrahan, 2004) but in 2014, 94% of the UK population had a mobile telephone (Statista, 2019) so the sampling error was likely to be small. One advantage of telephone interviews was that they enabled the inclusion of a greater number of participants from a wider geographical area than if face to face interviews had been conducted because of reduced travelling time and associated costs (Chapple, 1999; Glogowska *et al.*, 2011; Irvine, 2011).

Telephone interviews have previously been validated for collection of data on diet and exercise in dogs (Sonnenschein *et al.*, 1991; Slater *et al.*, 1992; Sallander *et al.*, 2001) by comparing data obtained from telephone interviews with that from a 7-day food or exercise diary. Questions on diet and feeding generally had a sensitivity of >70%, but the specificity was much more variable, *i.e.* responses were more likely to reflect reality when a certain food was said to be fed compared to when it was not (Sallander *et al.*, 2001). An open question about what the dog is fed, as used in the current study, may therefore produce similar quality data as asking the owner to respond 'Yes' or 'No' to a list of foodstuffs. Questions on frequency, intensity and type of exercise generally had sensitivities and specificities >70% and repeatability for questions on health, bodyweight and BCS were also excellent (Sallander *et al.*, 2001).

Benefits of conducting qualitative interviews over the telephone rather than face-to-face are increased anonymity for participants, which may make them feel more comfortable discussing potentially sensitive topics such as weight. (Chapple, 1999; Sturges and Hanrahan, 2004). Participants also have more control over their environment (Holt, 2010), making telephone interviews feel less intrusive and emotionally intense than a face-to-face interview (Irvine, 2011). Telephone interviews also minimize inconvenience for respondents, allow notes to be taken during the interview without distracting the interviewee and may increase the quality of the data obtained (Sturges and Hanrahan, 2004).

Disadvantages of telephone interviews are that it can be harder for the interviewer to build rapport with the participant without visual cues such as such as body language and facial expressions (Chapple, 1999; Sturges and Hanrahan, 2004) which could reduce the quality of data compared to a face-to-face interview (Glogowska *et al.,* 2011). It can also be more difficult for the researcher to encourage the participant to continue speaking when visual clues such as nodding cannot be appreciated, so short affirmations such as 'right', 'yes' or 'OK' can be used to encourage the interviewee to continue talking (Holt, 2010). These effects were probably minimal in the current study as GDO are less reliant on non-verbal cues than a sighted person because of their visual impairment. Moreover, it has been proposed that the lack of non-verbal cues

may generate much richer data because everything has to be articulated (Holt, 2010).

A semi-structured format was chosen for the interviews to make them feel less formal (Irvine, 2011) and to allow participants to express their opinions and ideas in terms meaningful to them (Stephens, 2007). The interview guide ensured that questions were asked in a consistent way, all the necessary topics were covered, and prompting and clarifying questions could be asked where appropriate (Stephens, 2007). The natural flow of the conversation may have meant that some areas of quantitative data collection were not fully explored in this study (Glogowska *et al*., 2011) but richer data could be collected than if a structured questionnaire had been used.

3.3.3 Limitations of the study

Study design

A major limitation of this study was the cross-sectional design, which could identify associations between weight status and potential risk factors, but not demonstrate causation (Kleinbaum *et al.*, 1982). The sample size was small, with only fifty GDO (around 1% of the 4800 GDO in the UK) interviewed due to time constraints (Section 3.2.1). No sample size calculation was performed, increasing the likelihood of a Type II error (false negative) and reducing the power of the study (its ability to detect a genuine association) (Hyde *et al*., 2021). *Post hoc* power calculations were not performed as they do not generally provide useful results (Zhang *et al*., 2019). Furthermore, the sample may not have been representative of the GDO population in the UK and so results must be interpreted with caution. There were also insufficient numbers of GSD and Golden Retrievers for separate statistical analyses of these breeds.

Participants

Participants were self-selected volunteers, which may have biased the sample towards GDO with a positive attitude, active and fulfilled lives and a satisfactory amount of social interaction (Yamamoto *et al.*, 2015; Glenk *et al.*, 2019). The majority (66%) of respondents were female, whereas at the time the interviews were conducted, 52% of GDO were female and 48% were male. This is in line with the findings of Smith (2008), but is another potential source of selection bias. In hindsight, a larger proportion of male GDO should have been interviewed to mirror the gender distribution of the GDO population.

If time and resources permitted, a formal sample size calculation could have been performed to determine the number of GDO required to ensure that the study was adequately powered. These GDO should be a random sample of all GDO and interviewed by a single interviewer. The use of a structured questionnaire, similar to that used for the BSH and PDO, would enable the collection of a larger quantity and higher quality of quantitative data. This would increase the reliability and generalisability of the findings to other GDO.

Sources of bias

The study was described as 'health-related research' and did not specifically mention dog weight to try to avoid selection bias relating to the weight status of the dog. Social desirability bias may have affected the responses given by the GDO during the interviews. Social desirability bias is where survey respondents answer questions in a way they think will be viewed more favourably than their true attitude or behaviour through a desire to avoid embarrassment (Fisher, 1993; Grimm, 2010; Kaminska and Foulsham, 2013). Although the GDO were assured of anonymity and confidentiality, they may have been concerned that information they provided would be passed on to GD, particularly if they were not adhering to GD guidelines. If non-adherence to feeding and exercise recommendations resulted in a dog becoming overweight, there could be repercussions for the GDO, with the dog being removed from the GDO in extreme cases (Jill Tromans, personal communication).

Recall bias, where GDO do not remember or give accurate responses to questions may also have affected the responses (Karvetti and Knuts, 1985; Krall *et al.*, 1988; Tooze *et al.*, 2004). This may be exaggerated in telephone interviews because interviewees have to give an answer immediately rather than having time to consider their responses (Regmi *et al.*, 2016). Differences in the phrasing and order of the questions may also have biased the results, although the use of an interview schedule, including prompt questions if necessary, helped to maximise consistency between participants.

Reflexivity, the interviewer's own influence on the data collection and interpretation process though their personal biases and assumptions, may have affected the results. It is possible that quantitative data were misinterpreted or not recorded during the interviews. There may have been errors in manual data entry, although care was taken to record data completely and accurately (Fan and Yan, 2010). Ideally data would have been extracted and recorded collaboratively or double-checked by a second person but this was not feasible due to time and financial constraints. For the qualitative study, the author conducted the interviews, a research assistant carried out the thematic analysis, with a second research assistant involved in double-coding, which increased the number of perspectives on the data collected (Jootun *et al.*, 2013).

Only nine of the 50 interviews (18%) were transcribed for thematic analysis. Ideally at least 12 interviews would have been transcribed and analysed to ensure data saturation was reached (Guest *et al*., 2006) but this was not possible within the time available. Recurring themes were still identifiable from the nine transcripts and these were sufficient to inform the response options for the BSH questionnaire. However further themes may have emerged if more interviews were transcribed and analysed.

Possible outcome variables

Body Condition Score

The original intention for the current study was to use the most recent BCS recorded on GDI-R for the WGD at the time of interview as the outcome variable. BCS is the most widely accepted clinical method of assessing weight status (Laflamme, 1997; Burkholder, 2000; German *et al*., 2006) and the majority of previously published studies on risk factors for overweight status in dogs (Spain *et al.*, 2004; McGreevy *et al.*, 2005; Colliard *et al.*, 2006; Lund *et al.*, 2006; Bland *et al.*, 2009; Courcier *et al.*, 2010; Heuberger and Wakshlag, 2010; Sallander *et al.*, 2010a; Warren *et al.*, 2011) used BCS as their outcome variable, although different scales (5-point, 7-point, 9-point and modified 5-point scales) were used. However, the inconsistencies between the BCS recorded on GDI-R and the percentage weight difference of the WGD demonstrated that the BCS recorded on GDI-R were unreliable. This was an unexpected but important finding of the current study as it revealed that even trained and experienced assessors do not consistently assign BCS.

Both the 5- and 9-point BCS systems have previously been shown to be reliable if assessors are trained in their use (Burkholder, 2000; Blageanu and Vulpe, 2018). GD dog care staff are trained in BCS using images and written descriptions of visible and palpable criteria for BCS and perform the assessment regularly. However, when people repeatedly perform tasks in the same context, those behaviours become habitual and automatic, with less awareness and conscious thought involved (Betsch *et al*.,1998; Kurzweil, 2006; Verplanken and Wood, 2006). This may lead to the BCS assigned by GD staff becoming less reliable over time.

BCS is a subjective assessment and even the use of scoring systems with defined criteria cannot completely eliminate inter-rater variation (Li *et al.*, 2012). There are over 35 dog care staff at the NBC, so inter-rater differences in assessing BCS could account for the discrepancies seen between BCS and bodyweight in some WGD. Regular 'refresher' training in BCS for GD dog care staff may help to ensure consistency between staff and over time. Alternatively, fewer people or even a single person assessing BCS would reduce inter-rater variability and improve the reliability of the BCS recorded but this may not be practical in a big organisation.

Guide Dog Owner-reported weight

Once the BCS of the WGD had been excluded as a reliable outcome variable, the use of the weight of the dog as reported by the GDO was considered. Owner-reported weights for their dogs have previously been used as outcome variables in studies investigating risk factors for overweight status in dogs (Robertson, 2003; Spain *et al.*, 2004; Bland *et al.*, 2009; Sallander *et al.*, 2010a; Heuberger and Wakshlag, 2011b). Although a higher bodyweight does not necessarily mean that a dog is overweight, both Robertson (2003) and Heuberger and Wakshlag (2011b) found that overweight dogs weighed significantly more than non-overweight dogs, although the weight status of the

dogs (underweight, correct weight or overweight) in both studies was owner-reported.

White *et al.* (2011) found that 69% of 121 owners knew their dog's weight in kilograms or pounds (lbs) when interviewed after a veterinary consultation and similarly, Courcier *et al* (2010) found that 426 of 696 dog owners (61%) could state their dog's weight when completing a questionnaire at their veterinary practice. Robertson (2003) interviewed 657 owners of 860 dogs and found that the weights of 386 dogs (45%) were known by their owners, although the time since the dog was last weighed was not recorded. Robertson (2003) also found that owners of overweight dogs were more likely to know the weight of their dog than owners of normal weight dogs. These findings show that many dog owners know the weight of their dog, particularly if their dog has been weighed recently or they think that their dog is overweight. Even if an owner does not know their dog's weight, they are able to estimate it accurately, with a high correlation (r=0.97) between measured and estimated weight (Colliard *et al.*, 2006). GDO may be more likely to know their WGD's current weight than PDO because of the regular monitoring of WGD weights by GD and the emphasis placed on maintaining WGD at a healthy weight. There was a good correlation between the GDO-reported weight of the WGD and the most recent weight recorded on GDI-R prior to the interview, suggesting that GDO generally knew and reported their WGD's weight accurately. The GDO-reported weights in the current study may still have been affected by recall and social desirability bias and so could be underestimates of the WGD actual weights (Grimm, 2010; Kaminska and Foulsham, 2013).

All the dogs in this study were WGD and therefore would have been at least 2 years old. Adult bodyweight is reached at around 325 and 326 days for female and male GSD respectively and 319 and 335 days for female and male Labradors (Helmink *et al.*, 2000), so the dogs in this study were fully grown (Salt *et al.*, 2017). This, together with the fact that all WGD were of similar breeds and from a limited gene pool, suggest that higher bodyweight could be linked with higher levels of body fat. However, actual or owner-reported bodyweights are only proxy measures of a dog's weight status (Dorsten and Cooper, 2004) and should be compared with the dog's ideal weight to give a true indication of its weight status (Elliott, 2006; Blageanu and Vulpe, 2018). Bodyweight can vary depending on hydration and gut fill and so may fluctuate from day to day and even within a day (Fabretti *et al*., 2020). Furthermore, bodyweight does not necessarily correlate with fat mass (German *et al*., 2009; Smith *et al*., 2018). By comparison, BCS is independent of bodyweight and frame size and is a more accurate measure of weight status (Burkholder, 2000; Blageanu and Vulpe, 2018). Ideally, a single trained assessor would have performed a hands-on assessment of each dog to obtain accurate BCS data for the WGD in this study, but time and geographical constraints meant that this was not feasible (Gant *et al*., 2016).

Percentage weight difference of the dog from its optimum weight

In this study, the percentage weight difference was calculated as the difference between the WGD actual weight and its optimum weight as recorded on GDI-R, expressed as a percentage of its optimum weight (Nijland *et al.*, 2009; German *et al.*, 2012a). Optimum weights are set based on the weight of the dog at BCS 5, but they are set by the regional DCWA and rarely confirmed by a second person (Guide Dogs, personal communication). GD have an in-house version of the 9-point BCS system which is used by all staff for BCS but there is little ongoing training and only one informal *ad hoc* check for BCS consistency between staff has been reported (Guide Dogs, personal communication). As BCS is a subjective measure of bodyfat (Burkholder, 2000), the degree of adiposity when present when the dogs were assigned a BCS of 5 and their optimum weights set may vary between DCWA. However, fewer people (n=23) are involved in setting optimum weights compared to assigning BCS, so inter-rater variability should be lower and reliability greater than BCS assigned by multiple people (Laflamme, 1997; Mawby *et al*., 2004; Elliott, 2006). Percentage weight difference reduces the effect of individual frame size on bodyweight and may be more objective than BCS (Blageanu and Vulpe, 2018).

3.3.4 Conclusion

The majority of the risk factors identified in this study were GDO behaviours relating to feeding, exercise and monitoring their dog's weight. However, WGD are a very specific population of dogs, who are all neutered, between 2 and 11 years of age and from a limited number of medium-sized breeds and their crosses. In addition, the bond between the GDO and their WGD may differ from that between a pet dog and its owner or a BSH and the brood/stud they care for, hence further studies are needed to investigate whether these findings can be generalized to other populations of dogs and their owners/carers.

The next chapter (Chapter 4) describes an investigation into how the feeding and exercise management of a sample of Guide Dogs' Breeding Stock affects the dog's weight status. These dogs belong to GD but are cared for by volunteers who keep them as pets in their own homes. The dogs are similar ages and from the same breeds and crosses as WGD but are all entire.

Chapter 4: Investigation of Risk Factors for Overweight status in Guide Dogs' Breeding Stock

The previous chapter (Chapter 3) explored possible links between GDO's and their dogs' characteristics and behaviours and the weight status of the dog. The main findings of that chapter were that predictors for the GDO-reported weight of the dog included the sex of the dog, the sex of the GDO, whether the GDO had had WGD previously and whether the GDO monitored the dog's weight by weighing it at the veterinary surgery. When the percentage weight difference of the dog was used as the outcome variable, the main predictors for the weight status of the dog were the duration of the dog's working exercise per day, whether the GDO took the dog's treats from its daily ration, monitored its weight by feel and the number of people in the household. Most of the explanatory variables significantly associated with the percentage weight difference of the dog in the final model were related to GDO behaviours around feeding, exercise and managing their dog's weight, demonstrating that GDO behaviours have a greater impact on the weight status of their WGD than dog behaviours such as scavenging and coprophagia.

For a GDO, their dog is a mobility aid, facilitating greater independence and increasing social interactions as well as being a companion. GDO may therefore have a different relationship with their dog to other dog owners/carers and different motivations for keeping their dog in optimum health (Introduction to Chapters 3, 4 and 5). This makes it important to compare the risk factors for overweight status found in the GDO study to those from other populations of dog owners/carers.

The first population chosen for comparison was BSH, volunteers who look after GD breeding stock in their own homes. GD breeding stock remain the property of GD and so the relationship between a BSH and their brood/stud is likely to differ from that of a WGD or pet dog and its owner. BSH are generally individuals who are highly motivated to care for their dogs, due to the extensive training and time commitment required for the ongoing management of the dogs. However, unlike a GDO, they do not rely on their dog as a mobility aid.

As with the GDO study (Chapter 3), the use of this second population of dogs belonging to GD addresses many of the limitations identified in the scoping review (Chapter 2). In summary, the broods/studs are from a limited number of medium sized breeds (Labradors, Golden Retrievers, Flat Coat Retrievers, GSD, Standard Poodles) and crosses of these breeds. GD breed the majority of their own dogs so both the breeding and working stock come from a small gene pool. The puppies bred by GD are all managed in a similar way, being cared for by PW from 7 weeks old until they are selected for training as working dogs or PBS at around 12-14 months old. During this time the dogs' weights are monitored and their food adjusted to maintain the dogs at a healthy weight. Both BSH and GDO are given substantial training by GD on exercising and feeding their dogs, and educated on the importance of keeping the dog at a healthy weight.

Similar to WGD (Section 3.2.13), all Guide Dogs' breeding stock have an optimum weight set by a single individual, the Breed Stock Health Advisor (BSHA) based on the dog's weight at a BCS of 5. This is initially done when the dogs are 12-14m old, but is reviewed again when the dogs are accepted as breeding stock at around 2 years of age and therefore fully grown (Helmink *et al.*, 2000; German *et al.*, 2017a,b; Salt *et al.*, 2017). The dog's weight at 2 years old and BCS 5 is formally recorded as the dog's optimum weight. GD check each brood's/stud's weight every 4-6 months and weights and BCS are recorded by a member of Guide Dogs' Dog Care staff (n=approximately 35) when visiting the NBC for mating, whelping or boarding. Any discrepancies between BCS and optimum weights are checked by the BSHA and amendments made as necessary. Although the optimum weights for all breeding stock are set by one individual, thereby eliminating inter-rater variability, they are rarely confirmed by a second person, and so may be affected by subjective interpretation of what constitutes a BCS of 5.

The main difference between the dogs in the GDO and BSH study populations is that all WGD are neutered, whereas all breeding stock are entire. The inclusion of breeding bitches in the study population meant that the potential effects of pregnancy and lactation on the weight status of the dog needed to be considered. Other minor differences between WGD and GD breeding stock are that breeding stock can enter the breeding program from 19 months of age, compared to WGD which would be around 24 months old at qualification. Females are retired from breeding at 7 years old and males when their health or fertility starts to decline, usually at around 9-10 years of age. WGD are retired at around 10 years old unless their health starts to decline earlier.

The main aim of this chapter was to investigate the risk factors for overweight status in a sample of GD breeding stock with a view to establishing links between dog and carer characteristics and behaviours and the weight status of the dog. A secondary aim of this chapter was to gather data to inform the development of an online questionnaire for pet dog owners of GD-type breeds (Chapter 5).

The following objectives were set for this study: (1) to develop and distribute an online questionnaire to all BSH on the GD email distribution list; (2) to interrogate the resulting data to look for links between the weight status of the dog and a) BSH behaviours around feeding, exercise and general care, b) the dog's behaviour around food, c) the BSH responses to these behaviours and d) dog and BSH characteristics; and (3) to generate data which would enable comparisons between the findings of the BSH questionnaire with those of the GDO (Chapter 3) and PDO (Chapter 5) surveys to determine similarities and differences between these groups of dog owners/carers.

4.1 Materials and Methods

4.1.1 Recruitment of participants

All BSH on the GD email distribution list (n=314) were invited to participate in the study. A formal sample size calculation was not performed but all BSH who were willing to participate were recruited. Informed consent was requested using six check boxes on the front page of the questionnaire. Identifying data about the BSH themselves were only collected if the BSH requested a summary of the results, therefore BSH are referred to by their respondent number *(BSH 1, BSH 2 etc)* from hereon.

4.1.2 Questionnaire design

A questionnaire was designed to investigate feeding and exercise management of GD breeding stock. The questions mirrored the questions used in the GDO interviews as far as possible, with the options for the tick box questions being informed by the quantitative and qualitative responses given by the GDO during the interviews.

The questionnaire was input into an online survey tool (www.surveygizmo.com/) utilising a variety of question types, such as dropdown menus, tick boxes and free text boxes as appropriate. The questionnaire link was then sent out to ten dog owners for piloting. This group of owners included three BSH plus a GD Research Associate who was also a BSH.

Seven of these dog owners completed the pilot questionnaire and the questionnaire was refined in response to their feedback. The final questionnaire was divided into 15 pages (Table 4.1) (Appendix 2).

Table 4.1: Summary of an online questionnaire on feeding and exercising their dog distributed to 314 Guide Dogs' Brood Stock Holders.

Page number	Page title	Summary of Contents	Type of Questions
Page 1	Welcome page	Introduction to the author and the study. Confidentiality and anonymity Ethical Approval Contact details of the author, a Canine Research Associate at Guide Dogs and the Head of the SVMS Ethics Committee.	N/A
Page 2	Consent form	Consent required for participation in the trial	Compulsory *
Page 3	Brood/stud details	Name of dog Breed, sex, age, length of time dog been with holder, number of broods/studs held previously	Free text Dropdown menus
Page 4	Other pets	Numbers and types of other pets in the household	Dropdown menu
Page 5	General care of brood/stud	Frequency of grooming and tooth brushing Other routine care	Dropdown menu Free text
Page 6	Rewards and Treats	How dog rewarded for good behaviour Situations where treats given Type of treat given Frequency of treats	Checkboxes with multiple options allowed plus boxes for comments. Dropdown menu
Page 7	Brood's /stud's interest in food	Brood's/stud's behaviour while BSH is preparing food/eating BSH interaction with dog while they are preparing food/eating	Checkboxes, some with multiple options allowed, plus boxes for comments.
Page 8	Brood's /stud's interest in food	Dog's begging behaviour BSH response to dog begging	Dropdown menu plus free text

		Vignette to assess dog's greed Scavenging Coprophagia	Free text Checkbox grids
Page 9	Feeding the Brood/Stud	Current food type Frequency of feeding Decision on and measurement of amount fed Dietary supplements given Routine at feeding time	Checkboxes, some with multiple options allowed, plus boxes for comments. Free text Dropdown menu
Page 10	Activity levels of Brood/Stud	Exercise on and off lead on weekdays and at weekends Activity levels at home	Textbox grid VAS with range: 'Not active at all, spends all their time asleep' to 'Extremely active, on the go all the time'
Page 11	Weight of Brood/Stud	BSH knowledge of brood's/stud's current and optimum weight BSH opinion of brood's/stud's weight	Dropdown menu VAS with range: 'Very underweight' to 'Very overweight'
Page 12	Health of Brood/Stud	Long term health problems	Checkboxes plus box for comments.
Page 13	BSH demographics	Location, age, sex of BSH Number of people in household, age of any children, working status Height and weight of BSH	Checkboxes plus boxes for comments. Dropdown menu Free text
Page 14	Additional comments	Any other relevant information Option to leave contact details if willing to help with future research	Free text
Page 15	Thank you page		N/A

BSH=Brood Stock Holder, SVMS=School of Veterinary Medicine and Science, University of Nottingham, VAS=Visual Analogue Scale

* Participants disqualified if consent not given

4.1.3 Questionnaire distribution

An email containing the link to the BSH questionnaire was sent to all BSH on the GD email distribution list (n=314) in April 2014. The email introduced the author, explained that the purpose of the study was to investigate feeding and exercise management of GD breeding stock and requested BSH participation in the study.

One month later, a further email was sent to all BSH via the GD distribution list, to thank the BSH who had already completed the questionnaire and remind any BSH who wished to take part in the survey, but had not yet done so, to complete the survey during the following week. The survey was closed a week later and the full dataset downloaded from SurveyGizmo into a spreadsheet (Microsoft Excel 2013; Microsoft Corp., Redmond, Washington) for cleaning.

4.1.4 Data cleaning

Any responses where no consent had been given or no questions had been answered beyond the consent page were deleted. Respondents who had partially completed the questionnaire were cross-checked using the 'Find' function in Microsoft Excel 2013 (Microsoft Corp., Redmond, Washington) to see whether that respondent had subsequently restarted and fully completed the questionnaire. If so, the partial response was deleted from the dataset.

Exercise data were cleaned in a similar way to the GDO data (Section 3.1.4). The heights of the BSH were rounded up if fractions of inches or centimetres were given *e.g.* 5'3½" was rounded to 5'4". If the BSH had given their height as a decimal, for example 5.5, it was assumed that this meant 5'5". Where an answer was given in feet but no inches were recorded, it was assumed that this meant the BSH was exactly 5'0" or 6'0" tall. If BSH had entered their weight as a decimal *e.g.* 9.2, it was assumed that this meant 9 stone 2 lb.

For BSH who had provided both their height and their weight, BMI were calculated as for the GDO (Section 3.1.4). If BSH had given their height or weight in both metric and imperial units, the imperial units were used.

Free text responses were categorised and grouped into similar responses to enable statistical analysis where appropriate. Examples of free text responses are denoted by respondent number *e.g. BSH 27.*

Where possible, the actual and optimum weights for each dog, its BCS and the date these measurements were recorded were obtained from GDI-R. The reproductive status of each bitch at the time of questionnaire completion was also calculated and these data added to the dataset for statistical analysis. The data for pregnant and lactating bitches were interrogated to see whether they should be excluded from the dataset.

4.1.5 Statistical analysis

Statistical analysis was carried out as for the GDO data (Section 3.1.5). Partial responses were included in the analyses, with cases excluded pairwise to deal

with missing data. Results were regarded as statistically significant if $p<0.05$ unless otherwise stated.

Mann-Whitney tests were carried out to investigate any differences in weight between male and female dogs and non-pregnant, pregnant and lactating bitches. A Kruskall-Wallis test was used to investigate any breed differences in weight. The weight distributions for dogs of different sexes and breed were controlled for as necessary by including them as random effects.

1. Selection of an appropriate outcome variable.

The lack of recent BCS recorded in GDI-R for WGD and the poor correlation of the recorded BCS with the percentage weight difference (Chapter 3) meant that alternative ways of assessing the weight status of the breeding stock were considered. The three outcome variables that were investigated were: the brood's/stud's BCS as recorded on GDI-R; the weight of the brood/stud as reported by the BSH; and the difference between the brood's/stud's actual weight and its optimum weight as recorded on GDI-R, expressed as a percentage of its optimum weight (Nijland *et al.*, 2009; German *et al.*, 2012a). This will be referred to as percentage weight difference:

$$\text{Percentage weight difference} = \frac{\text{actual weight} - \text{optimum weight of brood/stud}}{\text{Optimum weight of brood/stud}} \times 100$$

The most recent BCS, weight and optimum weight recorded on GDI-R before questionnaire completion were used for the analyses.

2. Associations between dog and BSH characteristics and behaviour and the weight status of the dog

The same 4-step process was repeated for all three outcome (dependant) variables:

Step 1. Univariate analysis

This was performed as for the GDO data (Section 3.1.5).

Step 2. Avoiding multicollinearity

This was performed as for the GDO data (Section 3.1.5).

The groups of dog and owner characteristics and behaviour were then checked for multicollinearity using Chi squared tests, Spearman's rank correlation coefficients, Mann-Whitney or Kruskal-Wallis tests, depending on the types of data being compared.

Step 3. Principal Components Analysis (PCA): Dog Characteristics and Owner Characteristics and Behaviour

A Principal Components Analysis (PCA) was carried out on the groups of significant dog and owner characteristics to reduce the number of variables. A PCA produces a single composite score for a number of associated variables and helps avoid multicollinearity (Budaev, 2010). Measures of sampling

adequacy (Bartlett's sphericity test and the Kaiser-Meyer-Olkin test) were checked for both dog and owner PCAs to ensure that PCA was appropriate for these data. The total variance explained by each component (group of variables) was examined and components with Eigenvalues >1 extracted, as these explain more variance than a single item. These components were then rotated using a Varimax (orthogonal) rotation (Tabachnick and Fiddell, 2007) to produce independent factors. Factor loadings > 0.4 were considered interpretable (Budaev, 2010). Any variables that cross-loaded across components were removed and the PCA repeated until each variable loaded onto a single component (Steptoe *et al*., 1995). The factor (regression) scores for each component were calculated, associations between these scores and the dependent variable investigated and underlying constructs for each component considered. Any factor scores that were significantly associated with the dependant variable ($p < 0.2$) were taken forward into the model in step 4.

Step 4. Model building

Factor scores where $p<0.2$ (Dohoo *et al.*, 2003) from both the BSH and brood/stud PCA went forward into a single modelling process, along with any variables that were associated with the outcome variable ($p<0.2$) that were not included in the factor scores. Dog breed was included as a random effect to control for weight differences between breeds. Both a forward regression and backwards elimination process were performed (Courcier *et al.*, 2011) and the significant variables ($p<0.05$) in the resulting models were checked for interaction. Each interaction was added to the relevant model and retained if statistically significant ($p<0.05$).

The residuals from the models were checked for homoscedasticity (*i.e*. that the variance around the regression line was the same for all values of the predictor variable) by plotting the standardised residuals against the standardised predicted values and visually assessing the scatter plot (Dohoo *et al.,* 2003).

4.2 Results

4.2.1 Response rate

Of the 314 BSH who were emailed the link to the questionnaire, 167 responded. One respondent did not answer the consent questions and so their responses were excluded from the analysis. This left 166 useable responses, giving a response rate of 53%. Not all respondents completed the entire questionnaire so results are presented as n=x/y where x=number of responses and y=number of respondents who answered the question.

4.2.2 Respondent demographics

The majority of respondents were female, but there was a range of responses to the other demographic questions (Table 4.2).

Only 132/160 (83%) respondents who completed the demographic questions gave both their heights and weights, enabling their BMIs to be calculated. The

median BMI was 24.3kg/m^2 (IQR: 22.1–27.4kg/m^2). Of these 132 BSH, 75 (57%) were a healthy weight (BMI 18.5–25kg/m^2), 38 (29%) were overweight (BMI 25.1–30kg/m^2) and 19 (14%) were obese (BMI>30.1kg/m^2).

Table 4.2: Demographics of 166 Brood Stock Holders who completed an online questionnaire about feeding and exercising their brood/stud.

Demographic question	Response: Number (%) of participants
BSH Sex	Male: 17/159 (11%) Female: 142/159 (89%)
BSH age (years)	18-24: 3/157 (2%) 25-34: 6/157 (4%) 35-44: 24/157 (15%) 45-54: 52/157 (33%) 55-64: 43/157 (27%) 65-74: 29/157 (18%) 75-84: 3/157 (2%)
BSH working status	Full time employment: 23/159 (14%) Part time employment: 51/159 (32%) Retired: 50/159 (31%) Homemaker: 29/159 (18%) Seeking work: 1/159 (1%) Other: 5/159 (3%)
Number of people in household	1: 12/160 (8%) 2: 73/160 (46%) 3: 19/160 (12%) 4: 36/160 (23%) 5: 14/160 (9%) More than 5: 6/160 (4%)
Number of children under 18 years of age old in household	No children reported: 103/166 (62%) 1: 20/166 (12%) 2: 28/166 (17%) 3: 13/166 (8%) 4: 2/166 (1%)
Age of youngest child (years)	None/not reported: 104/166 (63%) Median: 11, IQR = 6 (7–13)
Location	Urban: 10/160 (6%) Suburban: 66/160 (41%) Rural: 82/160 (51%) Other: 2/160 (1%)
Number of broods/studs held previously	None: 116/165 (70%) 1: 31/165 (19%) 2: 10/165 (6%) 3: 6/165 (4%) 4: 2/165 (1%)

BSH = Brood Stock Holder, IQR = Interquartile range

4.2.3 Brood/stud details

One BSH did not answer the question about the age of their brood bitch or how long they had had her but the questions about the breed and sex of the brood/stud were fully completed (Table 4.3).

Table 4.3: Demographics of 166 Guide Dogs' Broods/Studs from an online questionnaire about brood/stud feeding and exercise.

Brood/stud details	Response: Number (%) of participants
Sex	Male: 33/166 (20%) Female: 133/166 (80%) Neither pregnant nor lactating: 86 (52%) Pregnant: 16 (10%) Lactating (<6 weeks post-partum): 15 (9%) Uncertain reproductive status: 16 (10%)
Age (years)	Median: 3, IQR: 3(2–5)
Breed	Labrador: 108/166 (65%) Golden Retriever: 33/166 (20%) Labrador x Golden Retriever: 10/166 (6%)* German Shepherd: 10/166 (6%) Golden Retriever x Labrador: 3/166 (2%)* Golden Retriever x Flat Coat Retriever: 1/166 (1%) Standard Poodle: 1/166 (1%)
Length of time brood/stud been with holder (years)	Median: 2, IQR: 3(1–4)

IQR = Interquartile range

* These two groups were combined for statistical analysis

4.2.4 Care of the Brood/Stud

The majority of BSH (n=134/166, 81%) said that they groomed their dogs at least weekly, while only one BSH (1%) said that they never groomed their dog. In contrast, only 45 BSH (27%) said that they brushed their dog's teeth at least weekly, while 75 (45%) said that they never brushed their dog's teeth (Table 4.4).

Table 4.4: Frequency with which 166 Guide Dogs' brood stock holders reported that they groomed their dogs and brushed their dogs' teeth.

Frequency	Number (%) of responses to the question 'How often do you groom your dog?'	Number (%) of responses to the question 'How often do you brush your dog's teeth?'
Daily	29 (17%)	8 (5%)
Every 2-3days	55 (33%)	15 (9%)
Weekly	50 (30%)	22 (13%)
Fortnightly	14 (8%)	5 (3%)
Less often than fortnightly	16 (10%)	34 (20%)
Never	1 (1%)	75 (45%)
Prefer not to answer	1 (1%)	7 (4%)
No response	-	-
Total	**166**	**166**

There were free text comments from 53 BSH (32%) about the routine care of their brood/stud. Eleven BSH (21%) stated that they gave their brood/stud dental sticks, chews, bones, carrots or 'Plaque off' for dental health. Only one of the 53 BSH (2%) mentioned exercise and another one (2%) mentioned monitoring their stud's weight.

4.2.5 Exercise

The median length of time that BSH (n=158, 95%) reported that they walked their brood/stud for was 45mins on a typical weekday (IQR:25-60mins) compared to 60mins (IQR:25-68.5mins) at the weekend (n=151, 91%).

BSH (n=152, 92%) reported that their brood/stud was exercised off-lead away from the BSH house and garden on a typical weekday for a median of 45mins (IQR:30-60mins). At the weekend, this increased to 53mins (IQR:30-75mins) (n=153, 92%).

4.2.6 Activity level of Brood/Stud at home

The median response of the BSH (n=160, 96%) to the question about their brood's/stud's activity levels at home on a Visual Analogue Scale (VAS) where 0=not active at all, spends all their time asleep and 100=extremely active, on the go all the time was 49 (IQR:33-59.3).

4.2.7 Feeding

The majority of BSH fed their broods/studs twice a day (n=151/161, 94%). Five dogs (3%) were fed three times a day; two broods/studs (1%) were fed once a day in the evening and one stud dog (1%) once a day in the morning. One brood was currently being fed four times a day as she was feeding ten puppies, while another BSH stated that they left the bowl down all day for their stud.

All except one BSH fed their brood/stud dry food (n=161/162, 99%), with just one brood (1%) fed Butcher's Tripe. Similar numbers of BSH fed dry food 'as is' (n=75/161, 47%) and added water to it (n=71/161, 44%). Eleven of these 161 BSH (7%) reported adding oil to their brood's/stud's food, while four (2%) said they sometimes added fruit or vegetables. Three of the 161 BSH (2%) said they sometimes added gravy to the dry food, while two (1%) occasionally added table scraps. Three of the 161 BSH (2%) said that they added tinned food to encourage their dogs to eat, while natural yoghurt, treats or Plaque Off were each mentioned by one BSH (1%).

When asked how they decided how much to feed their brood/stud, the majority of BSH (n=146/162, 90%) said that they were told by GD how much to feed their dogs. Two BSH (1%) also said that their veterinary surgeon advised them on the amount of food to give. One BSH who fed her brood three times a day said she decided how much food to give based solely on the instructions on the food packaging *(BSH 97)* while another said that she used the instructions on the food packaging as one way to help her decide how much food to give *(BSH 152)*. Fifteen BSH (9%) said they adjusted the amount of food given according to the brood's/stud's activity levels, while 50 (31%) said they adjusted the amount of food according to the brood's/stud's weight. Three BSH (2%) said that they reduced their brood's/stud's food to compensate for any treats given, while one (1%) said that they gave table scraps if suitable and then reduced the feed accordingly.

When asked how they measured their brood's/stud's food, the majority of BSH (n=110/162, 67%) said that they weighed the food, while 59 (36%) said that they measured the food out with a scoop/cup. Eight BSH (5%) weighed out the food initially and then marked a container to the appropriate level and subsequently fed by volume. Two BSH (1%) said that they weighed the food out into containers or bags in advance. The one BSH (1%) whose brood was on canned food said that she fed her brood a whole tin of food.

4.2.8 Routine at feeding time

When asked about their routine at feeding time, the majority of BSH said that they fed their broods/studs to the whistle (n=103/162, 64%), while 54 (33%) used another form of command to tell the dog to eat. Only five BSH (3%) did not mention the use of a command.

When asked what they did while their brood/stud was eating, the majority of BSH (n=121/162, 75%) said that they did not stand over their brood/stud while they were eating, but were nearby. Twenty-four of the BSH (15%) said that they did not stay with their brood/stud while they were eating while 16 BSH (10%) said that they did.

4.2.9 Dietary supplements

The majority of BSH (n=140/162, 86%) said that they did not give any dietary supplements to their brood/stud while one BSH (1%) said that they were not sure but did not elaborate. Of the 21 BSH (13%) who did give supplements, 19 (11%) used oil such as cod liver oil or treats containing fish oils. Other supplements mentioned were dental health products (n=2, 1%); probiotics, Brewers' yeast tablets, natural yoghurt and glucosamine sulphate (n=1, 1% for each). Four BSH (2%) gave their brood/stud two supplements *e.g.* glucosamine sulphate and cod liver oil.

4.2.10 Treats

Multiple responses were permitted to the questions about treats and rewards, so the total percentage may add up to more than 100%. Depending on the question, three (2%) to five (3%) of the 164 BSH who answered the questions said that they never gave their dog treats, compared with 126 BSH (77%) who gave their brood/stud treats at least once a day (Table 4.5). The majority of BSH either used treats to reinforce training (n=133/164, 81%) or as a reward for good behaviour (n=112/164, 68%), while 20 BSH (12%) gave treats at the vets. A variety of treat types were used, with shop-bought treats and food taken from the daily allowance being the most commonly given (n=92/164, 56% and n=90/164, 55% respectively). Around a third of BSH (n=59/164, 36%) gave dental treats, while 64 BSH (39%) said they gave their dog fruit and vegetables.

Over half the BSH (n=92/164, 56%) used some form of exercise (play/toys or a special walk) as a reward for good behaviour. Food was also commonly used as a reward, with 78 BSH (48%) giving food taken from the dog's daily allowance, 76 BSH (46%) rewarding their dog with dog treats, and 55 (34%) giving fruit or vegetables (Table 4.5).

Table 4.5: Brood Stock Holder-reported use of dog treats and rewards in an online questionnaire about feeding and exercising their dogs (n=166).

Question	Response	Number (%) of respondents
How do you reward your dog for good behaviour? (Multiple responses permitted)	Praise	160 (98%)
	Fuss/cuddles	148 (90%)
	Play/toys	83 (51%)
	Food taken from daily allowance	78 (48%)
	Dog treats *e.g.* bought from a shop, table scraps	76 (46%)
	Fruit or vegetables	55 (34%)
	Special walk	9 (10%)
	Another form of reward	3 (2%)
	No response	2 (1%)
In what situations do you give your dog treats? (Multiple responses permitted)	To reinforce training	133 (81%)
	Reward for good behaviour	112 (68%)
	When leaving the dog on its own	68 (42%)
	Before bedtime	67 (41%)
	On or after a walk	64 (39%)
	At the vets	20 (12%)
	When introducing the dog to new people/animals	6 (4%)
	In response to begging	0 (0%)
	Other situations	2 (1%)
	I don't give my dog treats	4 (2%)
	No response	2 (1%)
What type of treat do you give to your dog? (Multiple responses permitted)	Shop bought treats *e.g.* Bonios	92 (56%)
	Food taken from daily allowance	90 (55%)
	Fruit or vegetables	64 (39%)
	Other types of dog chew *e.g.* Rawhide chews	63 (38%)
	Dental chews *e.g.* Dentistix	59 (36%)
	Table scraps	11(7%)
	Bones from butcher	7 (4%)
	Another type of treat	9 (5%)
	I don't give my dog treats	3 (2%)
	No response	2 (1%)
How often do you give your dog treats?	5 times a day or more	6 (4%)
	2-4 times a day	77 (47%)
	Once a day	43 (26%)
	Every 2-3 days	18 (11%)
	Weekly	5 (3%)
	Less often than weekly	6 (4%)
	Never	5 (3%)
	Other (please specify below)	4 (2%)
	No response	2 (1%)

When asked whether other people in their household gave the dog treats, 85/164 (52%) of the BSH stated that other people in their household gave the brood/stud treats, while 72 (44%) said that no one else in the household treated the dog. Two BSH (1%) were unsure whether anyone else in the house treated the dog, while five BSH (3%) said that the question was not applicable to them.

