Understanding Obesity among Companion Dogs: New Measures of Owner's Beliefs and Behaviour and Associations with Body Condition Scores

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Abstract

This research aimed to improve our understanding of how owners' beliefs and behaviour are associated with obesity in companion dogs. To do this, we employed new theoretical frameworks and integrated previously reported measures to curate a collection of brief, user-friendly self-report measures to assess owner factors. The reliability and validity of these was examined in two phases of empirical research, each with a cross-sectional questionnaire design that also examined the validity of assessing body condition score (BCS) from photographs submitted by owners. Phase 1 (n = 47 dog owners from France) found that the brief owner-report measures correlated with the long-form measures (all correlations except one exceeded r = 0.70). BCS as coded from photographs were highly correlated with a vet's assessment of the same dogs (r = 0.67). Phase 2 (n = 3,339 dog owners from France, Germany, the UK, Italy, and Russia) investigated which measures are associated with obesity among companion dogs. Perceptions of the dog's vulnerability to the threat of obesity, perceived weight status, perceived costs associated with ownership, normative beliefs about feeding, social support from friends, and being in the precontemplation stage of change predicted BCS alongside demographic factors (e.g., dog's age, neutered status). Taken together, the findings provide a method for assessing a wide range of factors that may be associated with obesity among companion dogs and point to potential targets for interventions designed to reduce obesity.

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Risk factors for obesity among companion dogs are multifactorial and include factors pertaining to the dog (e.g., genetics, breed, neutered status, age, sex, and responsiveness to food). However, owners typically control food intake and can moderate energy expenditure among companion animals (Association for Pet Obesity Prevention, 2014). This occurs via owners' feeding and exercise practices (Kienzle et al., 1998; Bland et al., 2009; Courcier et al., 2010), which are influenced by their knowledge and the presence of barriers to implementing good practice (Cutt et al., 2008; Endenburg et al., 2018; Webb et al., 2018), and their behavioural, normative, and control beliefs with respect to feeding and exercise (Cutt et al., 2008; Rohlf et al., 2010; 2012; Endenburg et al., 2018). Other factors that have been shown to be associated with obesity include owner perceptions and motivations for treat giving (White et al., 2016; Morelli et al., 2020), and the strength of the bond between dog and owner (Rohlf et al., 2012; Westgarth et al., 2014; 2016). Taken together then, it is clear that factors related to both owner and dog are associated with obesity in companion dogs.

While significant progress has been made in understanding how owners' beliefs and behaviours are associated with obesity among companion animals, research in this area lags behind understanding of behavioural factors in other domains, such as with respect to obesity in people. For example, although research has drawn on social cognitive frameworks like the Theory of Planned Behaviour (Ajzen, 1991) to identify the factors that are likely to be associated with obesity among companion animals (Rohlf et al., 2010; Cairns-Taylor & Fordyce, 2016), many theoretical frameworks that have proved useful in other areas have yet to be applied in this context and, often, research on factors associated with obesity among companion animals is conducted without the guidance of theory (e.g., Perry et al., 2020). While using theory is not a panacea for behaviour change (for a review of issues, see

Prestwich et al., 2015), there are clear advantages to so doing (e.g., theory can suggest potential predictors and explain how and why they are associated with outcomes) and so we suggest that it might be valuable for researchers and practitioners tasked with the challenge of reducing obesity among companion animals to consider theoretical frameworks that have proved useful in other areas. Specifically, we propose that five additional theoretical frameworks might provide useful insights.

Protection Motivation Theory (Rogers, 1983) suggests that two beliefs determine how motivated people are to protect themselves (or in this case their dog). The first belief is their appraisal of the threat, which comprises beliefs about how vulnerable their dog is to becoming overweight or to the negative consequences of obesity (termed *threat vulnerability*) and how severe they deem the threat (termed *threat severity*). In support of the role of severity, Muñoz-Prieto et al. (2018) found that dog owners who did not consider obesity to be a disease were more likely to have obese dogs. The second belief is owner's appraisal of their ability to cope with the threat, which includes beliefs about the efficacy of a potential response (e.g., whether altering feeding or exercise regimes would reduce the risk of obesity, termed *response efficacy*) and their personal ability to enact the required response (e.g., whether they would be able to alter feeding or exercise, termed *self-efficacy*).

Theoretical models that consider how people move through a series of stages of behaviour change are also worthy of consideration. For example, the **Transtheoretical – or 'stages of change' – model** (Prochaska & DiClemente, 1984) suggests that people progress through a series of five stages of behaviour change: *Precontemplation* (where they have not thought about the issue), *contemplation* (where they are intending to take action at some point in the (not immediate) future), *preparation* (where they are intending to take action and have started making plans as to how they will do so), *action* (where they have started to take action), and finally, *maintenance* (where they have taken action, achieved the desired

outcomes, and are now working to prevent relapse). As such, the model may provide a useful summary of the extent to which owners have begun to think about their dog's weight or started taking action and help to target interventions toward those for whom they are likely to be most appropriate and effective (Norcross et al., 2011).

The third framework that may offer useful insights is **Control Theory** (Carver & Scheier, 1982). Control Theory views goal directed behaviour as involving three main processes: goal setting, goal monitoring, and goal operating. The processes involved in setting goals are well accounted for by social cognition models such as the Theory of Planned Behaviour and Protection Motivation Theory, as described above. However, having set a goal (e.g., to feed a dog a certain amount of food a day, or to reduce overall weight), Control Theory suggests that the person needs to monitor the relation between the goal and the current state. In the context of striving to feed an appropriate amount of food to a dog, *monitoring* may involve keeping track of both the amount of food that is provided to the animal (at mealtime and as treats), and/or the weight of the animal.

Finally, volitional – or post-intentional – factors, may help to understand when and how motivation is translated into action. Evidence suggests that people often struggle to translate their motivation (as reflected by behavioural intentions) into action (Sheeran & Webb, 2016). For example, many dog owners are motivated to feed and exercise their dog appropriately, yet struggle to do so, possibly because they fail to appropriately restrict food or succumb to begging (Webb, 2015). Theoretical models like the **Health Action Process Approach** (Schwarzer, 2008) and the **Rubicon Model of Action Phases** (Heckhausen & Gollwitzer, 1987), therefore suggest volitional – or post-intentional – factors, which can help to understand when and how motivation is translated into action. Two key factors in this regard are *action planning* (planning when, where, and how to act) and *coping planning*

(identifying barriers that might derail intended actions and generating plans to manage or overcome them) (Zhang et al., 2019).

The Present Research

The present research sought to understand how owners' beliefs and behaviour are associated with obesity in companion dogs by developing brief measures of beliefs, behaviours, and risk factors, and exploring which factors are associated with canine obesity. Data collection was undertaken in two phases. In the first phase of the research, dog owners completed an online questionnaire containing brief and longer measures of each of the factors of interest, and we investigated whether brief measures can capture the same information as longer measures. In the second phase, a larger sample of owners across five countries completed the brief measures and a subsample completed them a second time so that test-retest reliability could be assessed. In both phases of the research, owners also uploaded photographs of their dog from which trained coders assessed body condition score (BCS; Laflamme, 1997).

Material and Methods

The methods were reviewed and approved by the Research Ethics Committee in the Department of Psychology at The University of Sheffield, UK (Application #022521).

Phase 1: Participants and measures. Power analysis suggested that 42 participants would provide 95% power to detect large-sized (i.e., $r = 0.50$) bivariate relationships between brief and full measures. Therefore, in November 2018, CEN Nutrition Animale recruited 47 dog owners living in France by sending an email to members of their panel. Figure 1 provides a visual representation of the recruitment process. To be eligible to take part in the study, participants needed to be over 18 years old and own (at least one) dog over the age of 1 and be primarily responsible for its care. Participants with dogs that had been diagnosed with a chronic or terminal illness were excluded.

Supplementary Material 1 shows the factors that were measured in Phase 1 mapped on to the theoretical frameworks from which they are derived, and the associated brief and complete (in italics) measures of each factor. Most measures were taken as is or slightly adapted (for country-specific differences) from established questionnaires (Cutt et al., 2008; Rohlf et al. 2010; Richards et al., 2013; Raffan et al., 2015), and recent studies on factors associated with human and canine obesity (Muñoz-Prieto et al., 2018). In addition, owners were asked to self-assess the body condition of their dog using the 5-point BCS scale, where 1 = severely underweight, 2 = thin, 3 = ideal weight, 4 = overweight, and 5 = obese. Participants were also asked to upload two photographs of their dog (one from above and one from the side), alongside a reference object for scale. Five veterinary students at the National Veterinary School of Toulouse were trained to use the submitted photographs to rate the dog's BCS. Finally, owners were asked to bring their dog to a vet who provided an additional assessment of body condition and weight.

Phase 2: Participants and measures. Power analysis suggested that 2,384 participants would provide 95% power to detect small-sized relationships (i.e.., $f^2 = .02$) between 62 potential predictors and body condition scores. Therefore, between February and April 2019, IPSOS MORI recruited 3,339 dog owners across five countries; France (n = 599), Germany (n = 626), the UK (n = 714), Russia (n = 687) and Italy (n = 713) by emailing pre-identified dog owners an invitation to take part in the research. Figure 2 provides a visual representation of the recruitment process. The eligibility criteria were the same as in Phase 1, except that only people aged between 18 and 65 were approached. A subsample of the dog owners living in France (18%; n = 107) completed the questionnaire a second time two weeks later to assess test-retest reliability.

Phase 2 used the brief measures developed in Phase 1 (see Supplementary Material 2 for full details of the factors that were measured in Phase 2 mapped on to the theoretical

frameworks from which they are derived, along with the associated measures) and asked owners to upload two pictures of their dog so that coders could assess BCS. *n* = 1645 of the participants (49%) provided two photographs in accordance with the specified guidelines. *n* = 870 participants (26%) submitted photographs that were not suitable (e.g., a photo of their dog jumping into a swimming pool), 241 (7%) of the participants submitted the same photo twice, and a further 583 (17%) of participants submitted photographs, but not of their dog (e.g., stock photographs from Google images). BCS was coded from these photographs by the same trained coders as in phase 1. There was good agreement between the coders (average weighted kappa = 0.62, *SD* = 0.10, range 0.49 to 0.74), according to Altman's (1991) guidelines for interpreting kappa.

The breed of the dogs (where specified by the owners) was coded into those prone to obesity (Cairn Terriers, Basset hounds, Cavalier King Charles Spaniels, Beagles, Cocker Spaniels, Dachshunds, Dalmatians, Labrador Retrievers, Golden Retrievers, Shetland Sheepdogs, Rottweilers) versus those not prone (other breeds, including mixed breed dogs), on the basis of Hand et al. (2000), Lund et al. (2006) and Delaney (2010).