4.2.11 Brood/stud behaviour around food

Multiple responses were permitted to the question about what the brood/stud did while the BSH was eating, so the total number of responses exceeds the number of respondents for this question.

Nearly two thirds of the BSH (n=104/164, 63%) reported that the brood/stud took no notice of them, while 34 (21%) said that the brood/stud sat and watched them. Six broods/studs (4%) were reported to seek the BSH's attention (*e.g.* by nudging them or lifting a paw) while four (2%) salivated or drooled and one (1%) begged.

Thirty-six BSH (22%) said that their broods/studs displayed 'Other' behaviours while the BSH was eating. These included staying in their bed, basket or chair (n=23/36, 64%) or sitting or lying with the BSH while they ate (n=13/36, 36%). Eight of the 36 BSH (22%) mentioned the use of or need for discipline for the brood/stud while they were eating.

When asked whether their brood/stud begged, 60/163 BSH (37%) stated that their brood/stud did (n=6, 4%) or sometimes begged (n=54, 33%), compared to 99 (61%) who said that their brood/stud never begged. Four BSH (2%) were unsure whether their brood/stud begged or not.

Sixty-eight BSH gave more details about their brood's/stud's begging, with some BSH mentioning more than one behaviour exhibited by their dog. The most frequently described behaviour (n=37/68 BSH (54%) was the brood/stud watching or staring at people while they were eating or preparing food, while 14 of the 68 broods/studs (21%) would try and get close to the BSH or the food. Ten of the 68 BSH (15%) reported that their dog would seek physical contact *e.g.* by nudging them or putting their head on the BSH lap, while eight broods/studs (12%) would drool or salivate. Six broods/studs (9%) would offer a paw and one brood (1%) was reported to whine.

Seven of the 95 BSH (7%) described their brood's/stud's behaviour in anthropomorphic terms such as the dog looking hungry *(BSH 105)* or pleading *(BSH 102).*

Four of the 95 BSH (4%) said that their dog would beg if they knew they routinely got a treat at a certain time while eight (8%) stated that their brood/stud would only beg from other people. One of the 95 BSH (1%) *(BSH 130)* said that their brood begged for attention more than food while another said their brood begged as a party trick *(BSH 164).*

Eighty-three of the BSH described their response to their brood/stud begging, with some BSH mentioning more than one possible response. Thirty eight of the 83 BSH (46%) said that they would ignore their brood/stud, 35 (42%) said that they would actively discourage their brood/stud from begging *e.g.* by sending them to bed or telling them to sit or lie down, and another 17 BSH (20%) said that they would tell their brood/stud to stop. Four BSH (5%) said that they would give their brood/stud a treat in specific circumstances *e.g.* as part of a normal routine but only three (4%) admitted to giving in to their brood/stud begging. One BSH admitted to sometimes giving in to the dog begging, even though he knew he shouldn't:

'Sometimes reward it - I know, I know! ... For example, by giving him a smidgeon of cheese if grating cheese for a meal' *(BSH 15).*

Another BSH justified their use of treats:

'Sometimes give a dog treat if the begging is a response to situation they know they have behaved well' *(BSH 25)*

When asked to describe how the brood/stud would react if the BSH accidentally spilled a large quantity of dog food on the floor while they were preparing their brood's/stud's meal, the responses fell in to four main categories: 59/163 BSH (36%) thought their brood/stud would try to eat the food but would leave it if told to, while 45/163 (28%) thought their dog would ignore or leave the food without being told. Thirty four of the 163 BSH (21%) thought that their brood/stud would attempt to eat as much of the food as possible while 22/163 BSH (13%) said their brood/stud would wait for the command to eat. Three of the 163 BSH (2%) said that they were not sure how their dog would react.

When asked whether their dog scavenged and in what situations, only 42/163 BSH (26%) were sure that their dog did not scavenge. Nine BSH (6%) answered 'Not sure' to at least one part of the question. The responses of the 118 BSH whose were sure their broods/studs did scavenge are summarised in Figure 4.1.

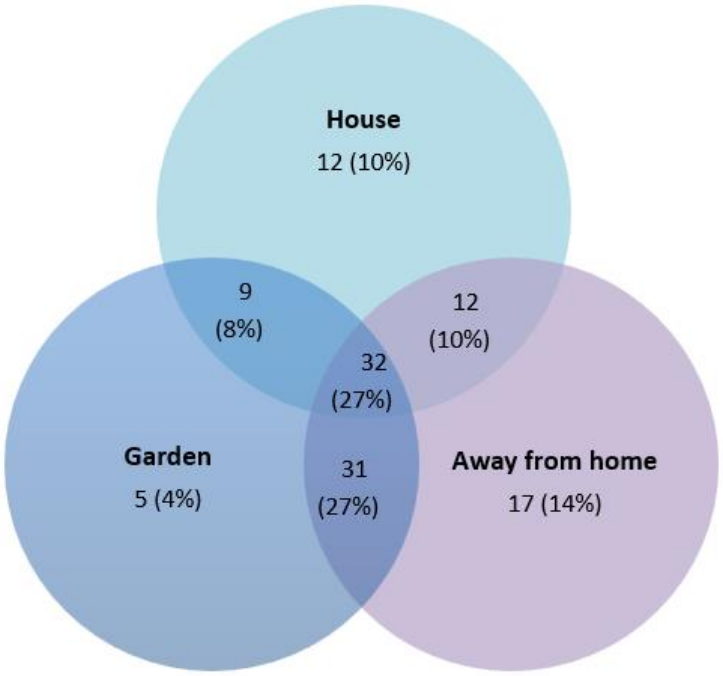


Figure 4.1: The number of broods/studs reported to scavenge in different environments (n=118) from an online survey of 166 Guide Dogs' brood stock holders.

When asked whether their brood/stud exhibited coprophagia and the type of faeces eaten, only 53/163 BSH (33%) were sure that their dog did not eat faeces, while 11 BSH (7%) answered 'Not sure' to at least one part of the question. The responses of the 103 BSH (63%) who were sure their broods/studs did exhibit coprophagia are summarised in Figure 4.2.

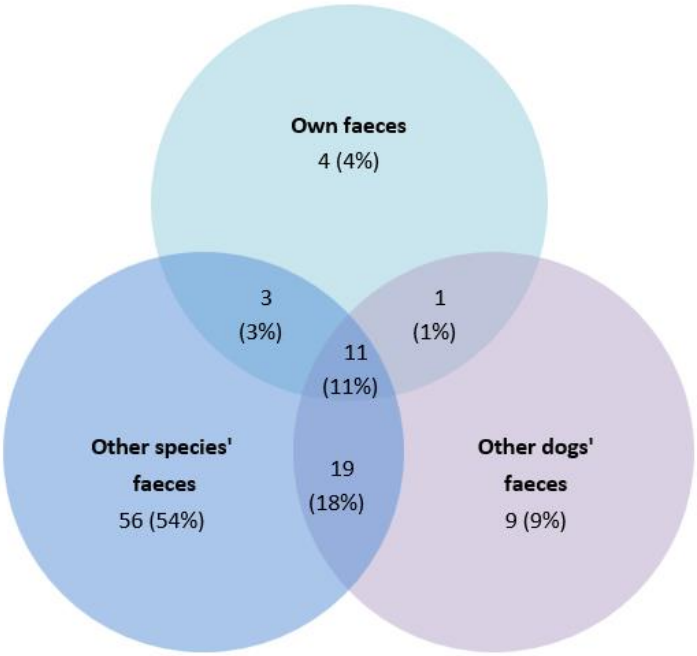


Figure 4.2: The number of broods/studs reported to display coprophagia (n=103) from an online survey of 166 Guide Dogs' brood stock holders.

Seven of the 77 brood bitch holders who gave more information on their dog's coprophagia (9%) related their answers to the breeding status of the brood *e.g.* only when pregnant or cleaning up after her pups. Fifteen of the 92 BSH who commented (16%) cited measures that they had taken to try to prevent or manage their brood's/stud's coprophagia *e.g.* muzzling the brood/stud while they were free-running, fencing off an area of the garden for the cat to use.

4.2.12 Brood Stock Holder behaviour around food

When asked whether they allowed their brood/stud in the kitchen while they were preparing food, the majority of BSH (151/164, 92%) said that they allowed their brood/stud in the kitchen at least sometimes while they were preparing food, compared with 13 (8%) who never did.

Multiple responses were permitted to the question about how the BSH interacted with their brood/stud while they (the BSH) were eating, so the total number of responses exceeds the number of respondents (n=164).

The majority of the BSH (n=117/164, 71%) said that they took no notice of the dog while they were eating. Similar numbers of BSH reported that they allowed the dog to sit or lie with them (n=51, 31%) or sent the brood/stud to bed (n=50, 30%), while 14 (9%) said that they sent the brood/stud out of the room. Three BSH (2%) said that they would pay attention to the brood/stud by *e.g.* talking to them or petting them, but none of the BSH said that they would give the dog treats or a toy.

4.2.13 Health conditions

Most of the 160 BSH (n=141/160, 85%) did not consider their brood/stud to suffer from any long-term health conditions. Only ten of the broods/studs (6%) were reported to have chronic health problems, including eye (n=3), ear (n=2), skin (n=1), gastrointestinal (n=1), anal gland (n=1) and prostate (n=1) problems and one brood who had been treated for a mast cell tumour.

4.2.14 Brood/stud weight

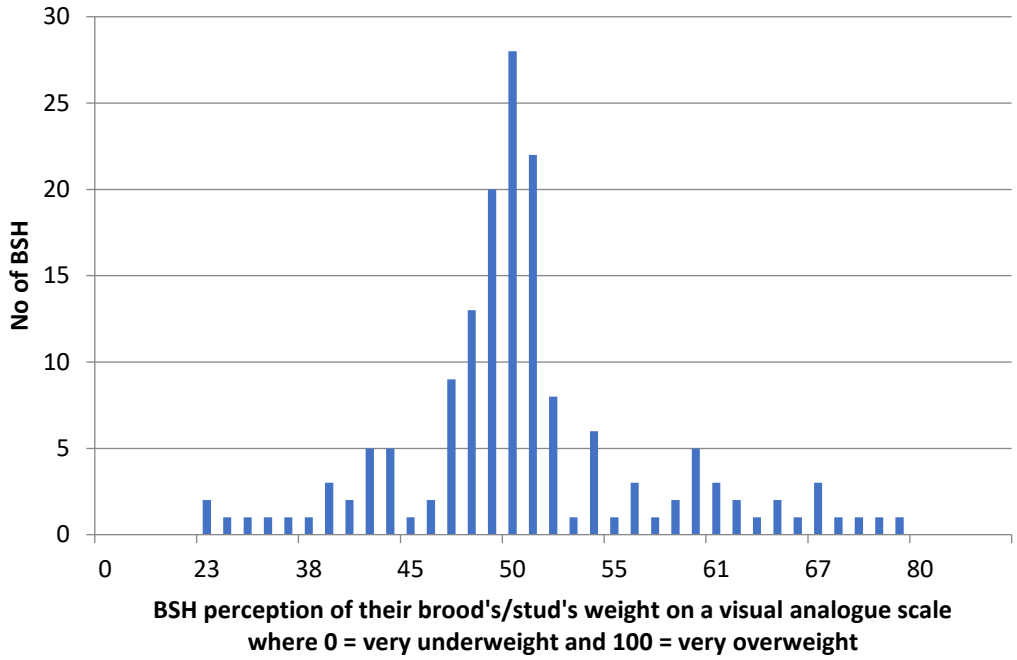
The majority of the BSH (n=153/160, 96%) provided a weight for their brood/stud and most of the BSH (n=146/160, 91%) gave an optimum weight for their brood/stud. The reported weights of the broods/studs ranged from under 25kg to 41kg, with a median reported weight of 29kg (IQR: 27-31kg). There was a good correlation between the BSH-reported weight for their brood/stud and the most recent weight recorded on GDI-R (Figure 4.4).

A Mann-Whitney test carried out to investigate any differences in BSH-reported weight between broods and studs showed that stud dogs (median 34kg, IQR: 33-36kg) were significantly heavier than brood bitches (median weight 28kg, IQR: 27-29kg) ($p<0.001$). The percentage weight difference was also significantly different between broods (median 2.83, IQR: -1.5–6.7) and studs (median 1.06, IQR: -4.2–2.9) ($p=0.047$).

Mann-Whitney tests showed that there were no significant differences in bodyweight between non-pregnant, pregnant and lactating bitches (non-pregnant v pregnant $p=0.746$; non–pregnant v lactating $p=0.667$; and pregnant v lactating $p=0.789$). Mann-Whitney tests also showed that there were no significant differences in percentage weight difference between non-pregnant, pregnant and lactating bitches (non-pregnant v pregnant $p=0.170$; non–pregnant v lactating $p=0.902$; and pregnant v lactating $p=0.178$).

A Kruskall-Wallis test to investigate any breed differences in weight showed that there were no significant differences between the weights of Labradors (median weight 28kg, IQR: 27–29.5), Golden Retrievers (median weight 30kg, IQR: 27-33) or Labrador retriever crosses (median weight 28kg, IQR: 27-30.5). There were insufficient numbers of the other breeds and crosses for statistical analysis.

When BSH were asked to indicate their opinion of their dog's weight on a VAS where 0=Very underweight and 100=Very overweight, most BSH thought that their dogs were around the correct weight, with a median score of 50.0 (IQR: 48.0–52.0) (Figure 4.3).



BSH=Brood Stock Holder

Figure 4.3: Perceptions of their dog's weight on a scale of 0 (very underweight) to 100 (very overweight) from an online survey of 166 Guide Dogs' brood stock holders.

4.2.15 Statistical analysis

1. Selection of an appropriate outcome variable.

a. The Brood's/Stud's BCS as recorded on GDI-R as an outcome variable

A BCS could be extracted from GDI-R for 147 of the 166 broods/studs (89%). The median BCS was 5 (IQR: 5-6).

Comparisons of weights and BCS recorded on GDI-R showed inconsistencies between the BCS and weight recorded for a number of broods/studs. For example, the brood bitch belonging to BSH 121 weighed 28kg at her first mating, when she was scored as BCS 5; at her second mating, the same brood bitch weighed 27.4kg, but was given a higher BCS of 6 despite having lost weight. Other similar inconsistencies in the BCS recorded by GD (Section 3.2.13, Figure 3.2) indicated that they were not a reliable measure of a dog's weight status and therefore the BCS recorded on GDI-R was rejected as an outcome measure. No further statistical analyses were performed on these data.

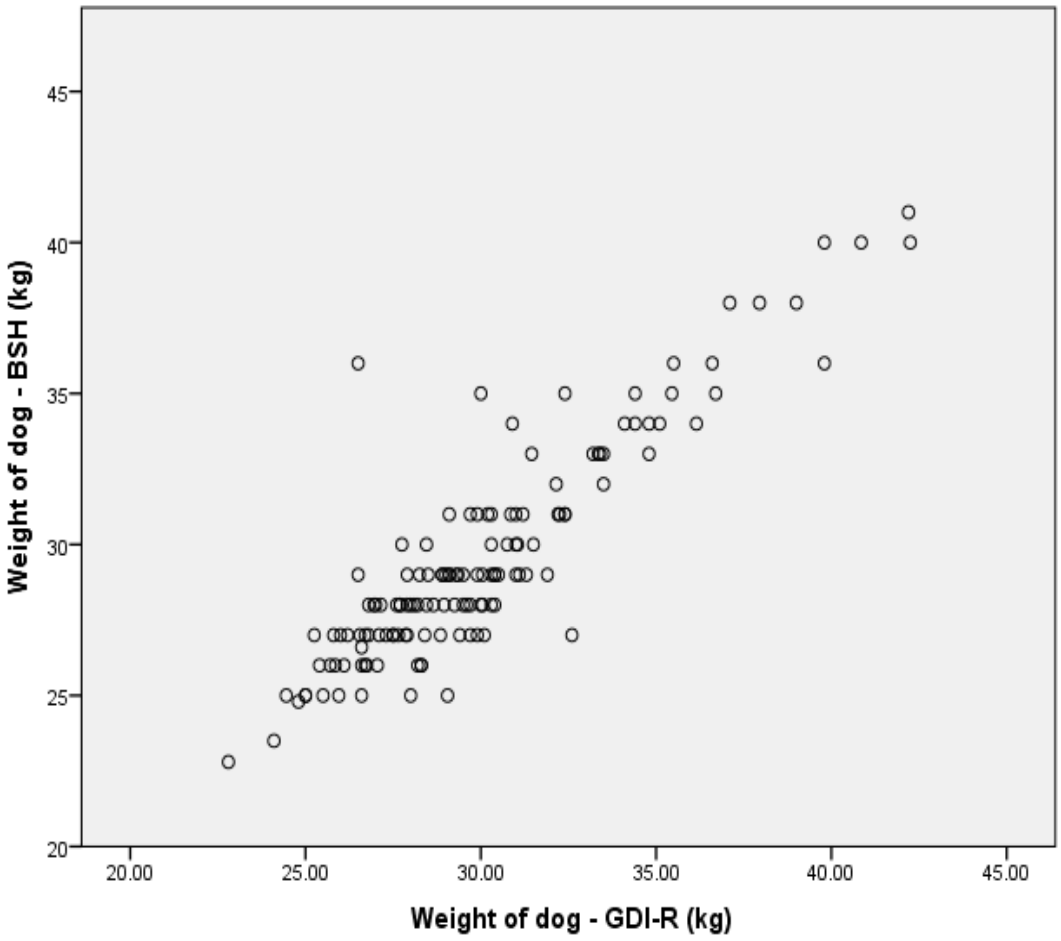
b. Percentage Weight Difference of the Brood/Stud from their optimum weight as an outcome variable.

Actual and optimum weights could be extracted from GDI–R for 146 of the 166 broods/studs (88%), enabling a percentage weight difference to be calculated. For the brood bitches, the most recent weights ranged from 18 days prior to

mating to 26 days post-mating. The mean percentage weight difference was 2.0 +/-5.8%.

c. The Brood's/Stud's Weight as reported by the BSH as the outcome variable

There was a good correlation (Spearman's rho 0.84, p<0.001) between the BSH-reported weight of the broods/studs and the most recent weight recorded on GDI-R prior to questionnaire completion (Figure 4.4).



GDI-R=Guide Dogs' database, BSH=Brood Stock Holder

Figure 4.4: Correlation between weights recorded by Guide Dogs (GDI-R) and Brood Stock Holder-reported weights of 166 Guide Dogs' Breeding Stock in an online questionnaire about feeding and exercise.

BSH-reported weights for their dogs were used as a second outcome variable to enable direct comparison of risk factors for overweight status with the Pet Dog Owners' survey (Chapter 5).

Statistical analysis

Statistical tests were regarded as statistically significant if p<0.05 unless otherwise stated.

a. The Brood's/Stud's BCS as recorded on GDI-R as an outcome variable

No statistical analyses were performed on these data.

b. The Percentage Weight Difference of the Brood/Stud from their optimum weight as an outcome variable.

Statistical Analysis

Step 1. Univariate analysis

There were a number of independent variables that were significantly associated ($p<0.2$) with the percentage weight difference (Tables 4.6, 4.7 and 4.8).

Step 2. Avoiding Multicollinearity

When tested for inter-variable associations, a large number of statistically significant correlations ($p<0.05$) were found between these independent variables. They were therefore divided into those which related to brood/stud characteristics, such as scavenging and begging behaviour (Table 4.6); BSH characteristics or behaviour, such as use of treats, frequency of feeding (Table 4.7); and those which did not relate exclusively to either brood/stud or BSH *e.g.* environment, length of time the brood/stud had been with the BSH (Table 4.8).

Table 4.6: Brood/Stud behaviours and characteristics significantly associated with the Percentage Weight Difference of the Brood/Stud from their Optimum Weight in an online survey of 166 Guide Dog Brood Stock Holders.

Brood/stud behaviours and characteristics as reported by BSH	P value	Unstandardised B/Difference	95% Confidence interval for B	
			Lower	Upper
Dog sex:*				
Female (Reference)				
Male	0.047	-2.399	-4.761	-0.037
Dog Breed:*				
Labrador (Reference)				
Golden Retriever	0.099	2.058	-0.392	4.507
Labrador-Retriever crosses	0.968	-0.071	-3.609	3.466
Dog eats faeces from species other than dogs:				
No (reference)				
Yes	0.112	-1.617	-3.617	0.383
Dog eats faeces from other dogs:				
No (reference)				
Yes	0.149	1.652	-0.597	3.902

BSH = Brood Stock Holder

Not included in PCA*

Table 4.7: Brood Stock Holders (BSH) behaviours and characteristics significantly associated with the Percentage Weight Difference of the Brood/Stud from their Optimum Weight in an online survey of 166 Guide Dog BSH.

BSH behaviours (self-reported)	P value	Standardised Beta coefficient	95% Confidence interval for B	
			Lower	Upper
BSH gives treats when introducing dog to new people or animals	0.016	0.200	1.193	11.203
BSH gives dog treats at the veterinary surgery	0.033	0.177	0.264	6.034
BSH never gives dog treats	0.035	0.175	0.466	12.710
BSH Body Mass Index (BMI)*	0.076	0.165	-0.023	0.471
BSH does not give dog any kind of treat	0.115	0.131	-1.402	12.788
How frequently BSH gives dog treats	0.121	- 0.130	-1.324	0.156
Length of walk BSH gives dog on a typical day at the weekend	0.137	- 0.128	-0.046	0.006
How frequently BSH feeds the dog	0.138	- 0.124	-5.201	0.724
Amount of food BSH gives dog is based on dog's activity levels	0.163	0.117	-0.957	5.639
BSH rewards dog with a special walk	0.179	- 0.112	-7.042	1.327
BSH gives dog dental treats	0.180	- 0.112	-3.340	0.631
BSH rewards dog with praise	0.184	- 0.110	-10.348	2.010

BSH = Brood Stock Holder, BMI=Body mass Index

Not included in PCA*

Table 4.8: Other independent variables significantly associated with the Percentage Weight Difference of the Brood/Stud from their Optimum Weight in an online survey of 166 Guide Dog Brood Stock Holders.

Other independent variables	P value	Standardised Beta coefficient	95% Confidence interval for B	
			Lower	Upper
Whether the dog is given any dietary supplements *e.g.* vitamins, cod liver oil*	0.034	-3.061	-5.884	-0.239
Age of the youngest child in the household*	0.195	0.250	-0.133	0.633

Not included in PCA*

Step 3a. PCA: Brood Stock Holder Characteristics and Behaviour

Bartlett's sphericity test (X^2=312.5, df=55, p<0.001) showed that the variables were correlated highly enough for PCA to be appropriate and the Kaiser-Meyer-Olkin test (KMO=0.59) showed that an adequate number of items were

predicted by each factor. The correlation matrix had a determinant of 0.11, showing a low level of multicollinearity between components.

Factors with Eigenvalues>1 were extracted, which resulted in four components. These components were then rotated using a Varimax (orthogonal) rotation to produce independent components (Table 4.9). When the factor (regression) scores were calculated for each component and checked for association with the outcome variable (Table 4.9), the factor scores for all four components were significantly related to the outcome variable. All four components were therefore taken forward into the modelling process.

Component 1 represented the frequency with which the BSH gave their brood/stud treats; component 2 represented the BSH using treats as positive reinforcement for their brood/stud; component 3 represented the BSH rewarding the dog and component 4 represented the BSH's management of the brood's/stud's feeding and exercise.

Table 4.9: The rotated factor loadings for Brood Stock Holder (BSH) behaviours and characteristics that were significantly associated with the Percentage Weight Difference of the Brood/Stud from their Optimum Weight in an online survey of 166 Guide Dog BSH. Significant loadings >0.4 are shown in bold.

	Component			
	1	2	3	4
BSH never gives dog treats	**0.915**	0.038	0.031	-0.027
BSH does not give dog any kind of treat	**0.903**	0.026	0.078	0.005
How frequently BSH gives dog treats	**-0.712**	0.142	0.183	-0.035
BSH gives dog treats at the veterinary surgery	-0.046	**0.815**	0.003	-0.022
BSH gives dog treats when introducing them to new people or animals	0.011	**0.803**	0.036	-0.038
BSH rewards dog with praise	-0.011	0.129	**0.768**	0.203
BSH gives dog dental treats	-0.230	0.019	**0.578**	-0.260
BSH rewards dog with a special walk	0.273	-0.226	**0.405**	-0.099
Length of walk BSH gives dog on a typical day at the weekend	0.206	-0.277	0.111	**0.644**
How frequently BSH feeds the dog	-0.012	-0.013	-0.017	**0.643**
Amount of food BSH gives dog is based on dog's activity levels	0.198	-0.205	0.169	**-0.469**
Significance of the association between the factor score for each component and the Percentage Weight Difference of the Brood/Stud	P=0.029*	P=0.007*	P=0.027*	P=0.049*
Standardised Beta coefficient	0.189	0.232	-0.191	-0.171
Underlying construct	Treat frequency	Treats as positive reinforce-ment	Type of treat and reward	Feeding and exercise manage-ment

BSH = Brood Stock Holder

*Significant at $P < 0.05$

Step 3b PCA: Dog Characteristics

There were only two dog characteristics significantly associated with the percentage weight difference of the brood/stud which were suitable for a PCA, so PCA was not performed.

Step 4. Model building

The forwards and backwards modelling processes resulted in similar final models. The models showed that the main influence on the percentage weight difference of the brood/stud was the way in which the BSH managed the brood's/stud's exercise and feeding, particularly in relation to the use of treats. In the backwards model, dog sex and whether the brood/stud ate faeces from species other than dogs were also significant (Table 4.10) and their inclusion increased the overall model fit (adjusted R^2) from 0.13 for the forwards model to 0.16 for the backwards model. The Durbin Watson statistic for the backwards model was 1.87, showing that the assumption of independent errors was met. No significant interactions ($p<0.05$) were found and a homoscedasticity plot showed that residuals for the model outputs had an approximately normal distribution.

Table 4.10: The backwards model for the percentage weight difference of the brood/stud from their optimum weight in an online survey of 166 Guide Dog Brood Stock Holders.

Predictor	P value	Unstandardised B	95% Confidence interval for B	
			Lower	Upper
Constant	<0.001	3.618	2.039	5.197
Component 1 from BSH PCA: Treat frequency	0.025	1.010	0.127	1.892
Component 2 of the BSH PCA: Treats used for positive reinforcement	0.004	1.298	0.410	2.186
Component 3 of the BSH PCA: Type of treat or reward	0.025	-1.016	-1.903	-0.129
Component 4 of the BSH PCA: Feeding and exercise management	0.031	-1.001	-1.911	-0.090
Dog is male	0.047	-2.384	-4.738	-0.031
Dog eats faeces from species other than dogs	0.042	-1.981	-3.886	-0.076

BSH = Brood Stock Holder
PCA = Principal Components Analysis

c. The Brood's/Stud's Weight as reported by the BSH as the outcome variable

Step 1. Univariate analysis

There were a number of independent variables that were significantly associated ($p<0.2$) with the weight of the brood/stud as reported by the BSH (Tables 4.11, 4.12 and 4.13).

Step 2. Avoiding Multicollinearity

When tested for inter-variable associations, a large number of statistically significant correlations ($p<0.05$) were found between these independent variables. As with the independent variables associated with the percentage weight difference (Section 4.2.15b), these were divided into those which related to brood/stud characteristics (Table 4.11), owner characteristics or behaviour (Table 4.12) and those which did not relate exclusively to either brood/stud or owner (Table 4.13).

Table 4.11: Brood/Stud behaviours and characteristics significantly associated with the Brood Stock Holders (BSH)-reported weight of the brood/stud in an online survey of 166 Guide Dog BSH.

Brood/stud behaviours and characteristics as reported by BSH	P value	Unstandardised B/Difference	95% Confidence interval for B	
			Lower	Upper
Dog's sex*	<0.001	6.002	4.919	7.085
Dog's Breed*:				
Labrador (Reference)				
Golden Retriever	0.116	1.086	-0.272	2.444
Labrador- Retriever crosses	0.595	-0.530	-2.497	1.438
Other	<0.001	5.176	3.057	7.296
Dog's age*	<0.001	0.741	0.434	1.049
Dog scavenges in the garden	0.001	-1.902	-3.038	-0.766
Dog scavenges away from home	0.009	-1.577	-2.750	-0.404
Dog eats faeces from other dogs	0.014	-1.669	-2.996	-0.341
Dog eats its own faeces	0.021	-2.100	-3.873	-0.328
Dog eats faeces from species other than dogs	0.034	-1.297	-2.494	-0.100
Dog has any chronic health problems	0.063	1.070	-0.059	2.199
Dog scavenges around the house	0.077	-1.076	-2.269	0.117

BSH = Brood Stock Holder

Not included in PCA*

Table 4.12: Brood Stock Holders (BSH) behaviours and characteristics that were significantly associated with the BSH-reported weight of the brood/stud in an online survey of 166 Guide Dog BSH.

BSH behaviours (self-reported)	P value	Unstandardised B	95% Confidence interval for B	
			Lower	Upper
BSH uses food taken from daily ration as rewards	<0.001	-2.293	-3.392	-1.194
BSH uses food taken from daily ration as treats	<0.001	-2.153	-3.264	-1.042
BSH measures dog's food on weighing scales	0.007	-1.675	-2.885	-0.465
BSH gives dog dental treats	0.013	1.500	0.318	2.681
BSH gives dog table scraps as a treat	0.031	2.514	0.235	4.792
BSH measures dog's food by volume (*e.g.* scoop, cup)	0.034	1.285	0.100	2.470
BSH allows dog to stay with them while BSH is eating	0.044	1.266	0.032	2.500
Amount of food BSH gives dog is based on instructions on food packaging	0.074	4.724	-0.464	9.911
BSH does not give dog any kind of treat	0.087	3.728	-0.551	8.006
BSH gives dog shop-bought treats	0.148	0.852	-0.307	2.010
BSH rewards dog with fruit or vegetables	0.155	-0.882	-2.100	0.336
BSH never gives dog treats	0.156	2.689	-1.039	6.417
Amount of food BSH gives dog is based on veterinary advice	0.165	3.681	-1.528	8.890
BSH rewards dog with a special walk	0.174	1.747	-0.779	4.274
How frequently BSH brushes dog's teeth	0.181	-0.240	-0.592	0.113
Amount of food BSH gives dog is based on dog's activity levels	0.194	-1.311	-3.297	0.675
BSH's sex*	0.199	-1.222	-3.091	0.648

BSH = Brood Stock Holder

Not included in PCA*

Table 4.13: Other independent variables significantly associated with the Brood Stock Holder (BSH)-reported weight of the brood/stud in an online survey of 166 Guide Dog BSH.

Other independent variables	P value	Unstandardised B/ Difference	95% Confidence interval for B	
			Lower	Upper
Length of time dog been with holder*	<0.001	0.658	0.363	0.953
Living environment*				
Rural (reference)				
Suburban	0.014	1.490	0.310	2.669
Urban	0.056	2.401	-0.066	4.868
Presence of other pets in household*	0.041	-1.206	-2.362	-0.050
Number of under-18s in the household*	0.129	-0.411	-0.943	0.122
Current diet*				
Eukanuba (reference)				
Royal Canin	0.044	1.445	0.038	2.852
Light	0.331	0.939	-0.965	2.844
Dog is given any dietary supplements *e.g.* vitamins, cod liver oil	0.155	1.240	-0.473	2.953
Age of the youngest child in the household*	0.187	0. .149	-0.074	0.372

Not included in PCA*

Step 3a. PCA: Brood Stock Holder Characteristics and Behaviour

Bartlett's sphericity test (X^2=791.1, df=136, p<0.001), the Kaiser-Meyer-Olkin test (KMO=0.55) and the determinant of the correlation matrix (0.01) showed that PCA was appropriate (Section 4.2.15).

Factors with Eigenvalues>1 were extracted, resulting in six components, which were rotated using a Varimax (orthogonal) rotation to produce independent components (Table 4.14).

Component 1 represented the BSH regulating the amount of food and treats given to the brood/stud; component 2 represented BSH adherence to GD advice around feeding their brood/stud; component 3 represented the BSH adherence to their brood's/stud's daily food allowance; component 4 represented the BSH giving extra food and treats; component 5 represented the BSH spending time with the dog; while component 6 comprised a single variable (frequency of tooth brushing).

When the factor (regression) scores were calculated for each component and checked for association with the outcome variable (Table 4.14), the factor scores for components 1, 2, 3 and 6 were significantly related to the outcome variable (P<0.2). Components 1, 2 and 3 were taken forward into the model; component 6 comprised a single variable which was entered into the model as an individual variable rather than as part of a component.

Table 4.14: Rotated factor loadings for Brood Stock Holder (BSH) behaviours and characteristics that were significantly associated with the BSH-reported weight of the brood/stud in an online survey of 166 Guide Dog BSH. Significant loadings >0.4 are shown in bold.

	Component					
	1	2	3	4	5	6
BSH does not give dog any kind of treat	**0.832**	0.115	-0.083	-0.171	0.269	-0.081
BSH never gives dog treats	**0.802**	0.212	-0.114	-0.237	0.201	-0.076
Amount of food BSH gives dog is based on veterinary advice	**0.718**	-0.081	0.063	0.108	-0.154	0.235
Amount of food BSH gives dog is based on instructions on food packaging	**0.706**	-0.158	-0.108	0.228	-0.161	-0.039
BSH measures dog's food by volume (*e.g.* scoop, cup)	0.016	**0.894**	0.012	0.053	0.114	0.131
BSH measures dog's food on weighing scales	0.009	**-0.856**	0.020	-0.094	-0.185	-0.101
BSH gives dog table scraps as a treat	-0.010	**0.489**	-0.269	-0.042	-0.261	-0.077
BSH uses food taken from daily ration as treats	-0.097	-0.031	**0.911**	-0.073	-0.102	-0.072
BSH uses food taken from daily ration as rewards	-0.090	-0.060	**0.877**	-0.036	-0.042	0.046
Amount of food BSH gives dog is based on dog's activity levels	0.234	-0.142	0.105	**0.684**	0.286	0.174
BSH gives dog shop-bought treats	-0.213	0.197	-0.204	**0.661**	-0.082	-0.024
BSH rewards dog with a special walk	0.028	0.145	0.038	0.112	**0.750**	-0.177
BSH allows dog to stay with them while BSH is eating	0.002	-0.027	-0.279	-0.097	**0.494**	0.196
How frequently BSH brushes dog's teeth	-0.008	0.184	-0.053	0.067	-0.061	**0.828**
BSH gives dog dental treats	-0.143	0.160	-0.312	0.392	-0.170	-0.380
BSH rewards dog with fruit or vegetables	-0.225	-0.298	-0.166	-0.293	0.081	0.185

Significance of the association between the factor score for each component and the BSH-reported weight of the brood/stud	p=0.121*	p=0.008 **	p<0.001 **	p=0.588	p=0.683	p=0.044 **
Standardised Beta coefficient	0.126	0.216	-0.321	0.044	0.033	-0.164
Underlying construct	Regulation of food and treats	Adherence to GD advice on feeding	Strict adherence to daily food allowance	Extra food or treats given	Spending time with the dog	Frequency of tooth-brushing

BSH = Brood Stock Holder Significant at P<0.2* Significant at P<0.05**

Step 3b. PCA: Brood/Stud Characteristics and Behaviour

Bartlett's sphericity test (X^2=151.0, df=21, p<0.001), the Kaiser-Meyer-Olkin test (KMO=0.70) and the determinant of the correlation matrix (0.34) showed that PCA was appropriate (Section 4.2.15). Factors with Eigenvalues >1 were extracted, resulting in three components, which were rotated using a Varimax (orthogonal) rotation to produce independent components (Table 4.15). Component 1 represented general scavenging behaviour of the brood/stud; component 2 represented conspecific coprophagic behaviour of the brood/stud while component 3 was comprised of a single variable, whether the dog had any chronic health problems.

When the factor (regression) scores were calculated for each component and checked for association with the outcome variable (Table 4.15), the factor scores for components 1 and 2 were significantly related to the outcome variable (p<0.2) and therefore taken forward into the model. Component 3 comprised a single variable (whether the dog had any chronic health problems) which was significantly associated (p<0.2) with the outcome variable (p=0.063) and so this was entered into the model as an individual variable rather than as part of a component.

Table 4.15: The rotated factor loadings for Brood/Stud behaviours and characteristics that were significantly associated with the Brood Stock Holder (BSH)-reported weight of the brood/stud in an online survey of 166 Guide Dog BSH. Significant loadings >0.4 are shown in bold.

	Component		
	1	2	3
Dog scavenges in the garden	**0.775**	0.207	0.055
Dog scavenges away from home	**0.744**	0.260	-0.141
Dog scavenges around the house	**0.689**	-0.191	0.280
Dog eats faeces from species other than dogs	**0.559**	0.270	-0.292
Dog eats its own faeces	0.058	**0.823**	0.108
Dog eats faeces from other dogs	0.228	**0.776**	-0.086
Dog has any chronic health problems	0.010	0.063	**0.928**
Significance of the association between the factor score for each component and the BSH-reported weight of the brood/stud	p = 0.006**	p = 0.028**	p = 0.417
Standardised Beta coefficient	-0.247	-0.200	0.074
Underlying construct	Scavenging	Conspecific coprophagia	Dog health

BSH=Brood Stock Holder Significant at P < 0.05**

Step 4. Model building

The backwards modelling process showed that the BSH-reported weight of the brood/stud could be predicted by the brood/stud's sex and the length of time the brood/stud had been with the BSH (Table 4.16). The Durbin-Watson statistic was 2.02 and the adjusted R^2 of the model was 0.51. No significant interactions ($p<0.05$) were found and a homoscedasticity plot showed that residuals for the model outputs had an approximately normal distribution.

Table 4.16: The multivariable model for the Brood Stock Holder (BSH)-reported weight of the brood/stud in an online survey of 166 Guide Dog BSH.

Predictor	**P value**	**Unstandardised B**	**95% Confidence interval for B**	
			Lower	**Upper**
Constant	<0.001	26.969	26.299	27.639
Dog is male	<0.001	5.812	4.808	6.816
Length of time dog been with BSH	0.008	0.567	0.350	0.784

BSH = Brood Stock Holder

4.3 Discussion

The main findings of this study were that the sex of the brood/stud and the length of time that the brood/stud had been with the BSH were significantly associated with the BSH-reported weight of the dog. When the percentage weight difference of the brood/stud was used as the outcome variable, the main predictors of the weight status of the brood/stud were the BSH's use of treats, specifically frequency of treat-giving and whether treats were used for training and rewards. Matching food and exercise levels, the brood's/stud's sex and whether it ate faeces from other species were also associated with the dog's percentage weight difference in the final model. Most of the explanatory variables significantly associated with the percentage weight difference of the brood/stud in the final model were related to the BSH management of the brood/stud. This mirrors the findings of the GDO study (Chapter 3) and Courcier *et al.* (2010) and highlights that the owners'/carers' management of the dog has a much greater impact on a dog's weight than dog behaviours such as scavenging and coprophagia.

4.3.1 Discussion of main findings

Dog Sex

The proportion of bitches and stud dogs for which the questionnaires were completed was not significantly different from the proportion of brood bitches and stud dogs held by Guide Dogs at that time (Guide Dogs, personal communication).

Analysis of the BSH-reported weight of the dogs showed that stud dogs weighed significantly more than brood bitches, mirroring the findings in WGD (Section 3.3.1). However, unlike WGD, the sex of the dog was also significant when the percentage weight difference was used as the outcome variable, with studs having a lower percentage weight difference than broods. This is in agreement with the findings of Sallander *et al.* (2010a) who found that female dogs were more than twice as likely to be overweight as male dogs in a study population that was 99% entire, and therefore similar to GD breeding stock who are all entire. In other previously published studies where female dogs were found to have a higher risk of being overweight than males (McGreevy *et al.*, 2005; Colliard *et al.*, 2006), neutering may have been a confounding factor. The association between dog sex and overweight status will be examined further in the Pet Dogs (Chapter 5) survey.

Length of time brood/stud had been with the BSH

The positive correlation between the length of time the brood/stud had been with the BSH and the dog's weight corresponds with the findings of Nijland *et al.* (2009), where length of ownership was associated with the weight status of the dog. Kienzle *et al.* (1998), Nijland *et al.* (2009) and Jung *et al.* (2017) agree that an owner's attitudes and behaviours around diet and exercise extend to their pets, therefore the longer a dog is under the influence of a particular owner/carer, the greater the effect that person's attitudes and behaviours will

have on the dog's weight. Furthermore, the strength of the owner/carer bond with their dog increases with increasing length of ownership (Schaefer, 2019). As food is often used as a sign of affection (White *et al.*, 2016; Mulroony, 2019), dogs who have been with their owners/carers for longer may have developed a stronger bond with them, either leading to, or resulting from more food being given. This could lead to increased bodyweight in the brood/stud. Another possible explanation for the association between the length of time the brood/stud had been with the BSH and its bodyweight is the positive correlation between the brood's/stud's age and the length of time it had been with its BSH. Although the age of the brood/stud was significantly associated with its weight in the univariate model ($p<0.001$), dog age did not appear in the final multivariable model. This is in contrast with the findings of Robertson (2003), Colliard *et al.* (2006) and Courcier *et al.* (2010), who found that the risk of a dog being overweight increased with age. McGreevy *et al.* (2005) and Lund *et al.* (2006) agreed that the risk of being overweight increases as the dog ages until about 10 years old but then decreases. In the current study, only two dogs were $\geq$8 years old, which may explain why dog age did not feature in the final model.