Results

Phase 1

Dog and owner characteristics. Owners were typically female (23% male), with an average age of 44 years (*SD* = 13, range: 26 to 70). Dogs were, on average 6.5 years old (*SD* = 3.2, range: 1 to 13); 51% were male and 51% were neutered.

Measures of body condition. Table 1 shows the correlation between the three measures of BCS that were employed in Phase 1 (owner's ratings, the average rating of five coders from the pictures that owners submitted, and ratings by the vets when the owners brought their dog to the clinic). The three measures were correlated; coders' ratings of BCS from the photographs that owners submitted were highly correlated with the vet's assessment

of BCS (r = 0.67) and more so than with the owners' self-ratings (r = 0.58), suggesting that coding BCS from photographs is a valid way to assess BCS; and likely more accurate than owners' self-ratings.

Validating brief measures of owner factors. To evaluate whether the brief self-report measures of owner factors provided an adequate measure of the respective constructs and thus could be used in Phase 2 of the research, correlations were examined between the brief and complete measures of each factor. These are reported in the final column of Supplementary Material 1. A correlation of r = 0.70 or above was taken to indicate a substantial (and therefore acceptable) correlation between the brief and complete measures. All of the brief measures met this criterion, with the exception of the measure of normative beliefs with respect to exercise (r = 0.39).

Phase 2

Dog and owner characteristics. Owners were typically female (37% male), with an average age of 44 years (*SD* = 12, range: 18 to 66). Dogs were, on average 5.9 years old (*SD* = 3.4, range: 1 to 19); 57% were male and 46% were neutered. Supplementary Material 3 shows this information by country of recruitment.

Test-retest reliability of the measures. The intra-class correlation co-efficient (ICC) was computed between the two administrations of the questionnaire in order to examine the test-retest reliability of the measures (see Table 2). Values between 0.40 and 0.60 indicate moderate agreement, 0.61 to 0.80 indicate good agreement, values > 0.80 indicate excellent agreement (see Landis & Koch, 1977). All of the measures were at least moderately reliable according to these guidelines and most indicated good agreement.

Owner and coder-rated assessments of body condition. Figure shows the BCS ratings provided by the owners against the ratings of BCS made by the coders on the basis of the photographs that the owners submitted. The two ratings were correlated (r = 0.41);

224 although owners' typically rated their dog's BCS lower than the coders (M = 3.13 vs. 3.54,
225 SD = 0.50 vs. 0.62, for owner and coder ratings, respectively, $t(1644) = 26.92$, $p < .001$) and
226 N = 539 owners (33% of the sample) rated the BCS of their dog as 'normal' (i.e., BCS = 3),
227 when the coders rated the dog as overweight (BCS = 4 or 5). We therefore used coders'
228 ratings of BCS in our analyses to identify the factors associated with BCS.

229 **Identifying the factors associated with BCS.** A three-step approach was used to
230 identify the factors associated with coders' ratings of BCS. Firstly, factors were identified
231 that correlated with BCS at a level that would not occur by chance in more than 10% of the
232 sample (i.e., $p < .10$). These factors are shown in Table 3, alongside the Pearson's
233 correlations (the full correlations by country of recruitment are shown in Supplementary
234 Material 3). Second, a series of hierarchical multiple regressions were conducted to identify
235 the factors within each domain (i.e., beliefs about overweight and obesity, dog-owner bond,
236 feeding, and exercise) that were correlated with BCS scores over and above demographic
237 factors (age of owner, age, gender, and size of dog; along with neutered status), which were
238 entered in Step 1. The findings of these regressions are shown in Table 4. Finally, the factors
239 that were significantly associated with BCS (i.e., $p < .05$) within each domain were entered in
240 a single hierarchical multiple regression, again controlling for demographic factors (Table
241 5).[1]

242 The overall model was statistically significant, $F(11, 1644) = 35.88$, $p < .001$, and
243 explained 19% of the variance in BCS. In the final step, the factors that explained significant
244 variance included (in order of the amount of variance explained): Threat vulnerability (*beta* =
245 0.20: Owners who believed that their dog easily puts on weight were more likely to have an
246 overweight dog), the age of dog (*beta* = 0.14: Older dogs were more likely to be overweight),

[1] For parsimony, we focus on the findings of the final hierarchical multiple regression in this report. However, further details of the other analyses, as well as the raw data are available by contact with the corresponding author.

weight status (*beta* = -0.12: Owners who thought that their dog was fit were less likely to have an overweight dog), perceived costs (*beta* = -0.20: Owners who associate dog ownership with more costs were less likely to have an overweight dog), normative beliefs about feeding (*beta* = 0.10: Owners who think that others believe they feed their dog too much were more likely to have an overweight dog), social support from friends (*beta* = -0.07: Owners whose friends support them to exercise their dog were less likely to have an overweight dog), stage of change: Precontemplation (*beta* = -0.06: Owners who think about their dogs weight were more likely to have an overweight dog), and neutered status (*beta* = 0.05: Neutered dogs were more likely to be overweight).

Discussion

The present research drew on a range of theoretical frameworks to identify and measure factors that are potentially associated with obesity among companion dogs. Having established that brief self-report measures of each factor were appropriate (Phase 1), a large sample of dog owners across five countries completed the measures and submitted photographs of their dogs, from which trained coders assessed their body condition (Phase 2). The findings indicated that, in addition to age, sex and neuter status, six owner-related factors were associated with BCS. Specifically, the owners of overweight or obese dogs were *more* likely to (i) think about their dog's weight (i.e., have moved past the precontemplation stage of change), (ii) believe that their dog is unfit, (iii) that it is vulnerable to gaining weight, and (iv) that others think their dog is fed too much. They were *less* likely to (v) believe that dog ownership is costly and (vi) have social support from friends for exercising their dog.

Some of these findings support those of previous research. For example, previous work has also found that normative beliefs are associated with owners' behaviour toward their dogs – e.g., Rohlf et al. (2012) found that, if other people important to the respondent were supportive of their performing beneficial behaviours (including the provision of a

nutritionally balanced diet), then those behaviours were more likely to be carried out. In the present research, norms were framed in terms of whether owners' belief that others are critical of their actions (e.g., believe that they feed their dog too much, as in Rohlf et al., 2010), rather than whether they support positive behaviours (e.g., providing a nutritionally balanced diet). However, the association found between norms and outcomes like weight reinforces the idea that owners are likely to consider others beliefs when deciding how to behave with respect to their dog.

In agreement with the current research, a number of studies have also shown that social support can be an important influence on dog walking. However, the majority of these studies focus on the support provided by the *dog* for walking (e.g., Kushner et al., 2006; Cutt et al., 2008; Johnson & Meadows, 2010; Higgins et al., 2013). The present research found that support from *friends* for dog walking (but not support from family or the dog) was associated with better outcomes for the dog. Such findings build on evidence that social support promotes physical activity among people (e.g., Wing & Jeffery, 1999, found that participants who joined a weight loss programme with three friends, family members, or co-workers lost more weight than those who joined alone) and provide a clear basis for interventions designed to provide social support (at least from friends, with respect to exercise) in an effort to help people to manage the weight of their dogs. For example, Richards et al. (2016) sent emails to dog owners encouraging them to walk their dog with friends and family in an effort to increase self-efficacy for overcoming barriers (e.g., it being dark or having family commitments) and Schneider et al. (2015) developed an online social network intended to increase walking in dog owners.

Novel findings from the current study extend our current understanding of obesity in companion dogs. For instance, we found that the owners of healthy weight dogs associate more costs with owning a dog, than the owners of overweight dogs. The perceived costs of

dog ownership were measured using items from the Monash Dog Owner Relationship Scale (MDORS; Dwyer et al., 2006) that reflect the extent to which ownership interferes with life etc, rather than financial costs. For example, participants were asked to what extent they feel that looking after their dog is a chore, find it hard to look after their dog, or find it annoying that they sometimes have to change their plans because of their dog. It seems possible therefore that people who have an overweight dog associate less costs with ownership simply because they don't do as much – i.e., they don't exercise their dog much, think about what to feed them etc. In other words, providing appropriate care for a dog and helping it to maintain a healthy weight is likely more onerous and time consuming than not doing so. Therefore, interventions designed to promote healthy weight might consider managing owner's expectations with respect to the effort involved in owning a dog.

The present findings also indicate that people with overweight dogs are more likely to think about their dog's weight. In other words, they are more likely than the owners of healthy weight dogs to believe that their dog has a weight problem and is vulnerable to gaining weight. On the one hand, these findings are intelligible in that they suggest that owners notice when their dog is overweight and have at least thought about trying to do something about it; however, they stand in contrast to evidence that people with overweight dogs are often not aware that their dog is overweight (Eastland-Jones et al., 2014) and our finding that many owners assess their dogs BCS as lower than that given by an objective, independent observer. In other words, although these findings support the idea that owners of overweight dogs typically underestimate the BCS of their dogs (White et al., 2011; Eastland-Jones et al., 2014), there was also evidence that the owners of overweight dogs were more likely to respond to measures in a way that acknowledges that their dogs are overweight. The implication is that, although the owners of overweight dogs typically underestimate their dogs' obesity problem using an objective measure, they typically do recognise that the dog is

overweight to some extent and so may be willing to engage with weight loss programs. Indeed, Raffan et al. (2015) found that the owners of overweight dogs were more likely to try to restrict their dog's food intake – although, evidently, they were not successful in doing so, suggesting that additional support may be needed to translate willingness into effective action.

The present study did not find any association between factors reflecting the strength of bond / attachment between dog and owner and BCS scores. However, this is not the first study to find no association; a study of risk factors for canine obesity in Denmark (Bjørnvad et al., 2019) found that attachment (as measured by the Lexington Attachment to Pets Scale, Johnson et al., 1992) was not associated with BCS. One explanation is that a strong human-animal bond can have both positive effects on behaviours that influence weight (e.g., lead owners to want to provide high quality diet and exercise regime/training etc., Westgarth et al., 2016) and negative effects (e.g., lead owners to give unsuitable feedstuffs / treats, not to walk the dog when it is raining etc.) These opposing influences may cancel each other out, suggesting that future research might try to distinguish between owners whose strong attachment leads to healthy versus unhealthy behaviours.

Finally, we did not find any association between feeding treats and obesity as has been reported by Kienzle et al. (1998) and Perry et al. (2020). However, other studies have reported similar findings. For example, German et al. (2011) did not find an association between feeding treats and the success of weight management, and Muñoz-Prieto et al. (2018) found that dogs were more prone to be overweight/obese if they did *not* receive treats. Taken together, these findings suggest that it is important to identify when feeding treats is associated with increased weight and when it is not. It may be that the term 'treats' is too generic, as Heuberger and Wakshlag (2011) found that feeding treats high in crude fibre actually reduced a dog's risk for obesity. This may suggest that the nutritional/energy content

of the treats, and other related behaviours (such as reducing the main ration to compensate for treat feeding) are important; and also point to the importance of manufacturer providing sufficient nutritional information on treats to consumers; something which is currently variable (Morelli et al., 2018; 2020). Future research should also ask owners what kind of treats they feed and whether they adjust the main meal to account for the additional calories provided by treats, in addition to how often they provide treats order to better understand the relationship between treats and weight.