Brood Stock Holder use of treats

BSH who indicated that they never gave their dogs treats or gave treats less frequently had dogs with a higher bodyweight than BSH who reported that they did give their dogs treats or gave them more frequently. This mirrors the findings in GDO when the use of treats was compared to the percentage weight difference of their dog (Section 3.3.1). Similar findings in both WGD and GD breeding stock supports the hypothesis that GDO and BSH with overweight dogs may reduce or eliminate treats in an attempt to manage their dogs' weight (Guide Dogs, 2014).

Another possible explanation is social desirability bias, where survey respondents answer questions in a way they think will be viewed more favourably than their true attitude or behaviour through a desire to avoid embarrassment (Fisher, 1993; Grimm, 2010; Kaminska and Foulsham, 2013). The error due to social desirability bias is likely to be small in the studies by Robertson (2003), Bland *et al.* (2009) and Courcier *et al.* (2010) because the dog owners in these studies were not accountable to anybody for the management of their dog and there would be no follow-up to any information they provided. Although the welcome page of the BSH questionnaire emphasised anonymity and confidentiality to minimise the effects of social desirability bias (Fernandes and Randall, 1992; Joinson, 1999; Lippitt *et al.*, 2014), BSH may have been concerned that information they provided would be passed on to GD, particularly if they were not adhering to GD guidelines. If non-adherence to feeding and exercise recommendations resulted in a brood/stud becoming overweight, there could be repercussions for the BSH, with the brood/stud being removed from the BSH in extreme cases. It is possible to measure the degree of social desirability bias using the 33-item Marlowe-Crowne Scale (Crowne and Marlowe, 1960) or the Balanced Inventory of Desirable Responding (BIDR) (Zerbe and Paulhus, 1987), but including one of these

instruments in the survey would have increased the length of the survey considerably and therefore increased the risk of survey fatigue (Saxon *et al.*, 2003; Kaminska and Foulsham, 2013).

Recall bias, where BSH do not remember or report accurately the number of treats given, may also have affected the BSH responses (Karvetti and Knuts, 1985; Krall *et al.*, 1988; Tooze *et al.*, 2004), but is equally likely to have biased the findings of Robertson (2003), Bland *et al.* (2009) and Courcier *et al.* (2010). Treats used in particular situations such as for training or as a reward may not be recognised as additional calories by the BSH (Michel, 2009) and therefore the daily ration may not be adjusted to compensate for these treats (White *et al.*, 2016). There may also be other variables related to treat feeding and the weight of the brood/stud that were not explored in this questionnaire that could explain this apparent anomaly. Interviewing BSH about their use of treats and comparing their responses with GD records may help to elucidate these.

Duration of Weekend Exercise

There was a negative association between the length of walk that broods/studs were reported to get at the weekend and the percentage weight difference, with dogs which were walked for longer being closer to or under their optimum weight. This corresponds with the findings of Robertson (2003) and Warren *et al.* (2011), who agree that a longer duration of exercise reduces the risk of a dog being overweight. Exercise leads to increased energy expenditure both directly and indirectly via muscle hypertrophy (Schafer and Hankel, 2020).

Feeding

There was a negative association between the frequency of feeding and the percentage weight difference, with dogs that were fed more often having a lower percentage weight difference. GD generally advise that dogs should be fed twice daily but pregnant or lactating bitches may be fed more frequently, if necessary, to maintain their bodyweight (Julie Davis, BSHA, personal communication). In this study, low bodyweight is likely to be a reason for, rather than a result of, increased frequency of feeding. In support of this, Robertson (2003) found that dogs fed once a day were more likely to be classed as overweight by their owners. Owners who consider their dogs overweight might reduce their meals to once daily as a way of reducing calorie intake, or it may be that once daily feeding predisposes dogs to becoming overweight (Robertson, 2003). Bland *et al.* (2009) agree that dogs considered overweight by their owners were more likely to be fed once a day but also found that some overweight dogs were fed more than three times a day. In these dogs, a larger number of meals is likely to result in an excessive calorie intake and hence weight gain (Kienzle *et al.*, 1998). Although feeding more frequently increases energy expenditure through thermogenesis, small meals must be given to achieve weight loss (Robertson, 2003).

BSH who adjusted the quantity fed according to the amount of exercise the brood/stud received had dogs with a greater percentage weight difference than those who did not. Duncan *et al.* (2001) and Adams *et al.* (2005) found that

people tend to overestimate their own exercise and activity levels therefore it is likely that BSH overestimate how much activity their dog has done. People also tend to underestimate their energy intake (Tooze *et al.*, 2004), and this, combined with an overestimate of activity levels, could lead to the BSH overfeeding their brood/stud (Zenor, 2018), which would then contribute to weight gain (Bland *et al.*, 2009; Kobayashi *et al.*, 2014; Payan-Carreira *et al.*, 2016). This is supported by the fact that many BSH tried to justify giving their dogs titbits (Section 4.2.11) or adding to their dog's dry food (Section 4.2.7) (White *et al.*, 2011).

Coprophagia

Broods/studs that ate faeces from species other than dogs tended to have a lower percentage weight difference than those who did not. The driver for coprophagia in dogs is uncertain. Hart and Hart (1985) and McKeown *et al.* (1988) suggested it could be due to starvation, an imbalanced diet or exocrine pancreatic insufficiency, leading to a lack of available nutrients, but this is unlikely to be the case in the broods/studs in this study due to the careful monitoring of the dogs' diet, health and weight. A consistent high fat, high protein, low carbohydrate diet fed twice a day at regular times with no treats or scraps has been recommended to help in the management of coprophagia (McKeown *et al.*, 1988), however GD broods/studs are generally fed twice daily on a complete balanced diet and the use of treats and snacks is discouraged, yet some broods/studs exhibit coprophagia while others do not. Dogs may enjoy the taste of faeces, or be instinctively driven to eat decaying food as a result of the diet of their wolf ancestors (O'Farrell, 1992). Coprophagia may also be a learned behaviour which is reinforced by the attention paid to the dog by the owner when it eats faeces (Hart and Hart, 1985). Anxiety, environmental stress and conflict have also been proposed as potential causes of coprophagia (McKeown *et al.*, 1988; Beerda *et al.*, 1999). It seems unlikely that there are nutritional reasons for coprophagia in GD broods/studs but potential stressors and inadvertent reinforcement of the behaviour by the BSH may be worth investigating in dogs where coprophagia is a problem.

4.3.2 Methodology

Questionnaires are a convenient, low cost and reliable way to collect large quantities of data (Smith, 2008). Compared to mail, email and telephone surveys, online questionnaires have shorter and cheaper distribution times, lower costs and more design options. There is also no requirement for manual data entry, reducing the possibility of human error (Fan and Yan, 2010). However lower response rates have been reported for online surveys compared to other methods, potentially leading to biased results (Manfreda *et al.*, 2008; Fan and Yan, 2010). Since these studies were published, the percentage of households with home computers in the UK has increased by around 10 percentage points, from 72% in 2008 and 77% in 2010 to 85% in 2014 when the current survey was distributed (Statista, 2020). As people have become more computer-literate, it is likely that the difference in response rates

between traditional survey methods and online questionnaires has become less pronounced, although no recent literature was found to support this.

The questionnaire comprised 48 questions and was estimated to take 10–15 minutes to complete. The majority of the respondents (159/166, 96%) completed the questionnaire, but survey fatigue may have resulted in some BSH putting less thought and effort into answering the questions, especially towards the end of the questionnaire (Saxon *et al.*, 2003; Kaminska and Foulsham, 2013).

4.3.3 Limitations of the study

Study design

A major limitation of this study was the cross-sectional design, which could identify associations between weight status and potential risk factors, but not demonstrate causation (Kleinbaum *et al.*, 1982). The population studied was small (n=314), therefore even with an acceptable response rate of 53% (Baruch, 1999; Richardson, 2005), the sample was relatively small (n=166). No sample size calculation was performed, increasing the likelihood of a Type II error and reducing the power of the study, therefore genuine associations may have been missed (Hyde *et al*., 2021). There were also insufficient numbers of GSD or Standard Poodles for separate statistical analyses of these breeds.

Participants

The link to the survey was sent out by email, and the questionnaire administered online, which effectively excluded non-computer literate BSH from participating. However, when this survey was conducted in 2014, 85% of households had a home computer so any sampling error was likely to be small (Statista, 2020). Data were obtained from just over half of the BSH invited to participate, which may be a source of selection bias. The study was described as investigating the dogs' feeding and exercise and did not specifically mention dog weight to try to avoid selection bias relating to the weight of the dog. Although the BSH were assured of anonymity and confidentiality, it is possible that BSH who were less compliant with GD recommendations on feeding and exercise and/or those with overweight dogs may not have completed the questionnaire (Berk, 1983; Grimes and Schulz, 2002).

The majority (86%) of respondents were female, in line with the findings of Smith (2008), which is another potential source of selection bias. No data were available on the gender distribution of the BSH at that time to compare the gender distribution of respondents with that of the sampling frame.

Thirty three of the dogs (20%) were male and 86 of the bitches (52% of the dogs in the survey) were neither pregnant nor lactating at the time of survey completion and so their reproductive status should have had no effect on their weight or food intake. Of the 16 bitches who were pregnant during questionnaire completion, 13 (8% of the dogs in the survey) were less than 40 days pregnant and so weight gain and increase in food intake should have been minimal (Moser, 1992; Malandain, 2006; Fontaine, 2012). Many bitches return

to their pre-breeding weight immediately after parturition (Fontaine, 2012) and the weight of lactating bitches is closely monitored by GD (Julie Davis, personal communication) so the weights of the lactating bitches (n=15/166, 9%) should be close to their pre-breeding weights. Only ten bitches (6% of the dogs in the survey) were between the second and fourth week of lactation, when energy intake would likely be between two and three times maintenance (Fontaine, 2012). Mann-Whitney tests confirmed that there were no significant differences between the bodyweights and percentage weight differences for the non-pregnant, pregnant and lactating bitches and therefore these dogs were not excluded from the study.

Possible outcome variables

BSH-reported weight

There was a good correlation between the BSH-reported weight of the broods/studs and the most recent weight recorded on GDI-R prior to questionnaire completion, suggesting that BSH generally knew and reported their brood's/stud's weight accurately. The BSH-reported weights in the current study may still have been affected by recall and social desirability bias and so be underestimates of the brood's/stud's actual weights (Grimm, 2010; Kaminska and Foulsham, 2013).

All the dogs in this study were GD breeding stock and therefore would have been at least 19 months (approximately 578 days) old (Guide Dogs, personal communication). Adult bodyweight is reached at around 325 and 326 days for female and male GSD respectively and 319 and 335 days for female and male Labradors (Helmink *et al.*, 2000) and therefore these dogs would have been fully grown (Salt *et al.*, 2017). This, together with the fact that all broods/studs were of similar breeds and from a limited gene pool, suggest that higher bodyweight could be linked with higher levels of body fat.

However, as discussed in Section 3.3.3, actual or owner-reported bodyweights are only proxy measures of a dog's weight status (Dorsten and Cooper, 2004) and are not necessarily representative of fat mass (German *et al*., 2009). Ideally BCS would have been used as the outcome variable as it is a more accurate measure of weight status (Burkholder, 2000; Blageanu and Vulpe, 2018) but the BCS recorded on GDI-R were unreliable. The possibility of the author attending an eye scoring session for GD breeding stock to obtain accurate BCS data was investigated, but timings made this unfeasible (Gant *et al*., 2016).

Percentage weight difference of the dog from its optimum weight

Comparing each brood's/stud's weight to their optimum weight reduces the effect of individual frame size on bodyweight, and may be more representative of bodyfat than weight alone (Blageanu and Vulpe, 2018). However, as with WGD, optimum weights are set when the dog has a BCS of 5, are set by one individual and rarely confirmed by a second person (Guide Dogs, personal communication). The limitations of using GD optimum weights have been discussed previously (Section 3.3.3). However, a single individual, the BSHA,

sets the optimum weights for the breeding stock, whereas BCS could be assigned by multiple people, such as a DCWA or veterinary surgeon, so the percentage weight difference is likely to be more reliable than BCS assigned by multiple people (Laflamme, 1997; Mawby *et al*., 2004; Elliott, 2006).

4.3.4 Conclusion

The main risk factors for higher bodyweight in GD breeding stock were the dog's sex and how long the brood/stud had been with the BSH. The main influences on the percentage weight difference of the brood/stud were BSH-related behaviours around feeding, treats and exercise, the dog's sex and interspecific coprophagia. This highlights the importance of BSH behaviour around feeding and exercise in controlling a dog's weight. These findings reflect those of the GDO study (Chapter 3) and the study by Courcier *et al.* (2010).

This study adds to previous studies investigating risk factors for dogs being overweight (Robertson, 2003; McGreevy *et al.*, 2005; Colliard *et al.*, 2006; Lund *et al.*, 2006) by investigating potential risk factors for overweight status in a well-defined population of entire dogs and bitches, with strict management and monitoring protocols. These broods/studs belonged to GD and were not owned by the people who cared for them. The GDO survey (Chapter 3) investigated risk factors in a similar population of neutered dogs, but where the dogs were owned by their carers. Further studies are needed to investigate whether the findings of these two studies can be generalized to the pet dog population, where there is much more variability in how the dogs are managed and how closely their weight is monitored. Furthermore, the relationship between the pet dog owner and their dog may differ from both that of the GDO and BSH and their dogs, which could influence the way in which the dogs are managed and hence their weight status. The next chapter describes how data was collected from the owners of GD-type breeds to ascertain whether the findings from the GDO (Chapter 3) and BSH surveys can be extrapolated to pet dogs and their owners, while controlling for breed differences (Chapter 5).

Chapter 5: Investigation of Risk Factors for Overweight status in Pet Dogs

The previous two chapters of this thesis investigated risk factors for overweight status in WGD (Chapter 3) and GD breeding stock (Chapter 4). GD provide the people who own and care for their dogs with extensive guidance and training around feeding and exercising their dog, but in contrast, there is no standard source of advice for PDO about feeding and exercising their dogs or managing their dog's weight. It is up to each owner to seek out any information they require.

Three studies have highlighted the importance of the veterinary surgeon as a source of information on dog nutrition and exercise (Kienzle *et al.*, 1998; Kuhl, 2015; Kogan *et al.*, 2018) but also revealed the range of other resources used by dog owners. The lack of consistent advice on diet and exercise for pet dogs likely leads to a large variation in the way these dogs are fed and exercised, in comparison to GD, where the management of GD puppies, WGD and breeding stock is well-controlled. WGD and breeding stock have regular health checks, are weighed and have their BCS assessed, therefore the owners/carers of the dogs are accountable to GD for their dog's health and weight. In contrast, PDO have very little accountability for their dog's health and weight, apart from the Animal Welfare Act (Great Britain, 2006).

Furthermore, all of the studies identified in the scoping review (Chapter 2) used pet dogs as their study population, therefore it was important to investigate risk factors for pet dogs being overweight to compare firstly to existing literature and secondly to the findings from WGD (Chapter 3) and GD breeding stock (Chapter 4). This would indicate whether the risk factors identified in previously published literature were relevant to the two GD dog populations.

The main aim of the PDO study was therefore to investigate the risk factors for dogs being overweight and establish any associations between pet dog and owner characteristics and behaviours and the weight status of the dog. A secondary aim of this study was to gather data that could be used to investigate similarities and differences between the findings in pet dogs and those of the previous studies on WGD (Chapter 3) and GD breeding stock (Chapter 4). This study therefore focussed on privately-owned pet dogs of similar breeds to those used by GD (Labradors, Golden Retrievers, Flat Coated Retrievers, GSD, Standard Poodles and their crosses) in the UK.

The following objectives were set for the PDO study: (1) to develop and pilot an online questionnaire for PDO based on the findings of the GDO survey and online BSH questionnaire; (2) to distribute the PDO questionnaire to owners of breeds of dog used by GD; (3) to interrogate the resulting data to look for links between dog and owner characteristics and behaviour and the weight of the dog and (4) to generate data which would enable comparisons between the findings of the PDO questionnaire with those of the GDO (Chapter 3) and BSH (Chapter 4) surveys to determine similarities and differences between these groups of dog owners/carers.

5.1 Materials and Methods

5.1.1 Participants

A convenience sampling and snowballing technique (Oxtoby and Mossop, 2019) was used to recruit pet dog owners of the breeds used by GD (Labradors, Golden Retrievers, Flat Coated Retrievers, GSD, Standard Poodles and their crosses), but who had no connection with the organisation. Owners were recruited via direct contact with relevant dog breed groups, social media and leaflets during Spring 2015. No formal sample size calculation was performed, but as many dogs as possible that met the eligibility criteria were recruited within the time available (Flanagan *et al*., 2017).

5.1.2 Questionnaire design

The online questionnaire used for the BSH (Appendix 2) was adapted for use with owners of pet Labradors, Golden Retrievers, Flat Coated Retrievers, GSD, Standard Poodles and their crosses (Appendix 3). The link to the pilot version of the questionnaire was distributed to eight pet owners, five of whom who were staff at SVMS, one postgraduate student, one dietician and one human General Practitioner (GP). Feedback was received from the GP, the dietician and four members of SVMS staff.

Table 5.1: Amendments to an online Guide Dogs' Brood Stock Holders' questionnaire for owners of pet Labradors, Golden Retrievers, Flat Coated Retrievers, German Shepherd Dogs, Standard Poodles and their crosses

Amendment	Reason for change
Question added about the neutering status of the dog after the question about the dog's sex (Q3 in the BSH questionnaire).	All Guide Dogs breeding stock are entire so this question was not necessary in the BSH questionnaire.
Question regarding the optimum weight of the dog (Q38 in the BSH questionnaire) removed.	Guide Dogs assign an optimum weight to all their dogs. This is not done routinely in pet dogs and therefore, the methods for determining their optimum weight could be variable.
Question about diet (Q26 in the BSH questionnaire) expanded to ask about different types of diet used *e.g.* canned, dry, home-cooked.	Guide dogs are fed on dry food (either Eukanuba® or Royal Canin®) and so the question about diet (Q26) focussed on these options.
Question about how the dog's food is measured (Q30 in the BSH questionnaire) expanded to include options relevant to other food types *e.g.* a proportion of a can of food.	Guide dogs are all fed dry food so the options for measuring food were limited to methods for measuring dry food.
Number of response options increased in the question about the dog's exercise in a typical day (Q34 in the BSH questionnaire)	Feedback from pilot
New question added after the question about the dog's weight (Q36 in the BSH questionnaire), asking whether the dog's weight was stable, increasing or decreasing.	Feedback from human dietician Study by Sallander *et al.* (2010a)
New question added after the question about the owner's weight (Q47 in the BSH questionnaire) asking whether the owner made a conscious effort to manage their own weight, and if so, how.	Feedback from pilot
Instructions on how to use the slider for the Visual Analogue Scale questions were reworded to make them clearer.	
Typographical errors corrected.	

BSH = Brood Stock Holder

5.1.3 Questionnaire distribution

Kennel Club

Breed club secretaries of the relevant breeds were contacted via the Kennel Club to ask for their assistance with distributing the survey link to their

members. The proportion of breed club secretaries who responded was very variable and several different methods of distribution were agreed (Table 5.2).

Table 5.2: Number of Kennel Club Breed Club Secretaries contacted regarding distribution of a questionnaire for owners of Labradors, Golden Retrievers, Flat Coated Retrievers, German Shepherd Dogs, and Standard Poodles, and details of the responses.

Dog breed	Number of Breed Club secretaries with email addresses	Number (%) of Breed Club secretaries who agreed to assist with survey distribution	Breed Club secretaries' proposed method of survey distribution
Labrador	12	2 (17%)	Facebook page (n=2)
Golden Retriever	12	1 (8%)	Not specified
Flat Coated Retriever	4	4 (100%)	Website (n=4)
German Shepherd Dog	36	4 (11%)	Monthly breed magazine (n=1), email (n=1), leaflets (n=2)
Standard Poodle	10	2 (20%)	Facebook (n=1) Dog show (n=1)

The Kennel Club also shared the survey link via Twitter and their Facebook page and distributed leaflets containing the survey details at Crufts in March 2015.

Social Media

A brief introduction and link to the survey were posted on the author's personal Twitter and Facebook pages. These links were retweeted and shared by the author's friends, family and colleagues. Veterinary practices and a Labrador Rescue Centre in Scotland known to the author were asked to post the survey link on their Facebook pages and survey details and links were posted on dog-related online fora: Pet Chat (http://www.petchat.co.uk) and Dog Chat (http://www.dogchat.co.uk/forum)

Royal Canin also shared the survey link on their Facebook page (https://www.facebook.com/RoyalCaninUK) and the link was distributed internally to Royal Canin employees.

Leaflets

A leaflet was produced to advertise the study to dog owners and provide them with the link to the survey. This was distributed via a veterinary practice in the Leamington Spa area which was known to the author, to mirror the geographical area from which the BSH were recruited.

The survey was closed on 15.04.2015 and the full dataset was downloaded from SurveyGizmo into Microsoft Excel 2013 (Microsoft Corp., Redmond, Washington) for cleaning.

5.1.4 Data cleaning

Data were cleaned as for the BSH data (Section 4.1.4).

Any dogs which were not one of the breeds or crosses used by GD were excluded from the analysis. Any dogs under 2 years old were also excluded to ensure that all dogs were fully grown (Helmink *et al.*, 2000; German *et al.*, 2017a,b; Salt *et al.*, 2017) and that they were similar in age to the GD working (Chapter 3) and breeding stock (Chapter 4).

5.1.5 Statistical analysis

Descriptive statistics were calculated in Excel (Microsoft, 2013) before the data were imported into SPSS v. 22 (SPSS Inc., Chicago, IL) for further statistical analysis. Tests were performed in the same way as for the BSH data (Section 4.1.5). Mann-Whitney tests were used to investigate any differences in weight between male and female dogs and neutered and entire dogs.

Associations between dog and owner characteristics and behaviour and the weight of the dog

A 4-step process was used for the analyses, as for the BSH data (Section 4.1.5) using the owner-reported weight of the dog as the outcome (dependant) variable.

5.2 Results

As a snowballing technique (Oxtoby and Mossop, 2019) was used to recruit pet dog owners, no response rate could be calculated.

5.2.1 Participants

There were a total of 1126 responses to the online questionnaire. Full consent had not been given for 395 (35%) of these responses and so these were excluded from any analyses. After exclusion of respondents not living in the UK, Ireland or the Isle of Man, removal of duplicate responses and dogs under 2 years old, there were 531 (47%) useable responses. Of these 531 responses, 462 (87%) were recorded as complete responses, with the remaining 69 (13%) questionnaires only partially completed.

5.2.2. Respondent demographics

Of the 468 owners who answered the demographic questions, only 371 (79%) gave both their height and weight, enabling their BMIs to be calculated. The median BMI of these 371 owners was 25.4kg/m^2 (IQR:22.6–29.0kg/m^2). Six (2%) of these owners were underweight (BMI<18.5kg/m^2), 172 (46%) were a healthy weight (BMI 18.5–25kg/m^2), 120 (32%) were overweight (BMI 25.1–30kg/m^2) and 73 (20%) were obese (BMI>30.1kg/m^2).

Table 5.3: Demographics of 531 owners of Labradors, Golden Retrievers, Flat Coated Retrievers, German Shepherd Dogs, Standard Poodles and their crosses who responded to an online questionnaire about feeding and exercise their dog.

Demographic question	Response: Number (%) of respondents
Sex	Male: 66/465 (14%), Female: 399/465 (86%)
Age (years)	18-24: 25/466 (5%) 25-34: 60/466 (13%) 35-44: 83/466 (18%) 45-54: 135/466 (29%) 55-64: 114/466 (24%) 65-74: 47/466 (10%) 75-84: 2/466 (<1%)
Working status	Full time employment: 186/466 (40%) Part time employment: 122/466 (26%) Retired: 92/466 (20%) Homemaker: 24/466 (5%) Full time student: 11/466 (2%) Unable to work: 10/466 (2%) Other: 21/466 (5%)
Number of people in household	1: 64/465 (14%) 2: 246/465 (53%) 3: 81/465 (17%) 4: 57/465 (12%) 5: 16/465 (3%) More than 5: 1/465 (<1%)
Number of children under 18 years of age in household	No children reported: 434 (82%) 1: 59 (11%) 2: 33 (6%) 3: 5 (1%)
Age of youngest child (years)	Median: 10 years, IQR: 6–15 years Number of responses: 100 (19%)
Location	Urban: 31/468 (7%) Suburban: 175/468 (37%) Rural: 256/468 (55%) Other: 6/468 (1%)
Number of dogs owned previously	None: 83/529 (16%) 1: 78/529 (15%) 2: 63/529 (12%) 3: 63/529 (12%) 4: 45/529 (9%) 5: 26/529 (5%) More than 5: 171/529 (32%)

5.2.3 Dog details

Two owners (<1%) did not answer the question about the sex of their dog. Of the remaining 529 owners, 266 (50%) completed the questionnaire for a male dog and 263 (50%) for a female. All 531 owners answered the question about

the neutering status of their dog; 342 (64%) dogs were neutered and the remaining 189 (36%) dogs were entire (Table 5.4).

Table 5.4: Demographics of 531 Labradors, Golden Retrievers, Flat Coated Retrievers, German Shepherd Dogs, Standard Poodles and their crosses in an online questionnaire about feeding and exercise of pet dogs.

Demographic question	Response: Number (%) of participants
Sex and Neutering Status	Male Entire: 126 (24%) Male Neutered 140 (26%) Female Entire: 61 (12%) Female Neutered: 202 (38%) Sex not stated, Entire: 2 (<1%)
Age (years)	Median 6, Interquartile range 6 (3 – 9)
Breed*	Labrador: 310 (58%) Golden Retriever: 59 (11%) German Shepherd: 60 (11%) Flat Coat Retriever: 36 (7%)* Standard Poodle: 25 (5%)* Cross of one of these breeds: 41 (8%)*
Length of time dog been with owner (years)	Median 5, Interquartile range: 3–8

*Breeds comprising <10% of the total number of dogs (Flat Coat Retriever, Standard Poodle, Crossbreed) were combined into a single category (n=102, 19%) for statistical analysis.

5.2.4 Care of the dog

The majority of the 531 dog owners who answered the question about frequency of grooming said that they groomed their dogs at least once a week (n=327/531, 62%), while only 26 owners (5%) said that they never groomed their dog. In contrast, the majority of the 527 dog owners who answered the question about the frequency of tooth brushing said that they never brushed their dog's teeth (n=329/527, 62%), while only 81 (15%) reported doing this at least once a week (Table 5.5).

Table 5.5: Owner-reported frequency of grooming their dogs and brushing their dogs' teeth in an online survey of 531 owners of pet Labradors, Golden Retrievers, Flat Coated Retrievers, German Shepherd Dogs, Standard Poodles and their crosses.

Frequency	Number (%) of responses to the question 'How often do you groom your dog?'	Number (%) of responses to the question 'How often do you brush your dog's teeth?'
Daily	51 (10%)	17 (3%)
Every 2-3days	111 (21%)	27 (5%)
Weekly	165 (31%)	37 (7%)
Fortnightly	55 (10%)	27 (5%)
Less often than fortnightly	123 (23%)	90 (17%)
Never	26 (5%)	329 (62%)
Prefer not to answer	0	4 (1%)
Total	531	531

When asked whether there was anything they would like to add about the routine care of their dog, 336 owners (63%) made no comment. Of the 195 owners (37%) who did comment, 81 (42%) mentioned dental care and 57 (29%) referred to coat care. Only seven of the owners (4%) mentioned exercise, with five of these owners referring to swimming. One owner stated that they gave their dog a "Measured amount of food twice a day at regular times", but none of the owners mentioned monitoring their dog's weight.

5.2.5 Exercise

The median length of time that PDO (n=389, 73%) reported that they walked their dog on a lead, exercised their dog off-lead or their dog played with other dogs or a ball on a typical weekday was 20mins (IQR: 10-30mins), 30mins (IQR: 20-60mins), 15mins (IQR: 5-40mins) and 10mins (IQR: 0-27.5mins) respectively.

The median length of time that PDO (n=389, 73.3%) reported that they walked their dog on a lead, exercised their dog off-lead or their dog played with other dogs or a ball at the weekend was 20mins (IQR: 10–37.5mins), 45mins (IQR: 20-80mins), 20mins (IQR: 5-60mins) and 15mins (IQR: 0-30mins) respectively.

5.2.6 Dog's activity level at home

When owners were asked to indicate their dog's activity levels at home on a VAS, where 0=not active at all, spends all their time asleep and 100=extremely active, on the go all the time, the median score was 48 (IQR:29–60.3). Fifty-five respondents (10%) did not answer the question.

5.2.7 Feeding

The majority of dogs were fed twice a day (n=419/507, 83%), while 60 (12%) were fed once a day. Twenty-one dogs (4%) were fed three times a day, four dogs (<1%) were fed more than three times a day and three dogs (<1%) were fed differently on different days.

Owners were able to select multiple responses to the questions about what their dogs were fed, how they decided how much to feed and how they measured their dog's food, so the total number of responses exceeds the number of respondents. Over half the dogs were fed on complete dry food fed 'as is' (n= 279/507, 55%), while 151 (30%) dogs were fed on a complete dry food moistened with liquid *e.g.* water or gravy. A raw meat diet was fed to 98 of the dogs (19%), while 83 dogs (16%) were fed canned food, 19 (4%) mixer, 16 (3%) pouches of food and ten (2%) trays. Fifty owners (10%) admitted to feeding their dog table scraps while 25 (5%) fed a homemade diet and 27 (5%) fed another unspecified type of diet. Ten dogs (2%) were fed a prescription diet.

The majority of owners said that they decided how much to feed their dog based on its weight (n=355/506, 70%), activity levels (n=276/506, 55%) or the amount recommended on the dog food packaging (n=168/506, 33%). Forty-four owners (9%) said that their vet advised them on the amount of food to give, while 23 owners (5%) followed a breeder's advice. A further 21 owners (4%) said that they used another method of determining how much to feed their dog.

Over half the owners (n=328/505, 65%) measured the food out with a scoop or cup, while 126 (25%) said that they weighed the dog's food. Sixty-five owners (13%) measured the food out by proportion (*e.g.* half a tin), while 27 (5%) measured the food out in handfuls and 28 (6%) used another method of measuring their dog's food.

5.2.8 Routine at feeding time

Of the 445 owners who answered the question about their routine at feeding time, 348 (78%) reported that they used a command (*e.g.* sit and wait) to give their dog permission to eat while the remaining 97 owners (22%) did not.

Of the 506 owners who answered the question about whether they stayed with their dog while it was eating, the majority (n=336/506, 66%) said that they did not stand over their dog while they were eating, but were nearby. Sixty-seven owners (13%) stayed with their dog while they ate compared with 103 (20%) who did not.

5.2.9 Dietary supplements

Of the 503 owners who answered the question about whether they gave any dietary supplements to their dog, 279/503 (55%) stated that they did not give any dietary supplements. The most common types of supplements given were oils such as cod liver oil, fish oils and coconut oil (129/224, 58 %) and joint supplements such as glucosamine (115/224, 51%).

5.2.10 Treats

When asked about treats and rewards, between 14 and 19 of the 531 owners (3%) said that they never gave their dog treats (Table 5.6). Most owners (n=419/527, 80%) gave their dog treats at least once a day. The majority of owners either used treats as a reward for good behaviour (n=372/527, 71%) or

to reinforce training (n=386/527, 73%), while 132 owners (25%) gave treats at the veterinary surgery. A variety of treat types were used, with shop-bought treats and dental treats being the most commonly given (n=336/524, 64% and n=240/524, 46% respectively). Around a quarter of owners (n=133/524, 25%) used food taken from the daily allowance as treats, while 200 owners (38%) said they gave their dog fruit and vegetables.

Nearly two thirds of owners (n=330/528, 63%) used some form of exercise (play/toys or a special walk) as a reward. Food was also commonly used as a reward for good behaviour, with 321 owners (61%) rewarding their dog with dog treats. Only 123 owners (23%) used food taken from the dog's daily allowance as a reward, while 148 owners (28%) gave fruit or vegetables (Table 5.6).

Table 5.6: Owner-reported use of dog treats and rewards in an online questionnaire of 531 owners of pet Labradors, Golden Retrievers, Flat Coated Retrievers, German Shepherd Dogs, Standard Poodles and their crosses about feeding and exercising their dogs

Question	Response	Number of respondents (%)
How do you reward your dog for good behaviour? (multiple options permitted)	Praise	510 (97%)
	Fuss/cuddles	399 (76%)
	Dog treats *e.g.* bought from a shop, table scraps	321 (61%)
	Play/toys	295 (56%)
	Fruit or vegetables	148 (28%)
	Food taken from daily allowance	123 (23%)
	Special walk	35 (7%)
	Another form of reward	44 (8%)
	No response	3 (1%)
In what situations do you give your dog treats? (multiple options permitted)	To reinforce training	386 (73%)
	Reward for good behaviour	372 (71%)
	When leaving the dog on its own	205 (39%)
	Before bedtime	203 (39%)
	On or after a walk	202 (38%)
	At the veterinary surgery	132 (25%)
	When introducing the dog to new people/animals	71 (13%)
	In response to begging	17 (3%)
	Other situations	22 (4%)
	I don't give my dog treats	19 (4%)
	No response	4 (1%)
What type of treat do you give to your dog? (multiple options permitted)	Shop bought treats *e.g.* Bonios	336 (64%)
	Dental chews *e.g.* Dentistix	240 (46%)
	Fruit or vegetables	200 (38%)
	Other types of dog chew *e.g.* Rawhide chews	199 (38%)
	Food taken from daily allowance	133 (25%)
	Bones from butcher	114 (22%)
	Table scraps	95 (18%)
	Another type of treat	99 (19%)
	I don't give my dog treats	16 (3 %)
	No response	7 (1%)
How often do you give your dog treats?	5 times a day or more	49 (9%)
	2-4 times a day	241 (46%)
	Once a day	129 (24%)
	Every 2-3 days	47 (9%)
	Weekly	21 (4%)
	Less often than weekly	10 (2%)
	Never	14 (3%)
	Other (please specify below)	16 (3%)
	No response	4 (1%)

When asked about other people in the household giving the dog treats, 296/528 owners (56%) stated that other people in their household gave the dog treats, while 192 (36%) said that no one else did. Eight owners (2%) were unsure whether anyone else in the house treated the dog, while 32 owners (6%) said that the question was not applicable to them.

5.2.11 Dog behaviour around food

Dog behaviour while the owner was eating was reported by 524 owners; multiple responses were permitted, so the total number of responses exceeds 524. Over half the owners (n=284, 54%) reported that the dog took no notice of them, while 218 (42%) said that the dog sat and watched them. Fifty-seven dogs (11%) salivated or drooled, while 21 (4%) were reported to seek the owner's attention (*e.g.* by nudging them or lifting a paw), eight (2%) begged and/or paced around and four (1%) whined or barked.

When asked whether their dog begged, 283/527 owners (54%) said no, 241/527 (46%) said that their dog begged at least sometimes and three (1%) owners were not sure.

When asked how their dog would react if the owner accidentally spilled a large quantity of dog food on the floor while they were preparing their dog's meal, the responses of the 456/531 owners who described what the dog would do fell into four main categories. Just over one third of these owners (157/456, 34%) thought that their dog would attempt to eat as much as possible, while similar numbers thought that their dog would try to eat the food but leave it if told to (89/456, 20%), or ignore the food without being told (98/456, 21%). The remaining 111 owners (24%) said that their dog would wait for the command to eat.

When asked whether their dog scavenged and in what situations, 180/508 owners (35%) said that their dog did not scavenge. The responses of the 328 owners whose dogs did scavenge are summarised in Figure 5.1.

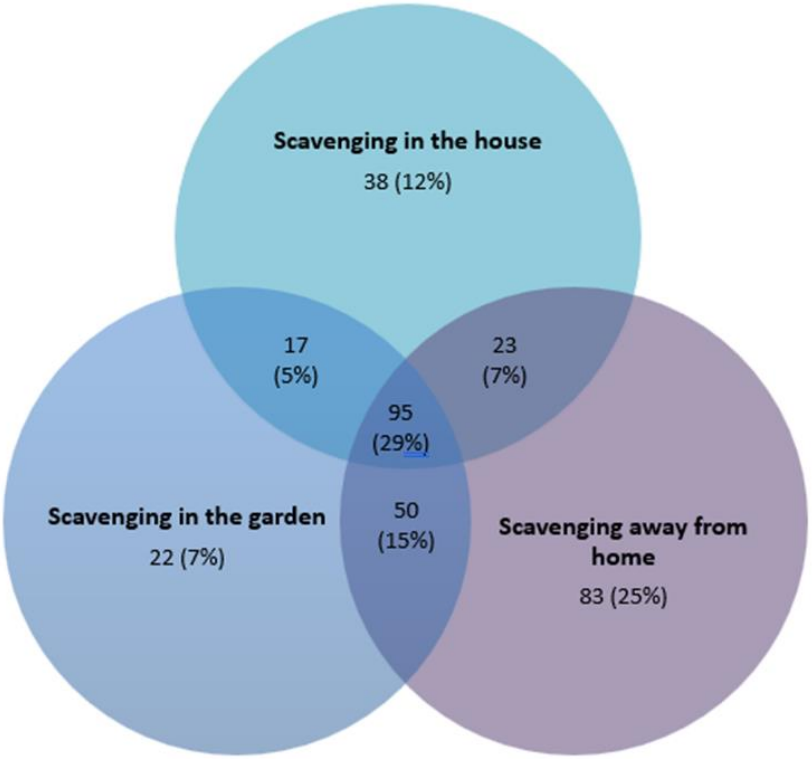


Figure 5.1: The number of pet Labradors, Golden Retrievers, Flat Coated Retrievers, German Shepherd Dogs, Standard Poodles and their crosses reported to scavenge (n=328) in different environments in an online survey of 531 dog owners.

When asked whether their dog exhibited coprophagia and in what situations, 226/509 owners (44%) said that their dog did not eat faeces. The responses of the 283 owners whose dogs did exhibit coprophagia are summarised in Figure 5.2.

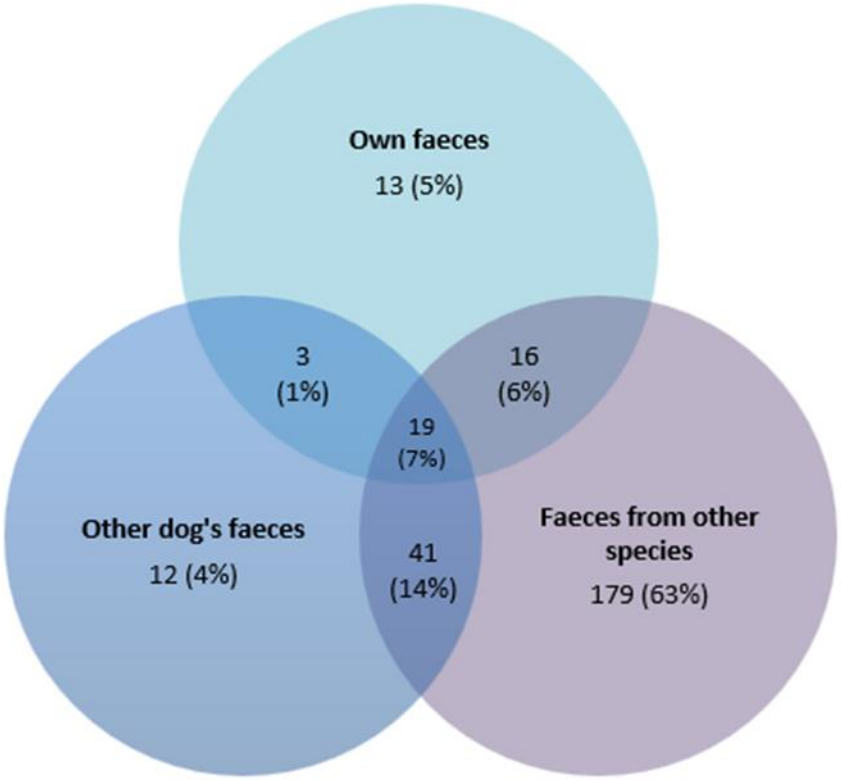


Figure 5.2: The number of pet Labradors, Golden Retrievers, Flat Coated Retrievers, German Shepherd Dogs, Standard Poodles and their crosses reported to exhibit coprophagia (n=283) with faeces from different animals in an online survey of 531 dog owners.

5.2.12 Owner behaviour around food

The majority of owners (n=460/527, 87%) said that they allowed their dog in the kitchen while they were preparing food at least sometimes, compared with 65 (12%) who never did. One owner (<1%) said that they would rather not answer that question.

Data were obtained about how 523 owners interacted with the dog while they (the owner) were eating; owners were able to select multiple options for this question, so the total number of responses exceeds 523. The majority of owners (n=368/523, 70%) said that they took no notice of the dog, whereas 23 owners (4%) said that they would pay attention to the dog by *e.g.* talking to them or petting them, two owners (<1%) said that they would give the dog a toy and four owners (1%) said that they would give the dog treats. One third of owners (n=174/523, 33%) said that they allowed the dog to sit or lie with them, compared with 99 owners (19%) who sent the dog to bed and 49 (9%) who sent the dog out of the room.

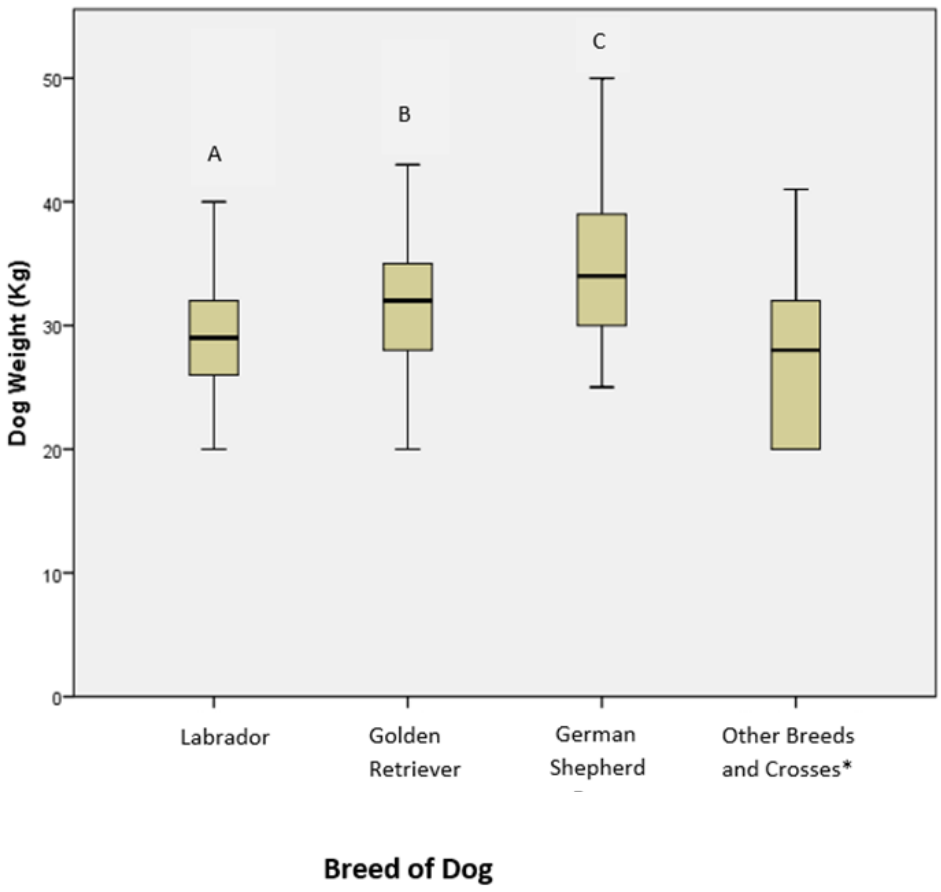
5.2.13 Health conditions

Seventy-two owners (14%) did not answer the question or were unsure whether their dogs suffered from any long-term health conditions. Of the 459 owners who did answer the question, 335 (73%) did not consider their dogs to suffer from any long-term health conditions. The remaining 124 dogs (23%) were reported to suffer from conditions such as musculoskeletal (n=69, 15%), skin (n=23, 5%), gastrointestinal (n=17, 4%), neurological (n=15, 3%), urinary tract (n=10, 2%) and/or cardiorespiratory (n=5, 1%) disorders.

5.2.14 Dog weight

Of the 531 respondents, 438 (82%) reported a weight for their dog. These ranged from <25kg to >45kg, with a median of 30kg (IQR: 26–34).

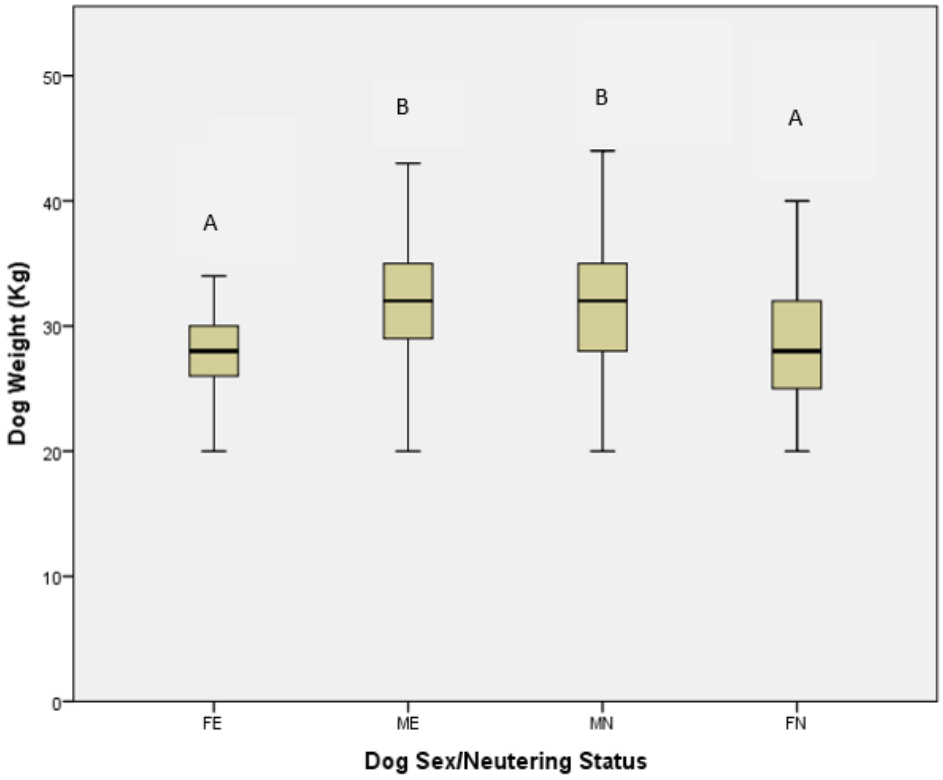
A Kruskal-Wallis test showed that median weights differed between breeds ($X^2(3)=40.3$, $p<0.001$). Mann-Whitney tests showed that there were differences between the median weights of Labradors (29kg) and both Golden Retrievers (31kg) ($U=4791.5$, $z= -2.7$, $p=0.007$) and GSD (34kg) ($U=3114.5$, $z = -5.4$, $p<0.001$). There was also a difference between the median weights of Golden Retrievers and GSD ($U=888.0$, $z = -2.5$, $p=0.012$) (Figure 5.3). Breed variation in weight was accounted for by including breed as a random effect in the modelling process.



*'Other breeds and crosses' included Flat Coated Retrievers, Standard Poodles and crosses of the breeds in the survey, where numbers were too small to analyse statistically (<10% of the total number of dogs).
A, B and C denote statistically significant weight differences between dog breeds.

Figure 5.3: The owner-reported weights of different dog breeds in an online survey of 531 owners of pet Labradors, Golden Retrievers, Flat Coated Retrievers, German Shepherd Dogs, Standard Poodles and their crosses.

Mann Whitney tests to investigate weight differences between dogs of different sexes and neutering status showed that there were differences between median weights of male and female dogs (U=13170.5, z= -8.4, p<0.001), but that there were no significant differences between the weights of neutered and unneutered dogs (U=19977.0, z= -1.8, p=0.075). There were significant differences between the weights of ME and FE dogs (U=1086.0, z= -5.8, p<0.001), MN and FE dogs (U=1536.5, z= -5.2, p<0.001), ME and FN dogs (U=4387.5, z= -6.3, p<0.001) and MN and FN dogs (U=5937.5, z= -5.8, p<0.001) (Figure 5.4).



MN=Male Neutered, ME=Male Entire, FN=Female Neutered, FE=Female Entire
A and B denote statistically significant weight differences between dog sex and reproductive status.

Figure 5.4: The owner-reported weights of male neutered (MN), male entire (ME), female neutered (FN) and female entire (FE) Labradors, Golden Retrievers, Flat Coated Retrievers, German Shepherd Dogs, Standard Poodles and their crosses in an online survey of 531 pet dog owners.

Owners were asked to indicate their perception of their dog's weight on a VAS where 0=Very underweight and 100=Very overweight. The majority of owners thought that their dogs were around the correct weight, with a median score of 53 (IQR: 48–53). Sixty respondents (11%) did not answer this question.

Of the 468 owners who answered the question about whether they thought their dog's weight was stable, increasing or decreasing, 33 (7%) thought their dog's weight was decreasing, 427 (91%) thought their dog's weight was stable and eight (2%) thought their dog's weight was increasing.

Twenty five of the 33 owners (76%) who said that their dog's weight was decreasing also thought that their dog was overweight. Of the eight owners who said their dog's weight was increasing, two (25%) thought their dog was underweight, while the remaining six (75%) thought their dog was overweight.

5.2.15 Statistical analysis

Step 1. Univariate analysis

There were a number of independent variables that were significantly associated ($p<0.2$) with the weight of the dog (Tables 5.7, 5.8 and 5.9).

Step 2. Avoiding Multicollinearity

When tested for inter-variable associations, a large number of statistically significant correlations ($p<0.05$) were found between these independent variables. As with the BSH data (Section 4.2.15), these were divided into those which related to dog characteristics (Table 5.7), owner characteristics or behaviour (Table 5.8) and those which did not relate exclusively to either dog or owner (Table 5.9).

Table 5.7: Dog-related variables significantly associated with the weight of the dog in an online survey of owners of Labradors, Golden Retrievers, Flat Coated Retrievers, German Shepherd Dogs, Standard Poodles and their crosses.

Dog behaviours and characteristics as reported by owner	P value	Unstandardised B/Difference	95% Confidence interval for B	
			Lower	Upper
Dog sex*	<0.001	4.362	3.371	5.354
Dog Breed* Labrador (Reference) Golden retriever German Shepherd Dog	 0.019 0.022	 1.970 -1.504	 0.330 -2.787	 3.611 -0.221
Dog eats faeces from species other than dogs	0.044	-1.098	-2.164	-0.031
Dog watches the owner while the owner is eating	0.059	1.042	-0.040	2.123
Dog's neutering status*	0.091	-0. 960	-2.074	0.154
Dog has any chronic health problems	0.124	0. 961	-0.266	2.188
Dog's activity levels at home	0.124	-0.018	-0.041	0.005
Dog's age*	0.155	-0.113	-0.270	0.043
Dog eats its own faeces	0.162	-1.275	-3.064	0.514

Not included in PCA*

Table 5.8: Self-reported owner-related variables significantly associated with the weight of the dog in an online survey of owners of Labradors, Golden Retrievers, Flat Coated Retrievers, German Shepherd Dogs, Standard Poodles and their crosses.

Owner behaviours (self –reported)	P value	Unstandardised B	95% Confidence interval for B	
			Lower	Upper
Owner gives dog dental treats	0.005	1.547	0.481	2.612
Amount of food owner gives dog is based on instructions on food packaging	0.012	1.467	0.323	2.610
Owner allows dog to stay with them while owner is eating	0.020	1.338	0.208	2.467
Owner gives treats as a reward for good behaviour	0.020	1.379	0.216	2.541
Owner gives dog shop-bought treats	0.022	1.292	0.189	2.396
Owner allows dog in kitchen while owner is preparing their own food	0.032	1.723	0.152	3.293
Owner sends dog to bed while owner is eating	0.036	-1.461	-2.828	-0.094
Owner measures dog's food out in handfuls	0.044	-2.462	-4.857	-0.068
Owner rewards dog with fuss/cuddles	0.049	1.234	0.004	2.465
Owner uses food taken from daily ration as treats	0.095	-1.046	-2.275	0.184
How frequently owner grooms dog	0.096	-0.322	-0.702	0.058
Owner measures dog's food by proportion (*e.g.* half a tin)	0.110	1.324	-0.300	2.949
Owner rewards dog with a special walk	0.117	1.724	-0.436	3.885
Owner's BMI*	0.134	0.088	-0.027	0.204
Owner rewards dog with play/toys	0.137	0.815	-0.259	1.890
Owner doesn't give dog any kind of treat	0.164	-2.228	-5.367	0.910
Owner sends dog out of room while owner is eating	0.179	-1.258	-3.094	0.579
Owner never gives dog treats	0.191	-1.925	-4.814	0.964
Owner gives the dog treats if they beg	0.192	-2.029	-5.077	1.020

BMI=Body Mass Index

Not included in PCA*

Table 5.9: Other independent variables significantly associated with the weight of the dog in an online survey of owners of Labradors, Golden Retrievers, Flat Coated Retrievers, German Shepherd Dogs, Standard Poodles and their crosses.

Other variables	P value	Unstandardised B/ Difference	95% Confidence interval for Difference/B	
			Lower	Upper
Location:* Rural (reference) Suburban Urban	 0.001 0.039	 1.883 2.315	 0.752 0.121	 3.014 4.508
Number of other dogs in household	0.007	-0.372	-0.643	-0.100
Presence of other pets in household	0.013	-1.460	-2.609	-0.310
Length of time spent playing with a ball per day at the weekend	0.070	0.019	-0.002	0.040
Length of time spent playing with a ball on a weekday	0.073	0.023	-0.002	0.048
Number of other cats in household	0.143	0.458	-0.155	1.070
Length of time spent playing with other dogs on a weekday	0.162	0.004	-0.002	0.009

Not included in PCA*

Step 3a PCA: Owner Characteristics and Behaviour

After removing items that cross-loaded across components (Steptoe *et al*., 1995), Bartlett's sphericity test (X^2=1104.2, df=120, p<0.001), the Kaiser-Meyer-Olkin test (KMO=0.60) and the determinant of the correlation matrix (0.12) showed that PCA was appropriate (Section 4.2.15).

Factors with Eigenvalues >1 were extracted, which resulted in seven components. These factors were then rotated using a Varimax (orthogonal) rotation to produce independent factors (Table 5.10).

Table 5.10: Rotated factor loadings for Owner Characteristics and Behaviour from a 49-item questionnaire on dog feeding and exercise routines completed by 531 UK owners of pet Labradors, Golden Retrievers, Flat Coated Retrievers, German Shepherd Dogs, Standard Poodles and their crosses. Loadings >0.4 are in bold.

	Component						
Owner Behaviours	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Owner does not give dog any kind of treat	**0.94**	-0.08	-0.02	0.01	0.03	0.02	-0.03
Owner never gives dog treats	**0.93**	-0.10	<0.01	0.04	0.01	0.01	-0.03
Owner rewards dog with play/toys	-0.02	**0.68**	-0.05	-0.08	0.06	0.21	0.05
Owner rewards dog with fuss/cuddles	-0.04	**0.62**	-0.03	0.08	-0.03	-0.02	0.08
Owner gives treats as a reward for good behaviour	-0.35	**0.56**	0.10	-0.15	0.01	<0.01	-0.04
Owner rewards dog with a special walk	0.04	**0.52**	0.06	0.11	-0.03	-0.35	-0.31
Owner sends dog to bed while owner is eating	-0.03	0.02	**0.75**	-0.09	-0.03	0.05	-0.07
Owner sends dog out of room while owner is eating	-0.04	0.01	**0.71**	0.05	0.13	0.06	0.06
Owner uses food taken from daily ration as treats	-0.12	0.16	0.14	**-0.73**	-0.05	-0.02	0.05
Owner measures dog's food by proportion (*e.g.* half a tin)	0.03	0.31	0.13	**0.55**	-0.18	-0.17	0.32
Owner gives dog shop-bought treats	-0.38	0.09	0.09	**0.50**	0.16	0.34	-0.16
Owner gives the dog treats if they beg	-0.01	0.13	0.14	-0.16	**0.72**	0.12	0.04
How frequently owner grooms dog	0.07	-0.14	-0.05	0.22	**0.69**	-0.22	-0.02
Amount of food owner gives dog is based on instructions on food packaging	0.04	0.06	0.08	0.03	-0.06	**0.82**	-0.043
Owner measures dog's food out in handfuls	-0.03	0.03	-0.03	0.01	0.04	-0.03	**0.89**
P value for the association between the factor score for each component and the dependant variable (Dog Weight)	0.18*	<0.01*	0.01*	0.01*	0.08*	0.02*	0.04*
Standardised Beta coefficient	- 0.06	0.15	- 0.12	0.12	- 0.08	0.12	- 0.10
Underlying Construct	Never giving dog treats	Means of rewarding dog	Sending dog away while owner eating	Use of food and treats	Care for dog	Source of feeding advice	Measure-ment of food

When the factor (regression) scores were calculated for each component and checked for association with the outcome variable (Table 5.10), the factor scores for all seven components were significantly related ($p<0.2$) to the outcome variable. All seven components were therefore taken forward into the modelling process.

Step 3b PCA: Dog Characteristics

Bartlett's sphericity test ($X^2=38.8$, df=10, $p<0.001$), the Kaiser-Meyer-Olkin test (KMO=0.56) and the determinant of the correlation matrix (0.92) showed that PCA was appropriate (Section 4.2.15).

Factors with Eigenvalues >1 were extracted, which resulted in two components. These factors were then rotated using a Varimax (orthogonal) rotation to produce independent factors (Table 5.11).

Table 5.11: Rotated factor loadings for dog characteristics and behaviour from a 49-item questionnaire on dog feeding and exercise completed by 531 UK owners of Labradors, Golden Retrievers, Flat Coated Retrievers, German Shepherd Dogs, Standard Poodles and their crosses. Loadings >0.4 are in bold.

Dog behaviours	**Component**	
	1	2
Dog has any chronic health problems	**0.70**	-0.01
Dog eats its own faeces	**0.65**	0.15
Dog's activity levels at home	**-0.54**	0.01
Dog watches the owner while the owner is eating	-0.11	**0.79**
Dog eats faeces from species other than dogs	0.20	**0.68**
P value for the association between the factor score for each component and the dependant variable (dog weight)	P=0.78	P=0.76

Neither of the factor (regression) scores were significantly associated with the outcome variable (Table 5.11), so the individual variables were taken forward into the modelling process.

Step 4. Model building

The backwards elimination model had an R^2 of 0.24 and an adjusted R^2 of 0.22 (Table 5.12). The Durbin-Watson statistic was 1.96, showing that the assumption of independent errors was tenable. No significant interactions ($p<0.05$) were found.

Table 5.12: Multivariable model for factors associated with higher bodyweight in pet Labradors, Golden Retrievers, German Shepherd Dogs, Flat Coated Retrievers, Standard Poodles and their crosses (n=531)

Predictor	P value	Unstandardised B coefficient	95% Confidence interval for B	
			Lower	Upper
Constant	<0.001	23.74	21.72	25.77
Dog sex:				
Female (Reference)				
Male	<0.001	4.54	3.64	5.45
Dog's Breed:				
Labrador (Reference)				
Golden Retriever	0.011	1.90	0.43	3.38
German Shepherd	0.006	-1.62	-2.77	-0.48
Owner gives dog dental treats				
No (Reference)				
Yes	0.023	1.07	0.15	1.99
Owner measures dog's food out in handfuls				
No (Reference)				
Yes	0.010	-2.71	-4.77	-0.66
Owner PCA component 3: Owner sends the dog away while owner is eating	0.001	-0.65	-1.28	-0.02
Living environment:				
Rural (Reference)				
Suburbs	0.001	1.65	0.70	2.60
Urban	0.151	1.35	-0.49	3.20

The adjusted R^2 for this model was 0.22, indicating that the model only explains 22% of the variability in the data. The remaining variability is likely due to factors not measured in this study.

5.3 Discussion

The results of this study showed that there were six main factors impacting on bodyweight in pet Labradors, Golden Retrievers, Flat Coated Retrievers, GSD, Standard Poodles and their crosses. These were the breed and sex of the dog; the location (rural, suburban or urban) where the dog lived; whether the owner gave the dog dental treats; whether the owner measured the dog's food out in handfuls and whether the owner sent the dog away while he/she was eating. GSD weighed significantly more than Golden Retrievers, which in turn were

significantly heavier than Labradors. Statistical analysis of the differences between the other breeds was not possible because of low numbers of dogs. Male dogs were significantly heavier than female dogs, and dogs living in a rural environment weighed less than those living in the suburbs or an urban area. Owners who gave the dog dental treats had heavier dogs and owners who measured their dog's food out in handfuls had lighter dogs than those who did not. Owners feeding dry food are more likely to measure their dog's food in this way, although diet type was not significantly associated with the dog's weight in this study. Owners who sent their dog to bed or out of the room while they were eating their own food had lower bodyweight dogs than those who did not.

5.3.1 Discussion of main findings

Dog Breed

In this study, there were statistically significant differences between the median reported weights of Labradors (29kg) and Golden Retrievers (31kg), Labradors and GSD (34kg) and Golden Retrievers and GSD. Statistical analysis of the differences between the other breeds was not possible because of low numbers of dogs. It was not possible to determine whether the observed weight difference between the breeds in the current study was due to differences in lean mass or body fat as no other morphometric or BCS data were collected. Previous studies in the UK, France and the USA found that Labrador retrievers, Golden Retrievers and cross-breeds were all predisposed to being overweight or obese (Mason, 1970; Colliard *et al.*, 2006; Lund *et al.*, 2006), but this was relative to all breeds of dog and rather than each other. In contrast, Courcier *et al.* (2010) found no significant association between breed and weight status. This may be because the study was limited to dogs attending five veterinary practices in the Glasgow area and factors such as location (urban or rural) can affect breed predispositions to being overweight (McGreevy *et al.*, 2005). In Australia, McGreevy *et al.* (2005) found that certain breeds, such as gundogs (including Flat Coated, Golden and Labrador Retrievers), were prone to becoming overweight after being neutered but that the opposite was true for Australian working dogs and terriers. No significant interaction between breed and neutering was found in the current study, although this may be due to the relatively small numbers of dogs of each breed.

A large national or multinational study of purebred dogs might help to clarify the effect of breed on weight status. Each dog would need its BCS and weight recorded by a trained assessor to ensure a reliable outcome variable. If this could be done at dog shows or other large gatherings of purebred dogs, it would minimise the number of assessors involved and help to reduce inter-rater variability in the BCS assigned. However, this could create selection bias in only selecting show dogs or those competing in particular types of activity. An alternative would be to ask veterinary surgeons to weigh and BCS every purebred dog they saw in practice; these data could then be extracted from the practice management system for analysis. However, this method would exclude non-vet visiting dogs, which may arguably be at greater risk of excessive weight gain if their weight and BCS is not being monitored by a

veterinary professional. A combination of recruitment methods could also be employed, but inter-rater reliability of BCS would need to be ensured if multiple assessors were used.

Dog Sex and Neutering Status

The current study found that male dogs weighed more than female dogs (median 32kg and 30kg respectively, $p<0.001$). These figures may reflect the fact that male dogs are generally larger and heavier than bitches (Mankowska *et al.*, 2017a; Smith *et al.*, 2018) rather than that the male dogs in this study were overweight (Section 3.3.1). The UK Kennel Club breed standards have different heights for dogs and bitches for Labradors, Golden Retrievers, Flat Coated Retrievers and GSD (The Kennel Club Limited, 2018), suggesting that size differences between males and females of the same breed are expected. It was not possible to determine whether the weight difference between the sexes was due to differences in overall body size or bodyfat specifically. To establish this, each dog would need to have its BCS assessed, ideally by a single investigator experienced in BCS. This would be a useful progression of this study as previous studies disagree about whether the sex of a dog affects the likelihood of it being overweight. McGreevy *et al.* (2005), Colliard *et al.* (2006) and Sallander *et al.* (2010a) all found that female dogs were at higher risk of being overweight than males, whereas Robertson (2003) and Bland *et al.* (2009) found no sex difference in prevalence of overweight dogs in Australia. However, these latter two studies relied on the owners' assessment of their dogs' weight (Robertson, 2003) or BCS (Bland *et al.*, 2009) whereas the studies by McGreevy *et al.* (2005) and Colliard *et al.* (2006) used veterinary surgeon-assigned BCS as the outcome variable, so the findings of these studies may be more reliable.

In the current study, FN dogs had a lower bodyweight than MN dogs (median 28kg and 32kg respectively). In contrast, Courcier *et al.* (2010) found that FN dogs were at greater risk of being overweight or obese than MN dogs. The lower bodyweight of FN dogs in the current study could have been due to the bodyweight differences between male and female dogs rather than the degree of adiposity (Section 3.3.1). There were no significant differences between the weights of MN and ME or FN and FE dogs in the current study (Figure 5.4), in agreement with an Australian study by Bland *et al.* (2009) and a USA study by Warren *et al.* (2011). However, Robertson (2003), Colliard *et al.* (2006) and Lund *et al.* (2006) all found that overweight dogs were more likely to be neutered (OR=2.8, 2.23 and 1.5 respectively). Reasons for these differences are not clear. It is unlikely that the inclusion of only dog breeds and crosses used by GD in the current study was a major factor as none of the other studies investigating the effects of neutering (Robertson, 2003; Colliard *et al.*, 2006; Lund *et al.*, 2006; Bland *et al.*, 2009) excluded particular breeds of dog, although the study by Warren *et al.* (2011) excluded small dogs (<10kg and/or <35cm high at the shoulder), and yet their findings were inconsistent. A higher percentage of dogs were neutered (53% of males and 77% of females) in the current study compared with that of Colliard *et al.* (2006), where only 16% and 50% of male and female dogs respectively were neutered. However, similar

percentages of neutered dogs were used in the current study and the study by Lund *et al.* (2006) (61% of male and 76% of female dogs neutered) and yet Lund *et al.* (2006) found an association between overweight status and neutering whereas the current study did not. The different countries where these studies were conducted (Australia, France and the USA respectively) is unlikely to explain these differences as studies within Australia (Robertson, 2003; Bland *et al.*, 2009) and the USA (Lund *et al.*, 2006; Warren *et al.*, 2011) showed conflicting results. A multinational study involving large numbers of entire and neutered dogs of both sexes and using a reliable outcome variable, such as a veterinary-surgeon assessed BCS, may help to clarify the effects of dog sex and neutering on the weight status of a dog.

Location

Dogs living in an urban or suburban location had a higher bodyweight than those living in a rural environment. It was not possible to determine from the results of this study whether these weight differences were due to differences in lean bodyweight or fat mass and it is possible that people living in a more urban environment have dogs of a larger body size. However, an Australian study showed that dogs living in urban environments get less exercise than those in a suburban or rural environment due to reduced access to parks and open spaces (Cutt *et al.*, 2008a,b), which may predispose them to being overweight. Conversely, McGreevy *et al.* (2005) found that dogs living in rural or semi-rural Australia were more likely to be overweight than dogs living in suburban or urban areas possibly due to easier access to food, especially on farms, and a lack of structured exercise (Bland *et al.*, 2009). Furthermore, dog owners living in flats or apartments in an urban location may need to need to take their dogs out more frequently to void if they do not have access to a garden (Degeling *et al.*, 2012; Westgarth *et al.*, 2014) and increased frequency of exercise has been linked with a lower prevalence of overweight status (Bland *et al.*, 2009). The climate in which these studies were conducted may explain the conflicting results as weather (Robertson, 2003) and season (Sallander *et al.*, 2010a) can affect the amount of exercise a dog gets. The studies by McGreevy *et al.* (2005), Cutt *et al.* (2008a,b) and Bland *et al.* (2009) included participants from the whole of Australia, Western Australia, and Victoria, Australia respectively where the climates are notably different (Australian government, undated) and the study by Degeling *et al.* (2012) was carried out in Calgary, Canada during the winter. Differences in weather, culture and lifestyles may mean that these findings cannot be extrapolated to the UK (Westgarth *et al.*, 2014).

Another reason for the difference in weight between dogs living in an urban/suburban and rural environment seen in the current study may be that pet owners living in the country are more strongly attached to their pets than those living in a town (Schaefer, 2019). Owners may reinforce their bond with their dog by walking them (Cutt *et al.*, 2008a,b; Rohlf *et al.*, 2012; Westgarth *et al.*, 2014) or giving them treats (Kienzle *et al.*, 1998; Rohlf *et al.*, 2012) and owners living in the countryside may be more inclined to walk their dogs as they live in a pleasant environment in which to exercise (Cutt *et al.*, 2008a,b).

However, there may be other unexplored reasons why dogs living in rural environments were found to have lower bodyweights in the current study and further research is needed to investigate this.

Owner use of dental treats

In the current study, there was a significant association between dogs being given dental treats and a higher bodyweight. An average dental treat contains over 100Kcal, which is around 7% of the maintenance energy requirements for a 30kg dog (Lindridge, 2015). Dog owners may not be aware of the calorie content of dental treats and give them because they think that they will benefit their dog's health (Rohlf *et al.*, 2012). Dental treats can make a significant contribution to a dog's daily calorie allowance and owners need to reduce their dog's food to compensate. More detailed nutritional information on dog treat packaging may help to increase owners' awareness of this (Lindridge, 2015; Morelli *et al.*, 2018).

Owner interactions with their dog at family mealtimes

Owners who sent their dog to its bed or out of the room while they were eating had lower bodyweight dogs than those who did not, in agreement with the study by Kienzle *et al.* (1998). This is likely due to no titbits or table scraps being fed to the dog at mealtimes (Kienzle *et al.*, 1998; Robertson, 2003; Lund *et al.*, 2006; Bland *et al.*, 2009; Courcier *et al.*, 2010; Sallander *et al.*, 2010a; Heuberger and Wakshlag, 2011b). Heuberger and Wakshlag (2011b) noted that although there was an association between feeding table scraps and excessive weight gain, there was no such link with commercial treats. This may be because table scraps are higher in fat and protein than commercial dog foods (Sallander *et al.*, 2010a,b). The veterinary profession may need to educate owners regarding the calorie content of non-commercial foods when addressing the problem of overweight pets (Lund *et al.*, 2006).

The feeding of table scraps may also reflect differences in attitudes and lifestyles between owners who feed table scraps and those who do not (Heuberger and Wakshlag, 2011b). Courcier *et al.* (2010) found that feeding table scraps was less common in owners with a higher income, which may be due to increased awareness of both the risks of excessive weight gain and their dog's weight (Buttriss, 1997). It is therefore unsurprising that higher income owners were less likely to have overweight dogs (Courcier *et al.*, 2010). The socioeconomic status of the respondents was not investigated in the current study, but this is an area that warrants further investigation.

Measuring food in handfuls

Owners who measured their dog's food out in handfuls had lighter dogs than those who did not. Owners feeding dry food are more likely to measure their dog's food in this way, although diet type was not significantly associated with the dog's weight in the current study. Measuring food by volume is inaccurate, with differences from the intended amount varying from an 18% underestimation to an 80% overestimation in one study (German *et al.*, 2011b)

and a 47% underestimation to a 152% overestimation in a second (Coe *et al.*, 2019). In both studies, the maximum overestimation was much greater than the largest underestimation, showing that over time, dogs are more likely to be overfed than underfed. It is therefore surprising that owners who measured their dog's food out in handfuls had lighter dogs than those who did not. It is possible that owners who use their hands to measure out their dog's food do so because of time pressure, so they may be less likely to 'top up' the amount of food they are giving compared to owners who use measuring cups or weighing scales to measure their dog's food. This would be an interesting area to explore further.

5.3.2 Limitations of the study

Study design

A major limitation of this study was the cross-sectional design, which prevented statistical analysis of causation (Kleinbaum *et al.*, 1982). The sample was a convenience sample, which limits the generalizability of the results to the rest of the UK population of dogs of the relevant breeds and their crosses. The sample was relatively small (n=531) with insufficient numbers of Flat Coated Retrievers and Standard Poodles for separate statistical analyses of these breeds. No sample size calculation was performed, increasing the likelihood of a Type II error (Hyde *et al*., 2021). A sample size calculation could have been performed to ensure that the study was adequately powered, but the calculation would have been based on data derived from all breeds of dog, rather than just those of GD-type breeds. However, data from the current study could be used in a sample size calculation for any future studies of guide-dog type breeds and their crosses to ensure that the study had sufficient power to detect genuine associations between potential risk factors and the dog's weight status. Inclusion of a greater proportion of Flat Coated Retrievers and Standard Poodles would enable more interbreed comparisons to be made. Further studies including all breeds of dog and their crosses would be necessary to investigate whether the findings can be generalised to the entire UK dog population.

Participants

The questionnaire was administered online, due to the logistics of offering a large number of dog owners the option of a paper copy. This would have favoured participation by dog owners who were computer literate, which may have biased the results (Berk, 1983). The participants were self-selected volunteers, which may have biased the sample towards time-rich dog owners with a particular interest in dog health.

One of the main methods of recruiting participants was via breed clubs, which may have skewed the sample towards dog breeders and owners with a particular interest in their breed. The proportion of Breed Club Secretaries who agreed to assist with survey distribution varied from 8% for Golden Retrievers to 100% for Flat Coated Retrievers, which may have resulted in Flat Coated Retrievers being over-represented. Equally, the Facebook page of the Labrador

Retriever Rescue Scotland has over 77,000 followers so this may have increased the proportion of Labrador owners completing the survey. No data were available on the number of dog owners who saw the link to the questionnaire, so no response rate could be calculated.

The questionnaire comprised 49 questions and was estimated to take 10–15 minutes to complete. Only 461 of the 531 respondents (87%) completed the questionnaire so survey fatigue may have resulted in some owners putting less effort into answering the questions (Kaminska and Foulsham, 2013). Social desirability bias, where survey respondents provide answers which are more socially acceptable than their true attitude or behaviour, may also have affected the results (Grimm, 2010; Kaminska and Foulsham, 2013).

Outcome Variable

The owner-reported weight of the dog was used as the outcome variable in the current study due to the inaccuracies in the BCS found on GDI-R (Figure 3.2, Sections 3.2.12 and 4.2.15). BCS is the most widely-accepted clinical method of assessing weight status in dogs (Laflamme, 1997; Burkholder, 2000; German *et al*., 2006), but practice is necessary to make body condition scoring a reliable assessment (Burkholder, 2000; Blageanu and Vulpe, 2018). Although owner-assigned BCS have been used in a number of previous studies into risk factors for dogs being overweight (Sallander *et al.*, 2010a; Bland *et al.*, 2009; Spain *et al.*, 2004), other studies have shown that owners tend to underestimate the BCS of their dogs (Singh *et al.*, 2002; Colliard *et al.*, 2006; Courcier *et al.*, 2011), even with the use of a BCS chart (Eastland-Jones *et al*., 2014). In addition, GD staff who had been trained in BCS were not able to accurately assess the BCS of the dogs they worked with (Figure 3.2), making it unlikely that BCS provided by untrained owners would be reliable. The accuracy of the BCS each owner assigned to their dog could have been checked by asking the participants to score images of dogs with known BCS as part of the questionnaire (Gant *et al.*, 2016), but this may have increased survey fatigue. Alternatively, the SHAPE BCS system (German *et al*., 2006) has been shown to be reliable in owners with no prior training in BCS, but no comparisons have yet been performed between the scores assigned by the SHAPE and the 9-point BCS system.

Owner-reported weights have been used as outcome variables in a number of studies investigating risk factors for dogs being overweight (Robertson, 2003; Spain *et al.*, 2004; Bland *et al.*, 2009; Sallander *et al.*, 2010a; Heuberger and Wakshlag, 2011b). Although a higher bodyweight does not necessarily mean that a dog is overweight, both Robertson (2003) and Heuberger and Wakshlag (2011b) found that overweight dogs weighed significantly more than healthy weight dogs, although the weight status of the dogs (underweight, healthy weight or overweight) in both studies was owner-reported. The limitations of using owner-reported bodyweights were discussed in Section 3.3.3.

5.3.3. Conclusion

The results of this study showed that there were six main factors impacting on bodyweight in pet dogs of the breeds and crosses used by GD. These were the

breed and sex of the dog; the location (rural v suburban/urban) where the dog lived; whether the owner gave the dog dental treats; whether the owner measured the dog's food out in handfuls and whether the owner sent the dog away while he/she was eating. While the first two factors are non-modifiable for a given dog, the latter three are owner behaviours, confirming the importance of owner behaviour around feeding and treats on the weight status of the dog. Behaviour change interventions directed at modifying owner behaviour around feeding, treating and exercising their dogs may therefore help to address the problem of overweight dogs.

Chapter 6: Protocol and Questionnaire Validation for Dog Interest in Food.

Protection Motivation Theory (Section 1.8) suggests that if an owner is informed about their dog's individual risk for becoming overweight and the potential consequences of this for the dog and themselves, then the owner might be more motivated to maintain their dog at a healthy weight. Human studies have shown that obese women who were informed of their genetic predisposition to obesity were then more confident in their ability to manage their weight and control their eating behaviour (Harvey-Berino *et al.*, 2001) and it was hypothesised that similar improvements in self-efficacy might be seen in GDO in relation to managing their WGD weight. The results of genetic testing for the *POMC* mutation in GD breeding stock (Raffan *et al.*, 2016) were not available for this study, and it has since been shown that within GD, the prevalence of overweight status in Labradors (who may have the mutation) was similar to that of Golden Retrievers, who do not (Moxon and England, 2017). An alternative method of assessing a dog's risk of becoming overweight was therefore required. Sallander *et al.* (2010a), Raffan *et al.* (2015) and Luno *et al.* (2018) all found that dogs with high food motivation were more likely to be overweight, therefore it was hypothesised that a dog's interest in food could be used to predict its risk of becoming overweight. Directly assessing food interest in a large number of dogs is not feasible but validated questionnaires to investigate food-related behaviours exist for both dogs (Raffan *et al.*, 2015) and children (Carnell and Wardle, 2007).

Questionnaires are a less time-consuming way to assess a dog's behaviour around food than direct observation (Sallander *et al.*, 2001b) and also allow the dog's responses to a greater number of situations to be explored (Taylor and Mills, 2006). In addition, the results obtained by direct observation may be affected by the dog's hunger, illness, and in the case of GD breeding stock, the stage of the reproductive cycle of the bitch at the time of testing, whereas questionnaires can gather data about the dogs' typical behaviour around food over a longer period (Taylor and Mills, 2006). Behaviour questionnaires can be validated by comparing the data they produce with measurements collected by direct observation to ensure that the questionnaire responses are an accurate measure of the dog's actual behaviour (criterion validity). Criterion validity comprises concurrent validity, where comparisons between the questionnaire responses and observed behaviours are made simultaneously; and predictive validity, where the correlation between the questionnaire responses and another criterion are investigated at a later date (Taylor and Mills, 2006).

A food distraction test has previously been designed and validated in guide dogs aged from 5-12 months (Harvey, 2014), providing one criterion for evaluation of concurrent validity of the questionnaire. Another test based on the assumption of the dog's interest in food is the 'Impossible task' (Miklósi *et al.*, 2003). This involves assessing a dog's responses to pieces of food in a container which cannot be opened by the dog (Marshall-Pescini *et al.*, 2009; Passalacqua *et al.*, 2013; D'Aniello *et al.*, 2015; Scandurra *et al.*, 2015) and has previously been used to evaluate dogs' problem-solving abilities and the human-animal bond (Passalacqua *et al.*, 2013; D'Aniello *et al.*, 2015).

The aims of this study were to develop a protocol to investigate dogs' behaviour around food; to develop and validate a questionnaire on dogs' behaviour around food; and then to investigate any correlation between each dog's interest in food and its weight status to see whether food interest could be used to predict a dog's risk of becoming overweight. The hypothesis for this study was that a dog's interest in food would be positively correlated with its weight status.

The objectives of the study were firstly to develop a protocol to assess the dog's interest in food based on existing test procedures; to develop a food interest questionnaire based on validated dog and child eating questionnaires; to investigate which questionnaire responses correlated with the dog's observed behaviour around food; to use the responses to those questions to assign a 'Food Interest Score' (FIS) to each dog; and to compare each dog's FIS with its percentage weight difference and BCS to test the hypothesis that dogs with a higher interest in food are more likely to be overweight.

6.1 Materials and Methods

6.1.1 Participants and animals.

A total of 305 BSH were contacted via email to invite them to take part in a study investigating the responses of GD breeding stock to food in different situations. These comprised all BSH who had participated in the initial questionnaire and whose dogs were still part of GD breeding program (n=105) and 200 BSH who had not participated in the original study. No formal sample size calculation was performed, but all BSH who were willing and able to participate were recruited by the GD Research Associate.