Theoretical Frameworks for Understanding Factors Associated with Obesity

The additional theoretical frameworks that were considered in the present research (namely, Protection Motivation Theory, the Transtheoretical or 'stages of change' model, Control Theory, the Health Action Process Approach and the Rubicon Model of Action Phases), alongside more traditional theoretical frameworks (e.g., the Theory of Planned Behaviour, Social Cognitive Theory) identified some useful additional factors that may be important for understanding obesity among companion dogs. For example, as discussed above, threat appraisals from Protection Motivation Theory were associated with body condition scores, such that owners of overweight dogs tended to believe that their dog was more vulnerable to the threat of obesity. Similarly, identifying owners 'stages of change' with respect to tackling obesity proved useful, in the sense that having an overweight dog likely prompted owners to think about taking action (i.e., move beyond the precontemplation stage of action).

There was less clear evidence that monitoring behaviours (e.g., activity levels, food consumed) or outcomes (e.g., weight) was associated with BCS. The bivariate correlations suggest that monitoring weight was associated with BCS, but monitoring weight was not predictive alongside other variables in the multivariate regressions. Furthermore, monitoring diet and exercise was predictive of BCS in the within-domain regressions; however, so doing

was associated with higher BCS, suggesting that owners may monitor these behaviours in an effort to tackle an existing weight problem. Similarly, the within-domain regressions provided some evidence that people with overweight dogs were more likely to have made plans specifying how to deal with barriers to appropriate feeding. However, for the most part, volitional factors like monitoring and planning were not associated with BCS, supporting assertions that interventions may need to focus on providing information and helping owners to set appropriate goals before encouraging them to think about how to translate these goals into action (Webb et al., 2018).

Assessing BCS from Photos

It is worth briefly reflecting on the finding that it was possible for trained coders to assess dogs' BCS from photographs. That is, Phase 1 of the present research found a strong correlation (r = 0.67) between BCS assessed from photographs submitted by owners (termed vBCS by Gant et al., 2016) and assessments of BCS made by a vet. This supports Gant et al. who suggested that it is possible to indirectly estimate body condition from photographs; a conclusion that is strengthened by their finding that age, sex, breed, coat length, and coat colour did not significantly affect vBCS. However, one caveat to this conclusion is that only around half of the owners submitted two photographs in accordance with the instructions (namely, from above and from the side). Therefore, it may be more appropriate to say that it was possible for trained coders to assess dogs' BCS if owners provide appropriate photographs, but that clear instructions and guidance are likely needed for owners to do so.

Limitations and Future Directions

The correlational, cross-sectional design of the research means that it is not possible to use the data to distinguish between factors that precede obesity (and thus might cause overweight) and consequences. Indeed, the direction of the relations between some of the factors and BCS scores suggests that some of the factors are likely to be consequences, rather

than predictors, of obesity. For example, the negative association between precontemplation and BCS scores suggests that having an overweight dog leads people to think about their dog's weight (and thus not be in the precontemplation stage of change), rather than the converse (i.e., that not thinking about the dog's weight predicts healthy weight). While such relationships are interesting in the sense that they help to understand how people with overweight dogs think about their situation and help to identify those who need to change (i.e., the challenge of diagnosis), these factors are unlikely to explain why dogs become overweight in the first place. In contrast, factors such as a lack of social support from friends for exercising seem more likely to represent predictors of obesity and, thus, targets for intervention. We therefore hope that the brief measures developed in the present research provide the tools needed for longitudinal and / or experimental studies that can examine the relationship between owners' beliefs and behaviour and obesity over time.

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555 **Figure 1**

556 *Recruitment Process (Phase 1)*

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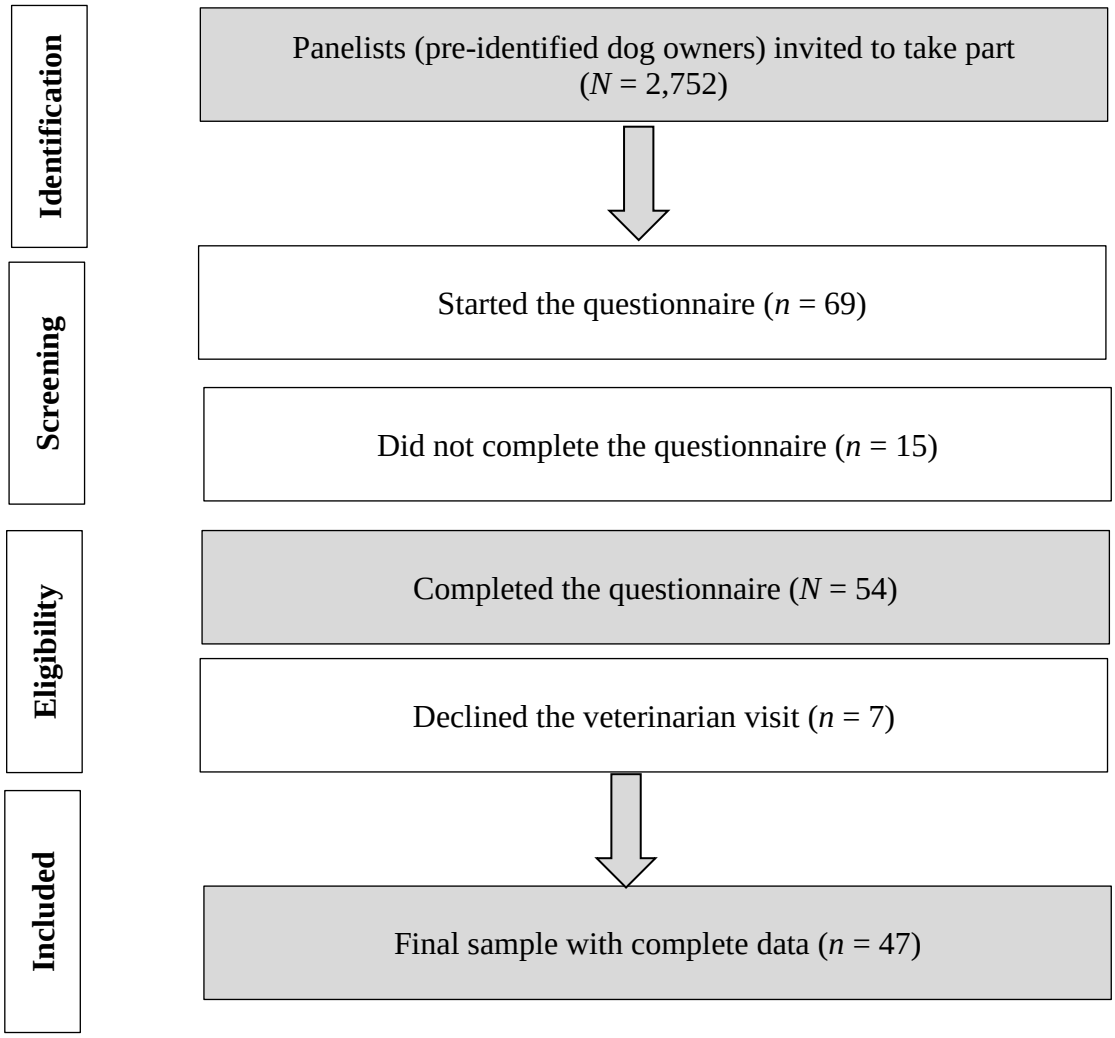

559 **Figure 2**

560 *Recruitment Process (Phase 2)*

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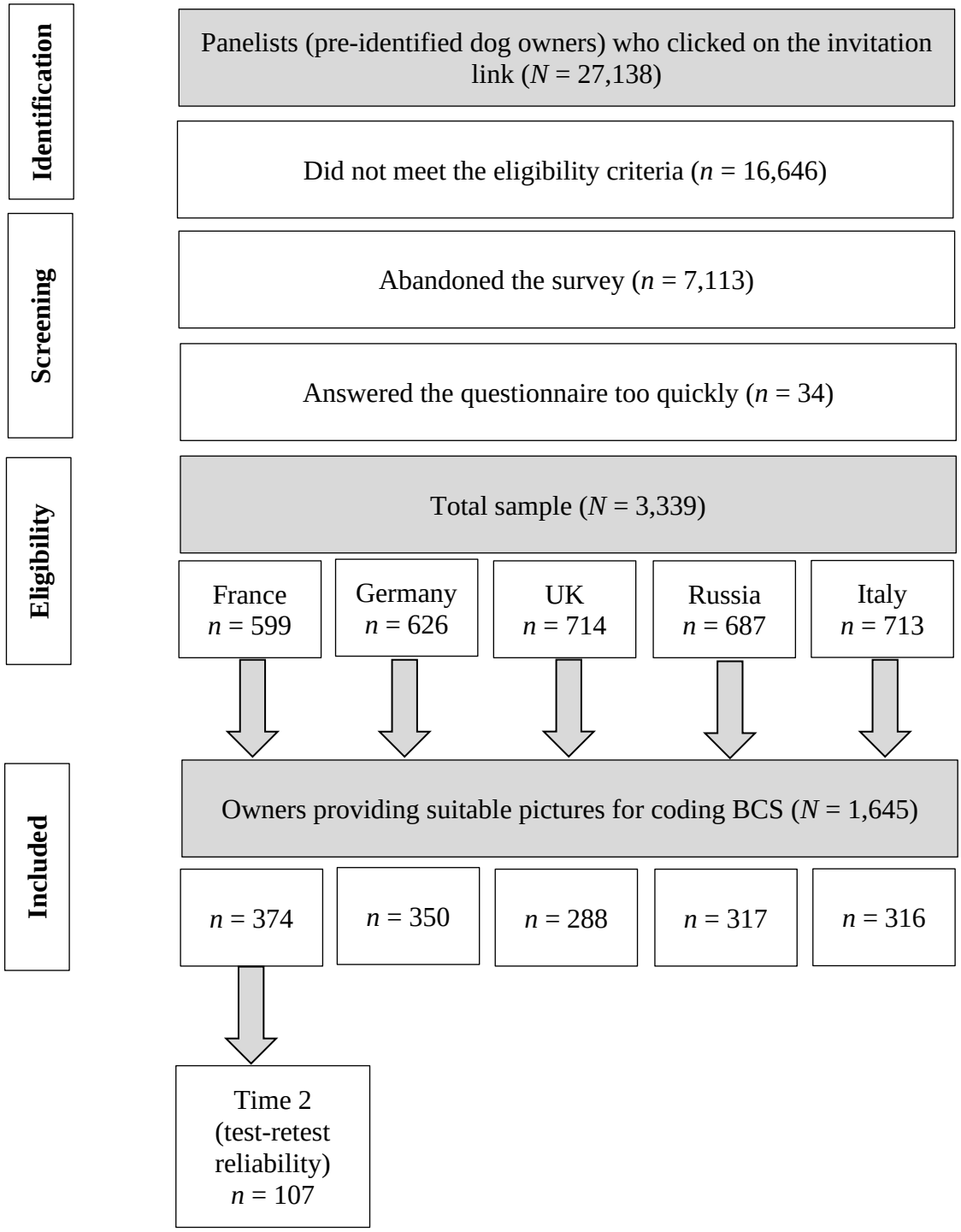