BSH were informed that the study would necessitate them bringing their dog to the NBC during August 2015 for assessment while they completed a questionnaire about the dog's behaviour around food. Contact details were provided for the author, a Research Associate at GD and the Head of the Ethics Committee at SVMS in case the recipients had any questions or concerns about the study.

6.1.2 Food response tests

Two tests (Test 1 and Test 2) were devised based on the concept of the 'Impossible task' (Miklósi *et al.*, 2003), which studies a dog's response to pieces of food in a container which is inaccessible to the dog (Marshall-Pescini *et al.*, 2009; Passalacqua *et al.*, 2013; D'Aniello *et al.*, 2015; Scandurra *et al.*, 2015). The 'Impossible task' is based on the assumption that the dog wants to get the food from the container and so seemed a suitable means of assessing a dog's interest in obtaining food. Hot dog sausages were used as the test food as these have previously been shown to discriminate between levels of food interest in guide dogs (Harvey, 2014).

Test 3, the food distraction test, had been designed and validated in guide dogs aged between 5 and 12 months (Harvey, 2014). In brief, each dog is walked past

a plate of tuna on the floor and the strength and duration of its orientation towards the tuna noted (Table 6.1).

Pilot studies

The tests were initially piloted at SVMS to assess the feasibility of the proposed tests and the data collection procedure. Three SVMS staff dogs (one Labrador, one Boxer and one Labradoodle) were used for the first pilot. The food container, test procedure and data collection process were modified and a second pilot carried out using the same dogs. The food container and test procedure were revised again and the data collection forms finalised. A final pilot was conducted at the NBC so that the test protocols could be adapted to the space where the assessments would be conducted. The pilot at the NBC used retired or boarding breeding stock that were not part of the main study.

Modifications resulting from the pilot studies

Several different types of plastic food containers were trialled in the pilot study before one of a suitable shape and design was found. The final study used microwaveable noodle bowls (17.2x15.6x9.7cm) with a vented clip-on lid (Sistema®, Sistema Plastics, New Zealand).

One of the dogs in the NBC pilot seemed to regard the food container on the floor as a toy and therefore a dog toy (rope or soft toy) was placed in the test room to try to distinguish the dogs' response to any object on the floor from their response to food.

Study outline

The food response tests were carried out by two fourth year veterinary students, referred to as research assistants from hereon. One acted as dog handler for the duration of the study, while the other acted as observer.

When the BSH arrived at the NBC with their dog, the food response tests were briefly explained and the BSH given the opportunity to ask questions about the process. Basic information about the dog and holder were recorded and verbal permission obtained to give the dog a small piece of hot dog sausage as part of the test procedure. The dog was then taken to the test room for the food response tests and BCS by the research assistants while the BSH completed an online questionnaire about their dog's response to food (Table 6.2). Paper copies of the questionnaire were available on request. Once the tests had been completed, the research assistants returned the dog to the holder and collected the completed questionnaire if necessary.

Testing the dogs' response to food.

The test room was a large first floor room with one end partitioned off with banner stands to create an enclosed area approximately 4.5mx5.3m (24m^2). The windows and glass panel in the doors of the test room were covered with sheets of A1 paper to eliminate external distractions and all furniture was removed from the test area apart from a round table 1.1m diameter and 72cm high (Figure 6.1). The table was arranged as a dining table with a plastic picnic

set comprising four sets of cutlery, plates and beakers, and four chairs were placed around it. The table was placed in the corner diagonally opposite the door, 1.4m away from the wall or window. A Vetbed® was placed near the door of the test room to mark the area where the dog was to sit before the start of each test. Separate Vetbeds® were used for dogs and bitches to minimise any scent distractions.

The research assistants walked each dog on a lead to the test room and assessed its BCS. The dog was then habituated to the test room by allowing it to explore freely for two minutes before the assessments began.

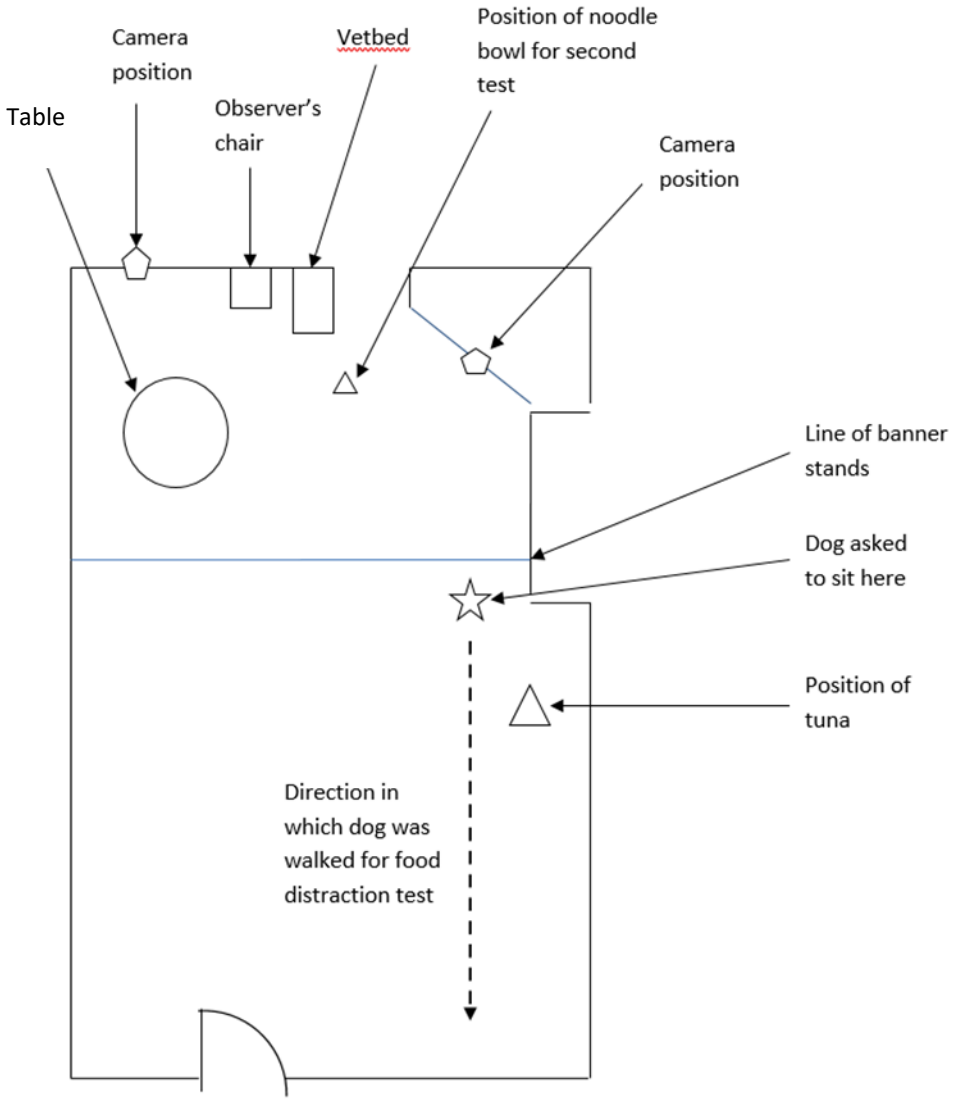


Figure 6.1: Layout of the test room for three tests used to assess the food interest and validate a food interest questionnaire in 115 Guide Dogs' breeding stock (not to scale)**.**

Microwaveable noodle bowls (Sistema®, Sistema Plastics, New Zealand) with a clip-on vented lid were used for the first two tests. The bowls were wiped with

an antibacterial wipe between each dog and then sprayed with water to remove any trace of chemicals. One hot dog sausage cut into quarters was placed into the noodle bowl and the lid clipped on.

A video camera (GoPro HD Hero 960, GoPro Inc, USA) was turned on and a whiteboard with the dog's details shown to the camera to enable the video footage to be linked to the appropriate dog at a later date.

Test 1: Food on the Table

The dog and the handler entered the test room and the dog was asked to sit on a Vetbed® to the left of the observer's chair, facing into the room. The observer then carried the noodle cup into the test room, gave the dog a piece of hot dog sausage from the noodle cup and placed the noodle cup in the centre of the table where it was secured with sticky hook and loop pads (Sellotape®) to make the food inaccessible. The observer then sat on the chair adjacent to the dog handler to minimise distraction for the dog. The research assistants simultaneously started a timer as the dog was released with the command 'OK, go free'. If the dog did not move, a gentle nudge was given. If the dog still did not move, no further encouragement was given for the duration of the test.

The handler's role was to time the length of the test (1 minute), while the observer measured the total length of time the dog was oriented towards the food on the table and noted the maximum intensity of the food-directed behaviour on a 4-point categorical scale (Table 6.1). At the end of the minute test period, the handler put the dog back on its lead, took it back to the corner with the observer's chair and asked it to sit on the Vetbed® while the observer moved the noodle cup containing the sausages into position on the floor in preparation for Test 2. The tests were carried out back-to-back with no break in between (Marshall-Pescini *et al.*, 2009).

Test 2: Food on the Floor.

Sticky hook and loop pads (Sellotape®) were preplaced on the floor 1.4m from the window and 1.3m from the Vetbed® to secure the noodle pot onto the floor. The observer secured the noodle cup in position and then returned to their chair in the corner of the room where the handler and dog were waiting. The test procedure and data collection were then as for Test 1.

Any unusual occurrences during either test such as external distractions or persistent behaviours by the dog which were unrelated to the food (*e.g.* trying to get out of the door) were noted on the data collection form.

Test 3: Food Distraction Test

This test was recorded on a GoPro HD Hero 960 (GoPro Inc, USA) video camera worn on a head mount by the dog handler. This was turned on before the dog and handler entered the test area and turned off once the test was complete.

This test was performed in a long, narrow area with a plate with 60g of tuna in brine (undrained) placed in a pre-marked position on the floor (Harvey, 2014) (Figure 6.1). The handler walked with the dog on their left-hand side in a straight line as if to walk straight past the tuna, but when they reached a predetermined point 2m from the tuna, the handler stopped and asked the dog to sit. After 10 seconds, the handler resumed walking in a straight line past the tuna. If the dog started to pull towards the tuna, the handler stopped walking as soon as the lead went taut, but did not try to pull the dog back. The handler called the dog's name once and the stopwatch was started at that point. For the duration of the test (40 seconds) the handler called the dog continuously using standard GD commands '[Dog's name] leave, [Dog's name] come'. The stopwatch was stopped if the dog oriented away from the tuna but restarted if it oriented back to the tuna during the test period. The total time the dog was oriented towards the tuna was recorded, along with the maximum level of interest in the tuna, measured on a 3-point categorical scale (Harvey, 2014) (Table 6.1).

Table 6.1: Scoring system for ethograms completed contemporaneously during three tests designed to assess a dog's interest in food.

Test	Criteria	Criteria description
Test 1 - Food on the table **and** **Test 2 - Food on the floo**r	Intensity of food-directed behaviours	The maximum intensity of the food-directed behaviour was recorded: Score 0 = No food directed behaviour displayed Score 1 = From a stationary position, the dog turns/lifts its head towards the food container/table without approach (**Gaze**). Score 2 = The dog moves towards the food container/table from anywhere in the room (**Move towards**). Score 3 = Any behaviour where the dog is physically in contact with the food container/table *e.g.* rubbing, nosing, licking, smelling, pawing or scratching (**Interaction**).
	Total duration of food-directed behaviours	Total length of time the dog was oriented towards the food on the table during the test period (60s). The stopwatch was stopped if the dog's attention moved from the food container/table and was restarted if/when its attention returned to the food container/table. A glance away (<1s) but with the body still directed towards the food container/table was counted as continuous gazing.
Test 3 - Food distraction test	Strength of pull	The maximum strength of pull towards the food was recorded: Score 1 = Lead may be tense but dogs is weight evenly distributed across all four feet and no straining against the lead (**None**) Score 2 = Head extended towards stimulus, weight pushing forwards and straining against the lead, all paws remain on the ground (**Medium**) Score 3 = Weight forwards, the dog is straining against the lead with head extended towards stimulus, back legs are stretched and one or more front paws raised off the floor (**Strong**)
	Total duration of food-directed behaviours	Total length of time the dog was oriented towards the food during the test period (40s). The stopwatch was stopped if the dog's attention moved from the food and was restarted if/when its attention returned to the food. A glance away (<1s) but with the body still directed towards the food was counted as continuous orientation.

6.1.3 Questionnaire design

A questionnaire was designed to investigate the behaviour of GD Breeding Stock around food. The questionnaire was based upon pre-existing questionnaires about appetite and obesity in dogs: the Dog Obesity Risk and Appetite (DORA) questionnaire (Raffan *et al.*, 2015); dog behaviour (University

of Ghent, 2015) and eating behaviour in children (Wardle *et al.*, 2001). The questionnaire was input into SurveyGizmo (SurveyGizmo, Boulder, CO), an online questionnaire delivery tool. A variety of question types, such as dropdown menus, VAS and free text boxes were utilised, depending on the question. The questionnaire link was then sent out to ten dog owners for piloting; these included two holders of retired brood bitches, one of whom was also a GD Research Associate. Eight of these dog owners completed the pilot questionnaire and refinements were made in response to their feedback. The final questionnaire was divided into nine pages (Table 6.2).

Table 6.2: Summary of an online questionnaire for Guide Dogs' Breeding Stock Holders regarding their brood's/stud's behaviour around food.

Page number	Page title	Summary of Contents	Type of Questions
1	Welcome page	Introduction to the author and the study. Confidentiality and anonymity Ethical Approval Contact details of the author, a Canine Research Associate at GD and the Head of the SVMS Ethics Committee.	N/A
2	Consent form	Consent required for participation in the trial	Compulsory *
3	Brood/stud details	Name and ID number of dog Date of birth Breed, sex, length of time dog been with holder	Free text Dropdown menus
4	Feeding your Brood/Stud	Current food Type of bowl used Frequency of feeding Speed of eating Amount fed Time taken to eat most recent meal Time of dog's last meal or titbits Frequency of finishing meal	Checkboxes, some with multiple options allowed, plus boxes for comments. Free text Dropdown menu VAS Range: Never to Always
5	Brood's /stud's interest in food	Excitement around food Interest in human food Satiety Fussiness Scavenging Pica	VAS - Range: Least excited/interested possible to Most excited/interested possible My dog would never eat food that they weren't familiar with to My dog would eat anything Never to Always
6	You and your Dog	Holder's view of: - their relationship with their dog - their role in caring for their dog - animals in general - giving up a dog	Checkboxes with only one option permitted.

		- euthanasia of their dog Reason for holder volunteering as a BSH Type of dog BSH wanted and why Whether BSH got the type of dog they wanted Where responsibility for dog's health and welfare lies	Free text VAS - Range: Guide Dogs to Brood/Stud dog holder
7	Visit to the Guide Dogs' National Breeding Centre today	Mode of transport Length of journey Dog's behaviour on journey Dog's familiarity with the test room	Checkboxes with only one option permitted plus box for comments. Free text Checkboxes with only one option permitted plus box for comments.
8	Additional comments	Any other relevant information Option to leave contact details if would like summary of findings	Free text
9	Thank you page		N/A

* Participants disqualified if consent not given

BSH=Breeding Stock Holder
SVMS=School of Veterinary Medicine and Science
GD=Guide Dogs
VAS=Visual Analogue Scale

6.1.4 Data cleaning

The data from the paper questionnaires were input to an Excel (1997 – 2003) spreadsheet (Microsoft, Washington, USA) with the scores from the VAS responses converted to a percentage of the total line length. The data from the online questionnaires were downloaded and cleaned. Responses for the items which were scored negatively were reversed for both datasets. Reproductive cycle data for the brood bitches were extracted from GDI-R to enable investigation of any effects of pregnancy or lactation. The three sources of data were combined into a single Excel spreadsheet for analysis.

6.1.5 Statistical analysis

Descriptive statistics were calculated in Excel (Microsoft, 2013) and SPSS v21 (SPSS Inc, Chicago, IL, USA) used for further statistical analysis. Kolmogorov–Smirnov tests for normality (Nijland *et al.*, 2009) were performed on all continuous outcome variables and parametric or non-parametric tests used as appropriate. Cases were excluded pairwise to deal with missing data. Results were regarded as statistically significant if $p<0.05$ unless otherwise stated.

Correlation between questionnaire responses and food response tests

The Kolmogorov-Smirnov test showed that neither the food response test data nor the responses to the VAS questions were normally distributed ($p <0.05$ for all). Therefore, non-parametric tests (Spearman's correlation) were used to calculate the correlation between each food response test score and each

questionnaire response. Questions that were not correlated with any of the food response test results were excluded from further analysis.

Grouping of results

A PCA was carried out on both the responses to the food interest items in the questionnaire and the food response tests to investigate whether the responses grouped into categories. Any resulting groups of variables (components) could then be represented by a factor score to reduce the number of variables and help to avoid multicollinearity (Budaev, 2010).

Measures of sampling adequacy (Bartlett's sphericity test and the Kaiser-Meyer-Olkin test) were checked for both datasets to ensure that they were suitable for PCA.

Components with Eigenvalues>1 were extracted and rotated using a Varimax (orthogonal) rotation to produce independent factors (Budaev, 2010). Items which did not load clearly onto a single factor were discarded and the PCA rerun where necessary (Steptoe *et al*., 1995).

A Cronbach's alpha test was performed on the resulting components to check internal consistency, and the effect of removing each item calculated.

Correlation between questionnaire components and food response tests

Spearman's correlations were used to investigate any correlations between the questionnaire components and the food response test data.

6.1.6 Calculation of Food Interest Scores

Cronbach's alpha scores were calculated across all the food response tests and all the VAS questions that correlated with the food response tests.

The Cronbach's alpha across all questions correlated with the food response tests was compared to the alphas for the components derived from the PCA. The internal reliability was higher using all items correlated with the food response tests than for the PCA components so the mean of the VAS responses to all the questions correlated with the food response tests was taken as the FIS for each dog.

6.1.7 Correlation of Food Interest Scores with dog weight status

Spearman's correlations were used to compare a dog's FIS with its BCS and percentage weight difference as the data were not normally distributed.

6.2 Results

6.2.1 Participants and animals

A total of 115 GD breeding stock, cared for by 113 BSH took part in the study. Seven of the dogs (6%) belonged to Guide Dogs' staff, the remaining 108 (94%) were cared for by volunteers. Eight dogs (7%) were boarding at the NBC, the remaining 107 dogs (93%) were brought to the NBC by their BSH on the day of the test.

The dogs' ages ranged from 1 to 8 years old (median: 4; IQR: 2-5 years) and the length of time they had been with their BSH ranged from 6 months to 7 years (median: 2.5; IQR: 1-3.5 years). Over half of the dogs in the study were Labradors (Table 6.3).

Table 6.3: Breeds of dog which took part in food response tests carried out at the Guide Dogs' National Breeding Centre

Breed	**Number (%) of dogs**
Labrador	59 (51%)
Golden Retriever	30 (26%)
Golden Retriever/Labrador crosses	15 (13%)
Golden Retriever x Flat Coated Retriever	2 (2%)
German Shepherd dog	8 (7%)
Standard Poodle	1 (1%)
Total	**115**

Of these 115 dogs, 78 were female and 37 were male. Two of the bitches had come into oestrous on the day of their test and another three bitches had been mated 8, 9 and 16 days previously. None of the bitches had whelped within the 48 days preceding the test date (range: 48–768 days, median: 228; IQR: 145–388 days).

The most recent mating for the male dogs ranged from 44 to 690 days prior to the test date (median: 99; IQR: 66-242 days). The dogs had been mated between 0 and 36 times previously (median: 6; IQR: 4–16 times).

The median BCS for the dogs was 5 (range: 4–7; IQR: 5–6).

For the 88 dogs for which data were available, 87 (99%) had been fed on the day of the test, the other dog (1%) was last fed the previous day at an undisclosed time.

Fifty-nine (51%) BSH reported that their dogs had previously been in the test room, 40 BSH (35%) stated that their dogs had not and 16 BSH (14%) were unsure.

6.2.2 Food response tests

The length of time the dogs spent oriented towards the food ranged from 0-40s (median: 3; IQR: 1-8) in Test 1, 3-60s (the full duration of the test) (median: 23; IQR: 14-40) in Test 2 and 0-40s (the maximum duration of the test) (median: 10; IQR: 4-17) in Test 3.

There were a range of intensities in the food directed behaviours in Test 1, with around 21% of dogs showing no food directed behaviours while over 70% moved towards or interacted with the table or food container. In comparison, all dogs interacted with the food container in Test 2 (Table 6.4). Around two-

thirds of dogs showed no food directed behaviour in Test 3 while 13% responded strongly (Table 6.5).

Table 6.4: Maximum intensity of food-directed behaviours in Tests 1 (Food on the table) and 2 (Food on the floor) shown by 115 Guide Dogs' (GD) breeding stock at GD National Breeding Centre

Maximum Intensity of Food-directed behaviour	Test 1: no (%) of dogs	Test 2: no of dogs
Score 0 = No food directed behaviour displayed	24 (21%)	0
Score 1 = From a stationary position, the dog turns/lifts its head towards the food container/table without approach **(Gaze)**	8 (7%)	0
Score 2 = The dog moves towards the food container/table from anywhere in the room **(Move towards)**	34 (30%)	0
Score 3 = Any behaviour where the dog is physically in contact with the food container/table *e.g.* rubbing, nosing, licking, smelling, pawing or scratching **(Interaction)**	49 (43%)	115
Total	**115**	**115**

Table 6.5: Maximum intensity of food-directed behaviours in Test 3 (Food distraction test) shown by 115 Guide Dogs' (GD) breeding stock at GD National Breeding Centre

Maximum strength of pull towards the food	Test 3: no (%) of dogs
Score 1 = Lead may be tense but dog's weight is evenly distributed across all four feet and no straining against the lead **(None)**	73 (64%)
Score 2 = Head extended towards stimulus, weight pushing forwards and straining against the lead, all paws remain on the ground **(Medium)**	27 (24%)
Score 3 = Weight forwards, the dog is straining against the lead with head extended towards stimulus, back legs are stretched and one or more front paws raised off the floor **(Strong)**	15 (13%)
Total	**115**

6.2.3 Questionnaire responses

Brood's /Stud's Interest in Food

A wide variation was reported in the brood's/stud's interest in food, ranging from 0 (never/least interested possible/least excited possible) to 100 (always/ most interested possible/most excited possible) for the majority of questions (Table 6.6). However, most BSH reported that their dog always (n=52/115, 45%) or at least 90% of the time (n=42/115, 37%) finished its meal and never (n=27/115, 23%) or less than 10% of the time (n=58/115, 50%) refused food.

Table 6.6: Guide Dogs' broods'/studs' interest in food in different situations as reported by the Brood Stock Holder (n=115) on a Visual Analogue Scale where 0=never/least interested/least excited possible and 100 =always/most interested/most excited possible.

Question	Median	1st quartile	3rd quartile	Interquartile Range
Frequency of finishing meal	99	96	100	4
Level of excitement around food	75	51	94	43
Level of interest when BSH preparing their own food	45	15	78	63
Level of interest when BSH is eating	33	8	59	51
Level of interest in food immediately after a meal	47	16	76	60
Frequency of food refusal*	3	1	11	11
Fussiness with food	86	57	99	42
Frequency of scavenging in the house	4	0	28	28
Frequency of scavenging away from home	52	13	84	71
Frequency of attempting to eat carcasses etc	5	2	23	21
Frequency of pica	3	1	10	9
Frequency of food distraction	23	3	51	47

BSH= Brood Stock Holder

* Item scores reversed

6.2.4 Statistical analysis

The dogs' response to food

There were no significant differences in any of the test results between the dogs belonging to members of staff at Guide Dogs and dogs whose holders were members of the public; the type or amount of food a dog was fed or dogs that were fed from a regular dog bowl and those that were fed from a slow feeder ($p>0.05$ for all). Likewise, the results did not differ significantly depending on whether the dog had been in the test room previously or ate hot dog sausage in the test room ($p>0.05$).

The dogs' BCS and percentage weight difference were not significantly correlated with the intensity or duration of food directed behaviours ($p>0.05$ for all).

The age of the dog was negatively associated with the length of time orientated towards the tuna (Test 3) (r_s= -0.184, p=0.049). Similarly, the length of time the dog had been with its holder was negatively associated with the length of time spent orientated towards the food in Test 2 (r_s= -0.192, p=0.040). Dogs that were boarding at the NBC were oriented towards the food on the table for longer than those that were brought in by their BSH (*U*=352.0, p=0.036).

The only significant breed differences in the food response tests were a longer orientation towards the food in Test 2 in Labradors compared to Golden Retrievers (p=0.002) and Labrador-Retriever crosses (p=0.005) and a higher intensity of behaviours directed towards food on the table in Labrador-Retriever crosses compared to Golden Retrievers (p=0.037).

Bitches showed a higher intensity of food-directed behaviours compared to male dogs (p=0.030) and were orientated towards the food for longer (p=0.019) in Test 1.

The number of litters a dog or bitch had had was negatively correlated with the duration of food directed behaviours in Tests 2 and 3 (r_s= -0.238, p=0.010 and r= -0.209, p=0.025 respectively). The number of litters was also negatively correlated with the intensity and duration of food directed behaviours in Test 1 (r_s= -0.211, p=0.024 and r_s= -0.198, p=0.034 respectively). However, number of litters may be a confounding factor as stud dogs sire more litters than brood bitches.

Questionnaire responses and the dogs' response to food

All dogs displayed the maximum intensity of food directed behaviours in Test 2 so it was not possible to calculate correlations for this test. Frequency of food refusal was significantly correlated with all the food response tests while frequency of pica and scavenging at home were not correlated with any (Table 6.7).

Table 6.7: Correlation between Guide Dogs' breeding stock behaviour around food as reported by their holder and observed response to food. Statistically significant responses in bold.

		Food directed behaviour				
		Test 1 – Food on Table		Test 2 – Food on Floor	Test 3 - Food distraction test	
Questionnaire item	**Value**	**Duration**	**Intensity**	**Duration**	**Duration**	**Intensity**
Frequency of finishing meal	Spearman's rho	0.153	0.111	**0.343****	**0.208***	**0.211***
	P value	0.096	0.230	**<0.001**	**0.022**	**0.021**
Level of excitement around food	Spearman's rho	0.152	0.120	**0.181***	**0.232***	**0.222***
	P value	0.098	0.195	**0.048**	**0.011**	**0.015**
Level of interest when BSH preparing their own food	Spearman's rho	0.065	-0.021	0.015	**0.232***	**0.208***
	P value	0.483	0.817	0.869	**0.011**	**0.023**
Level of interest when BSH is eating	Spearman's rho	0.065	0.057	0.103	**0.225***	**0.253****
	P value	0.482	0.540	0.266	**0.014**	**0.005**
Level of interest in food immediately after a meal	Spearman's rho	0.161	0.179	0.116	**0.240****	**0.327****
	P value	0.081	0.052	0.210	**0.009**	**<0.001**
Frequency of food refusal	Spearman's rho	**-0.290****	**-0.206***	**-0.306****	**-0.232***	**-0.308****
	P value	**0.001**	**0.026**	**0.001**	**0.011**	**0.001**
Fussiness with food	Spearman's rho	**0.274****	**0.267****	**0.323****	0.080	0.088
	P value	**0.003**	**0.003**	**<0.001**	0.388	0.340
Frequency of scavenging in the house	Spearman's rho	0.066	0.011	0.077	0.103	0.086
	P value	0.476	0.905	0.403	0.264	0.354
Frequency of scavenging away from home	Spearman's rho	**0.216***	0.166	**0.190***	**0.274****	**0.220***
	P value	**0.018**	0.071	**0.038**	**0.002**	**0.016**
Frequency of attempting to eat carcasses etc	Spearman's rho	0.132	0.086	**0.229***	**0.330****	**0.240****
	P value	0.150	0.352	**0.012**	**<0.001**	**0.008**
Frequency of pica	Spearman's rho	-0.035	-0.077	0.104	0.134	0.072
	P value	0.709	0.409	0.260	0.147	0.439
Frequency of food distraction	Spearman's rho	**0.198***	0.174	0.104	0.161	**0.188***
	P value	**0.031**	0.058	0.260	0.079	**0.040**

BSH=Brood Stock Holder

* Correlation is significant at the 0.05 level **Correlation is significant at the 0.01 level

As the responses to the questions about the frequency of scavenging in the house and frequency of pica were not correlated with any of the food response test results, these questions were excluded from any further analysis.

Grouping of food response tests

As all the dogs displayed the maximum intensity of food-directed behaviour (Score 3: interaction) for Test 2, this item was excluded from the PCA analysis.

Bartlett's sphericity test (X^2=160.0, df=10, p<0.001), the Kaiser-Meyer-Olkin test (KMO=0.59) and the determinant of the correlation matrix (0.25) showed that PCA was appropriate for these data.

Extraction of components with Eigenvalues >1 resulted in two components, which were rotated using a Varimax (orthogonal) rotation to produce independent factors (Table 6.8).

Table 6.8: Rotated factor loadings from three food response tests carried out using 115 Guide Dogs' Breeding Stock and the resulting two components. Significant loadings >0.4 are in bold

Food response test		**Component**	
		1	2
Test 1 – Food on Table	Duration	0.184	**0.871**
	Intensity	-0.030	**0.890**
Test 2 – Food on Floor	Duration	**0.589**	0.355
Test 3 – Food Distraction Test	Duration	**0.863**	0.019
	Intensity	**0.898**	-0.006

Component 1 comprised the dogs' interest in food on the floor while component 2 comprised the dogs' interest in food on the table.

A Cronbach's alpha test was performed on the two components to check internal consistency. Alphas of 0.361 and 0.386 were obtained for Components 1 and 2 respectively, showing poor internal consistency. Removal of Test 3 - Intensity from Component 1 increased the alpha to 0.427; repeating Cronbach's with items deleted was not possible for component 2 as it only comprised two items. A Cronbach's alpha score was also calculated for the five food response tests where responses varied. These questions were also found to have a low level of internal consistency (5 items; α=0.431). Removal of Test 1-Intensity increased the alpha to 0.439. Cronbach's alpha scores <0.5 are unacceptable and therefore mean scores could not be calculated for these data (Cronbach, 1951).

Grouping of Food Interest Items from questionnaire

Bartlett's sphericity test (X^2=447.8, df=45, p<0.001), the Kaiser-Meyer-Olkin test (KMO=0.77) and the determinant of the correlation matrix (0.02) showed that PCA was appropriate for these data.

Factors with Eigenvalues >1 were extracted, resulting in three components, which were then rotated using a Varimax (orthogonal) rotation to produce independent factors. The dog's level of excitement around food cross-loaded across two components so this item was excluded and the PCA rerun (Steptoe *et al*, 1995) (Table 6.9).

Table 6.9: Rotated factor loadings for the responses to Visual Analogue Scale questions regarding dog behaviour around food from 115 Guide Dogs' Breeding Stock. Significant loadings >0.4 are shown in bold.

Dog Behaviour	Component		
	1	2	3
Level of interest when Breeding Stock Holder is preparing their own food	**0.812**	0.131	0.159
Level of interest when Breeding Stock Holder is eating	**0.910**	0.051	0.039
Level of interest in food immediately after a meal	**0.665**	0.337	0.331
Frequency of food refusal*	0.097	**0.860**	0.095
Frequency of finishing meal	0.109	**0.852**	0.010
Fussiness with food	0.187	**0.669**	0.335
Frequency of scavenging away from home	0.197	0.170	**0.781**
Frequency of food distraction	0.314	0.012	**0.749**
Frequency of attempting to eat carcasses etc	-0.039	0.129	**0.703**

* Item score reversed

Component 1 comprised the dogs' interest in food around human or dog meal times; Component 2 consisted of items relating to the dog's response to food they are offered and Component 3 comprised items related to scavenging.

Correlation between questionnaire components and food response tests

Statistically significant correlations were found between the duration of food directed behaviours in Tests 1 and 2 and Components 2 and 3. The duration of food directed behaviours in Test 3 was also correlated with Component 3.

The intensity of food directed behaviours in Test 1 was not significantly correlated with any of the components, but the intensity of food-directed behaviours in Test 3 was correlated with Components 1 and 3 ($p<0.05$ for both).

Internal Consistency

A Cronbach's alpha test was performed on each of the three components to check internal consistency. Cronbach's alphas of 0.790, 0.732 and 0.672 were obtained for Components 1, 2 and 3 respectively, showing good internal consistency within each component. The alpha for Component 2 increased to 0.766 if 'Fussiness' were deleted and that of Component 3 to 0.714 when 'Frequency of eating carcasses' was removed. The alpha for component 1 was lower if any items were deleted.

A Cronbach's alpha score was then calculated for all the VAS questions that were correlated with the food response tests. These questions were also found to have high internal consistency (10 items; $\alpha=0.834$) and this did not increase

if any of the items were deleted. The Cronbach's alpha across all ten questions was higher than the maximum alphas for the three PCA components, therefore the mean of the ten VAS responses was calculated for each dog and used as its FIS.

6.2.5 Correlation of Food Interest Score with dog weight status

There was only a weak and non-significant correlation (Spearman's rho=0.157, p=0.094) between a dog's FIS and its BCS and a weak but significant correlation between a dog's FIS and its percentage weight difference (Spearman's rho=0.227, p=0.015) (Akoglu, 2018).

6.3 Discussion

The aims of this study were firstly to develop a protocol and develop and validate a questionnaire to investigate dogs' behaviour around food, and then to investigate any correlation between a dog's interest in food and its weight status to see whether food interest could be used to predict a dog's risk of becoming overweight. The hypothesis that dogs with a higher interest in food were more likely to be overweight could not be confirmed from these data.

6.3.1 Discussion of main findings

The main findings of the study were that ten of the 12 questionnaire items concerning the dog's behaviour around food were significantly correlated with the dog's observed behaviour around food in three different test situations. The VAS responses to these ten questions had a higher internal consistency than the three components arising from a PCA on the same questionnaire items and so the mean of the ten questionnaire responses was used to represent the dogs' FIS.

There were only weak correlations between a dog's FIS and both its BCS (p=0.094) and percentage weight difference (p=0.015) therefore the hypothesis that dogs with a higher interest in food were more likely to be overweight was rejected. This meant that a dog's FIS could not be used to predict the likelihood of it becoming overweight. This contrasts with studies by Sallander *et al.* (2010a), Raffan *et al.* (2015) and Luno *et al.* (2018), where a good appetite was associated with being overweight. Possible reasons for these differences are that the dogs' BCS were assessed by the owners in the three previously published studies, so may be underestimates of the dogs' true BCS (German *et al.*, 2006; Courcier *et al.*, 2011; White *et al.*, 2011; Eastland-Jones *et al.*, 2014; Gerstner and Liesegang, 2017), whereas two trained veterinary students agreed on the dogs' BCS in the current study, making their assessments more reliable. Furthermore, the dogs in the study by Sallander *et al.* (2010a) were between 1 and 3 years old, compared to the dogs in the current study, which were between 1 and 8 years old. A significant age effect was noted in Test 3, with younger dogs oriented towards the tuna for longer, so the inclusion of more mature dogs in the current study could explain this difference. The dogs in the study by Sallander *et al.* (2010a) were all pure breeds, with the four most common being Dachshunds, GSD, Golden Retrievers and Labradors. The latter

three breeds and their crosses comprised 99% of the dogs in the current study, but the large number of Dachshunds in the study by Sallander *et al.* (2010a) could explain the discrepancy as Dachshunds are at increased risk of being overweight or obese (Lund *et al.*, 2006). The study by Luno *et al.* (2018) contained approximately equal numbers of male/female and entire/neutered dogs, compared to the current study where 65% of the dogs were female and all were entire. Bitches were orientated towards the food for longer and showed a higher intensity of food-directed behaviours compared to male dogs in Test 1, so the higher proportion of females and absence of neutered dogs in the current study could account for this difference.

Labradors (Section 6.3.2) and dogs that had been with their holder for less time spent longer oriented towards the food in Test 2. The latter could be related to the dog's age and the training the dog had received from the BSH around food rather than the dog's food interest *per se*.

6.3.2 Results of food response tests

Labradors spent longer orientated towards the food than other breeds in Test 2. A genetic mutation has been identified in Labradors that increases their food motivation, which is present in around 75% in GD breeding stock (Moxon and England, 2017). Although the presence or absence of this mutation was unknown in the individual Labradors tested, it could explain why Labradors spent longer oriented towards the food than other breeds.

Bitches were orientated towards the food for longer and showed a significantly higher intensity of food-directed behaviours than the male dogs in Test 1. None of the bitches used in the study were more than 16 days pregnant and none of them had whelped in the 48 days prior to the test, so the results of their food interest tests should not have been influenced by the increased energy demands of pregnancy or lactation (Johnson, 2008). There were too few bitches at each stage of the reproductive cycle for further statistical analysis.

The more litters a dog or bitch had produced, the shorter the duration of food directed behaviours in all three tests and the lower the intensity of food directed behaviours in Test 1. This may be due to a stronger association between the NBC and mating in dogs which had produced more litters (Guide Dogs, personal communication). Ideally the tests would have been carried out in a neutral location to avoid previous experience of the test location influencing the test results.

6.3.3 Calculation of Food Interest Score

Various methods of grouping the food response test data and the responses to the food interest items from the questionnaire were evaluated. Low Cronbach's alphas showed that the responses to the food response tests had low internal reliability and so could not be grouped. PCA on the food interest items in the questionnaire produced three components but the maximum Cronbach's alpha from each of the components was lower than that of the ten items, so the mean of the ten items from the questionnaire was used as each dog's FIS.

Other factors which were not included in the FIS calculation may have influenced the dogs' interest in food. Bitches were orientated towards the food for longer than male dogs and showed a higher intensity of food directed behaviours in Test 1. Younger dogs spent longer orientated towards the food in Test 3 and dogs that had been with their holders for less time spent longer orientated towards the food in Test 2. Incorporating variables such as dog sex, breed, age and length of time with holder into the FIS calculation may have increased its predictive validity for being overweight; this would be interesting to investigate further.

6.3.4 Limitations of the study

Participants

As this was an exploratory study, no sample size calculations were conducted (Jones *et al*., 2003) so the study may have been underpowered to detect genuine associations between variables (Garamszegi, 2015). The BSH were told what the study entailed beforehand and participation was voluntary, which may have selected for participants who adhered to GD feeding guidelines, were disciplined around food and whose dogs were close to their optimum weight.

Testing the Dogs' Response to Food

The time between the dogs' last meal or food treat and the test could not be standardised as Guide Dogs would not allow the dogs' feeding routines to be changed. Ideally each dog would have been starved for 4 hours before the test to standardise the procedure between dogs (Marshall-Pescini *et al.*, 2008, 2009; Passalacqua *et al.*, 2011, 2013; D'Aniello *et al.*, 2015; Scandurra *et al.*, 2015). The time since the dogs last ate may have affected their reactions to food in the test situation (Lubbs *et al.*, 2010), therefore questions about what and when the dog was last fed were included in the BSH questionnaire. Unfortunately, there was too much missing data for meaningful statistical analysis. The time of day the test took place, the length of the car journey to the NBC, the weather and the presence or absence of air conditioning in the car may also have affected the test results (Finke, 1991). Finke (1991) found that the energy intake of Labradors decreased as the environmental temperature increased up to 23.5C, therefore the dogs' responses to food may have been blunted on warmer days. Recording internal and external temperatures may be useful if these tests were repeated to allow this phenomenon to be explored.

Conducting the food response tests at the NBC may have affected the dogs' responses to food because of their previous experiences there. Stud dogs can get particularly excited when taken to the NBC because they associate that location with mating (Guide Dogs, personal communication), which may have reduced their interest in food. Ideally the tests would have been carried out in an unfamiliar location to avoid previous experience of the test location influencing the dogs' responses. Familiarity with the test room had no effect on a dog's responses to food. Fifty-nine (51%) of the 115 dogs tested were reported to have been in the test room previously, but there were no significant

differences in any of the test responses between dogs that had been in that room before and those that had not.

Each dog was assessed on a single occasion, so its responses on the day of the test may not have been typical. Ideally each dog would have been tested on multiple occasions to ensure that the behaviours recorded were representative of that dog's usual behaviour, but this was not possible because of time constraints and inconvenience to the BSH. The two research assistants agreed on the scores assigned to each dog for the food interest tests, thus minimising interobserver variability (Mitchell, 1979). Test-retest reliability could also have been investigated for both the food response tests and the BSH food interest questionnaire (Greco *et al.*, 1987; Hendrickson *et al.*, 1993) but this was not feasible in the time available. The inter-rater reliability of the questionnaire could have been checked by asking all adults living with a particular brood/stud to complete the questionnaire and then comparing their responses using Cohen's kappa (Hallgren, 2012).