562 **Figure 3**

563 *Owner Versus Coder-Rated BCS (Phase 2)*

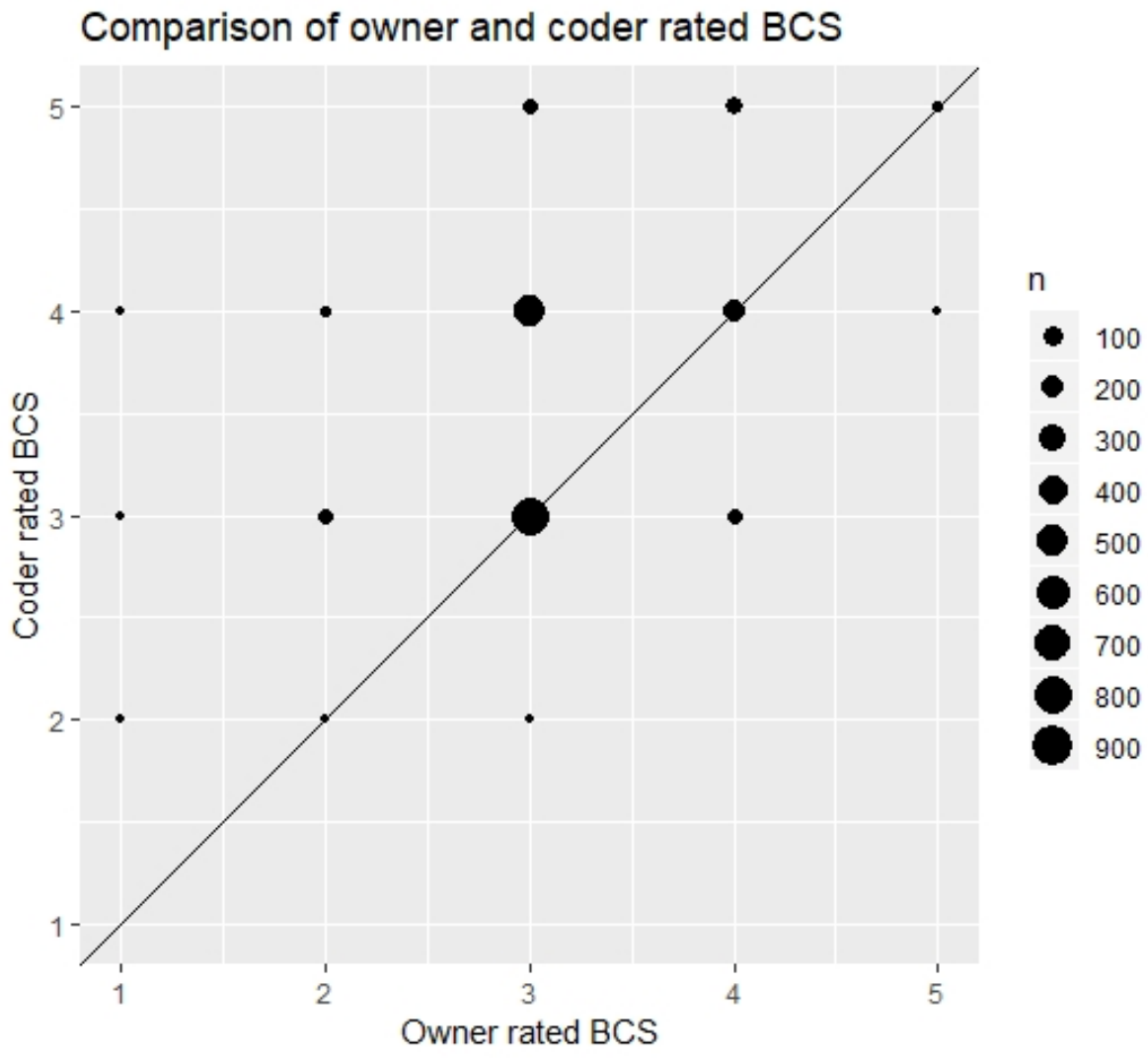

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Table 1

Descriptive Statistics and Correlations between the Measures of BCS (Phase 1)

	Mean (*SD*)	Owner-rated	Vet-rated	Coder-rated
Owner-rated	3.47 (0.55)	1.00		
Vet-rated	3.60 (0.54)	.58***	1.00	
Coder-rated	3.51 (0.51)	.57***	.67***	1.00

Note. *** $p < .001$

Table 2

Descriptive Statistics, Internal Reliability (Alpha) and Test-Retest Reliability (ICC) of Measures in Phase 2

Factor	*M* (or median)	*SD*	Alpha	ICC
Dog and owner characteristics				
Age of owner	43.65	11.75	Single item	n/a
Gender of owner	Female		Single item	n/a
Age of dog	5.89	3.41	Single item	n/a
Gender of dog	Male		Single item	n/a
Breed (not prone vs. prone)	No		Single item	n/a
Size of dog (height)	Reaches knee		Single item	n/a
Neutered status	No		Single item	n/a
Coder-rated BCS	3.54	0.62	kappa = 0.62	n/a
Owner-rated BCS	3.14	0.53	Single item	0.88
Beliefs about obesity / overweight				
Knowledge of dog's weight	Yes		Single item	0.55
Stage of change: Precontemplation	2.36	1.17	Single item	0.65
Stage of change: Contemplation	3.32	1.18	Single item	0.59
Stage of change: Preparation	3.60	1.06	Single item	0.61
Stage of change: Action	3.80	0.99	Single item	0.55
Stage of change: Maintenance	3.50	1.25	Single item	0.65
Threat appraisal: Severity	4.50	0.64	0.73	0.62
Threat appraisal: Vulnerability	2.60	1.08	0.77	0.86
Coping appraisal: Response efficacy	4.46	0.61	0.74	0.66
Coping appraisal: Self-efficacy	4.16	0.70	0.67	0.62
Self-monitoring (of outcomes)	4.12	0.86	Single item	0.61
Weight status	4.16	0.79	0.67	0.88
Dog-owner bond				
Time spent with dog	3.40	1.39	Single item	0.65
Play games with dog	4.70	0.70	Single item	0.41
Take dog to visit people	2.85	1.31	Single item	0.56
Perceived emotional closeness	4.40	0.67	0.68	0.86
Perceived costs	1.94	0.95	0.56	0.84
Feeding				
What kind of food do you typically buy?	Kibble		n/a	Categorical
How many times a day do you feed your dog	1.96	0.73	n/a	0.90
How much do you feed your dog each day? (cups)	1.5 to 2		n/a	Categorical
Knowledge	3.96	0.83	0.55	0.59
Importance of appropriate feeding	4.37	0.64	0.66	0.71
Behavioural beliefs - feed to please	2.69	0.96	0.48	0.67
Normative beliefs	1.88	0.93	0.88	0.80
PBC / self-efficacy	4.05	0.83	0.83	0.75
Intention	4.09	0.87	0.76	0.61

Food monitoring	3.55	0.95	0.64	0.70
Action planning	4.01	0.92	0.78	0.58
Coping planning	3.02	0.99	0.58	0.68
Goal operating (restrictions on human food)	2.73	1.13	0.75	0.68
Responsiveness to food	3.30	0.96	0.64	0.73
Fussiness	3.21	1.06	0.54	0.65
Interest in food	3.47	0.94	0.59	0.72
Barriers	1.87	0.81	0.86	0.74
Beliefs about treats	3.38	0.74	0.71	0.79
Knowledge about treats	3.73	0.96	n/a	0.51
Follow treat guidelines	3.48	1.09	n/a	0.69
Exercise				
Knowledge	3.51	1.09	0.80	0.66
Behavioural beliefs: Value of exercise	4.19	0.81	0.61	0.45
Behavioural beliefs: Dog centred	3.94	0.71	0.74	0.73
Outcome expectations (owner)	4.26	0.71	0.74	0.70
Outcome expectations (dog)	4.39	0.65	0.72	0.72
Normative beliefs	2.21	1.01	0.83	0.77
PBC / self-efficacy	3.78	0.96	0.85	0.79
Intentions	3.93	1.03	0.87	0.78
Goal monitoring	2.80	1.14	0.79	0.64
Action planning	3.34	1.09	0.82	0.67
Coping planning	3.13	1.11	Single item	0.39
Behaviour	3.61	0.95	0.62	0.79
Barriers	1.97	0.79	0.91	0.73
Facilitators	3.95	1.00	0.78	0.65
Social support (dog)	3.92	0.90	0.73	0.79
Social support (family)	3.17	1.00	0.51	0.71
Social support (friends)	2.52	1.00	0.53	0.59

Note. Alpha = Cronbach's alpha. ICC = Intraclass Correlation Co-efficient between the two administrations of the questionnaire (i.e., test-retest reliability). Values between 0.40 and 0.60 indicate moderate agreement, 0.61 to 0.80 indicates good agreement, values >.80 indicate excellent agreement (see Landis & Koch, 1977).