The Food distraction test (Test 3) had only previously been validated in GD puppies between 5 and 12 months old. The breeding stock used for the food response tests were all over 12 months old and a significant age effect was seen, with older dogs orientated toward the tuna for significantly less time. Similarly, dogs who had been with their holder for less time spent longer orientated towards the food in Test 2. These dogs would generally be younger dogs, so these findings may reflect the higher energy intake required by young Labradors to maintain their bodyweight (Kienzle and Rainbird, 1991) or the greater maturity and training of older dogs who have been with their holders for longer.

The food distraction test (Test 3) involved the dog handler calling the dog away from the tuna, so differences in responses could be due to the dogs' obedience and the level of discipline they were accustomed to around food rather than their food interest *per se*. To clarify this, further tests could be carried out to observe the dogs' general obedience and recall with the BSH. It would also be useful to observe how each BSH responded when their dog showed an interest in food in different situations *e.g.* food dropped on the floor or when the BSH is eating. The BSH may consciously or unconsciously either positively reinforce the behaviour, or actively discourage the behaviour, which could affect the dog's behaviour around food (Bentosela *et al.*, 2008). Questionnaire items around dog training and the dog's general obedience could also be used, although the responses could be affected by social desirability bias.

The absence of the BSH during the tests may also have affected the dog's response to food. Previous studies using the 'Impossible task' on which Tests 1 and 2 were based showed that the dogs looked to their owners for help when they were unable to access the food (Marshall-Pescini *et al.*, 2008; Passalacqua *et al.*, 2011; D'Aniello *et al.*, 2015). When Harvey (2014) conducted a range of obedience tests on GD puppies aged between 5 and 12 months, including the food distraction test (Test 3), the dog's behaviour varied between the dog's puppy walker and the experimenter, and this difference increased with age.

The youngest dog in the current study was 15 months of age, so it would be interesting to investigate whether the dogs' performance in the tests were different if the holder was present.

Questionnaire Responses

The responses given by the BSH may have been affected by social desirability bias (van de Mortel, 2008), whereby a respondent answers questions in a manner that they think will be viewed favourably by others. BSH receive strict guidelines from GD about the way they feed and exercise their dogs and the majority of BSH in the study completed the questionnaire in a public area on Guide Dogs' premises. They knew that the questionnaire would be linked with their dog and therefore themselves which may have biased their responses to give the impression that they were following GD guidelines or had a dog who was well-behaved around food.

Additional factors that were not included in the questionnaire may have had an impact on the dogs' interest in food in the test situation *e.g.* whether the dog had previously been fed hot dog sausages or tuna. Including questionnaire items around the dog's previous experience of the test foods may be worth considering if these tests are used again in the future to investigate whether these affect the dogs' responses.

Detailed ethograms were recorded for each dog from the video footage of the food response tests but were not analysed as part of this study. These data could assist in refining the food interest questionnaire for future use.

Generalisability

A limited number of breeds, mainly Labradors, Retrievers and their crosses, were used in the food response tests, so it is unclear whether the results of this study could be extrapolated to other breeds of dog. In addition, the prevalence of the *POMC* deletion is >75% in Labradors from Guide Dogs' breeding stock, compared to 23% in the general UK Labrador population (Moxon and England, 2017) meaning that the Labradors used in the food response tests may have been more food-motivated than the general UK Labrador population. The results of these food response tests and validity of the questionnaire may therefore be limited to the UK Guide Dog population.

6.3.5 Conclusion

The first aim of this study, to develop a protocol and develop and validate a questionnaire to investigate dogs' behaviour around food was achieved. Ten questionnaire items concerning the dog's behaviour around food were significantly correlated with the dog's observed behaviour around food in three different test situations. Statistical analysis showed that the mean of the ten questionnaire responses could be used to represent the dogs' FIS.

Only weak correlations were found between a dog's FIS and its BCS and percentage weight difference, so the hypothesis that dogs with a higher interest in food were more likely to be overweight could not be confirmed. This

conflicted with previously published studies (Sallander *et al.*, 2010a; Raffan *et al.*, 2015; Luno *et al.*, 2018), which found that a good appetite was associated with being overweight. This finding was disappointing as it was hoped that a dog's FIS could be used to predict its risk of becoming overweight for the intervention study (Chapter 7). This information was to be given to new GDO to investigate the effectiveness of including Protection Motivation Theory in a behaviour change intervention. As the results of this study showed that a dog's risk of becoming overweight could not be predicted from its FIS, an alternative strategy was required.

Chapter 7: Evaluation of a Behaviour Change Intervention for Guide Dog Owners to improve management of Guide Dog Weight.

The scoping review described in Chapter 2 identified a number of risk factors for dogs being overweight or obese. These included dog-related factors such as breed and sex; environmental factors such as the number of other people in the household; and owner-related factors such as the frequency of feeding treats and the duration and intensity of exercise the dog received. Surveys of GDO, BSH and PDO (Chapters 3, 4 and 5) showed similar risk factors, with a lower percentage weight difference being noted for example in stud dogs compared to brood bitches; WGD living in a household with two or more people; and WGD where the GDO monitored the dog's weight by feel.

Risk factors can be divided into those that are modifiable, where implementing changes can reduce the probability of disease, and non-modifiable risk factors, which cannot be changed (Burt, 2001). Examples of modifiable risk factors for dogs being overweight in the context of an individual GDO, BSH or PDO and their dog would be the frequency of treat-giving and the type of treat given by the owner/carer, whereas non-modifiable risk factors would include the breed and sex of the dog.

As discussed in Section 2.4.2 and the GDO (Chapter 3), BSH (Chapter 4) and PDO (Chapter 5) surveys, many of the modifiable risk factors for dogs being overweight relate to the behaviour of the owner (Courcier *et al.*, 2010). It is the owner that typically feeds and exercises the dog, hence determining its energy intake and expenditure and therefore its weight (Krasuska and Webb, 2018). Owners of overweight dogs tend to walk their dogs less, give them more treats and table snacks and weigh them less often than owners of healthy-weight dogs (Kienzle *et al.*, 1998; Robertson, 2003; Bland *et al.*, 2009; Courcier *et al.*, 2010; Heuberger and Wakshlag, 2010; Sallander *et al.*, 2010a; Warren *et al.*, 2011).

Interventions to encourage dog owners to change potentially obesogenic behaviours may therefore assist in weight management of their dogs (Krasuska and Webb, 2018). Previous studies into weight management in dogs have targeted owner behaviour, either alone (Rhodes *et al.*, 2012) or in combination with other strategies (Krasuska and Webb, 2018) such as an energy-restricted diet (German *et al.*, 2007). Combining the behavioural intervention with another weight-loss strategy makes it hard to distinguish the contribution that owner behaviour change makes to any observed weight loss. However, Porsani *et al.* (2019) found that owner adherence to feeding and exercise recommendations was significantly associated with the rate of weight loss, whereas the diet, activity levels, age, sex and reproductive status of the dog were not. This demonstrates the importance of owner behaviour relative to other variables that can influence weight loss in dogs.

The aims of this chapter were firstly to investigate the impact on GDO behaviour of an intervention designed to utilise the threat appraisal aspect of Protection Motivation Theory (Section 1.8) by informing new GDO of their dog's food interest (Chapter 6), and to give them additional information about weight

management, including tools and strategies to help them manage their dog's weight. The hypothesis for this study was that if a GDO was informed about their dog's interest in food and the potential consequences of it becoming overweight, they would be more likely to follow weight management advice to maintain their dog at a healthy weight. The second aim of this chapter was to investigate the opinions of the GDO in the intervention group of the additional information and the format in which it was provided.

The population selected for this study was GDO and their WGD because the dogs are fully grown adults, are all neutered and of a limited number of breeds and their crosses. The dogs are weighed and monitored regularly by GD and are less likely to be lost to follow-up than pet dogs and their owners. The sample comprised GDO who had been newly matched with one of the WGD from a cohort of nearly 200 puppies selected by GD based on the dog's expected date of qualification.

The following objectives were set for this study: (1) to collect data from PW who had previously cared for the dogs in the intervention study to enable the food interest scores of those dogs to be calculated; (2) to develop educational materials based on published literature (Chapter 2), the findings of the GDO, BSH and PDO studies (Chapters 3, 4 and 5) and GD standard advice to inform GDO of the risks to dogs of being overweight and give them strategies to help them manage their dog's weight; (3) to provide half the GDO in the intervention study with GD standard advice around feeding, exercising and monitoring their dog's weight (control group), with the remaining GDO (intervention group) provided with the additional materials and informed of their dog's food interest; (4) to conduct telephone interviews with the GDO around managing their dog's weight 5-7 months after matching with their new WGD; and (5) to ascertain how useful the GDO in the intervention group found the additional information provided.

7.1 Materials and Methods

7.1.1 Recruitment of participants for Puppy Walker's questionnaire

GD staff identified 189 WGDs who were in Advanced Training as potential recruits for the intervention study. The PW that had previously cared for these dogs were contacted in June/July 2015 via email where possible. The email included information about the study, contact details for the author and a research associate at GD if further information was required and a link to an online questionnaire. Paper copies of the questionnaire were posted out on request. If no email address was available, PW were posted a project information sheet, a paper copy of the questionnaire (Appendix 5), and a self-addressed envelope to return the completed questionnaire. The study was described as 'health-related research' and did not specifically mention dog weight to try to avoid bias in both the PW who responded (selection bias) and the responses given by the PW (social desirability bias).

7.1.2 Development of questionnaire

The questionnaire distributed to the PW that had previously cared for the dogs in the intervention study asked about the dog's activity levels and behaviour around food at the end of puppy walking, *i.e.* when the dog was around 12-14 months old. The questionnaire included the questions from the Food Interest questionnaire (Chapter 6) that had been used to calculate the FIS of the broods/studs in that study (Table 7.1).

Table 7.1: Summary of a questionnaire on Guide Dog Puppies' behaviour around food distributed to 189 Guide Dogs' Puppy Walkers.

Topics	Information requested	Type of Questions
Study information	Introduction to the author and the study. Confidentiality and anonymity Ethical Approval Contact details of the author, a Canine Research Associate at Guide Dogs and the Head of the Ethics Committee at the School of Veterinary Medicine and Science, University of Nottingham	N/A
Consent form	Informed consent for participation in the trial	Compulsory Tick boxes
Dog details	Name, breed, age, sex and neutering status Length of time dog was with PW	Free text Tick boxes
Feeding	Current food Frequency of feeding Routine at feeding time Any dietary supplements given	 Tick boxes Free text
Dog's interest in food	Speed of eating meals Excitement around food Frequency of finishing meal Interest in food immediately after a meal Frequency of food refusal Fussiness over food Interest in food that PW is preparing /eating Frequency of scavenging	Tick box Visual Analogue Scales
Dog exercise and activity	Activity levels of dog at home Length of time spent on lead walks and free running on a weekday Length of time spent on lead walks and free running on at the weekend	Visual Analogue Scale Textbox grid
Dog health	Any long-term health problems	Tick box and space for comments
Dog's weight	PW-reported weight of dog at the end of Puppy Walking PW opinion of dog's weight at the end of Puppy Walking	Free text Visual Analogue Scale
PW demographics	Location (urban, suburban, rural) Number of people and other pets currently in the household PW sex, age and working status PW height and weight to enable calculation of BMI	Tick boxes Free text
Additional comments	Any other relevant information	Free text

PW = Puppy Walker BMI = Body Mass Index

7.1.3 Data cleaning

Any responses where no consent had been given or no questions had been answered beyond the consent page were deleted. Respondents who had partially completed the questionnaire were cross-checked using the 'Find' function in Excel (Microsoft, 2013) to see whether that respondent had subsequently restarted and fully completed the questionnaire. If so, the partial response was deleted from the dataset.

7.1.4 Calculation of the dog's Food Interest Score

As described in the Questionnaire Validation Study (Chapter 6), the mean score of the ten questions which correlated highly with the observed behaviour of the dog around food was used as its FIS.

To investigate the effect of Protection Motivation Theory and threat appraisal on the behaviour of the GDO, it was necessary to divide the dogs in the intervention study into high and low food interest groups. As there was no strong, statistically significant association between a dogs' FIS and its weight status (Section 6.2.5), the dogs in the current study were ranked by FIS and the 15% with the lowest FIS described as the low food interest group (Sallander *et al.*, 2010a), leaving the remaining 85% as the high food interest group.

7.1.5 Development of resources for Guide Dog Owners in the Intervention group

Initially a pragmatic approach was taken with the development of the resources for the GDO in the intervention group, based on published literature (Chapter 2), the findings of the GDO, BSH and PDO studies (3, 4 and5) and GD standard information (Trybocka, 2008). During resource development, it became apparent that the planned intervention fitted with the COM-B system of behaviour and the Behaviour Change Wheel (Michie *et al.*, 2011). This framework was then used to refine the resources.

An information sheet (Appendix 6) was produced for each GDO in the intervention group, personalised by using the dog's name and he/she as appropriate throughout the document. The information sheet gave some background to the current study, highlighting the prevalence and consequences of guide dogs being overweight (Hess *et al.*, 1999; Kealy *et al.*, 2002; German, 2006; Trybocka, 2008; German *et al.*, 2012b; Yam *et al.*, 2016) and listing some of the risk factors associated with overweight status in WGD and breeding stock (Chapters 3 and 4). Each dog's food interest category (High or Low) was provided, based on the PW questionnaire responses.

Recommendations for maintaining a dog at its optimum weight were listed, based on GDO and BSH behaviours previously identified as contributing to a dog being overweight and GD standard advice. These included weighing out the dog's food on kitchen scales for every meal and using a command to tell the dog they can eat.

The section on additional food and treats included the amount by which the daily ration should be reduced or the additional exercise required to compensate for a typical Labrador being fed a medium dental treat. Giving a Labrador 1oz cheese or one rawhide bone was put into perspective by equating it to a human eating two and ten doughnuts respectively (Lindridge, 2015).

Methods used by GDO for assessing the weight of their dog (Chapter 3) were included as suggestions for ways GDO could monitor their dog's weight. These included the fit of the harness, the ease of feeling the dog's ribs and how obvious the dog's waist was.

Staff at GD provided feedback during the development of the information sheet and the final version was approved by GD before distribution. A poster displaying these recommendations (Appendix 7) was available to GDO on request if there were sighted people involved in the dog's care (Table 7.2).

GDO were informed that they would be sent monthly reminders about the weight management recommendations (Brown, 1989; Sallander *et al.*, 2010b; German *et al.*, 2015a, 2016a,b) and that they would be invited to take part in a telephone interview about 6 months after qualification with their new dog. Anonymity and confidentiality were assured and contact details for the author and her supervisor, the Head of the Ethics Committee at SVMS and a Canine Research Associate at GD were provided in case of any questions or concerns from the GDO.

Table 7.2: Additional information given to new Guide Dog Owners (GDO) (n=22) in a study comparing the effects of an intervention on GDO behaviour around managing their dog's weight with that of GDO (n=36) given Guide Dogs' standard advice alone.

Information provided	**Source of Information**	**Format(s) in which information delivered to GDO**
Dog's food interest score (High or Low)	Food interest and questionnaire validation study (Chapter 6) Responses to Puppy Walker questionnaire enabled this to be calculated for the study population (Section 7.1.4) Sallander *et al.* (2010a)	GDO information sheet Verbally from Guide Dogs' DCWA
Prevalence of overweight guide dogs	Trybocka (2008, 2011)	GDO information sheet Verbally from DCWA Poster
Conditions for which being overweight is a predisposing factor *e.g.* cardiovascular and respiratory disease, arthritis	Hess *et al.* (1999) Kealy *et al.* (2002) German (2006) German *et al.* (2012b)	GDO information sheet Verbally from DCWA Monthly email reminders Poster

	Yam *et al.* (2016)	
Treats and food given in addition to the daily ration are a risk factor for being overweight	Robertson (2003) Bland *et al.* (2009) Courcier *et al.* (2010) Heuberger and Wakshlag (2011b) Lindridge (2015) GDO and BSH surveys (Chapters 3 and 4)	GDO information sheet Verbally from DCWA Monthly email reminders Poster
Treats and rewards should be taken from the dog's daily ration	Heuberger and Wakshlag (2011b) GDO and BSH surveys (Chapters 3 and 4)	Monthly email reminders
Do not allow the dog to have treats at the veterinary surgery	BSH Survey (Chapter 4)	GDO information sheet Verbally from DCWA
Dogs are more likely to be overweight if the owner is overweight	Kienzle *et al.* (1998) Nijland *et al.* (2009)	GDO information sheet
Strategies to maintain a dog at a healthy weight		
Weigh out the dog's food on kitchen scales for every meal	BSH Survey (Chapter 4) German *et al.* (2011) Murphy *et al.* (2012) Coe *et al.* (2019)	GDO information sheet Verbally from DCWA Monthly email reminders
Reduce the dog's daily ration to compensate for any treats given	Heuberger and Wakshlag (2011b)	GDO information sheet Verbally from DCWA
Use a command to tell the dog they can eat.	Guide Dogs, personal communication	GDO information sheet Verbally from DCWA Monthly email reminders
How to assess the dog's weight status		
The harness feels tighter	GDO survey (Chapter 3) – monitor weight by feel	Poster
The ribs are harder to feel	GDO survey (Chapter 3) – monitor weight by feel	Poster
The waist is less obvious	GDO survey (Chapter 3) – monitor weight by feel	Poster

GDO=Guide Dog Owner BSH=Brood Stock Holder DCWA=Dog Care and Welfare Advisor

7.1.6 Recruitment of Guide Dog Owners

Unfortunately, some of the dogs in the cohort had qualified before the intervention materials had been finalised and approved, so the first half of the cohort to qualify as WGD were used as the control group, while dogs qualifying from April 2016 onwards were allocated to the intervention group. In the control group, the GDO were given GD standard advice on feeding, exercise and weight management when they were matched with their new dog.

In preparation for dogs allocated to the intervention group qualifying as WGD, GD DCWA, who provide information on feeding and weight management to new GDO, were emailed to inform them about the study. Two conference calls were then conducted with the author, the Research Associate at GD and the DCWA to explain more about the study and to try and ensure consistency in the way the additional information was communicated to the new GDO. The DCWA were sent an information sheet for each dog in the intervention group that they were responsible for, which they could read out or give to the GDO as appropriate. A personalised information sheet was also sent directly to the GDO in their preferred format (Braille, audio, large print). A poster was offered to all GDO in the intervention group to inform sighted members of the household and visitors to the house about the risks of excessive weight gain in dogs and possible prevention strategies (Golley *et al.*, 2010) and a reminder relating to one of the points on the poster was sent to GDO in the intervention group in their preferred format every month.

Once the dog-GDO partnership had been established for about 4.5 months, permission was requested from GD to contact the GDO to arrange a telephone interview about the dog's feeding and exercise. Where permission was granted, telephone interviews were scheduled with the GDO between 5 and 7 months after qualification. The interviews were carried out by the author or one of two third year veterinary students.

7.1.7 Development of interview schedule

An interview schedule was developed to survey GDO about feeding, exercise and weight management of their WGD, their dog's interest around food and their relationship and interaction with their dog (Table 7.3). The questions for the interview were informed by the findings of previous chapters of this thesis (Appendix 8).

The effectiveness of the intervention was explored by asking GDO in the intervention group to evaluate the usefulness of the additional information provided to them, the different formats in which the material was provided, and whether knowing their dog's food interest affected the way they managed their dog.

The interview schedule was designed to be semi-structured, with prompt questions for use if necessary. It was piloted on four pet-owning members of staff and PhD students at SVMS and the introductory script and questions modified after each pilot interview in response to the feedback given. No

changes were suggested after the fourth interview so no further piloting was carried out.

Table 7.3: Telephone interview schedule used with 58 new Guide Dog Owners to explore managing their dog's weight.

Topics	**Information requested**	**Scale used for responses** (where applicable)	**Examples of prompt questions**
Dog details	Name, sex, breed, age of dog Length of time dog been with owner		
GDO pet ownership experience	Number of previous WGD Previous pet dogs Other pets currently in the household		
Dog exercise and activity	Activity levels of dog at home Dog's workload on weekdays Dog's workload at weekend Amount of free running dog gets per week	NRS 0=minimum activity –100=maximum activity	
Feeding	Current food Environment where dog is fed How often GDO weighs dog's food on kitchen scales	NRS: 0=never–100=always	Are there other people and/or animals around your dog while it eats?
Dog's interest in food	Excitement around food Speed of eating meals Frequency of finishing meal Interest in food immediately after a meal Frequency of food refusal Fussiness over food Interest in food that GDO is preparing /eating Frequency of scavenging	NRS: 0=never/minimum possible–100=always/ maximum possible	
Treats	Frequency of treat-giving Type of treats given		
Dog's weight	Awareness of BCS system Frequency of monitoring BCS and/or weight Other ways of assessing dog's weight GDO opinion of dog's weight	NRS: 0=very underweight–100=very overweight	What do you understand by the term Body Condition Scoring?
Managing the dog's weight	Importance of managing dog's weight Effort put into managing dog's weight Ease of managing dog's weight	NRS: 0=minimum possible–100=maximum possible	

	Confidence in managing dog's weight Particular challenges in managing dog's weight		Dog seems hungry, scavenging, stealing food. Other people feeding dog Visual impairment
**Opinions of Intervention*	**Were you told your dog had a high or low interest in food?* **How useful was it to know this?* **How much did knowing this affect the way you fed and exercised your dog and monitored its weight?*	*NRS: 0=not at all useful/no effect at all–100=couldn't be more useful/maximum effect.*	
	**How useful was the extra information on managing your dog's weight?* **How useful was the poster, information sheet or equivalent?* **How helpful were the monthly email reminders?*	*NRS: 0=not at all useful–100= couldn't be more useful*	
Human-animal Bond	Reasons why GDO wanted a WGD	NRS: 1=disagree strongly–10 agree strongly (Scantlebury *et al.,* 2014).	To increase independence and confidence, as a companion
	How GDO view their WGD	5-point Likert scale: Agree, somewhat agree, neutral, somewhat disagree, disagree (Scantlebury *et al.,* 2014).	Working animal, pet, mobility aid, companion
GDO interaction with dog	Importance of verbal and tactile interaction, grooming, treats, play and toys	NRS: 0=minimum possible importance –100=maximum possible importance	
GDO lifestyle	GDO diet and exercise	NRS: 0=couldn't be less healthy–100=couldn't be healthier	How would you rate how healthy your lifestyle is? (Hjermstad *et al.*, 2011)
GDO demographics	GDO age, height and weight		
Additional comments	Any other relevant information		

*Questions asked only to the intervention group.

GDO=Guide Dog Owners
WGD=Working Guide Dogs
NRS=Numeric Rating Scale
BCS=Body Condition Scoring

7.1.8 Conducting the interviews

The interviews were arranged and carried out as for the original GDO interviews (Sections 3.1.1 and 3.1.3) between August and November 2016.

These interviews were not recorded but contemporaneous notes were taken and answers to closed questions recorded on a data collection form. These data were transferred to a Microsoft Excel (1999–2003) spreadsheet (Microsoft, Washington, USA) as soon as practical after the interview for cleaning and descriptive statistical analysis.

7.1.9 Statistical analysis

The cleaned data were imported into SPSS v.25 (SPSS Inc., Chicago, IL, USA) for further statistical analysis. The analysis was conducted on a per-protocol basis as it was discovered during the interviews that the some of the GDO assigned to the intervention group had not received the additional information intended for them. Kolmogorov–Smirnov tests for normality (Nijland *et al.*, 2009) were performed on all continuous variables and parametric or non-parametric tests used as appropriate. Cases were excluded pairwise to deal with missing data. Results were regarded as statistically significant if $p<0.05$ unless otherwise stated.

Differences between the characteristics and self-reported behaviours of the intervention and control groups were investigated, along with the confidence GDO felt around managing their dog's weight and how easy they found it to do this. For the intervention group, GDO opinions were sought on the usefulness of the additional information, the different formats in which they received it and any impact of knowing their dog's food interest.

7.2 Results

7.2.1 Response rate

There were 102 responses from the 189 PW who were sent a questionnaire on their puppy's behaviour around food, a response rate of 54%.

Nine of these dogs were permanently withdrawn from training before being matched with a GDO, and permission was not received from GD to contact 33 of the GDO who were matched with the remaining dogs (35%), leaving a potential sample of 60 GDO. Two of these GDO declined to take part in the study, therefore 58 GDO were interviewed. Although half of these GDO were allocated to the intervention group, only 22 GDO (38%) received the additional information intended for the intervention group, resulting in a control group of 36 (62%).

7.2.2 Guide Dog Owner demographics

There were no significant differences in the sex distribution ($p=0.104$), age ($p=0.756$) or BMI ($p=0.303$) of GDO in the intervention and control groups. There were no significant differences between the intervention and control groups in the number of WGDs held previously ($p=0.145$), whether the GDO

had other pets (p=0.783), and if so, the number of other dogs (p=0.798), cats (p=0.689) or other species of pet (p=0.420) owned.

7.2.3 Dog details

Of the 58 WGD-GDO dyads remaining at the interview stage of the study, eight dogs (14%) were in the low food interest group, and 50 (86%) in the high food interest group. During data analysis, it was noted that one dog from the intervention group that should have been in the low food interest group had been misclassified as high food interest. This dog had the highest FIS in the low food interest group, which is probably how the error occurred. This dog was left in the high food interest group for the remainder of the analyses as its FIS was borderline and the GDO had already been informed of the dog's FIS. The error is regretted.

There were no significant differences between the number of male and female dogs (p=0.837), the number of dogs of each breed or cross (p=0.669) or the number of dogs assigned to the high and low food interest groups (p=0.479) in the intervention and control groups. There were no significant differences between the weights of the dogs or the percentage weight difference between the two groups.

7.2.4 Guide Dog behaviour around food

There were no significant differences in the GDO responses to any of the individual questions about the dog's interest in food or the dog's FIS based on the PW responses for dogs in the intervention and control groups.

7.2.5 Guide Dog Owner behaviours

There was a statistically significant difference between the intervention and control groups in how often the GDO weighed their dog's food out on kitchen scales (U=195, p<0.001). Only six GDO (17%) in the control group said that they always weighed their dog's food out on kitchen scales, compared to 14 (64%) in the intervention group.

There were no differences between the intervention and control groups in the diets the dogs were fed (p=0.359), the environment where the dog was fed (p=0.695), the frequency with which GDO gave their dogs treats (p=0.239), or how often they took their dog's treats from the daily ration (p=0.374).

The GDO in the intervention group were less likely to use rawhide or other chews as treats compared to the GDO in the control group (p=0.019). There were no statistically significant differences between the intervention and control groups in the other types of treats given.

There were no differences between the intervention and control groups in the length of time the dogs were worked for on a weekday (p=0.444), at the weekend (p=0.562), how long they were allowed to free run per week (p=0.492) or how active the dogs were at home (p=0.371).

7.2.6 Guide Dog Owners' management of their dogs' weight

There were no differences between the intervention and control groups in the GDO perception of their dog' weight (p=0.447), the methods the GDO used to monitor their dog's weight, whether the GDO was familiar with Body Condition Scoring (p=0.798) or how frequently they weighed their dog (p=0.231).

There were no differences between the intervention and control groups in their ratings of the importance of managing their dog's weight (p=0.112), the effort put into managing their dog's weight (p=0.091), how easy they found it to manage their dog's weight (p=0.523) and their confidence in managing their dog's weight (p=0.133).

The main challenge reported by GDO in managing their dog's weight was their visual impairment, with GDO in the intervention group rating their lack of vision as a greater challenge than those in the control group (p=0.012). Several GDO reported that a lack of vision made it difficult for them to ascertain whether their dog was scavenging while free-running. In contrast, GDO in the intervention group rated their dog being hungry (p=0.022) and scavenging (p=0.012) as less of a challenge in managing its weight than the GDO in the control group.

7.2.7 Human-Animal Bond

There were no differences in how strongly the GDO in the intervention and control groups agreed with the statements about their reasons for wanting a WGD or how they rated the importance of different types of interaction with their WGD. However, GDO in the intervention group agreed more strongly than GDO in the control group that their WGDs were mobility aids (*U*=297.0, p=0.025) and companions (*U*=253.0, p=0.003). There were no differences in how important the GDO in the intervention and control groups rated different ways of interacting with their dog.

7.2.8 Intervention group opinions of the additional resources

Of the 22 GDO who received the additional information designed for the intervention group, only 11 (50%) remembered whether their dog had been assigned to the high or low food interest group. However, when these GDO were asked to rate on a scale of 0–100 how useful they found it to know this (where 0=least useful possible and 100=most useful possible), the mean rating was 68.6+/-30.7. The GDO whose dog had been misclassified could not remember the food interest group of his WGD.

There was a lot of variation in the responses to the questions asking how much of an effect knowing the dog's FIS had on the way the GDO fed and exercised their dog. The largest effect was on how the GDO monitored their dog's weight (median: 75; IQR: 17.5-90) on a scale of 0–100 where 0=no effect at all and 100=maximum possible effect. There was some effect on the way the GDO fed their dog (mean 54.6+/-36.5), how the GDO gave their dog treats (mean 59.5+/-36.0), and how other members of the household gave the dog treats (mean 63.0+/-39.3). Knowledge of the dog's FIS had little impact on how the GDO

(median: 5.0, IQR: 0-21.3) or other members of the household (median: 0, IQR: 0-0) exercised their dog.

The additional information given to the GDO (content: median: 95.0, IQR: 73.8-100.0) and the different formats in which it was provided (email: median: 90.0, IQR: 60.0-100.0 and information sheet: median: 92.5, IQR: 80.0-100.0) were generally rated as very useful. Too few GDO (n=3/22, 14%) rated the usefulness of the poster for meaningful statistical analysis.

7.3 Discussion

The aims of this chapter were firstly to test the hypothesis that informing a GDO about their dog's interest in food, the potential consequences of a dog being overweight and giving them specific tools and strategies to help them manage their dog's weight would increase adherence to weight management advice. The second aim was to investigate the opinions of GDO in the intervention group on the additional information on weight management and the format in which it was provided.

The main findings of this study were that GDO in the intervention group weighed their dog's food out on kitchen scales more frequently and were less likely to use rawhide or other chews as treats for their dogs than the GDO in the control group. There were no differences in GDO demographics to explain this, although the GDO in the intervention group rated their dogs more highly as mobility aids and companions than those in the control group. The intervention may have been responsible for modifying these GDO behaviours, although the impact of the differences in the GDO relationship with their dog between groups cannot be discounted.

The GDO in the intervention group reported that they found the additional information on managing the dog's weight helpful, with the information sheet being rated slightly more useful than the monthly reminders. Although only 50% of the GDO in the intervention group remembered whether their dog had a high or low FIS, those that did said that they found this information useful.

7.3.1 Discussion of main findings

The majority of the interviews were not conducted by the individuals responsible for the design and distribution of the additional materials to encourage honest responses from the GDO. However, social desirability bias, where survey respondents answer questions in a way that they think will be viewed more favourably by others in order to avoid embarrassment, may have biased the results (Fisher, 1993; Grimm, 2010; Kaminska and Foulsham, 2013).

It is unclear why so few GDO in the intervention group could remember their dog's food interest category. All GDO in the intervention group received a copy of the information sheet containing their dog's FIS in their preferred format for reference. GDO may have thought that the information was not important or relevant as it was followed by examples of likely dog behaviours around food rather than linked to the dog's risk of becoming overweight (Section 6.2.5). Alternatively, GDO may have deliberately disregarded the information,

particularly if they had developed strong habitual behaviours around feeding and exercise with previous WGD and were reluctant to change their behaviour (Verplanken and Wood, 2006). This was demonstrated by a reference to frequency of feeding in Chapter 3:

'I don't always listen to what Guide Dog people tell me' *(GDO 22, five previous WGD).*

Another possible explanation is the way in which the information was presented by the DCWA as GD were keen to ensure that the dogs with a high FIS were not perceived as 'problem' dogs. Interestingly, GD did not express any concerns about GDO being told that their dogs had a low FIS, which could have resulted in GDO complacency about the need to monitor and manage their dog's weight. This may suggest that GD consciously or unconsciously prioritise GDO satisfaction with their dog over the WGD's weight.

For the GDO who could remember their dog's food interest category, there was a wide range of responses to all questions about how much this knowledge affected their behaviour around food, treats and exercise for their dog. According to Protection Motivation Theory, GDO who thought that their WGD had a high interest in food should be more motivated to maintain their dog at a healthy weight (Milne *et al*., 2002). It was therefore hypothesised that GDO who were informed that their dog had a high FIS would adhere to the weight management guidelines more closely but this did not seem to be the case in the current GDO study population. Qualitative data would need to be collected from these GDO and analysed to explore the reasons for this.

The hypothesis that owners/carers who were informed that their dog had a high FIS would adhere to weight management guidelines more closely could be tested on new BSH and their broods/studs to investigate whether Protection Motivation Theory had any impact on this group of carers. The questionnaire developed and validated in Chapter 6 could be used to establish FIS for PBS and this information passed on to the BSH when they took on their new dog. A combination of questionnaires, telephone interviews and focus groups could be used once the brood/stud had been with the BSH for 6 months to enable the collection of both qualitative and quantitative data. It would also be interesting to repeat the study with PDO, although it would be more difficult to establish FIS for pet dogs. Dog rescue centres could be useful in this regard as rescue centre staff might become familiar enough with the behaviours of longer-term rescue dogs to be able to complete the food interest questions before the dog was rehomed. The information could then be passed onto the new owner when they collected the dog and permission sought to contact the owner again after 6 months for an interview.

7.3.2 Behaviour Change Theory and Intervention

According to the COM-B model of behaviour proposed by Michie *et al.* (2011), the education aspect of the intervention, such as the energy content of dog treats, addresses psychological capability and reflective motivation, while persuasion, such as potential sequelae of dogs being overweight, addresses

both reflective and automatic motivation. Opportunity (O) of the COM-B model was indirectly addressed in the current intervention because the sample comprised GDO who had been newly matched with a guide dog. Providing information designed to change habits during a period of transition in an individual's life is more effective because the context in which the behaviour is performed is changing naturally (Verplanken and Wood, 2006).

Opportunity can also be targeted with environmental restructuring, such as prompts or cues to decrease undesirable behaviours or promote desirable ones. For GDO with visual impairment, this could be a dog treat jar which gives an audible reminder about the use of treats when the lid is lifted. Opportunity can also be targeted via enablement, whereby barriers are reduced or means given beyond education, training and environmental restructuring to increase capability or opportunity. The support GD provide to their GDO could fall into this category but all GDO in this study, not just those in the intervention group, would have received similar GD support.

The information sheets were personalised with the dog's name and relevant pronouns to try and make it relevant to each GDO. Health information tailored to individuals is more effective in bringing about behaviour change than generic information, probably because people consider health-related information more carefully if they perceive it as relevant to them (Kreuter *et al.*, 1999). Although the information sheets provided to the GDO were not tailored in terms of customising the content to the individual's beliefs, motivations, barriers and self-efficacy, they were delivered in the preferred media of the GDO, thus taking some individual preferences into account. Personalisation of generic health information (*i.e*. using an individual's name on a generic document) does not increase its effectiveness and may even be detrimental (Kreuter *et al.*, 1999). This could be another possible reason why half of the GDO in the intervention group did not remember their dog's FIS.

Specific actions were advised to help manage the WGD weight, such as taking the dog's treats and rewards from its daily ration (Abraham and Sheeran, 1994; Milne *et al* 2002). This may help the GDO with Action Planning (Section 1.8) by enabling them to devise a weight management strategy for their dog which fits with their current lifestyle (Webb *et al.*, 2018).

7.3.3 Limitations of the study

Despite identifying 189 puppies for potential inclusion, the final study cohort was only 58 dog-owner dyads. Dogs were lost at various stages of the process, due to a lack of response from the puppy walker, the dog failing to qualify as a WGD or permission not being granted to interview the GDO. If a similar study were to be carried out again, a sample size calculation should be carried out to calculate the number of GDO interviews required to adequately power the study. This number would then need to be multiplied three or fourfold to allow for a similarly high dropout rate.

The dogs in the study population were allocated according to GD standard policy, therefore the GDO to whom the dogs were allocated were a random sample of GDO. However, permission was not granted by GD for over one third of these GDO to be interviewed. No explanation was given for any of the GDO who were excluded from the study but this may have biased the sample of GDO who were interviewed.

Dividing the dogs into high and low food interest groups based on questionnaire responses from their PW has a number of limitations. The questionnaire was validated in GD breeding stock from 1– 8 years old (Chapter 6) whereas the questionnaire for the dogs in the current study would have been completed based on their behaviour around food at 12-14 months of age. A significant age effect was noted in Food Response Test 3 (Chapter 6), with younger dogs oriented towards the tuna for longer, which may affect the validity of the questionnaire in a younger population of dogs. All the dogs in the questionnaire validation study were entire, whereas the dogs in the intervention study were neutered as they were intended as WGD. Furthermore, the study used as the basis for the decision to rank the dogs by FIS and take the 15% with the lowest FIS as the low food interest group comprised 99% entire dogs 1-3 years of age (Sallander *et al.*, 2010a), so although the age range of the dogs was similar between the two studies, the neutering status differed. The dogs in the study by Sallander *et al.* (2010a) were all pure breeds, with the four most common being Dachshunds, GSD, Golden Retrievers and Labradors. The latter three breeds and their crosses comprised 99% of the dogs in the current study, but inclusion of many Dachshunds in the study by Sallander *et al.* (2010a) may mean that the proportions of dogs with high and low food interests would differ between the two study populations.

The responses to the food interest questionnaires were subjective and likely influenced by any previous experience the PW had with dogs. Responses may also have been affected by selection, recall and social desirability bias.

The WGD with the borderline FIS that was misclassified was retained in the dataset due to the subjectivity of the FIS, the high dropout rate and the resulting small sample size. As the GDO could not remember the dog's food interest level, and the dog's food interest group was not the main focus of the study, the misclassification should not have affected the results, but in hindsight, this WGD-GDO dyad should have been excluded from the analysis.

Several different DCWA were responsible for passing on the additional weight management information to the GDO in the intervention group, so there may have been inconsistencies in the way in which this was delivered. The DCWA were provided with an information sheet for each dog in the intervention group to read out or give to the GDO as appropriate and the GDO were also sent the information sheet for their dog directly in their preferred format to try to ensure that each GDO received the information in a consistent manner.

A numeric rating scale (NRS) was used for questions relating to GDO perceptions of the intervention and the format in which the additional

information was delivered but GDO sometimes struggled to quantify their responses. GDO often responded with information related to the question, which would have been useful to refine and improve the materials provided (Denford *et al.*, 2016), but that was not the purpose of this study. A quantitative response was needed so GDO were given time to consider their answers (Regmi *et al.*, 2016) and/or encouraged to give their response as a percentage, but some apparent difficulties in answering the questions in this way may have affected the validity and reliability of some responses.

Allocation of dogs to the intervention or control groups would ideally have been randomised but this was not possible as the first dogs in the cohort had qualified before the intervention materials had been finalised and approved. Allocation to the intervention or control groups was therefore based on date of qualification, which occurred over a relatively short period of time during which there were no known changes in GD feeding and exercise recommendations. However, it is possible that certain dog characteristics *e.g.* higher food motivation leading to increased trainability meant that there were differences between the dogs that qualified earlier and those that qualified later in the cohort.

Ideally the interviewers would have been blinded as to which arm of the study the GDO had been assigned to, but the use of telephone questionnaires prevented this because of the additional questions required for the intervention group. The majority of the interviews were conducted by undergraduate veterinary students who had no other involvement with the study, however the influence of reflexivity and unconscious bias cannot be ruled out.

Data were analysed on a per-protocol rather than an intention-to-treat basis because some of the GDO assigned to the intervention group reported during the interview that they had not received any of the materials intended for that group. Per-protocol analyses estimate the true efficacy (method effectiveness) of an intervention but tend to exaggerate its effects and are more prone to bias (Ranganathan *et al*., 2016). For example, DCWA may have decided not to pass on the additional information to certain GDO allocated to the intervention group, leading to differential exclusion of participants (Porta *et al*., 2007; Ranganathan *et al*., 2016). In comparison, intention-to-treat analyses demonstrate the effectiveness of an intervention in real-life situations (Porta *et al*., 2007; Sedgwick, 2015) and help to account for non-adherence (Dohoo *et al*., 2003). As this was an exploratory study and there appeared to have been some oversight or miscommunication in the delivery of the intervention, a per-protocol analysis was used. However, an intention-to-treat analysis would have been necessary if the participants had been truly randomised to ensure the intervention and control groups remained balanced and to minimise confounding between groups (Porta *et al*., 2007; Sedgwick, 2015; Ranganathan *et al*., 2016).

Further studies are necessary to establish whether the differences noted between the intervention and control groups in this study were genuine or due

to the lack of randomisation and per-protocol analysis. Ideally a cohort of new GDO and their dogs would be randomised, the intervention would be delivered in a consistent manner by a single individual to all participants in the intervention group and the analysis would be carried out on an intention-to-treat basis.

7.3.4 Future work

In the current study, only the effect of the intervention on GDO behaviour was investigated. The weight status of the dog was not considered as an outcome variable because the dogs' reduced workload as they transition from training to working often leads to weight gain. It can take around a year for the dog's routine with their new owner to become established and their weight to stabilise (Trybocka, 2008) but time constraints meant that it was not possible to delay the interviews until these dogs had been qualified for a year.

Future work could involve monitoring the weight status of this cohort of dogs over a longer time period to see whether the intervention did have any impact on the weight status of the dogs. Although the intervention only succeeded in encouraging GDO to weigh their dog's food on kitchen scales and reduce their use of dog chews as treats, establishing these behaviours when the GDO was initially matched with their dog should lead to the maintenance of these desirable habits (Verplanken and Wood, 2006). If sustained, these changes might be enough to maintain the dog at its optimum weight in the longer term. However, a meta-analysis of 14 studies designed to change owner behaviour to better manage their dog's weight found that the interventions had only a small effect on the dog's weight status (Krasuka and Webb, 2018). The effect on modifying the owner's behaviour was reported to be much greater, although it is not clear how this was ascertained (Krasuka and Webb, 2018). Any self-reported behaviours are subject to social desirability and recall bias (Fisher, 1993; Grimm, 2010; Kaminska and Foulsham, 2013) and it is not clear whether these interventions coincided with any other changes in the dog owners' lives and so whether the context for the behaviours was changing anyway (Verplanken and Wood, 2006). Furthermore, the average duration of the interventions in the meta-analysis was only 3.5 months, with an average follow up of 5 months, so it is possible that a greater change would be observed in the weight status of the dogs if a longer follow-up period were used. Luszczynska *et al.* (2007) suggested a follow-up period of a year in human weight-loss subjects after an Implementation Intention intervention, and a similar or longer follow-up period should be possible for this study cohort using GD records.

Although this intervention was successful in modifying certain GDO behaviours around feeding and treating their dog, further studies could help to clarify the features that contributed to its effectiveness. Giving the control group of GDO the same intervention at a later date could demonstrate the importance of the timing of the intervention. Comparing the effectiveness of the intervention in changing GDO behaviour in experienced GDO and GDO taking on their first WGD could demonstrate whether GDO who have established feeding and exercise routines with previous WGD find it more difficult to establish new

habits than a new GDO. Qualitative analysis of semi-structured interviews with GDO could assist in identifying the successful aspects of the intervention and refining and improving its implementation and delivery if this were something that GD wished to pursue (Denford *et al.*, 2016).

In both the current study and the original GDO survey (Chapter 3, Table 3.12), GDO identified several barriers and challenges to successfully managing their dogs' weight. Some Implementation Intention interventions encourage participants to plan how they will overcome specific barriers to achieving their intentions (Coping Plans) as well as forming Action Plans (Sniehotta *et al.,* 2005). Combined planning interventions have higher success in changing behaviour than Action Plans alone (Sniehotta *et al.,* 2005), therefore GDO who have particular challenges in managing their dog's weight could be encouraged to think about possible ways to respond to these challenges in any future interventions. GD could also suggest strategies to deal with commonly identified challenges, as Implementation Intentions have been shown to be equally effective whether formulated by the individual themselves or provided by another (Armitage, 2009). An example of a Coping Plan for a problem commonly reported by GDO could be that if the WGD was given a treat by a member of the public, then the GDO would reduce the dog's feed by 10% that evening or take it for an extra 30mins walk.

Further studies are also needed to investigate whether a similar intervention would be successful with PDO. The motivation for a GDO to keep their dog at a healthy weight may differ from that of a PDO due to the WGD role as a mobility aid as well as a companion (Audrestch *et al.*, 2015). GDO may also have different challenges to PDO in managing their dog's weight due to their visual impairment. An equivalent intervention for PDO could include data about the prevalence of overweight status in the relevant dog breed, along with the energy equivalent of common dog treats. It could be difficult to provide the owner of a new pet dog with their dog's FIS but risk factors for overweight status in dogs identified in the PDO study (Chapter 5) could be reported along with ways to mitigate these. The information could be given to new dog owners at their first visit to the veterinary surgery with their new dog or puppy so that good habits around feeding, treats and exercise can be established as the owner adapts their routine to accommodate their new pet (Verplanken and Wood, 2006).

In summary, providing GDO with information about their new WGD's interest in food seemed to have little effect, as many GDO could not remember their dog's FIS. Those GDO who did correctly remember their dog's FIS reported a variable effect on their behaviours around feeding, treating and exercising their dog, suggesting that Protection Motivation Theory may not be particularly useful in behaviour change interventions to manage the weight of WGD. The additional information the GDO in the intervention group received seemed to encourage them to weigh their dog's food out on kitchen scales more frequently and reduce their use of rawhide and other dog chews compared to GDO in the control group. The timing of the intervention may have helped in

changing behaviour as the GDO established new routines and habits with their new dog. Further qualitative studies are needed to investigate the usefulness of the different components of the intervention.

Chapter 8: Final Discussion

Previous studies have investigated risk factors for overweight status and obesity in pet dogs (Chapter 2). This work focussed on WGD, GD breeding stock and pet dogs of the breeds used by GD and their crosses to help to control for the effect of breed. The risk factors identified in Chapters 3, 4 and 5 for these breeds being overweight were largely related to owner behaviour, particularly around feeding, exercise, the use of treats and monitoring the dog's weight.

The risk factors identified in Chapters 3, 4 and 5 were used in the development and evaluation of an intervention to assist weight management in WGD. This intervention required the development of materials to inform GDO of the potential consequences of a dog becoming overweight, provide them with practical strategies to help them manage their dog's weight and monthly reminders explaining the reasons behind those strategies. The intervention also involved informing the GDO of their dog's food interest, as behaviour change theories and human weight management studies suggest that if GDO know that their dog has a high food interest, they will be more motivated to follow weight management guidelines. The intervention reduced potentially obesogenic behaviours in GDO during the follow-up period (Chapter 7), although longer-term studies are required to establish the impact of the intervention on the weight status of the dogs.

8.1 Overview of key findings

The management, behaviours and characteristics of the dogs and their owners/carers that were significantly associated with the dogs' weight status depended on the measures used to assess the weight status of the dogs. When the BSH-reported weight of the dog was used as the outcome variable, the sex of the brood/stud and the length of time that they had been with the BSH were significantly associated with the dog's weight. However, when the percentage weight difference of the brood/stud was used as the outcome variable, the main influence on the weight status of the brood/stud was the BSH's use of treats, specifically frequency of treat-giving and whether treats were used for training and rewards. How the BSH managed the brood's/stud's feeding and exercise was also associated with the brood's/stud's percentage weight difference in the final model, along with the dog's sex and whether it ate faeces from species other than dogs. Similarly, in the GDO survey, when the GDO-reported weight of the dog was used as the outcome variable, whether the GDO had had WGD previously and monitored the dog's weight by weighing it at the veterinary surgery were significantly associated with the dog's weight, along with the sex of the dog and the GDO. When the percentage weight difference of the WGD was used as the outcome variable, the main influences on the weight status of the dog were whether the GDO monitored the dog's weight by feel, used food taken from the daily ration as treats, the amount of working exercise the dog did and the number of people in the household. The outcome variable used to assess a dog's weight status may therefore need to be taken into consideration when making comparisons between studies (Munoz-Prieto

et al., 2018). The studies of risk factors for overweight status and obesity in dogs identified in the scoping review (Chapter 2) used a combination of BCS (Spain *et al.*, 2004; McGreevy *et al.*, 2005; Colliard *et al.*, 2006; Lund *et al.*, 2006; Bland *et al.*, 2009; Courcier *et al.*, 2010; Heuberger and Wakshlag, 2010; Sallander *et al.*, 2010a; Warren *et al.*, 2011), the weight of the dog (Robertson, 2003; Colliard *et al.*, 2006; Sallander *et al.*, 2010a; Warren *et al.*, 2011), the owner's opinion on whether the dog was overweight or not (Robertson, 2003; Bland *et al.*, 2009) and the estimated percentage the dog was overweight (Nijland *et al.*, 2009) as outcome variables. Despite this, there were few contradictory results, although the risk factors associated with the weight status of the dog varied between studies. Finding similar associations in different study populations with different outcome variables suggests that these associations are genuine and not due to bias (Grimes and Schultz, 2002), therefore the associations found in the scoping review (Chapter 2) and in the GDO (Chapter 3), BSH (Chapter 4) and PDO (Chapter 5) chapters are likely to be authentic. The different outcome variables used in different studies may explain why different risk factors were associated with the weight status of the dog.

Although there were differences in the precise risk factors for overweight status in the three populations of dogs, common themes were the owner's/carer's behaviours around exercising, feeding and treating their dog. Monitoring the weight of the dog was also significant in both GDO models (Chapter 3).

Other common factors across the populations of dogs were the effects of dog sex and breed on weight and/or weight status. In agreement with Mankowska *et al.* (2017a) and Smith *et al.* (2018), male dogs weighed significantly more than females in all three populations of dogs. Male dogs were more likely to be closer to their optimum weight than bitches within GD breeding stock, in agreement with McGreevy *et al.* (2005), Colliard *et al.* (2006) and Sallander *et al.* (2010a). In contrast, there was no sex difference in percentage weight difference amongst WGD, concurring with the findings of Robertson (2003) and Bland *et al.* (2009). The relationship between dog sex and overweight status needs further clarification. GD may be a useful source of data for further studies because their two distinct populations of dogs, breeding stock (entire) and WGD (neutered) would enable the effects of dog sex on weight status to be investigated independently of the effects of neutering.

There were also significant differences in weight between breeds within the pet dog population (Salt *et al.*, 2017). However, there were no breed differences in the percentage weight difference of WGD or GD breeding stock. This may be due to GD regularly monitoring the weight status of their dogs and taking remedial action for any dogs with excessive weight changes. Although previous studies have found that Labrador Retrievers, Golden Retrievers and cross-breeds were predisposed to being overweight (Mason, 1970; Colliard *et al.*, 2006; Lund *et al.*, 2006), this was in comparison to the general dog population rather than relative to each other. Large scale studies including all breeds of dog would be required to investigate this further.

The Food Interest Questionnaire validation study (Chapter 6) showed that ten items from the food interest questionnaire correlated well with a dog's behaviour around food in a test situation and that the mean of those ten items could be used as a dog's FIS. However, the dog's FIS correlated poorly with its weight status, in contrast to studies by Sallander *et al.* (2010a), Raffan *et al.* (2015) and Luno *et al.* (2018). This may be due to the way that BSH are taught to discipline their dogs around food and so these findings may not be generalisable to dogs outside of GD. The poor correlation between a dog's FIS and its weight status meant that the FIS could not be used to predict a dog's likelihood of becoming overweight. As one of the aims of the intervention study (Chapter 7) was to assess the impact of Protection Motivation Theory on GDO adherence to weight management advice, GDO in the intervention group were told their dog's FIS (high or low). The intervention group were also given information on the potential consequences of a dog being overweight and practical suggestions around how to manage their dog's weight. Although the sample size was small and the analysis conducted on a per-protocol basis, GDO in the intervention group reported that they weighed their dog's food out on kitchen scales more frequently and were less likely to give dog chews as treats than GDO in the control group. Only 50% of the GDO in the intervention group remembered their dog's food interest category, suggesting that threat appraisal had little effect on GDO adherence to the weight management advice. Further behaviour change intervention studies incorporating a more clearly defined 'threat', targeting other areas of the Behaviour Change Wheel (Section 1.8) and qualitative data collection are required to determine the effectiveness of the different components of the behaviour change intervention.

The follow-up period for these dogs was too short to investigate the effect of the GDO behaviours on the weight status of their dogs, but it would be interesting to extract the weights for this cohort of dogs from GDI-R to see whether the intervention group did remain closer to their optimum weights than the control group. It would also be useful to re-interview the GDO in the intervention group to see whether they continued to adhere to the weight management recommendations once the monthly reminders stopped. As the intervention was introduced at the same time as another change was taking place in the GDO's life, namely the acquisition of a new dog, the new behaviours developed as a result of the intervention could become habitual and part of the GDO's normal routine for the duration of their partnership with that dog. The GDO's self-reported adherence to the dietary and exercise guidelines could then be compared to the dog's weight status to see whether maintenance of recommended behaviours around treats and feeding correlated with the dogs staying close to their optimum weight.

8.2 Methodology

Data collection methods

A mixed methods approach was taken in Chapters 3-5, with GDO being interviewed by telephone for consistency (Section 3.3.2). This facilitated the collection of both quantitative and qualitative data to investigate GDO opinions and experiences of managing their dog's weight and to inform the development of the questionnaires used with BSH and PDO. The BSH and PDO questionnaires were both administered as online questionnaires for consistency between the two groups. The method of data collection can affect the level of social desirability bias, with a lower prevalence found in self-administered surveys compared with face-to-face interviews (Callegaro, 2011). There may therefore have been less social desirability bias in the online BSH and PDO surveys compared with the GDO telephone interviews. The studies identified in the scoping review (Chapter 2) used a variety of data collection methods such as postal questionnaires (Bland *et al.*, 2009; Heuberger and Wakshlag, 2011b), interviewer-administered questionnaires (Colliard *et al.*, 2006; Courcier *et al.*, 2010; Heuberger and Wakshlag, 2011a), telephone questionnaires (Robertson, 2003), a combination of postal and telephone questionnaires (Sallander *et al.*, 2010a; Degeling *et al.*, 2012) and veterinary practice data (Spain *et al.*, 2004; McGreevy *et al.*, 2005; Lund *et al.*, 2006). The results of these different studies were largely in agreement with each other, suggesting that the method of data collection had little effect on the findings. Similarly, although different methods of data collection were used in the current study, the results from all three groups of owners/carers highlighted the impact of human behaviour on the weight of the dog.

Chapters 6 and 7 used purely quantitative survey methods, using a combination of online and paper questionnaires for the PW and Food Interest questionnaire validation studies and telephone interviews for the GDO in the intervention study. One advantage of online questionnaires is that participants have time to consider their answers before giving them (Regmi *et al.*, 2016), which may explain why some GDO seemed to struggle with the use of a verbal NRS in the intervention study. The questions were asked in this way for consistency with the online and paper-based BSH and PW questionnaires but any comparisons between these data and the GDO data must be interpreted with caution. Although there was no mention of question types, a study of tobacco use (Steffen *et al.*, 2014) showed no statistically significant differences between the results obtained using face-to-face interviews, online and paper-based questionnaires and Sallander *et al.* (2001b) found good correlations between dog feeding and exercise data collected via telephone and paper questionnaires. Continuous data were collected in the study by Sallander *et al.* (2001b) although the question format was not reported. These findings suggest that the way in which the questionnaire is delivered probably has little effect on the data produced, although care should be taken when using a NRS to explain the required response format and give participants time to consider their answers.

Participants

Convenience samples were used for the GDO and PDO surveys, with participants being self-selected, which may have biased the samples towards time-rich dog owners/carers with an interest in dog feeding and exercise management. All BSH were invited to complete the BSH questionnaire (Chapter 4); those who did so were invited to take part in the Food Interest tests and questionnaire validation study (Chapter 6), along with other BSH (n=200) selected by GD to increase the sample size. Due to the travel and time commitment involved in the Food Interest questionnaire survey, the BSH who participated were also likely to be those with an interest in dog feeding and exercise management and/or time-rich volunteers. The same bias is probably also true of the PW who responded to the PW survey.

Social desirability bias in owner/carer reported behaviours may have been more likely in the GDO and BSH surveys due to the owners'/carers' accountability to GD, although there was good correlation between GDO and BSH-reported weights for their dogs and those extracted from GDI-R (Figures 3.1 and 4.4). Conversely, social desirability bias or inaccuracies in owner-reported weight may have been more likely in the PDO if their dogs were not weighed regularly, whereas pet dog owners have far less accountability for the way they feed and exercise their dogs and therefore their self-reported behaviours may have been more reliable. However, people still tend to underestimate their own food intake (Tooze *et al.*, 2004) and overestimate their activity levels (Duncan *et al.*, 2001; Adams *et al.*, 2005) and it is likely that the same inaccuracies apply to feeding and exercising their dogs. The use of food and exercise diaries may have enabled more accurate data to be collected but were not utilised in the current study due to concerns about the increased demands on participant time and the practical difficulties of completing a food and exercise diary for visually impaired GDO.

For the intervention study, the potential study population comprised all GDO who were matched with one of the puppies from the PW survey, making it more likely to be a representative sample of GDO than the first GDO survey (Chapter 3). Unfortunately, permission was not granted to contact over one-third of these new GDO (n=35/93, 38%) regarding the study. No reasons were given for excluding these owners, but it is possible that the relationship between the GDO and either GD or their new WGD was difficult. This may have biased participants towards GDO in a successful match and who were compliant with GD guidelines.

8.3 Key messages for dog owners

The risk factors for overweight status identified in the GDO, BSH and PDO studies (Chapters 3-5) largely agree with those found in the studies identified in the scoping review (Chapter 2), showing that the key messages to GDO, BSH and PDO about managing their dogs' weights are similar across all three groups of dog owners/carers. This is unsurprising as although GDO, BSH and PDO have dogs for different reasons, most dogs are owned for companionship and to provide social and emotional support (Mariti *et al.*, 2013). GDO may have a

stronger bond with their dog due to their greater social and psychological needs (Whitmarsh, 2005; Mariti *et al.*, 2013), but neither Bjornvad *et al.* (2019) or Webb *et al.* (2020) found any association between the strength of the dog-owner bond and risk factors for overweight status in dogs, probably because a strong dog-owner bond could result in behaviours that both promote (*e.g.* walking the dog) and impede (*e.g.* giving treats) the maintenance of a healthy weight (Webb *et al.*, 2020). Most BSH volunteer to care for GD breeding stock because of a desire to help the charity and the wish to have a dog (Quarmby, unpublished data). Several BSH stated that they had been a puppy walker for their brood/stud and then became a BSH because they did not want to give the dog up, suggesting a level of affection for the dog. Each owner/carer bond with their dog is unique (McCune *et al.*, 2014) but the way owners/carers feed, treat and exercise their dogs is usually based on a wish to do what is best for their dog's health and wellbeing (Lane *et al.*, 1998). The behaviours of GDO and BSH around feeding and exercising their dogs may also be influenced by their accountability to GD, who provide guidance in these areas and monitor the dogs' health and weight. In contrast, PDO have no standard source of advice on feeding and exercising their dogs and little accountability for their dog's health and weight, so PDO behaviours around feeding, treating and exercising their dogs are more likely to be internally motivated than based on a desire to satisfy others (Ajzen, 1985,1991; Sullivan *et al.*, 2002).

Key messages for owners/carers around weight management in their dogs are discussed below:

Dry dog food should ideally be weighed on kitchen scales for each meal. Overestimates of the intended quantity of food is common when dry dog food is measured by volume (German *et al.*, 2011b; Coe *et al.*, 2019), with excess calories over time leading to weight gain. If weighing food for each meal is too onerous, owners could calibrate their own measuring devices by weighing the required amount of food, pouring it into a small container and marking the level. This process would need to be repeated each time the amount or type of food is changed (German *et al.*, 2011b). The size of the measuring device is important as smaller food scoops and feeding bowls help to reduce the risk of overfeeding (Murphy *et al.*, 2012).

Feeding a high-fibre diet, especially one that is also high in protein, can help with weight management (Heuberger and Wakshlag, 2010b) as high protein, high fibre diets are more satiating than diets containing high fibre or high protein alone. Satiety should reduce begging and scavenging, lowering the risk of dogs becoming overweight (Weber *et al.*, 2007; German *et al*., 2010a).

Dog treats should comprise less than 10% of a dog's daily calorie allowance (Perry *et al.*, 2020). Dog owners may not consider treats used for training (Section 4.2.10) or dental treats (Chapter 5.2.10) as a source of calories and so may not factor them into the dog's daily food intake. Dog owners may need reminding that *everything* they feed their dog counts towards its daily food intake (Michel, 2009). Additional nutritional information on dog treat packaging, such as calorie content presented in the context of the typical

energy requirement of different sized dogs, would enable owners to make informed decisions about the type, quantity and frequency of treats to feed (Morelli *et al.*, 2018). Alternatively, owners could be encouraged to set aside some of their dog's daily ration each day to use as treats (Linder, 2020).

For households comprising multiple people who might treat the dog, putting the dog's daily treat allowance in a certain place, and not replenishing it until the following day, could prevent the dog being overfed. Alternatively, a 'treat chart' could be marked off each time the dog was given a treat, with a limited number of treats permitted each day (Section 3.2.13c).

Dogs should be kept out of the kitchen and dining area when the owner is preparing and eating their own food to avoid the temptation to give the dog scraps and titbits (Kienzle *et al.*, 1998). Dogs fed table scraps regularly are more likely to be overweight (Heuberger and Wakshlag, 2011b) as scraps are higher in fat than commercial treats (Sallander *et al.*, 2010a,b). Keeping the dog out of the dining area may be particularly important if there are children in the household, as children often drop food and may feed the dog titbits even if told not to (Bland *et al.*, 2009).

Feeding recommendations for commercial dog foods are merely guidelines (Hodgkinson *et al.*, 2008) because energy requirements vary greatly between individual dogs (Sallander *et al.*, 2010a; Miller, 2011). Bitches have a lower energy requirement than male dogs (Diez *et al.*, 2002; Sallander *et al.*, 2010a) and neutering can reduce a dog's energy requirement by 20-30% (Miller, 2011). After neutering, owners should reduce the amount of food offered, feed measured meals rather than feeding *ad lib*, use a low-fat or low-calorie diet and increase their dog's exercise to prevent weight gain (McGreevy *et al.*, 2005; Lund *et al.*, 2006; Miller, 2011). Nutritional requirements also alter with age and growth (Miller, 2011), so monitoring the dog's weight and BCS regularly throughout the dog's life is important to enable energy intake to be adjusted as necessary.

Owners should regularly monitor their dog's weight at home or check their dog's weight at the veterinary practice (Section 3.3.1). Alternatively, owners could be taught to BCS their dogs using the SHAPE BCS system, which has been shown to be reliable in owners with no prior training in BCS (German *et al*., 2006). Monitoring the dog's weight regularly would enable owners to adjust the amount fed to maintain their dog at its optimum bodyweight and BCS (Hodgkinson *et al.*, 2008). This is particularly important for owners of breeds that are prone to being overweight such as Labradors and Golden retrievers (Colliard *et al.*, 2006; Lund *et al.*, 2006). Regular weight monitoring is also important in older dogs as exercise tolerance may reduce with age and concurrent disease (Robertson, 2003; McGreevy *et al.*, 2005; Colliard *et al.*, 2006; Lund *et al.*, 2006; Courcier *et al.*, 2010). Owners may need to reduce their dog's food to avoid weight gain which could exacerbate conditions such as osteoarthritis (Impellizeri *et al*., 2000; Marshall *et al*., 2010; Christmann *et al*., 2018).

Although owners of older dogs may need to reduce their dog's food to compensate for reduced exercise tolerance, owners should avoid increasing their dog's food in response to a perceived increase in activity (Section 4.3.1) unless the dog starts to lose weight.

Increasing length and frequency of dog walks helps to maintain lean muscle mass and low levels of body fat in dogs (Robertson, 2003; Bland *et al.,* 2009; Courcier *et al.*, 2010). Higher intensity exercise such as running or swimming may also be beneficial for weight management (Crane, 1991). Other dogs or children in the household can be encouraged to play with the dog to increase energy expenditure (Robertson, 2003; Bland *et al.*, 2009), although play should not replace regular walks (Bland *et al.*, 2009).

8.4 Drawing together key findings

Chapters 1–5 highlighted that the modifiable risk factors consistently associated with dogs being overweight are mainly related to the owner's/carer's management of the dog, in particular around feeding, treating and exercising their dogs and monitoring their weights. These risk factors are at the Environment, Skills and Behaviour levels of Dilts' Logical Levels model (Table 1.1). What individuals or organisations believe is the cause of a problem will determine where they look for a solution (Brickman *et al.*, 1982; Dilts, 1990), hence most weight-loss strategies for dogs to date (Section 1.6) have focussed on addressing environment, owner skills and behaviours directly (Yaissle *et al.*, 2004; German *et al*., 2007; Yamka *et al.*, 2007; Chauvet *et al.,* 2011). Although these methods have been shown to be effective in colony dogs (Carciofi *et al*., 2005), the prevalence of overweight status in pet dogs is still increasing (Kienzle *et al.*, 1998; Colliard *et al.*, 2006; German, 2006; Nijland *et al.*, 2009; Farcas and Michel, 2016), showing that these strategies are less successful in pet dogs. Owner adherence to weight-loss recommendations has a greater effect on the success or failure of a dog weight-loss program than the details of the weight-loss strategy itself (Carciofi *et al.,* 2005; Porsani *et al.*, 2019), therefore, long-term changes in owner behaviour are essential for the success of a dog's weight-loss program. Successfully changing owner behaviours may require a different approach to weight management discussions, which in turn will necessitate changes in behaviour from those advising owners about their dog's weight.

Human behaviour fits into a hierarchy of processes known as Dilts' Logical Levels (Section 1.9). Dilts' Logical Levels (Dilts, 1990) could provide an alternative approach to changing behaviour to improve weight management in dogs as it has practical applications not only for individual dog owners, including GDO and BSH, but also for GD as an organisation (Dilts, 2014). Dilts (1990) suggests that in order to effect behaviour change, interventions need to be targeted at higher levels of the model, namely Skills and Capabilities, Values and Beliefs or even Identity (Table 1.1). Although the intervention used in Chapter 7 mainly addressed Behaviours, Skills and Capabilities, it did appear to be effective in changing self-reported GDO behaviour around weighing their dog's food and use of treats during the study period.

8.4.1 Dilts' Logical Levels and individual Guide Dog Owners

Identity

Visually impaired individuals may be perceived as helpless and therefore offered unwanted assistance or patronised by the public; conversely, they may be avoided because people feel uncomfortable around them. Perceived lack of competence and negative encounters with sighted individuals may lead visually impaired people to feel that they have lost their adult identity (Sanders, 2000).

The acquisition of a WGD can reduce feelings of helplessness and give the GDO a sense of control and independence (Sanders, 2000). This empowerment, along with the WGD's constant presence and the development of a deep emotional bond between the WGD and the GDO (Sanders, 2000; Kwong and Bartholomew, 2011; Schaefer, 2019) may increase the GDO self-esteem and help the GDO to address any issues related to their personal identity (Luyckx *et al.*, 2013).

Having a healthy WGD also provides the GDO with an identity as a caregiver, somebody who is emotionally committed to nurturing their dog (Jyrinka, 2012; Schaefer, 2019). Pets also represent the identity of their owners (Hirschman, 1994), so caring for their dog could also be regarded as a form of self-care by the owner (Jyrinka, 2005). In addition, feeding pets and seeing them enjoy their food gives pleasure to the owner (vicarious consumption) (Jyrinki and Leipamaa-Leskinen, 2006).

Pets are also symbolic of positive aspects of a person's identity which they wish to demonstrate to themselves and others (Jyrinka, 2005; Hill *et al.*, 2008). Having a healthy weight WGD indicates that a GDO has self-restraint and control around food (Hirschman, 1994), so GDO who struggle to manage their own weight may take pride in the fact that they can successfully manage the weight of their WGD (Jyrinka, 2005; Boya *et al.*, 2015).

The functional and emotional attachment of the GDO to their WGD leads many GDO to regard their dog as an extension of themselves and part of their social identity (Jyrinka, 2005; Dotson and Hyatt, 2008; Kwong and Bartholomew, 2011). Despite this, some GDO feel that they are seen merely as the WGD owner rather than a person with their own identity (Sanders, 2000; Whitmarsh, 2005). This demonstrates the conflict individuals may experience between maintaining their own personal identity (autonomy) and the desire for interpersonal connections to give them a sense of belonging (Jyrinka, 2012).

Dog owners who regard their dog as an extension of themselves are often more concerned about the nutritional and health benefits of their dog's food and following professional advice around feeding their dog than they are about their own nutrition (Boya *et al.*, 2015). They may be genuinely more concerned about feeding their dog correctly than they are themselves, or find it easier to manage their dog's weight than their own (Boya *et al.*, 2015). GDO may have

comorbidities and/or the practical difficulties associated with their visual impairment may make managing their own weight challenging (Crews *et al.,* 2006; Court *et al.*, 2014) but they can take pride in keeping their dog at a healthy weight (Kwong and Bartholomew, 2011). Alternatively, GDO may share their food consumption pattern with their dogs as part of their shared identity (Jyrinki and Leipamaa-Leskinen, 2006), in which case a GDO with unhealthy eating habits is likely to have an overweight dog while a health-conscious GDO would probably have a healthy weight dog.

Ownership of a WGD indicates that a GDO has accepted their identity as a visually impaired individual (Lambert, 1990) and has taken on the collective identity of a GDO (Sanders, 2000). Many GDO feel the need to represent GD in a positive light and feel under pressure to respond positively to interactions from the public, even if unwanted or inappropriate (Sanders, 2000). This may explain why some GDO are reluctant to reprimand members of the public who offer their dog food or treats (Chapter 3).

Values

Many GDO take pleasure and pride in caring for their dogs (Kwong and Bartholomew, 2011). This caregiving relationship is a reciprocal one, with the GDO and the WGD both caring for each other and relying on each other (Kwong and Bartholomew, 2011; Schaefer, 2019). Caregiving is associated with the values of benevolence (enhancing the welfare of those one is close to) and conformity (self-restraint to avoid breaking social expectations or norms) (Schwartz, 2012). Both values encourage supportive relationships but benevolence motivates such behaviours through altruism, whereas conformity promotes cooperation for one's own self-interest (Schwartz, 2012). If GD could ascertain which of these values is more important to an individual GDO, using one of the validated versions of Schwarz' values questionnaire (Schwartz, 1992; Lindeman and Verkasalo, 2005), the behavioural advice around weight management of their dog could be expressed to that GDO in terms of their higher priority value. For example, if benevolence was a higher priority for the GDO, then weight management advice could be focussed around the benefits to the dog of keeping it at a healthy weight, whereas if conformity was the higher priority value, then emphasizing the responsibility of the GDO to follow GD feeding recommendations and keep the dog at a healthy weight may be more successful (Schwartz, 2012).

Owning a WGD also gives the GDO a sense of control and responsibility (Kwong and Bartholomew, 2011), which are linked to values such as achievement and security (Schwartz, 2012). Owning a pure bred or well-trained dog is seen as a status symbol and indicates that an individual is a competent owner who has control over their animal (Sanders, 2000).

Extrapolating from the human situation where self-restraint around food leads to feelings of self-righteousness and a sense of control (Owen Jones, 2007), owning a dog of a healthy weight would also appeal to the values of achievement and security (Schwartz, 2012). If those values were important to a GDO, then weight management strategies to address those values could be

employed. For example, a GDO who values achievement highly could be praised at every suitable opportunity for maintaining their dog at its optimum weight whereas a GDO who values security might adhere more closely to a weight management program if this were framed as a way to keep their WGD healthy and fit to work for as long as possible.

However, sometimes the behaviours associated with these values may conflict. For example, if the values of benevolence (enhancing the welfare of those one is close to) and achievement (competence according to social standards) were both equally important to a GDO, they may be torn between opposing behaviours: the short-term rewards of giving their WGD a treat, or the longer-term reward of maintaining their dog at a healthy weight (Lane *et al.*, 1998). Often the short-term reward is prioritised over long-term health benefits (Davis *et al.*, 2004). Another possible explanation for why many GDO give their dog treats in addition to their daily ration is a conflict between values such as self-direction (freedom of choice) and conformity (obedience and self-restraint) (Lindeman and Verkasalo, 2005). The desire of the GDO to exert their autonomy rather than follow GD advice on treats may reflect the increased sense of independence gained by the GDO from owning a WGD (Lane *et al.*, 1998; Moxon *et al.*, 2016; Glenk *et al.*, 2019).

Life purpose

For some GDO, caring for their WGD becomes their purpose in life (Hudd, 1998; Kwong and Bartholomew, 2011). Life purpose is the highest level of Dilts' Logical Levels, so changes arising from this level should have the greatest impact on the levels below it, including behaviour (Dilts, 1990). For GDO whose WGD is their reason for living, explaining weight management strategies as the optimal way to care for their dog should encourage behaviour change as the desired behaviours will be seen as aligning with the GDO's life purpose, identity and values.

Existing weight-loss strategies for dogs have mainly targeted dog owners as individuals rather than as a group (Yaissle *et al.*, 2004; German *et al*., 2007; Yamka *et al.*, 2007; Chauvet *et al.,* 2011). Reynolds *et al.* (2015) proposed that sustained behaviour change in large groups of people can be brought about by exploiting the collective identity of the group and manipulating the group social norms, which is often more effective than trying to change behaviour in individuals (Frieden, 2010). GD may be able to exploit the collective identity of GDO by manipulating the group's social norms to manage the weight of their WGD rather than trying to change the behaviour of individual GDO. The information around these social norms needs to be provided in a context where collective identity is most relevant to behaviour (Reynolds *et al.*, 2015). An example could be informing GDO during Advanced Training that the majority of GDO set aside some of their dog's daily ration for training purposes. This example also capitalises on the transition already occurring in the GDO's life as they adjust to a new dog, which makes the development of new behaviours and habits more likely (Dilts, 1990; Verplanken and Wood, 2006).

8.4.2 Dilts' Logical Levels and Guide Dogs (organisation)

Dilts Logical Levels can be applied to organisations as well as to individuals (Dilts, 2014). Within an organisation, Environment refers to the work place, its location, buildings and facilities. Behaviour relates to work patterns, communication and procedures, while Skills and Capabilities are the infrastructures which support these. Values and Beliefs determine the culture of an organisation while Identity concerns the role and mission of the organisation. The relationships between the levels parallel those of an individual.

Although research within GD has identified overweight status as a problem in their dogs (Trybocka, 2008), data collected on GD working and breeding stock in the first GDO and BSH surveys (Chapters 3 and 4) showed that BCS are infrequently and inconsistently reported and recorded. This suggests that behaviour change is needed amongst GD staff who are responsible for this task. This may be best achieved by interventions targeted at the organisation itself, using the higher levels of Dilts' Logical Levels model such as Values and Identity (Dilts, 1990).

Guide Dogs' 2018 – 2023 'By My side' strategy (Guide Dogs, 2020) expresses their mission:

"Our ambition is a future where every person with sight loss has the confidence and support they need to live their lives to the full"

and also includes the statement:

"Our wonderful dogs will remain at the heart of our organisation, and we will ensure we make the best use of each and every one of them… "

Although this implies that Guide Dogs value their dogs, the word 'use' suggests that they regard them more as a tool rather than an animal with health and welfare needs. A shift in organisational culture within GD to make dog weight management a more explicit value may be required to change staff behaviours around weight management. This could potentially give WGD a longer working life (Caron-Lormier *et al.*, 2016) hence maximising GD use of their dogs and aligning more closely with their mission statement.

The application of Dilts' Logical Levels (Dilts, 1990) to GD as an organisation to improve weight management in its dogs has parallels with the Health Literate Care Model proposed for the USA healthcare system by Koh *et al.* (2013). This model suggests that Health Literacy (the ability to obtain, understand and implement basic health information) should become an organisational value, which is modelled by its leaders and integrated into all areas of planning and operations. GD could use this as a basis for developing a Weight Management Literate model, where weight management in its dogs becomes one of its most

important values and is integrated into all its decisions and operations. Engaging all staff in developing the model should result in GD staff taking ownership of their role in the weight management of the dogs (Sullivan *et al.*, 2002) and engender a sense of united purpose within the organisation, the highest level of Dilts' model (Dilts, 1990). This should result in GDO feeling better informed, more engaged and empowered to manage their dog's weight (Table 3.12). The Health Literate Care Model also involves families and caregivers, so members of the GDO household could be involved in discussions around managing the dog's weight to ensure that they understand and support the process (Koh *et al.*, 2013). This could be particularly important in larger households where multiple people may feed and treat the dog (Section 3.2.13c).

Development of a Weight Management Literate model would require the leadership of GD to promote a corporate identity which believed and valued the maintenance of their dogs at a healthy weight (Wagner *et al.*, 1996; Barr *et al.*, 2003). Reinforcing this aspect of the organisational identity would facilitate changes in beliefs and values, which should then be enacted in behaviours. The establishment of behavioural norms around weight management, such as weighing and BCS dogs at every visit and recording those data in a consistent way could be encouraged by ensuring staff have the necessary skills and capabilities to perform these tasks and providing training if necessary. The working environment should support this, with the provision of weighing scales, BCS posters, and a user-friendly database to input the data. These organisational changes may be time consuming and costly to implement but should ultimately improve efficiency and weight management in guide dogs. Costs should be offset if the changes resulted in WGD remaining healthy and fit for work for longer (Barr *et al.*, 2003).

Following the Health Literate Care Model (Koh *et al.*, 2013), the GD organisation would need to be structured to make each interaction between GD staff and GDO as productive as possible. This could involve changes in four different areas of the Model:

1. *Self-management support* – GDO are empowered to manage their dog's weight (Section 3.2.14). This could involve collaborative assessment of the dog's weight, goal setting and problem solving, where GDO are encouraged to develop their own personal action plan with tasks broken down into manageable chunks (Koh *et al.*, 2013; Cairns-Haylor and Fordyce, 2017). This would allow the GDO to select strategies in line with their beliefs and values, making adherence more likely (Dilts, 1990). Educational resources, tailored to the GDO where possible (Kreuter *et al.*, 1999; German, 2016c), could be provided in the GDOs preferred format (Braille, audio etc). These should contain clear, actionable information, and the GDO should be encouraged to form Action Plans *i.e.* think about exactly how, when and where they would implement these recommendations in their home environment (Gollwitzer, 1999). Skills training may also be required to bridge the gap between beliefs and behaviours (Dilts, 1990; Barr *et al.*, 2003).

2. *Decision support* – evidence-based guidelines (Barr *et al.*, 2003) and GDO values and beliefs are considered during decision-making so that it is a shared process (Koh *et al.*, 2013). To maximise the benefit to service users, efforts must be made to ensure that the GDO's needs, circumstances, beliefs and values are fully understood (Whitmarsh and Nzegwu, 2001). The more that a GDO feels that their beliefs and values are being challenged, the more they will cling onto their existing beliefs in order to maintain their identity (Furtado, 2021). This could then lead to a vicious cycle where GD staff increase their efforts to persuade the GDO about a particular course of action, resulting in frustration and a potential breakdown in the relationship (Dilts, 1990). However, if common values and beliefs such as the importance of the dog's welfare can be found, these can be used as the basis for a mutually acceptable weight management plan.

3. *Delivery system design* – the way in which weight management advice is presented to the GDO *e.g.* clearly defined roles for GD staff, regular reminders and follow-ups of GDO (Barr *et al.*, 2003). This could also include presenting weight management information to the GDO in a way that highlights its congruence with their values and beliefs (Section 8.5).

4. *Computer systems and data organisation/records* – This area was identified in the GDO and BSH surveys (Chapters 3 and 4) as requiring significant improvement. As discussed in Section 8.4.2, this could involve reminders for GD staff to weigh, BCS and record these data for each dog at every visit (Koh *et al.*, 2013). BCS charts or an algorithm such as the SHAPE BCS system (German *et al.*, 2006) could be provided to GD staff to maximise consistency of BCS. Alerts could be used to highlight any dogs where weight or BCS had not been recorded in the previous 6 months (for example) along with reminders to follow up GDO whose dogs were gaining weight or who needed extra support to manage their dog's weight (Barr *et al.*, 2003). A proactive approach should enable early intervention by GD to prevent significant weight gain in their dogs.

A well-managed database would also enable monitoring of outcomes, both of the process, such as frequency of weighing and BCS dogs, and the effects of that process *e.g.* the proportion of dogs who were overweight. GD staff and GDO feedback on the process would also be important to enable continuous improvement (Koh *et al.*, 2013).

8.5 Future recommendations

Rather than focussing on the 'mechanics' of weight management in dogs, such as the amount, type and frequency of food and exercise that dog owners/carers provide for their dogs, the emphasis should shift towards a more owner-centred approach. Owners' identities and values in relation to food, feeding and exercising their dog, and their beliefs around the importance of food and exercise in their relationship with their dog should be incorporated into any feeding and exercise advice given. Understanding this for an individual dog owner would enable GD staff or veterinary professionals to work with that dog's owner/carer to agree on a sustainable exercise and feeding regime, including the incorporation of treats into the dog's daily calorie allowance if

that was important to the owner. This would require a change of approach from a formulaic solution for overweight dogs, where owners' beliefs and values may be seen as a barrier to following feeding and exercise recommendations, to a more individualised approach, where an owner's beliefs and values form the basis of the weight management program.