Table 3

Factors Correlated with (Coder-rated) BCS (p < .10), Phase 2

Factor	*r*
Dog and owner characteristics	
Age of owner	0.06
Age of dog	-0.06
Gender of dog	-0.08
Size of dog (height)	0.22
Breed (not prone vs. prone)	0.12
Neutered status	0.14
Beliefs about obesity / overweight	
Knowledge of dog's weight	-0.06
Stage of change: Precontemplation	-0.11
Stage of change: Contemplation	0.10
Stage of change: Action	-0.05
Stage of change: Maintenance	0.06
Threat vulnerability	0.35
Coping self-efficacy	-0.14
Self-monitoring weight	-0.05
Thoughts / feelings about dog's weight	-0.33
Dog-owner bond	
Play games with dog	-0.04
Take dog to visit people	-0.05
Perceived costs	-0.07
Feeding	
Knowledge (feeding)	-0.12
Knowledge (treats)	-0.10
Restrictions on human food	0.09
Interest in food	0.09
Importance of appropriate feeding	-0.04
Normative beliefs	0.26
PBC / self-efficacy	-0.08
Coping planning	0.07
Barriers	0.20
Exercise	
Knowledge	-0.06
Exercise behaviour	-0.12
Monitoring activity levels	-0.04
Normative beliefs	0.12
PBC / self-efficacy	-0.07
Intentions	-0.05
Barriers	0.04
Facilitators	-0.10
Social support (dog)	-0.06
Social support (friends)	-0.06

Table 4

Hierarchical Regressions of (vet-rated) BCS on Factors Reflecting (i) Beliefs about Outcomes (Regression 1), Human-Animal Bond (Regression 2), Feeding (Regression 3), and Exercise (Regression 4), Controlling for Demographics

	Step 1	Step 2
Age of owner	0.03	
Gender of owner	-0.01	
Size of dog	-0.03	
Gender of dog	-0.05*	
Age of dog	0.20***	
Neutered status	0.10***	
F	23.02***	
R^2	0.07	
Regression 1: Beliefs about outcomes		
Knowledge of dog's weight		-0.04
Stage of change: Precontemplation		-0.07*
Stage of change: Contemplation		-0.03
Stage of change: Action		-0.06*
Stage of change: Maintenance		0.02
Threat vulnerability		0.24***
Self-efficacy		0.03
Self-monitoring		0.01
Weight status		-0.16***
F change		26.47***
R^2 change		0.12
Regression 2: Human-animal bond		
Play games		0.00
Visit people		-0.04
Perceived costs		-0.06*
F change		2.51†
R^2 change		0.00
Regression 3: Feeding		
Knowledge (feeding)		-0.03
Knowledge (treats)		-0.03
Restrictions on human food		0.01

Importance of appropriate feeding	0.01
PBC / self-efficacy	0.03
Coping planning	0.06*
Barriers	0.17***
F change	9.84***
R^2 change	0.04

Regression 4: Exercise

Knowledge	-0.01
Behaviour	-0.05
Monitoring	0.06*
PBC / self-efficacy	-0.07
Intention	0.07
Barriers	0.00
Facilitators	-0.02
Social support (dog)	-0.00
Social support (friends)	-0.03
F change	2.29***
R^2 change	0.01

Note. Values alongside factor names represent beta values. *F* and R^2 change refer to additional variance explained by inclusion of predictors in Step 2, over and above those included in Step 1.

Table 5

Regression of (vet-rated) BCS on Factors that were Significant Predictors of BCS in the Within-Domain Models, Controlling for (Significant) Demographics

	Step 1	Step 2
Gender of dog	-0.06**	-0.02
Age of dog	0.20***	0.14***
Neutered status	0.10***	0.05*
Threat vulnerability	-	0.20***
Weight status	-	-0.12***
Perceived costs	-	-0.10***
Normative beliefs (feeding)	-	0.10**
Social support (friends)	-	-0.07**
Stage: Precontemplation	-	-0.06*
Stage of change: Action	-	-0.05
Normative beliefs (exercise)	-	-0.00
F	37.50***	35.88***
Adj. R^2	0.06	0.19
F change		33.07***
R^2 change		0.13

Note. Values alongside factor names represent beta values. *F* and R^2 change refer to additional variance explained by inclusion of predictors in Step 2, over and above those included in Step 1.

Supplementary Material 1

Theoretical Frameworks and Associated Factors and Measures (Phase 1). Measures in italics represent the additional questions comprising the complete measure against which the briefer measures of each factor were validated. The final column shows the correlation between the brief and complete measures, where relevant.

Theoretical framework	Factor	Measure	Response scale	*r*
	Age of participant	In what year were you born?	Open	-
	Gender of participant	What is your gender?	Male / Female / Prefer not to say	-
	Age of dog	How old is your dog?	Open	-
	Gender of dog	Is your dog male or female?	Male / Female	-
	Breed of dog	What breed is your dog?	Drop down menu including 'Other' category	-
	Size of dog	How tall is your dog?	He/she reaches my ankle (1), knee (2), thigh (3), hip (4), tummy (5)	-
	Neutered status	Is your dog neutered	Yes / No	-
	Knowledge of dog's weight	Do you know how much your dog weighs?	Yes / No	-
	Weight of dog	If so, please specify (in kgs)	Open	-
	Owner-rated BCS	Choose the most appropriate illustration that corresponds to your dog	5 pictures	-
Transtheoretical Model	Stage of change: Precontemplation	I do not think about my dog's weight	5 point: Strongly disagree to Strongly agree	-

Transtheoretical Model	Stage of change: Contemplation	I'm seriously intending to take action in the next 6 months to ensure that my dog is a healthy weight	5 point: Strongly disagree to Strongly agree	-
Transtheoretical Model	Stage of change: Preparation	I have definite plans to take action to ensure that my dog is a healthy weight	5 point: Strongly disagree to Strongly agree	-
Transtheoretical Model	Stage of change: Action	I am doing something now to ensure that my dog is a healthy weight *I am careful to regulate the exercise that my dog gets in order to keep him / her slim (RECODED)* *I alter the food that my dog gets in order to control his / her weight (RECODED)* *I am careful about my dog's weight (RECODED)*	5 point: Strongly disagree to Strongly agree	0.73
Transtheoretical Model	Stage of change: Maintenance	I took action more than 6 months ago to ensure that my dog is a healthy weight and I'm working hard to maintain this change	5 point: Strongly disagree to Strongly agree	-
Protection Motivation Theory	Threat appraisal - severity	Overweight and obesity cause severe problems in dogs The health risks associated with overweight and obesity in dogs are severe	5 point: Strongly disagree to Strongly agree	-
Protection Motivation Theory	Threat appraisal - vulnerability	The chances are high that my dog is, or will become, overweight My dog easily puts on weight	5 point: Strongly disagree to Strongly agree	-
Protection Motivation Theory	Coping appraisal - response efficacy	Ensuring my dog is the correct weight will help to reduce health problems Ensuring my dog is the correct weight will mean that they have a long and healthy life	5 point: Strongly disagree to Strongly agree	-
Protection Motivation Theory	Coping appraisal - self-efficacy	I am capable of keeping my dog at a healthy weight I am capable of helping my dog to lose weight if needed	5 point: Strongly disagree to Strongly agree	-

Control Theory	Monitoring (outcomes)	I pay attention to my dog's weight	5 point: Strongly disagree to Strongly agree	-
Control Theory	Weight status	I am happy with my dog's weight My dog is very fit *I think my dog could do with losing some weight (RECODED)*	5 point: Strongly disagree to Strongly agree	0.95
	Time spent with dog	How long do you spend with your dog each day?	< 2 hours / 2-4 hours / 4-6 hours / 6-8 hours / > 8 hours	-
	Dog owner interaction	How often do you play games with your dog? How often do you take your dog to visit people? *How often do you give your dog food treats?* *How often do you kiss your dog?* *How often do you take your dog in the car?* *How often do you hug your dog?* *How often do you buy your dog presents?* *How often do you have your dog with you while relaxing, i.e., watching TV?* *How often do you groom your dog?*	At least once a day / Once every few days / Once a week / Once a month / Never	0.79
	Perceived emotional closeness	My dog helps me get through tough times. My dog provides me with constant companionship. *My dog is there whenever I need to be comforted.* *I would like to have my dog near me all the time.* *If everyone else left me my dog would still be there for me.* *My dog gives me a reason to get up in the morning.* *I wish my dog and I never had to be apart.*	5 point: Strongly disagree to Strongly agree	0.75

	My dog is constantly attentive to me.		
	How often do you tell your dog things you don't tell anyone else?	At least once a day / Once every few days / Once a week / Once a month / Never	
	How traumatic do you think it will be for you when your dog dies?	Very large trauma / Great trauma / Average trauma / Slight trauma	
Perceived costs	How often do you feel that looking after your dog is a chore?	At least once a day / Once every few days / Once a week / Once a month / Never	0.79
	It is annoying that I sometimes have to change my plans because of my dog.	5 point: Strongly disagree to Strongly agree	
	It bothers me that my dog stops me doing things I enjoyed doing before I owned it.		
	There are major aspects of owning a dog that I don't like.		
	How often does your dog stop you doing things you want to?		
	My dog makes too much mess.		
	My dog costs too much money.		
	I find it hard to look after my dog		
	How often do you feel that having a dog is more trouble than it is worth?	At least once a day / Once every few days / Once a week / Once a month / Never	

	Behaviour (feeding)	What kind of food do you typically buy for your dog? How many times a day do you feed your dog (include main meals only, not snacks and treats) How much do you feed your dog each day?	Raw food / Kibble / Mix of kibble and wet food Open Less than ½ cup a day / ½ to 1 cup a day / 1 cup a day / 1 to 1 ½ cups a day / 1 ½ to 2 cups a day / 2 to 2 ½ cups a day / 2 ½ to 3 cups a day / 3 to 3 ½ cups a day / 3 ½ to 4 cups a day / 4 to 4 ½ cups a day / 4 ½ to 5 cups a day / Over 5 cups a day / Food is always available	-
	Knowledge (feeding)	I don't know how much to feed my dog. (RECODED) *I don't know what type of food to feed my dog. (RECODED)* *I don't know how many times a day I should feed my dog. (RECODED)* I feel I have enough nutritional knowledge/information about the food I feed to my dog	5 point: Strongly disagree to Strongly agree	0.92
Theory of Planned Behaviour	Behavioural beliefs - importance of appropriate feeding	It's important that I feed my dog the appropriate type of food. It's important that I feed my dog the appropriate amount of food.	5 point: Strongly disagree to Strongly agree	0.77

		It is important that I feed my dog the appropriate number of times a day		
Theory of Planned Behaviour	Behavioural beliefs - feed to please	It's important that I feed my dog whatever they like It's important that I feed my dog as much as they want. *It is important that I feed my dog whenever he/she likes.*	5 point: Strongly disagree to Strongly agree	0.93
Theory of Planned Behaviour	Normative beliefs (feeding)	People who are important to me believe that I feed my dog too much. *My vet believes that I feed my dog too much.* *Other dog owners believe that I feed my dog too much.* *My vet believes that I don't feed my dog the appropriate type of food.* *My vet believes that I should feed more frequent meals during the day.* *Other dog owners believe that I should feed more frequent meals during the day.* *Other dog owners believe that I don't feed my dog the appropriate type of food.*	5 point: Strongly disagree to Strongly agree	0.81
Theory of Planned Behaviour	PBC / self-efficacy (feeding)	Overall, how much control do you feel you have over the amount that you feed your dog? (RECODED) Overall, how much control do you feel you have over the type of food you feed your dog? (RECODED) *Overall, how much control do you feel you have over the number of times you feed your dog? (RECODED)*	100 point slider: No control to Complete control	0.93
Theory of Planned Behaviour	Intention (feeding)	I intend to feed my dog the appropriate amount over the next month. I intend to feed my dog the appropriate type of food in the next month. *I intend to feed my dog the appropriate number of times a week in the next month.* *How likely is it that you will feed your dog the appropriate type of food in the next month? (RECODED)*	5 point: Strongly disagree to Strongly agree	0.74