In order to do this, each owner's capabilities, beliefs, values and identities (both personal and collective) around food, feeding and exercising their dog need to be established. Each owner's beliefs and values around food and feeding will be prioritised in different ways which need to be explored before constructive discussions about managing their dog's weight can take place. This may be a time-consuming process but would help to establish the basis for a dog's weight management plan.

No data about GDO beliefs, values and identities are currently collected as part of the GD application process, but these areas could be explored with potential GDO. Validated questionnaires exist to ascertain values (Schwartz, 1992; Lindeman and Verkasalo, 2005), although these would need to be adapted for delivery in an appropriate format for GDO (Braille, audio etc). If values for each new GDO could be established, GD could tailor their weight management advice for each GDO to appeal to their individual values. A person's values are relatively stable over time (Bardi and Schwarz, 2003; Wilson *et al.*, 2010) although their relative priorities may change, so occasional re-evaluation of a GDO's values and priorities might be warranted, for example each time the GDO acquires a new WGD.

For pet dog owners, collecting data around beliefs, values and identities may be challenging as veterinary surgeons in practice feel that time constraints are a barrier to weight discussion with owners (Robinson, 2015; Belshaw, 2018). This task could be taken on by veterinary nurses, who often run the weight-loss clinics in small animal practices (Espley and Bowes, 2019; Mulrooney, 2019). Validated questionnaires could be utilised as a formal way to ascertain values (Schwartz, 1992; Lindeman and Verkasalo, 2005) or clues as to the owner's identity, values and beliefs could be noted during the initial consultation. For example, if an owner of an overweight dog mentioned that they were a grandparent, they might be motivated to commit to a weight-loss program for their dog if they thought that the dog might be able to play with the grandchildren for longer if it lost weight. Comparing owners' perceptions of the values questionnaire and the more informal approach to establishing values along with the weight loss achieved by their dog might either show that one approach is more effective than the other, or highlight that owner differences in identities, values and beliefs extends to their preferred approach, with some owners favouring the structure of a questionnaire, and others preferring a less formal approach.

Once an owner's values, beliefs and identity have been ascertained, these can be utilised when discussing a weight-loss program for the dog. Many pet owners will still require information on when, what and how much to feed and exercise their dog (Webb *et al.*, 2018) as unlike GDO, they do not have one

single source of information or advice on feeding and exercising their dog. Involving the owner in decisions around how best to incorporate this advice into their current lifestyle and routine should give them a sense of control and responsibility for the process and strengthen their self-efficacy (belief that they can follow the plan) (Furtado *et al.*, 2020). Ownership of the process also addresses values such as self-direction, conformity and security while still allowing the expression of behaviours relating to tradition and hedonism. If the reasons underlying the recommendations are discussed, owners may feel empowered to adapt the process as necessary (autonomy) while still adhering to the broad principles of a calorie deficit for weight loss.

If an owner's current obesogenic behaviours around feeding, exercising and treating the dog are habitual, they may be difficult to change (Gollwitzer and Sheeran, 2006). Setting goal intentions may not be enough to override the owner's automatic, unconscious responses to particular situations *e.g.* measuring out their dog's food with a scoop when it is time to feed the dog. Furthermore, owners may remember their intended behaviours and recognise the opportunity, for example remembering that they had planned to play with the dog rather than give it a treat, but may have to overcome an initial reluctance to act (Gollwitzer and Sheeran, 2006). This is common when people decide to start a behaviour that has desirable long-term consequences (*e.g.* dog weight-loss) but less attractive short-term consequences (*e.g.* more time-consuming) (Gollwitzer and Sheeran, 2006). Specific Action Plans including how, when and where to implement the new behaviours will help to link those behaviours to a specific context. For example, an owner might plan to weigh out their dog's food on kitchen scales in the kitchen every morning while they wait for the kettle to boil or set six pieces of kibble aside in a bag for use as treats during the day once they had weighed out their dog's food. Repeated performance of the behaviours in that same context over time should help them become habitual (Gollwitzer and Sheeran, 2006).

Potential problems and barriers can also be identified and Coping Plans in the form of Implementation Intentions (If-then plans) drawn up (Gollwitzer, 1999). An example of an 'If-then' plan for a GDO could be 'If I want to reward my dog for exceptional work, then I will give them extra fuss when we get home' or 'If I am unable to take my dog for a free run, then I will play with it indoors' (Webb *et al.*, 2018). Setting Implementation Intentions in advance means that when the specified situation arises, the predetermined desirable behaviour should be automatically triggered without the need for conscious thought (Gollwitzer and Sheeran, 2006).

Ascertaining owner beliefs and values and using these as a basis for their dog's weight management plan is relevant to dog owners who are already aware that their dog needs to lose weight and are in the Contemplation or Preparation stages of the Transtheoretical (Stages of Change) Model (Prochaska and DiClemente, 1983). However, many owners either do not believe that their dogs are overweight, or are unaware of the potential consequences of their dog's weight and therefore do not see the need to change. These owners are in the Precontemplation stage (Prochaska and DiClemente, 1983) and are

unlikely to be receptive to weight management discussions (Velicer *et al.*, 1998; Verplanken and Wood, 2006; Bartges *et al.*, 2017). Churchill and Ward (2016) suggest that in these cases, the topic of the pet's weight should be broached in terms of improving its health and quality of life and reducing the risks of chronic diseases which may be costly to treat. This should be done in a non-judgemental, caring and empathetic manner so as not to make the client feel guilty or irresponsible as an owner (Furtado *et al.*, 2020). With horse owners, it often took a health-related trigger to make an owner realise that their horse had reached an unhealthy level of body fat and that this was something that they needed to address (Furtado *et al.*, 2020). It would be useful to investigate whether a similar trigger is needed to move dog owners from the Precontemplation to the Contemplation stage, where they are considering change but weighing up the costs and benefits. Focus groups or one-to-one interviews with dog owners who had successfully completed a weight-loss program for their dog, started a weight-loss program for their dog but failed to complete it or been told that their dog was overweight by a veterinary professional but declined to enrol on a weight-loss program may provide valuable insights into how owners can be persuaded of the benefits of a weight-loss program for their dog and what encourages them to complete it. The data gained from this qualitative investigation would highlight which tools and strategies owners found useful during their dog's weight-loss program. It could also be used to inform the development of weight-related communication training such as that designed for equine colic triage (Lightfoot *et al.,* 2020).

In addition to trying to effect behaviour change in individual dog owners, social norms and collective identity could be considered as a means to bring about behaviour change in groups of dog owners (Reynolds *et al.*, 2015). The Kennel Club, breed societies and high-profile dog shows such as Crufts could be used to help promote healthy weights in dogs. These organisations could include weight and BCS-related measures in their breed standards and judging criteria to ensure that only healthy-weight dogs are selected as exemplars of their breed. Similar to the British Veterinary Association position statement on pets in advertising (BVA, 2018), these organisations should ensure that only healthy-weight dogs are used in their promotional materials and that any images showing dogs being fed depict suitable types and quantities of food.

8.6 Conclusion

This work has identified and examined risk factors for overweight status in dogs and produced new evidence which identified owner behaviours around feeding, treats and exercise as key risk factors for overweight status in GD breeds. These findings highlight the importance of human behaviour change in the management of overweight dogs. The focus of the empirical work was on developing and evaluating an intervention to change the behaviour of the dog owners themselves, however, changing owner behaviour in the longer term will require changes in the behaviour of the people that advise those dog owners too.

One possible approach to behaviour change in both individuals and organisations is to draw on Dilts' work on Logical levels (Dilts, 1990). Dilts proposes that behaviour can be changed more effectively by understanding and utilising the levels above behaviour, such as beliefs, values, identity or life purpose. For individual dog owners, this could involve aligning any proposed weight management program with the owner's values, beliefs and identity. Discovering what is important to people and using that to motivate them to change their behaviour should encourage greater adherence to weight loss programs and make them more effective in the long term. Within GD, weight management might be improved if GD adopted weight management of its dogs as one of its organisational values.

This research has demonstrated the potential for integrating behaviour change interventions into weight management programs for dogs. Further work is required to investigate whether similar interventions will be successful in changing owner behaviour and/or improving weight management in pet dogs. Taking this work forward will require engagement with key groups and individuals who advise dog owners and could involve collaboration with behaviour change specialists to investigate how behaviour change interventions can be used most effectively in weight management strategies for dogs.

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Appendix 1: GDO Questionnaire

Demographics	Response	Needed prompt?
1. What is your dog's name?		
1. What gender is your dog?		
2. What breed is your guide dog?		
3. How old is your guide dog?		
4. How long have you had your guide dog?		
5. Have you had guide dogs before your current dog?		
Interaction with dog		
6. Could you describe a typical day for you and the dog?		
○ Lifestyle: sedentary → v active		
• Differences between weekday and weekend?		
○ Working status?		
• Day-to-day care of the dog?		
○ How often do you groom your dog?		
○ How often do you clean your dog's teeth?		
○ Anything else?		
7. How do you reward your dog for good behaviour?		
○ Praise?		
○ Cuddles/fuss?		
○ Play/toys?		
○ Food/treats?		
▪ What type of food/treat? Commercial treats/table scraps/part of ration?		
○ Other?		
8. What do you understand by the term 'dog treat'?		
9. In what situations do you give your dog treats? • Circumstances – training reward/after a working walk/before bed time/in response to begging/when leaving the dog on its own/other etc		

10. What type of food/treat do you give? Commercial treats/table scraps/part of ration?		
11. Why do you choose to give your dog this type of treat? (If you do use part of the ration, why/why not?)		
12. How often do you give your dog treats?		
13. Do other members of the household give the dog treats?		
If so, how often?		
14. Does your dog beg?		
15. What does your dog do when they are begging?		
16. How often does your dog beg?		
17. In what circumstances does your dog beg?		
18. What do you do if your dog begs?		
19. What would your dog do if you gave him/her an extra portion of food?		
Food and Water		
20. What is dog fed (%)?		
• Dry food (as is)		
• Dry food (soaked/moistened with liquid *e.g.* water, gravy)		
• Canned food/pouches/foil trays		
• Table scraps/leftovers		
• Other		
21. How often do you feed your dog?		
22. What is your routine at feeding time?		
23. Do you keep the dog company while it eats? Why/why not?		
24. How do you decide how much to feed your dog?		
• Dog's response to amount of food in bowl – plz give details		
• Dog's weight – feel ribs, appearance, wt in kg…. Assessment of condition of dog?		
• Other		

25. How do you measure the amount of food to give?		
• Cups/scoops		
• Weight		
• Handfuls		
• Other?		
26. What do you think of the food that GD provide? Why do you say that?		
27. Do you think your dog is happy with the food GD provide? Why/why not?		
28. What are the challenges regarding feeding your dog?		
• Dog still hungry		
• Visual impairment		
• Other?		
29. Does your dog have access to other sources of food around the home? *e.g.* Table scraps, children dropping food, steals food from other animals in house/food put out for birds/ fruit trees etc		
• Other?		
30. Do you allow the dog in the kitchen while you are preparing your own food?		
31. What does the dog do while you are eating?		
32. What do you do/How do you interact with the dog while you are eating?		
▪ Do you make the dog lay down/go to its bed/leave the room or is it allowed to sit next to the table etc?		
33. Do you give your dog any dietary supplements such as vitamins/minerals or cod liver oil?		
• What?		
• Why do you use that supplement for your dog?		
34. Does your dog scavenge outside of the house/garden? E.g. raid bins, eat things it shouldn't		

35. Does your dog ever eat its own faeces or faeces from other animals?		
Exercise		
36. How many working walks would your GD do in a week?		
• How long working for each time?		
37. What other exercise does your GD get outside of your home?		
• Length of time?		
• Frequency?		
• Intensity? – walk, trot/jog, run		
• Playing with other dogs/swimming/playing with toys outside of the house/garden		
38. How active is the dog when it's at home?		
• Does dog play with other pets/children/toys in house or garden?		
General Health		
39. Does your dog have any health problems?		
40. Do you know your dog's weight?		
41. How would you describe your dog's weight?		
• V underweight/ underweight/ normal/overweight/v overweight		
42. Do other people ever comment on your dog's weight/appearance?		
43. Do you monitor your dog's weight?		
• If so, how?		
44. Do you know your dog's optimum weight?		
45. Has anyone discussed a healthy weight for your dog with you? *Vet GD etc*		
46. What do you know about Body Condition Scoring dogs?		

• How often do you BCS your own dog? When did you last do it?		
• How easy/difficult do you find it?		
O perception of healthy lifestyle		
47. How would you describe your own diet in terms of how healthy it is?		
48. How much exercise do you do in a typical week apart from walks with your Guide dog?		
Personal Information		
49. Do you have any other pets in the household apart from a GD?		
50. How would you describe the place you live *e.g.* village, city centre		
51. How many people live in your household including yourself?		
52. Could you tell me the ages of anyone in your household who is under 18?		
53. How many people in the household have a role in feeding the dog?		
54. Who in the household most frequently feeds the dog?		
○ Working status?		
55. Would you mind telling me your age?		
56. Would you mind telling me your weight?		
57. Would you mind telling me your height?		
Is there anything else that you would like to tell me relating to the topics I've asked you today?		

Thank you very much!

Appendix 2: Feeding and Exercise Management of Guide Dogs' Breeding Stock

Brood/Stud Details

1) **What is your brood's/stud's name? (Optional)** If you have more than one brood/stud, please complete the questionnaire for the brood/stud that you have had the longest.

2) What breed is your brood/stud?

3) What sex is your brood/stud?

4) How old is your brood/stud?

5) How long have you had your brood/stud?

6) How many broods/studs have you had previously?

7) Are there any other pets in your household apart from your brood/stud?

Other pets

8) How many pets are there in your household apart from the brood/stud you are completing this questionnaire for?

	0	**1**	**2**	**3**	**4**	**5**	**5+**
Dogs							
Cats							
Rabbits							
Other							

General Care of Brood/Stud

9) How often do you groom your brood/stud?

10) How often do you brush your brood's/stud's teeth?

11) Is there anything else you would like to add about general care of your brood/stud?

Rewards and Treats

12) How do you reward your brood/stud for good behaviour?

13) In what situation(s) do you give your brood/stud treats?

14) What type of treat do you give to your brood/stud?

15) How often do you give your dog treats?

16) Do other members of the household give the brood/stud treats?

Brood's/Stud's Interest in Food

17) Do you allow the brood/stud in the kitchen while you're preparing your own food?

18) What does your brood/stud do while you are eating?

19) How do you interact with your brood/stud while you are eating?

Brood's/Stud's Interest in Food

20) Does your brood/stud beg?

21) What does your brood/stud do when they are begging?

22) What do you do if your dog begs?

23) What would your brood/stud do if you accidentally spilled a large quantity of their food on the floor while you were preparing their meal?

24) Does your dog scavenge?

	Yes	**Sometimes**	**No**	**Not sure**	**Prefer not to answer**
Around the house?					
In the garden?					
Away from home?					

25) Does your dog exhibit coprophagia (eat faeces)?

	Yes	Sometimes	No	Not sure	Prefer not to answer
Its own faeces?					
Other dogs' faeces?					
Faeces from other animals? (please specify below)					

Feeding your Brood/Stud

26) What is your brood/stud currently fed?

27) Do you add anything to your brood's/stud's dry food?

28) How often do you feed your brood/stud?

29) How do you decide how much to feed your brood/stud?

30) How do you measure the amount of food to give your brood/stud?

31) What is your routine at feeding time?
For example, do you make your dog sit and wait for a command before they start eating?

32) Do you stay with your brood/stud while he/she is eating?

33) Do you give your brood/stud any dietary supplements such as vitamins/minerals, cod liver oil?

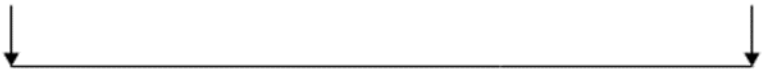
Activity Levels

34) How much exercise does your brood/stud get outside of your house and garden on a typical day?

	Weekday	**Weekend**
Walks (minutes)		
Free runs (minutes)		

35) How active is the brood/stud when they are at home?
Please place a cross at the appropriate point on the line.

Not active at all, spends all their time asleep — Extremely active, on the go all the time

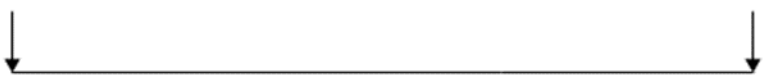


Weight

36) Do you know what your brood/stud weighs?

37) How would you describe your brood's/stud's weight?
Please place a cross at the appropriate point on the line.

Very underweight — Very overweight



38) Do you know your brood's/stud's optimum weight?

Health

39) Does your brood/stud suffer from any long-term health conditions?

Demographics

40) How would you describe the place where you live?

41) How many people live in your household including yourself?

42) Could you tell me the ages of anyone in the household who is under the age of 18?

Please skip this question if not applicable.

	Age	Prefer not to answer
Child 1		
Child 2		
Child 3		
Child 4		
Child 5		
Child 6		

43) How would you describe your working status?

44) What is your gender?

45) What age are you?

46) How tall are you?

47) What is your weight?

Additional comments

48) Is there any other information you feel would be relevant to this study?

Thank you very much for taking the time to complete this survey.

Appendix 3: Feeding and Exercise of Pet Dogs

Dog's Details

1) What is your dog's name? (Optional)
If you have more than one dog of the specified breeds or crosses, please complete the questionnaire for the dog that you have had the longest.

2) What breed is your dog?

3) What sex is your dog?

4) Has your dog been neutered or spayed?

5) How old is your dog?

6) How long have you had your dog?

7) How many dogs have you had previously?

8) Are there any other pets in your household apart from the dog you are completing this questionnaire for?

Other pets
9) How many pets are there in your household apart from the dog you are completing this questionnaire for?

	0	**1**	**2**	**3**	**4**	**5**	**5+**
Dogs							
Cats							
Rabbits							
Other							

General Care of your Dog

10) How often do you groom your dog?

11) How often do you brush your dog's teeth?

12) Is there anything else you would like to add about general care of your dog?

Rewards and Treats

13) How do you reward your dog for good behaviour?

14) In what situation(s) do you give your dog treats?

15) What type of treat do you give to your dog?

16) How often do you give your dog treats?

17) Do other members of the household give the dog treats?

Dog's Interest in Food

18) Do you allow the dog into the kitchen while you're preparing your own food?

19) What does your dog do while you are eating?

20) How do you interact with your dog while you are eating?

21) Does your dog beg?

22) What does your dog do when they are begging?

23) What do you do if your dog begs?

24) What would your dog do if you accidentally spilled a large quantity of their food on the floor while you were preparing their meal?

25) Does your dog scavenge?

	Yes	**Sometimes**	**No**	**Not sure**	**Prefer not to answer**
Around the house?					
In the garden?					
Away from home?					

26) Does your dog exhibit coprophagia (eat faeces)?

	Yes	**Sometimes**	**No**	**Not sure**	**Prefer not to answer**
Its own faeces?					
Other dogs' faeces?					
Faeces from other animals? (please specify below)					

Comments:

Feeding your Dog

27) What is your dog currently fed?

28) How often do you feed your dog?

29) How do you decide how much to feed your dog?

30) How do you measure the amount of food to give your dog?

31) What is your routine at feeding time?
For example, do you make your dog sit and wait for a command before they start eating?

32) Do you stay with your dog while he/she is eating?

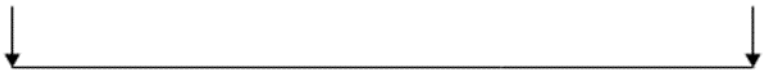
33) Do you give your dog any dietary supplements such as vitamins/minerals, cod liver oil?

Activity Levels

34) How active is your dog when they are at home**?** *Please place a cross at the appropriate point on the line.*

Not active at all,
spends all their time asleep

Extremely active,
on the go all the time



35) How much exercise does your dog get outside of your house and garden on a typical day?

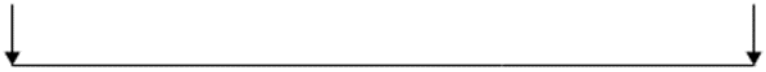
	Weekday (minutes)	**Weekend (minutes)**
Walking on the lead		
Walking off the lead		
Running		
Playing with other dogs		
Swimming/playing in water		
Chasing balls etc		
Other (please specify below)		

Weight

36) Do you know what your dog weighs in kg or lbs?

37) How would you describe your dog's weight? *Please place a cross at the appropriate point on the line.*

Very underweight **Very overweight**



38) Is your dog's weight stable?

Health

39) Does your dog suffer from any long-term health conditions?

Demographics

40) How would you describe the place where you live?

41) How many people live in your household including yourself?

42) Could you tell me the ages of anyone in the household who is under the age of 18?

Please skip this question if not applicable.

	Age	Prefer not to answer
Child 1		
Child 2		
Child 3		
Child 4		
Child 5		
Child 6		

43) How would you describe your working status?

44) What is your gender?

45) What age are you?

46) How tall are you?

47) What is your weight?

48) Do you make a conscious effort to manage your own weight?
For example, do you exercise regularly or count calories?

Additional comments

49) Is there any other information you feel would be relevant to this study?

Thank you very much for taking the time to complete this survey!

Appendix 4: Brood Stock Holder Questionnaire: Food Interest Tests

Brood/stud's Details

1) What is your brood/stud's name?

2) What is your brood/stud's computer number?

3) What breed is your brood/stud?

4) What sex is your brood/stud?

5) What is your brood/stud's date of birth?

6) How long have you had your brood/stud?

Feeding your Brood/Stud

7) What is your brood/stud currently fed?

8) Do you add anything to your brood's/stud's dry food?

9) What type of bowl do you usually use to feed your brood/stud?

10) How many grams of food is your brood/stud fed at each meal?

11) Is your brood/stud on a light or restricted calorie diet?

11a) Why is your brood/stud on a light or restricted calorie diet?

11b) For how long has your brood/stud been on a light or restricted calorie diet?

12) How often do you normally feed your brood/stud?

13) When did your brood/stud have their most recent meal?

Yesterday

Today **Time:**

14) When did your brood/stud last have any treats or titbits?

Day: **Time:**

15) How long did your brood/stud take to finish their most recent meal (in seconds)?

16) How quickly does your brood/stud usually eat his/her meals?

Rapidly (eats with large bites and doesn't pause, food is gone within seconds)

Neither rapidly or slowly (eats with normal sized bites, may pause between bites and may take a minute or so to consume all food, depending on the size of the meal)

Slowly (frequently pauses while eating, may appear disinterested, may walk away with food remaining in the bowl)

Comments:

17**) How often does your brood/stud finish his/her meal?** *Please place a cross at the appropriate point on the line*

Never **Always**



Brood/Stud's Interest in Food

18) How excited does your brood/stud get when there is food around? *Please place a cross at the appropriate point on the line*

Least excited possible **Most excited possible**



19) How interested does your brood/stud seem when you are preparing your own food?

Please place a cross at the appropriate point on the line

Least interested possible **Most interested possible**



20) How interested does your brood/stud seem when you are eating? *Please place a cross at the appropriate point on the line*

Least interested possible **Most interested possible**



21) How interested is your brood/stud in food immediately after they have had a meal? *Please place a cross at the appropriate point on the line*

Least interested possible **Most interested possible**



22) How often does your brood/stud refuse food? *Please place a cross at the appropriate point on the line*

Never **Always**



23) How would you describe how fussy your brood/stud is about food? *Please place a cross at the appropriate point on the line*

My dog would never eat a food that they weren't familiar with **My dog would eat anything**



24) How often does your brood/stud search for food in the house eg raid bins, steal food left on the worktop? *Please place a cross at the appropriate point on the line*

Never **Always**



25) How often does your brood/stud try to eat food dropped on the pavement etc? *Please place a cross at the appropriate point on the line*

Never **Always**



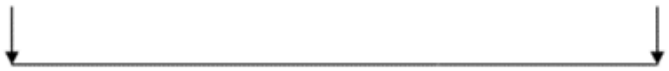
26) How often does your brood/stud try to eat dead birds/rabbits etc? *Please place a cross at the appropriate point on the line*

Never **Always**



27) How often does your brood/stud eat (swallow) non –food items like stones, toys or socks? *Please place a cross at the appropriate point on the line*

Never **Always**



28) **How often does your brood/stud go out of his/her way to search for food when you are out and about?** *Please place a cross at the appropriate point on the line*

Never **Always**



You and Your dog

In the following questions, please select the option which best reflects how you feel about your brood/stud.

29) How do you see your brood/stud?

I see my brood/stud as a child/grandchild, somebody to treat
I see my brood/stud as a companion or an equal
I see my brood/stud as having a lower status than a human being, being below humans in the pecking order

30) How would you describe your role in caring for your brood/stud?

I am like a caretaker/guardian/companion for my brood/stud
I am like an owner/employer of my brood/stud
I am like a parent/friend to my brood/stud

31) How do you feel about animals in general?

Different types of animal have different purposes
I care about my own brood/stud and generally like other dogs
I care about the welfare of all animals equally.

32) Hypothetically speaking, how would you feel about giving up your dog?

I would never rehome this dog, although I have given other dogs up
I would never rehome any dog I took on
I would give this dog up if it became inconvenient or a problem
I would give up this dog at the end of its breeding career

33) Hypothetically speaking, how would you feel if your dog was seriously ill and the vet advised that he/she needed euthanizing (putting to sleep)?

It would be difficult, but I would have the dog put to sleep if it was the best thing for the dog
It would be difficult, but I could get another one
I would do anything possible to keep this dog alive

34) Why did you want to become a brood/stud dog holder?

35) What type of brood/stud did you want and why?

36) Did you get the type of brood/stud you wanted?

37) Where do you think the responsibility for your brood/stud's health and welfare lies? *Please place a cross at the appropriate point on the line*

Guide Dogs **Brood/stud dog holder**



Background Information for Today's Study

38) How did you travel to the NBC today?

39) How long did your journey take (in minutes)?

40) Please describe your brood/stud's behaviour on the journey today? Eg excited, nervous

41) Has your brood/stud previously attended any activities or events in the Mark Jenkins room (the room where Dog Club is held)?

Thank you very much for your help today!

Appendix 5: Puppy Walker Questionnaire

Dog's Details

1) What is your dog's name?

.....

2) What is your dog's computer number?

.....

Puppy's Interest in Food

3) How often did your puppy finish his/her meal? Please place a cross at the appropriate point on the line

Never **Always**



4) How excited did your puppy get when there was food around? Please place a cross at the appropriate point on the line

Least excited possible **Most excited possible**



5) How interested did your puppy seem when you were preparing your own food? Please place a cross at the appropriate point on the line

Least interested possible **Most interested possible**



6) How interested did your puppy seem when you were eating? Please place a cross at the appropriate point on the line

Least interested possible **Most interested possible**



7) How interested was your puppy in food immediately after they had had a meal? Please place a cross at the appropriate point on the line

Least interested possible **Most interested possible**



8) How often did your puppy refuse food? Please place a cross at the appropriate point on the line

Never **Always**



9) How fussy was your puppy was about food? Please place a cross at the appropriate point on the line

My dog would never eat a food that they weren't familiar with **My dog would eat anything**



10) How often did your puppy scavenge for food in the house eg raid bins? Please place a cross at the appropriate point on the line

Never **Always**



11) How often did your puppy try to eat food dropped on the pavement etc? Please place a cross at the appropriate point on the line

Never **Always**



12) How often did your puppy try to eat dead birds/rabbits etc? Please place a cross at the appropriate point on the line

Never **Always**



13) How often did your dog ingest (swallow) non –food items like stones, toys or socks?

Never **Always**



14) How often did your puppy go out of his/her way to search for food when you were out and about? Please place a cross at the appropriate point on the line

Never **Always**



Additional comments

15) Is there any other information you feel would be relevant to this study?

Thank you very much for taking the time to complete this survey.

Without your input, this research would not be possible. Your responses to this survey will be anonymised and combined with the responses from other participants to help Guide Dogs improve the health and welfare of their dogs.

Appendix 6: Information for new Guide Dog Owner on research study

As a puppy, your new guide dog was involved in a research project looking at dogs' behaviour around food. We would really like to follow your dog through the early part of his/her working life, so we are providing you with some information about your dog's previous behaviour around food and then would like to interview you in about 6 – 8 months' time to see how your dog's behaviour around food as a puppy compares to its behaviour around food as a working guide dog.

Obesity is a significant problem amongst guide dogs. In 2012:

- 31.1% of dogs were at their optimum weight
- 38.6% of dogs were overweight (between 0.1% and 15% over their optimum weight)
- 9.7% of dogs were obese (more than 15% over their optimum weight)

So in total, almost half (48.3%) of Guide Dogs were above their optimum weight.

The consequences of a dog becoming overweight or obese include:

- Reduced life expectancy
- Increased risk of:
- heart disease
- respiratory disease
- mammary tumours ('breast cancer') especially in entire bitches
- heat stroke
    - bone and joint diseases *e.g.* arthritis
    - pancreatitis
    - skin disease (atopic dermatitis)
- Lack of mobility
- Exercise intolerance/lethargy
- Reduced quality of life.

Background:

Dogs by nature are scavengers. Their ancestors were wolves who hunted or scavenged for their food. Wolves had to compete with the rest of their pack to get their share of food. As a result of this, some domesticated dogs show more food-seeking behaviours than others. Certain breeds (eg Labradors) have a reputation for being particularly interested in food, but there is considerable variation between individuals within a breed. This means that not all Labradors will be totally focussed on food!

Information from **Dog's Name's** Puppy Walker suggests that he/she has a **high** interest in food. This means that he/she is very likely to:

- Finish his/her meal every time
- Still be looking for food immediately after a meal
- Be very interested when you are preparing food for or having something to eat yourself.
- Look for food when you are out and about, including food dropped on the pavement, dead birds etc
- Eat anything and never refuse food!

Knowing that **Dog's Name** is very motivated by food may help you to manage his/her weight.

OR

Information from **Dog's Name's** Puppy Walker suggests that he/she has a **low** interest in food. This means that he/she:

- May not always finish their meal
- Is unlikely to be interested in food immediately after a meal
- Will probably take no notice when you are preparing food for or having something to eat yourself.
- Will probably not be distracted by food when you are out and about
- Would probably refuse food if they are unfamiliar with it

Knowing that **Dog's Name** has a low interest in food may help you to manage his/her weight.

Some earlier research carried out in Guide Dogs showed several things that increase the likelihood of dogs becoming overweight:

1. Treats and rewards

    a. If your dog's treats are in addition to, rather than taken from, its daily ration he/she is more likely to become overweight.

    b. If you reward your dog using food that is not taken from his/her daily ration, he/she is more likely to become overweight.

    c. If you give your dog treats at the vets he/she is more likely to become overweight.

2. If you give your dog dental treats. One medium Dentaflex contains 226 cals, which is almost 1/5th of a typical Labradors' daily calorie requirement! If you do give your dog dental treats, you need to cut down the amount of food you give him/her accordingly. An alternative to reducing your dog's food would be to increase his/her exercise – but you need to walk a typical 30kg dog for an extra 70 mins (over 4 miles) to burn off the calories in one Dentiflex!

3. If you struggle to manage your own weight or are overweight yourself

Things that reduce the likelihood of your dog gaining excess weight:

4. If you whistle-feed your dog or use some other command to tell your dog they can eat their meal, he/she is less likely to get overweight.

5. If you weigh your dog's food out on kitchen scales FOR EVERY MEAL rather than measuring it with a tin can etc. This ensures your dog is getting the correct amount of food at each meal. Some GDO weigh out a week's worth of food into small food bags every weekend to make feeding the correct amount during the week easier.

6. If any treats or rewards you give your dog are taken from, rather than in addition to, its daily ration.

Based on these findings, to maintain the optimum body weight of your dog, it is important that you:

- Always take your dog's food rewards and treats from his/her daily food ration
- Weigh your dog's food out for every meal
- Ensure your dog only eats once the whistle or command has been given

If you would like an A4 sized poster to help other people involved in your dog's care implement these recommendations, then please get in touch with Caroline Quarmby using the contact details below.

We would also like to email you some background information about the research behind these findings every month or so over the next six months. If you would prefer this as a CD, large print or Braille document please let Caroline Quarmby know using the contact details below.

Caroline Quarmby or another researcher from the School of Veterinary Medicine and Science at the University of Nottingham would like to interview you by telephone later in 2016, once your new dog has settled in and you have had the chance to get to know them. We would like to find out about:

- Your dog's current behaviour around food
- How useful it was to know your dog's previous behaviour around food

- How useful you found the additional information and guidance about managing your dog's weight
- How useful you found the poster, monthly emails (or equivalent) etc

This will give us a better understanding of dogs' interest in food and whether that changes over time. It may also enable Guide Dogs to tailor their weight management advice for individual dogs which could make it easier for Guide Dog Owners (and Brood Stock Holders) to manage their dogs' weight more effectively. This could help to reduce the number of health issues in Guide Dogs, which would in turn improve the dogs' welfare and quality of life.

Participation is entirely voluntary. If you do not wish to take part in the project you are not obliged to do so. Non-participation in the study will not impact your relationship or status with Guide Dogs now or in the future. However the information you provide could be of great importance to Guide Dogs and we would really appreciate your assistance with this study. Please let Rachel Moxon or your GDMI know if you do not wish to help with the final stage of my research.

Anonymity and confidentiality: Any data collected during the study will be securely stored at the University of Nottingham or in the possession of the researcher and will only be accessible to her and her supervisors. All data will be anonymised so that neither you nor your dog can subsequently be identified. Anonymised information from the questionnaire may be published and combined with data from Guide Dogs to help improve the health and welfare of their dogs. The only time that anonymity may be breached would be if there were serious concerns about yours or someone else's safety. In this case, these concerns would be discussed with you first to try to identify any further support that might be required.

If you have any questions or require any further information please do not hesitate to contact the researcher at caroline.quarmby@nottingham.ac.uk or 0115 9516588. Alternatively you can contact the research supervisor, Gary England at gary.england@nottingham.ac.uk; Rachel Moxon, Canine Research Associate at Guide Dogs at rachel.moxon@guidedogs.org.uk; or David Haig, the Head of the SVMS Ethics Committee at david.haig@nottingham.ac.uk.

Thank you for your help!

Appendix 7: Intervention Study Poster



Appendix 8: GDO Interviews 2016

Dog details	
Name	
Sex	
Breed	
Age	
BIOP	
Dog ownership experience	
Have you had a guide dog before?	
If yes – how many?	
Have you had pet dogs in the past?	
Do you have any other pets now?	
Dog's activity levels	
On a scale of 0–100 where 0=Not active at all, spends all their time asleep and 100=Extremely active, on the go all the time:	
How would you describe your dog's activity levels at home?	
On a scale of 0–100 where 0=Not working at all and 100 working all day:	
How would you describe your dog's workload on a weekday?	
How would you describe your dog's workload at the weekend?	
How long does your dog spend free running per week?	
Food related questions	
What food is your dog currently on?	
How quickly does your dog usually eat his/her meals?	

Rapidly (eats with large bites and doesn't pause, food is gone within seconds)	Neither rapidly or slowly (eats with normal sized bites, may pause between bites and/or may take a minute or so to consume all food, depending on the size of the meal)	Slowly (frequently pauses while eating, may appear disinterested, may walk away with food remaining in the bowl)
Environment where dog is fed:	Secluded area/alone	With just you around
	With other animals around	With other people around/busy area
On a scale of 0–100 where 0=Never and 100=Always:		
How often does your dog finish his/her meal?		
How often does your dog refuse food?		
How often does your dog try to eat food dropped on the pavement etc?		
How often does your dog try to eat dead birds/rabbits etc?		
How often does your dog go out of his/her way to search for food when you are out and about?		
On a scale of 0–100 where 0=Least excited possible and 100=Most excited possible		
How excited does your dog get when there is food around?		
On a scale of 0–100 where 0=Least interested possible and 100=Most interested possible:		
How interested does your dog seem when you are preparing your own food?		
How interested does your dog seem when you are eating?		
How interested is your dog in food immediately after they have had a meal?		
On a scale of 0–100 where 0=My dog would never eat a food that they weren't familiar with and 100=My dog would eat anything		

How would you describe how fussy your dog is about food?		
On a scale of 0–100 where 0=Never and 100=Always:		
How often do you weigh your dog's food on kitchen scales?		
How often do you give your dog treats?	5 times a day or more	2-4 times a day
	Once a day	Every 2-3 days
Weekly	Less often than weekly	Never
What type of treats do you give?	Shop bought treats eg Bonios	Table scraps
	Dental chews eg Dentistix	Fruit or vegetables
Other types of dog chew eg Rawhide chews	Food taken from daily allowance	Other (please specify)
On a scale of 0–100 where 0=Never and 100=Always:		
When you give your dog treats, how often are they taken from their daily food allowance?		
Monitoring weight		
What do you understand by the term Body Condition Scoring (BCS)?		

How often do you BCS your dog?	More than once a week	Weekly
	Fortnightly	Monthly
Less often than monthly	Never	The vet does it for me
Other (please specify)		
How often do you weigh your dog?	More than once a week	Weekly
	Fortnightly	Monthly
Less often than monthly	Never	Just when my dog needs to go to the vets

Other (please specify)		
Are there any other ways you monitor your dog's weight?		
Feel ribs	Feel waist	Fit of harness
General handling eg grooming	Comments from friends/family/public	
Other (please specify)		
On a scale of 0–100 where 0=Very underweight and 100=Very overweight:		
How would you describe your dog's current weight?		
On a scale of 0-100 where 0=Couldn't be less important and 100=Couldn't be more important:		
How important is it to you to manage your dog's weight?		
On a scale of 0-100 where 0=I do nothing at all to manage my dog's weight and 100=I do everything possible to manage my dog's weight:		
How actively do you try to manage your dog's weight?		
On a scale of 0-100 where 0=Couldn't be more difficult and 100=Couldn't be easier:		
How easy do you find it to manage this dog's weight?		
Do you have any particular challenges in managing your dog's weight?		
Dog seems constantly hungry	Dog stealing food from other animals	Dog scavenging
Other people (eg family, friends, the public) feeding my dog without my knowledge/consent	Children dropping food	Visual impairment eg hard to tell whether the dog is scavenging/ looking for food when FR?
Other (please specify)		

On a scale of 0 100 where 0=Couldn't be less significant and 100=Couldn't be more significant:	
How significant are each of these challenges for you in relation to managing this dog's weight?	
How do you manage these challenges?	
Intervention study	
Was your dog in the high or low food interest category?	
On a scale of 0–100 where 0=Least useful possible and 100=Most useful possible	
How useful was it to know this?	
On a scale of 0–100 where 0=No effect at all and 100=Maximum possible effect	
How much did knowing your dog's food interest affect the way you fed your dog?	
How much did knowing your dog's food interest affect the way *you* gave your dog treats?	
How much did knowing your dog's food interest affect the way *other members of your household* gave your dog treats?	
How much did knowing your dog's food interest affect the way *you* exercised your dog?	
How much did knowing your dog's food interest affect the way *other members of your household* exercised your dog?	
How much did knowing your dog's food interest affect the way *you* monitored your dog's weight?	
On a scale of 0–100 where 0=Least useful possible and 100=Most useful possible	
How useful was the additional information and guidance on managing your dog's weight?	
How helpful were the monthly emails?	
How helpful was the poster (if applicable)?	

How helpful was the information sheet (or equivalent) provided when you took the dog on?	

Human Animal Bond Questions

Some of these questions are a bit more personal so if there are any that you don't want to answer, then please say so

Here is a list of reasons why people might want a guide dog. Could you tell me how relevant they are to you on a scale of 1–10 where 1=Disagree strongly and 1=Agree strongly:

I wanted a GD to increase my independence	
I wanted a GD as a companion	
Are there any other reasons why you wanted a guide dog?	

Here is a list of ways in which people might relate to their guide dog and 5 possible responses.

The options are: Agree Somewhat agree Neutral Somewhat disagree Disagree

Using those 5 categories, could you tell me to what extent you view your current guide dog as:

A pet	Agree	Somewhat agree	Neutral	Somewhat disagree	Disagree
A working animal	Agree	Somewhat agree	Neutral	Somewhat disagree	Disagree
A mobility aid	Agree	Somewhat agree	Neutral	Somewhat disagree	Disagree
A companion	Agree	Somewhat agree	Neutral	Somewhat disagree	Disagree

Here is a list of ways in which people might interact with their guide dog. Could you tell me how important they are to you on a scale of 0–100 where 0=Least important possible and 100=Most important possible?

Talking to your dog	
Stroking and cuddling your dog	
Grooming your dog	

Food and treats		
Play and toys		
Other? (please specify)		
Demographics		
On a scale of 0–100, where 0=Couldn't be less healthy and 100=Couldn't be healthier:		
How would you describe how healthy your own lifestyle is?		
Now the really personal bit… feel free not to answer any of these questions if you don't want to:		
Would you mind telling me your age?		
Would you mind telling me your height?		
Would you mind telling me your weight?		
Is there anything else that you would like to tell me relating to the topics we've talked about today?		

Thank you very much for your help!