		How likely is it that you will feed your dog the appropriate amount of food in the next month? (RECODED)		
Control Theory	Monitoring (feeding)	I keep track of how much food I give to my dog each day. I count the number of treats that my dog receives each day. I weigh or measure how much food I give my dog.	5 point: Strongly disagree to Strongly agree	-
HAPA / Model of Action Phases	Action planning (feeding)	I have planned when I will feed my dog. I have planned what I will feed my dog.	5 point: Strongly disagree to Strongly agree	-
HAPA / Model of Action Phases	Coping planning (feeding)	I have planned how to stop my dog getting leftovers. I have planned how to reduce the temptation to give my dog treats.	5 point: Strongly disagree to Strongly agree	-
Control Theory	Goal operating (restrictions on human food)	My dog gets bits of human food when we are eating. My dog often gets human food. *My dog gets no food at human mealtimes. (RECODED)* *My dog gets human leftovers in his / her food bowl.*	5 point: Strongly disagree to Strongly agree	0.83
	Responsiveness to food	My dog gets excited when there is food around. My dog will turn down food if they are not hungry. (RECODED) My dog finishes a meal straight away. *After a meal my dog is still interested in eating.* *My dog takes his / her time to eat a meal. (RECODED)* *My dog seems to be hungry all the time.* *My dog is very greedy.*	5 point: Strongly disagree to Strongly agree	0.94
	Fussiness	My dog inspects unfamiliar foods before deciding whether to eat them. *My dog is choosy about which titbits he eats.* My dog would eat anything. (RECODED)	5 point: Strongly disagree to Strongly agree	0.94

	Interest in food	My dog hangs around for titbits even if there is not much chance of getting them. My dog hangs around when I am preparing or eating human food.	5 point: Strongly disagree to Strongly agree	-
	Barriers (feeding)	What factor do you consider to be the biggest challenge to correctly feeding your dog? *My dog is overfed because they always want food.* *My dog isn't given the appropriate type of food because others feed them.* *I feed my dog inappropriate types of food because they like these kinds of food.* *My dog isn't fed the appropriate number of times per day because others feed him / her.* *I feed my dog inappropriate food because I like to spoil them.* *My dog is overfed because I indulge them.* *I feed my dog inappropriate food because the other food is too expensive.*	Open 5 point: Strongly disagree to Strongly agree	-
Theory of Planned Behaviour	Beliefs about treats	Feeding treats is an important way for me to show love and affection towards my dog. I feed treats as it makes my dog happy. I believe that treats are an essential part of my dog's diet. I believe that treats are appropriate positive reinforcement for desired behaviour. Treats (and titbits) are much more interesting for my dog to eat than normal dog food. I feel I have enough nutritional knowledge/information about the treats I feed to my dog. I regularly follow treat-feeding guidelines (where available) on packets etc.	5 point: Strongly disagree to Strongly agree	
	Knowledge (exercise)	I don't know how often I should exercise my dog		0.95

		I don't know the appropriate length of time my dog should be exercised. *I don't know what type of exercise to give my dog.*	5 point: Strongly disagree to Strongly agree	
Theory of Planned Behaviour	Behavioural beliefs - value of exercise	It is important that I exercise my dog the appropriate amount. My dog doesn't need exercise. (RECODED) *It is important that I exercise my dog the appropriate number of times a week.* *It is important that I give my dog the appropriate type of exercise.* *It is important to me that my dog is fit.* *It's important that I exercise my dog for the appropriate length of time.* *It is important that I exercise my dog the appropriate number of times a week.*	5 point: Strongly disagree to Strongly agree	0.88
Theory of Planned Behaviour	Behavioural beliefs - dog centred	It's important that I exercise my dog as frequently as they like. It's important that I exercise my dog for as long as they like. It's important that I give my dog the type of exercise that they like.	5 point: Strongly disagree to Strongly agree	-
Theory of Planned Behaviour	Outcome expectations (owner)	Exercising with my dog will improve my health. Exercising with my dog will improve my mood. *Exercising with my dog will provide me with companionship.* *I will enjoy exercising with my dog.* *Exercising with my dog will give me a sense of accomplishment.* *Exercising with my dog would help me to maintain or lose weight.* *Exercising with my dog would help me to do my own exercise.*	5 point: Strongly disagree to Strongly agree	0.87

		Exercising with my dog would stop me from feeling guilty. *Exercising with my dog would be enjoyable.* *Exercising with my dog would help me to relax.*		
Theory of Planned Behaviour	Outcome expectations (dog)	Exercising with my dog will improve the health of my dog. Exercising with my dog will make my dog happy. *Exercising with my dog(s) will make my dog behave better.*	5 point: Strongly disagree to Strongly agree	0.87
Theory of Planned Behaviour	Normative beliefs (exercise)	People who are important to me think that I should exercise my dog daily. *My vet believes that I don't exercise my dog for the appropriate length of time.* *Other dog owners believe that I don't exercise my dog for the appropriate length of time.* *My vet believes that I don't exercise my dog as frequently as I should.* *Other dog owners believe that I don't exercise my dog as frequently as I should.* *My vet believes that I don't give my dog the appropriate type of exercise.* *Other dog owners believe that I don't give my dog the appropriate type of exercise.*	5 point: Strongly disagree to Strongly agree	0.39
Theory of Planned Behaviour	PBC / self-efficacy (exercise)	Overall, how much control do you feel you have over how frequently you exercise your dog? (RECODED) Overall, how much control do you feel you have over the length of time you exercise your dog? (RECODED)	100 point slider: No control to Complete control	0.88
		I am confident that I could exercise my dog on most days of the week in the next month. (RECODED)	5 point: Strongly disagree to Strongly agree	
		Overall, how much control do you feel you have over the type of exercise that you give your dog? (RECODED)	100 point slider: No control to Complete control	

		Please rate how confident you are that you would consistently do the following activities if you really wanted to: *Get up early, even on weekends, to exercise your dog.* *Exercise the dog after a long, tiring day at work.* *Exercise the dog even though you are feeling depressed.* *Exercise the dog when undergoing a stressful life change (divorce, death in family, moving, new baby, health issues).* *Exercise the dog even in the dark.* *Exercise the dog when your family is asking for more time from you.* *Exercise the dog when you have household chores to do.* *Exercise the dog when social obligations are very time consuming.* *Exercise the dog when you have excessive demands at work.*	5 point: Not at all confident to Very confident	
Theory of Planned Behaviour	Intentions (exercise)	I intend to exercise my dog daily (RECODED) I will exercise my dog daily (RECODED) *How likely is it in the future that you will exercise your dog for the number of times per week? (RECODED)* *How likely is it in the future that you will provide your dog with the appropriate type of exercise? (RECODED)* *How likely is it in the future that you will exercise your dog for the appropriate length of time? (RECODED)*	5 point: Strongly disagree to Strongly agree	0.95
Control Theory	Goal monitoring (exercise)	I keep track of the amount of time that my dog is active each day. I keep track of the amount of time that my dog sleeps each day.	5 point: Strongly disagree to Strongly agree	-
HAPA / Model of Action Phases	Action planning (exercise)	I have planned when I will exercise my dog. I have planned how I will exercise my dog.	5 point: Strongly disagree to Strongly agree	-

HAPA / Model of Action Phases	Coping planning (exercise)	I have planned how to overcome things that make it difficult to exercise my dog.	5 point: Strongly disagree to Strongly agree	-
	Behaviour (exercise)	My dog runs around a lot. My dog gets a lot of exercise. My dog's walks are mostly on the lead. (RECODED) *My dog's walks involve a lot of energetic play or chasing.* *My dog spends most of his/ her walks off the lead.*	5 point: Strongly disagree to Strongly agree	0.92
	Barriers (exercise)	What factor do you consider to be the biggest barrier to exercising your dog adequately? *I don't exercise my dog frequently enough because I don't like to.* *I don't exercise my dog for long enough because I don't like to.* *I don't give my dog the appropriate type of exercise because I don't like to.* *I don't give my dog the appropriate kind of exercise because he / she doesn't like that type.* *I don't exercise my dog as frequently as I should because he / she is badly behaved.* *I don't exercise my dog as frequently as I should because I don't have time.* *I don't give my dog the appropriate type of exercise because I don't have access to the appropriate areas.* *My dog isn't exercised frequently enough because others exercise the dog.* *My dog isn't given the appropriate type of exercise because others exercise the dog.* *My dog isn't exercised long enough because others exercise the dog.*	Open 5 point: Strongly disagree to Strongly agree	-

	Which of the following factors discourage you from exercising with your dog? *The shorter days in winter.* *The weather (e.g., too cold, too hot, raining)* *My long working hours.* *My family commitments.* *The unavailability of dog-poo bags.* *The lack of bins available for dog poo.* *Dog owners not picking up after their dogs.* *The poor health or age of my dog.* *The difficulty of walking with 2 dogs (as opposed to 1).* *My fear of other people's dogs.* *Not having places to walk to (e.g., parks, shops).* *My dog would be unfriendly or difficult to control.* *Seeing other people out walking their dogs.* *Small dog.* *It is difficult for me to walk.* *My dog isn't reliable at coming back if let off the lead.*	Tick all that apply	
Facilitators (exercise)	My dog loves exercise. My dog isn't very interested in exercise. (RECODED) My dog pesters me to go out. *Which of the following factors encourage you to exercise with your dog?* *The fact that I feel safe when walking with my dog.* *My enjoyment of the outdoors.* *Knowing my dog enjoys going for a walk.* *Concern that my backyard / garden is too small.*	5 point: Strongly disagree to Strongly agree Tick all that apply	-

	Social support (dog)	Having my dog makes me exercise more. My dog encourages me to exercise. *My dog supports me to exercise*	5 point: Strongly disagree to Strongly agree	0.96
	Social support (family)	My family exercise the dog with me. Family encourage me to exercise the dog. *My family change their schedule to exercise the dog with me.* *My family plans activities with me that include dog walking.*	5 point: Strongly disagree to Strongly agree	0.90
	Social support (friends)	Friends exercise the dog with me. Friends encourage me to exercise the dog. *My friends change their schedule to exercise the dog with me.* *My friends plan activities with me that include dog walking.*	5 point: Strongly disagree to Strongly agree	0.89

Note. BCS = Body Condition Score, HAPA = Health Action Process Approach

Supplementary Material 2

Theoretical Frameworks and Associated Factors and Measures (Phase 2).

Theoretical framework	Factor	Measure	Response scale
	Age of participant	In what year were you born?	Open
	Gender of participant	What is your gender?	Male / Female / Prefer not to say
	Age of dog	How old is your dog?	Open
	Gender of dog	Is your dog male or female?	Male / Female
	Breed of dog	What breed is your dog?	Drop down menu including 'Other' category
	Size of dog	How tall is your dog?	He/she reaches my ankle (1), knee (2), thigh (3), hip (4), tummy (5)
	Neutered status	Is your dog neutered	Yes / No
	Knowledge of dog's weight	Do you know how much your dog weighs?	Yes / No
	Weight of dog	If so, please specify (in kgs)	Open
	Owner-rated BCS	Choose the most appropriate illustration that corresponds to your dog	5 pictures
Transtheoretical Model	Stage of change: Precontemplation	I do not think about my dog's weight	5 point: Strongly disagree to Strongly agree
Transtheoretical Model	Stage of change: Contemplation	I'm seriously intending to take action in the next 6 months to ensure that my dog is a healthy weight	5 point: Strongly disagree to Strongly agree

Transtheoretical Model	Stage of change: Preparation	I have definite plans to take action to ensure that my dog is a healthy weight	5 point: Strongly disagree to Strongly agree
Transtheoretical Model	Stage of change: Action	I am doing something now to ensure that my dog is a healthy weight	5 point: Strongly disagree to Strongly agree
Transtheoretical Model	Stage of change: Maintenance	I took action more than 6 months ago to ensure that my dog is a healthy weight and I'm working hard to maintain this change	5 point: Strongly disagree to Strongly agree
Protection Motivation Theory	Threat appraisal - severity	Overweight and obesity cause severe problems in dogs The health risks associated with overweight and obesity in dogs are severe	5 point: Strongly disagree to Strongly agree
Protection Motivation Theory	Threat appraisal - vulnerability	The chances are high that my dog is, or will become, overweight My dog easily puts on weight	5 point: Strongly disagree to Strongly agree
Protection Motivation Theory	Coping appraisal - response efficacy	Ensuring my dog is the correct weight will help to reduce health problems Ensuring my dog is the correct weight will mean that they have a long and healthy life	5 point: Strongly disagree to Strongly agree
Protection Motivation Theory	Coping appraisal - self-efficacy	I am capable of keeping my dog at a healthy weight I am capable of helping my dog to lose weight if needed	5 point: Strongly disagree to Strongly agree
Control Theory	Self-monitoring (of outcomes)	I pay attention to my dog's weight	5 point: Strongly disagree to Strongly agree
Control Theory	Weight status	I am happy with my dog's weight My dog is very fit	5 point: Strongly disagree to Strongly agree
	Time spent with dog	How long do you spend with your dog each day?	< 2 hours / 2-4 hours / 4-6 hours / 6-8 hours / > 8 hours

	Play games with dog	How often do you play games with your dog?	At least once a day / Once every few days / Once a week / Once a month / Never
	Take dog to visit people	How often do you take your dog to visit people?	At least once a day / Once every few days / Once a week / Once a month / Never
	Perceived emotional closeness	My dog helps me get through tough times. My dog provides me with constant companionship.	5 point: Strongly disagree to Strongly agree
	Perceived costs	How often do you feel that looking after your dog is a chore?	At least once a day / Once every few days / Once a week / Once a month / Never
		It is annoying that I sometimes have to change my plans because of my dog.	5 point: Strongly disagree to Strongly agree
	Behaviour (feeding)	What kind of food do you typically buy?	Raw food / Kibble / Mix of kibble and wet food
		How many times a day do you feed your dog	Open
		How much do you feed your dog each day? (cups)	Less than ½ cup a day / ½ to 1 cup a day / 1 cup a day / 1 to 1 ½ cups a day / 1 ½ to 2 cups a day / 2 to 2 ½ cups a day / 2 ½ to 3 cups a day / 3 to 3 ½ cups a day / 3 ½ to 4 cups a day / 4 to 4 ½ cups a day / 4

			½ to 5 cups a day / Over 5 cups a day / Food is always available
	Knowledge (feeding)	I don't know how much to feed my dog I feel I have enough nutritional knowledge/information about the food I feed to my dog	5 point: Strongly disagree to Strongly agree
Theory of Planned Behaviour	Importance of appropriate feeding	It's important that I feed my dog the appropriate type of food. It's important that I feed my dog the appropriate amount of food.	5 point: Strongly disagree to Strongly agree
Theory of Planned Behaviour	Behavioural beliefs - feed to please	It's important that I feed my dog whatever they like It's important that I feed my dog as much as they want	5 point: Strongly disagree to Strongly agree
Theory of Planned Behaviour	Normative beliefs (feeding)	People who are important to me believe that I feed my dog too much. My vet believes that I feed my dog too much. Other dog owners believe that I feed my dog too much.	5 point: Strongly disagree to Strongly agree
Theory of Planned Behaviour	PBC / self-efficacy (feeding)	Overall, how much control do you feel you have over the amount that you feed your dog? Overall, how much control do you feel you have over the type of food you feed your dog?	5 point: No control to Complete control
Theory of Planned Behaviour	Intention (feeding)	I intend to feed my dog the appropriate amount over the next month I intend to feed my dog the appropriate type of food in the next month	5 point: Strongly disagree to Strongly agree
Control Theory	Monitoring (feeding)	I keep track of how much food I give to my dog each day I count the number of treats that my dog receives each day I weigh or measure how much food I give my dog	5 point: Strongly disagree to Strongly agree
HAPA / Model of Action Phases	Action planning (feeding)	I have planned when I will feed my dog I have planned what I will feed my dog I have planned how to stop my dog getting leftovers	5 point: Strongly disagree to Strongly agree

HAPA / Model of Action Phases	Coping planning (feeding)	I have planned how to reduce the temptation to give my dog treats	5 point: Strongly disagree to Strongly agree
Control Theory	Goal operating (restrictions on human food)	My dog gets bits of human food when we are eating My dog often gets human food	5 point: Strongly disagree to Strongly agree
	Responsiveness to food	My dog gets excited when there is food around My dog will turn down food if they are not hungry (RECODED) My dog finishes a meal straight away	5 point: Strongly disagree to Strongly agree
	Fussiness	My dog inspects unfamiliar foods before deciding whether to eat them My dog would eat anything (RECODED)	5 point: Strongly disagree to Strongly agree
	Interest in food	My dog hangs around for titbits even if there is not much chance of getting them My dog hangs around when I am preparing or eating human food My dog eats titbits straightaway	5 point: Strongly disagree to Strongly agree
	Barriers (feeding)	My dog is overfed because they always want food. My dog isn't given the appropriate type of food because others feed them I feed my dog inappropriate types of food because they like these kinds of food. My dog isn't fed the appropriate number of times per day because others feed him / her. I feed my dog inappropriate food because I like to spoil them My dog is overfed because I indulge them	5 point: Strongly disagree to Strongly agree
Theory of Planned Behaviour	Beliefs about treats	Feeding treats is an important way for me to show love and affection towards my dog I feed treats as it makes my dog happy I believe that treats are an essential part of my dog's diet	5 point: Strongly disagree to Strongly agree

		I believe that treats are appropriate positive reinforcement for desired behaviour Treats (and titbits) are much more interesting for my dog to eat than normal dog food	
	Knowledge about treats	I feel that I have enough nutritional knowledge/information about the treats I feed to my dog	5 point: Strongly disagree to Strongly agree
	Follow treat guidelines	I regularly follow treat-feeding guidelines (where available) on packets etc.	5 point: Strongly disagree to Strongly agree
	Knowledge (exercise)	I don't know how often I should exercise my dog (RECODED) I don't know the appropriate length of time my dog should be exercised (RECODED)	5 point: Strongly disagree to Strongly agree
Theory of Planned Behaviour	Behavioural beliefs – value of exercise	It is important that I exercise my dog the appropriate amount. My dog doesn't need exercise. (RECODED)	5 point: Strongly disagree to Strongly agree
Theory of Planned Behaviour	Behavioural beliefs – dog centred	It's important that I exercise my dog as frequently as they like It's important that I exercise my dog for as long as they like It's important that I give my dog the type of exercise that they like	5 point: Strongly disagree to Strongly agree
Theory of Planned Behaviour	Outcome expectations (owner)	Exercising with my dog will improve my health. Exercising with my dog will improve my mood.	5 point: Strongly disagree to Strongly agree
Theory of Planned Behaviour	Outcome expectations (dog)	Exercising with my dog will improve the health of my dog. Exercising with my dog will make my dog happy.	5 point: Strongly disagree to Strongly agree
Theory of Planned Behaviour	Normative beliefs (exercise)	People who are important to me think that I should exercise my dog more frequently My vet thinks that I should exercise my dog more frequently Other dog owners think that I should exercise my dog more frequently	5 point: Strongly disagree to Strongly agree

Theory of Planned Behaviour	PBC / self-efficacy (exercise)	Overall, how much control do you feel you have over how frequently you exercise your dog? Overall, how much control do you feel you have over the length of time you exercise your dog?	5 point: No control to Complete control
		I am confident that I could exercise my dog on most days of the week in the next month	5 point: Strongly disagree to Strongly agree
Theory of Planned Behaviour	Intentions (exercise)	I intend to exercise my dog daily I will exercise my dog daily	5 point: Strongly disagree to Strongly agree
Control Theory	Monitoring (exercise)	I keep track of the amount of time that my dog is active each day I keep track of the amount of time that my dog sleeps each day	5 point: Strongly disagree to Strongly agree
HAPA / Model of Action Phases	Action planning (exercise)	I have planned when I will exercise my dog I have planned how I will exercise my dog	5 point: Strongly disagree to Strongly agree
HAPA / Model of Action Phases	Coping planning (exercise)	I have planned how to overcome things that make it difficult to exercise my dog	5 point: Strongly disagree to Strongly agree
	Behaviour (exercise)	My dog runs around a lot My dog gets a lot of exercise My dog's walks are mostly on the lead (RECODED)	5 point: Strongly disagree to Strongly agree
	Barriers (exercise)	I don't exercise my dog frequently enough because I don't like to. I don't exercise my dog for long enough because I don't like to. I don't give my dog the appropriate type of exercise because I don't like to. I don't give my dog the appropriate kind of exercise because he / she doesn't like that type. I don't exercise my dog as frequently as I should because he / she is badly behaved.	5 point: Strongly disagree to Strongly agree

		I don’t exercise my dog as frequently as I should because I don’t have time. I don’t give my dog the appropriate type of exercise because I don’t have access to the appropriate areas. My dog isn’t exercised frequently enough because others exercise the dog. My dog isn’t given the appropriate type of exercise because others exercise the dog. My dog isn’t exercised long enough because others exercise the dog.	
	Facilitators (exercise)	My dog loves exercise My dog isn't very interested in exercise (RECODED)	5 point: Strongly disagree to Strongly agree
	Social support (dog)	Having my dog makes me exercise more My dog encourages me to exercise	5 point: Strongly disagree to Strongly agree
	Social support (family)	My family exercise my dog with me Family encourage me to exercise my dog	5 point: Strongly disagree to Strongly agree
	Social support (friends)	Friends exercise my dog with me Friends encourage me to exercise my dog	5 point: Strongly disagree to Strongly agree

Note. HAPA = Health Action Process Approach

Supplementary Material 3

Descriptive Statistics and Correlations with (Coder-rated) BCS for Measures in Phase 2 by Country

	UK			France			Germany			Italy			Russia		
Factor	*M*	*SD*	*r*	*M*	*SD*	*r*	*M*	*SD*	*r*	*M*	*SD*	*r*	*M*	*SD*	*r*
Dog and owner characteristics															
Age of participant	43.57	11.54	.05	47.26	9.94	.00	41.63	11.82	.13	43.05	10.00	-.03	43.06	14.16	.07
Gender of participant	Female		-.07	Female		-.05	Female		.01	Female		.01	Female		-.02
Age of dog	6.00	3.49	.23	6.85	3.54	.23	5.61	3.17	.18	5.96	3.34	.22	5.13	3.30	.26
Gender of dog	Male		-.02	Male		-.15	Male		.08	Male		-.15	Male		-.17
Breed (not prone vs. prone)	Not prone		-.08	Not prone		.24	Not prone		.04	Not prone		.18	Not prone		.16
Size of dog (height)	Knee		-.14	Knee		-.07	Knee		-.07	Knee		-.07	Knee		.00
Neutered status	Yes		.14	No		0.20	No		.07	No		.17	No		.13
Coder-rated BCS	3.66	0.64	1.00	3.52	0.60	1.00	3.44	0.57	1.00	3.53	0.61	1.00	3.58	0.66	1.00
Owner-rated BCS	3.16	0.58	.37	3.18	0.50	.38	3.08	0.46	.29	3.13	0.57	.52	3.14	0.50	.49
Beliefs about obesity / overweight															
Knowledge of dog's weight	Yes		.04	Yes		-.03	Yes		-.01	Yes		-.02	Yes		-.16
Stage of change: Precontemplation	2.33	1.20	-.13	2.36	1.04	-.19	2.83	1.32	-.06	2.18	1.21	-.08	2.44	1.05	-.03
Stage of change: Contemplation	3.41	1.17	.20	3.07	1.07	.20	3.49	1.29	-.06	3.57	1.17	.07	3.17	1.00	.20
Stage of change: Preparation	3.91	0.96	.01	3.17	0.98	-.09	3.76	1.12	-.07	3.59	1.12	-.03	3.62	0.87	-.06
Stage of change: Action	4.01	0.94	-.02	3.64	0.89	-.05	4.06	0.95	-.07	3.80	1.05	-.07	3.52	0.91	-.01
Stage of change: Maintenance	3.27	1.21	.18	2.94	1.17	.11	3.34	1.33	-.03	3.27	1.25	.06	3.16	1.08	.03

Threat appraisal: Severity	4.45	0.72	-.02	4.39	0.57	.07	4.47	0.69	-.07	4.44	0.75	-.06	4.37	0.66	-.06
Threat appraisal: Vulnerability	2.72	1.09	.32	2.66	1.02	.40	2.59	1.16	.20	2.64	1.13	.36	2.73	0.91	.48
Coping appraisal: Response efficacy	4.47	0.63	-.01	4.26	0.57	.11	4.54	0.61	-.04	4.39	0.77	-.03	4.36	0.59	-.02
Coping appraisal: Self-efficacy	4.32	0.70	-.12	3.93	0.61	.10	4.33	0.65	-.18	3.98	0.84	-.20	4.05	0.61	-.18
Self-monitoring (of outcomes)	4.23	0.82	.03	3.97	0.83	.02	4.31	0.79	-.09	4.15	0.91	-.09	3.82	0.86	-.08
Weight status	4.15	0.83	-.30	4.07	0.72	-.33	4.26	0.70	-.24	4.04	0.94	-.44	4.16	0.64	-.33
Dog-owner bond															
Time spent with dog	3.77	1.22	.07	2.93	1.31	.00	3.58	1.27	-.00	3.13	1.40	-.04	3.05	1.41	.02
Play games with dog	4.56	0.82	-.06	4.60	0.79	-.05	4.72	0.69	.01	4.71	0.60	-.06	4.75	0.60	-.03
Take dog to visit people	3.17	1.29	-.10	2.78	1.25	-.00	3.26	1.16	.00	3.41	1.26	-.03	2.16	1.17	-.05
Perceived emotional closeness	4.43	0.67	.11	4.39	0.64	.04	4.39	0.70	.03	4.40	0.75	-.03	4.15	0.68	.00
Perceived costs	2.01	1.08	-.14	1.83	0.82	-.09	1.87	0.94	-.02	2.41	1.12	-.13	1.99	0.87	.03
Feeding															
What kind of food?	Wet food			Kibble			Wet food			Wet food			Mix		
How many times a day do you feed	2.19	0.94	-.10	1.67	0.64	-.07	2.04	0.90	-.00	2.05	0.69	-.10	2.25	0.68	-.01
How much do you feed (cups)	2 to 2.5		.02	2 to 2.5		-.07	2 to 2.5		-.04	1.5 to 2		-.12	1.5 to 2		-.05
Knowledge	3.97	0.88	-.12	3.76	0.88	-.06	4.12	0.84	-.13	3.92	0.85	-.13	3.72	0.73	-.16
Importance of appropriate feeding	4.44	0.67	-.01	4.39	0.57	.06	4.41	0.67	-.11	4.38	0.74	-.18	3.99	0.58	.01
Behavioural beliefs - feed to please	2.59	1.15	.03	2.61	0.84	-.03	3.00	0.76	.12	2.66	1.13	.06	3.08	0.80	-.01
Normative beliefs	1.99	1.07	.24	1.87	0.90	.17	1.69	0.99	.15	2.16	1.10	.27	2.19	0.77	.47
PBC / self-efficacy	4.37	0.68	-.04	3.82	0.83	.02	4.38	0.66	-.10	3.97	0.76	-.24	3.57	0.86	-.10
Intention	4.33	0.76	-.15	4.03	0.77	.06	3.98	1.00	-.07	4.29	0.82	-.13	3.61	0.77	.06
Food monitoring	3.73	0.87	-.00	3.61	0.91	.10	3.21	1.05	-.02	3.86	0.85	-.15	3.34	0.78	-.02

Action planning	4.26	0.75	-.08	4.26	0.64	.05	3.31	1.17	-.12	4.09	0.83	-.17	3.98	0.70	-.05
Coping planning	3.31	0.92	.09	2.96	0.87	.08	2.67	1.08	.03	3.34	0.95	.02	3.05	0.88	.03
Restrictions on human food	2.98	1.16	.13	2.58	1.04	-.02	2.45	1.08	.07	2.76	1.17	.15	3.14	0.99	.01
Responsiveness to food	3.42	0.91	-.07	3.20	0.95	.06	3.10	1.09	-.09	3.51	0.80	.05	3.19	0.76	.05
Fussiness	3.17	1.03	.11	3.15	1.01	-.02	3.24	1.08	.07	2.94	0.96	-.04	3.59	0.86	-.08
Interest in food	3.67	0.99	.10	3.16	0.91	.12	3.29	0.95	.02	3.62	0.85	.06	3.51	0.75	.06
Barriers	2.16	1.03	.21	1.86	0.76	.06	1.74	0.90	.18	2.18	0.99	0.22	1.98	0.60	.29
Beliefs about treats	3.58	0.73	.03	3.21	0.78	.00	3.32	0.72	.02	3.44	0.79	.02	3.48	0.57	-.07
Knowledge about treats	3.89	0.95	-.08	3.41	1.01	-.06	3.90	0.89	-.12	3.72	0.97	-.15	3.76	0.80	-.10
Follow treat guidelines	3.50	1.11	.02	3.50	1.03	-.01	3.21	1.13	-.02	3.81	1.02	-.09	3.49	0.94	-.01
Exercise															
Knowledge	3.73	1.10	-.01	3.09	1.04	-.06	4.11	0.98	-.03	3.25	1.07	-.07	3.12	0.89	-.07
Behavioural beliefs: Value of exercise	4.35	0.79	.01	4.16	0.71	.08	4.55	0.72	.04	3.92	0.86	-.02	3.66	0.77	-.01
Behavioural beliefs: Dog centred	4.14	0.67	.06	3.96	0.59	.13	4.16	0.64	.07	3.89	0.75	-.20	3.53	0.70	.02
Outcome expectations (owner)	4.41	0.66	.04	4.01	0.72	.08	4.39	0.67	-.01	4.24	0.80	-.08	4.05	0.67	-.04
Outcome expectations (dog)	4.52	0.64	.08	4.24	0.63	.08	4.49	0.62	-.04	4.28	0.77	-.07	4.16	0.62	-.01
Normative beliefs	2.14	1.11	.10	2.33	0.94	.08	1.82	1.04	.11	2.71	1.03	0.20	2.60	0.81	.10
PBC / self-efficacy	4.33	0.68	-.02	3.45	0.81	-.03	4.39	0.61	-.07	3.62	0.81	-.15	3.16	0.95	-.12
Intentions	4.43	0.78	-.02	3.62	0.90	-.02	4.59	0.66	-.07	3.75	0.98	-.12	3.24	0.91	.01
Goal monitoring	3.07	1.07	.01	2.88	0.96	.07	1.86	1.07	.00	3.28	1.03	-.09	3.33	0.91	.01
Action planning	3.92	0.94	-.05	3.51	0.88	-.05	2.83	1.23	-.09	3.34	1.06	-.15	3.27	0.91	-.02
Coping planning	3.52	1.08	-.00	3.14	0.95	-.03	2.69	1.29	-.02	3.36	1.09	-.12	3.17	0.89	-.05
Behaviour	4.10	0.79	-.09	3.25	0.91	-.13	3.98	0.75	.05	3.61	1.01	-.27	3.27	0.79	-.18

Barriers	1.87	0.95	-.01	2.08	0.71	-.04	1.71	0.88	.12	2.21	0.94	.07	2.49	0.54	.03
Facilitators	4.25	0.91	-.15	3.90	0.97	-.05	4.37	0.84	-.04	3.67	1.04	-.18	3.41	0.83	-.08
Social support (dog)	4.21	0.81	-.08	3.72	0.93	-.05	4.31	0.68	.01	3.88	0.91	-.09	3.47	0.79	-.09
Social support (family)	3.30	1.05	-.21	3.10	0.94	.09	3.12	0.94	.05	3.24	1.10	-.05	3.37	0.85	-.12
Social support (friends)	2.63	1.14	-.15	2.41	0.98	0.02	2.81	0.98	-.01	2.73	1.16	-.04	2.69	0.81	-.06

Note. M denotes the mean value is for continuous measures, median for categorical.