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Krasuska, M. and Webb, T.L. orcid.org/0000-0001-9320-0068 (2018) How effective are interventions designed to help owners to change their behaviour so as to manage the weight of their companion dogs? A systematic review and meta-analysis. *Preventive Veterinary Medicine*, 159. pp. 40-50. ISSN 0167-5877

<https://doi.org/10.1016/j.prevetmed.2018.08.016>

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4 **How effective are interventions designed to help owners to change their behaviour so as**
5 **to manage the weight of their companion dogs? A systematic review and meta-analysis**

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Marta Krasuska, PhD and Thomas L. Webb, PhD

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Department of Psychology, The University of Sheffield, UK

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10 Preventive Veterinary Medicine ms# PREVET_2018_174 R1

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12 **Corresponding author:**

13 Thomas L. Webb

14 Department of Psychology, The University of Sheffield, Cathedral Court, 1 Vicar Lane,

15 Sheffield, S1 2LT, UK

16 t.webb@sheffield.ac.uk

17 **Abstract**

18 **Objective.** The present review sought to evaluate whether – and to what extent – targeting
19 owners’ behaviour is an effective way to reduce the problem of overweight and obesity among
20 companion dogs.

21 **Methods.** A systematic search of electronic databases identified 14 studies that evaluated the
22 effect of an intervention targeting owners’ behaviour on (i) the owner’s behaviour or (ii) the
23 weight, (iii) body fat, or (iv) body condition of the dog. We coded aspects of the study design
24 (e.g., the outcome variable), intervention (e.g., use of theory, specific behaviour change
25 techniques or BCTs, inclusion of nutritional intervention alongside the behavioural
26 intervention), and sample (e.g., age, gender, and weight of the dogs at baseline) that could
27 influence the effect sizes.

28 **Results.** The interventions had, on average, a medium sized effect on outcomes ($d_+ = 0.59$,
29 95% CI: 0.23 to 0.96, $k = 14$, $N = 384$). The effect sizes from the primary studies were relatively
30 homogenous, $Q(13) = 12.10$, $p = .52$ and the nature of the intervention, methodological and
31 sample characteristics did not moderate the effect sizes.

32 **Conclusions and clinical relevance.** The findings of the review suggest that targeting owners’
33 behaviour can be an effective way to reduce overweight and obesity among companion dogs.
34 However, this conclusion is based on a limited number of studies and so we hope that the
35 present findings serve as the impetus for further research in this area.

36

37 **Keywords:** Obesity; weight; behaviour; intervention; feeding; exercise

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Introduction

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Overweight and obesity¹ are common problems in dogs; and between 30 and 60% of adult companion dogs worldwide are estimated to have an excess of body fat (McGreevy et al., 2005; Colliard et al., 2006; Lund et al., 2006; Mao et al., 2013). An excess of body fat can predispose dogs to a number of serious health conditions, including musculoskeletal disorders, diabetes, cardiovascular disease, and cancers (Rocchini et al., 1987; Perez Alenza et al., 2000; Rand et al., 2004; Marshall et al., 2009). It has also been linked to a reduced life span (Kealy et al., 2002) and impaired wellbeing; in part, as a result of reduced energy and activity levels (Yam et al., 2016). Overweight and obesity can also have financial implications for the owner, who will likely have to pay for treatment. Together then, it is clear that what has been termed ‘the obesity epidemic’ among companion dogs is a serious concern (Kushner et al., 2006; Sandoe et al., 2014) and that there is a need to identify effective ways to address this problem.

Traditionally, weight management interventions for companion dogs have centred around prescribing specific foods or feeding regimes to reduce energy intake (Laflamme et al., 1997; Burkholder & Bauer, 1998). This approach has been shown to produce desired outcomes in dogs kept in experimental conditions where feeding and living conditions can be easily controlled (Laflamme et al., 1997; Yamka et al., 2007). However, its effectiveness in dogs living in domestic contexts is less clear (German et al., 2012). This might be because the effectiveness of nutritional interventions for dogs living at home depends on owners adhering to the feeding regime; something which has been shown to be less than optimal (German et al., 2012). More recently, pharmacological treatments have become available to treat overweight

¹ It is difficult to define overweight and obesity in dogs, primarily because breeds differ in size so that simple calculations of, for example, the ratio of height to weight (as used to compute BMI in humans), are not possible. There have been some efforts to quantify obesity (e.g., Simpson et al., 1993, stated that an animal could be deemed obese when it was 15% over its optimal weight); however, most people use the terms overweight or obese simply to refer to “an excess of body fat or adipose tissue (e.g., Crane, 1991), which is typically operationalised in terms of a body condition score (Laflamme et al., 1997). Scores of 6 or 7 on the 9-point BCS (or 4 on the 5-point BCS) mean that the dog is overweight; scores of 8 or 9 on the 9-point BCS (or 5 on the 5-point BCS) mean that the dog is obese.

59 and obesity in dogs (Roudebush et al., 2008). However, while pharmaceutical treatments have
60 been shown to assist weight loss (Pena et al., 2014) they can be associated with side-effects
61 (Wren et al., 2007) and, similarly to nutritional interventions, they rely on the owners'
62 adherence to a medication regime which has, again, been shown to be problematic (Gosselin
63 et al., 2007).

64 **Managing the weight of dogs by targeting owners' behaviour**

65 One key factor that influences a dog's weight is their owner's behaviour. That is, it is
66 typically the owner that feeds and exercises the dog and thus dictates their energy intake and
67 expenditure. Perhaps not surprisingly then, evidence suggests that the behaviour of owners of
68 overweight and obese dogs differs from that of the owners of healthy weight dogs. For example,
69 the owners of overweight and obese dogs tend to walk their dogs less frequently, feed them
70 more treats, and weigh their dog less often than owners of dogs of an optimal weight (Kienzle
71 et al., 1998; Robertson, 2003; Bland et al., 2009; Raffan et al., 2015). Therefore, promoting
72 weight loss in companion dogs likely involves finding ways to help the owner to feed and
73 exercise their animal appropriately (Webb, 2015; White et al., 2016).

74 Researchers have started to develop interventions that explicitly target owners'
75 behaviour, either as part of a multi-component intervention or as its primary focus. For
76 example, German et al. (2007) designed an intervention that combined a nutritional component
77 (each dog was fed high protein, fat restricted food with the size of the portion tailored to the
78 specific needs of each dog), with advice to owners on strategies to prevent excessive feeding
79 (e.g., providing non-food-related rewards) and to increase the dog's physical activity levels
80 (e.g., playing with the dog indoors). The intervention also provided owners with feedback on
81 their dog's weight during the intervention. Another intervention exclusively targeted the
82 behaviour of owners of overweight dogs in an effort to increase the amount of time that they
83 spend walking their dog - owners received information on the health benefits of exercising the

84 dog, the likely exercise needs of their dog (stratified by breed and age), and instructions on
85 how to start walking their dog more (Rhodes et al., 2012). Despite the recent interest in
86 interventions designed to modify owners' behaviour however, to date, there has not been a
87 systematic review of these studies. As a result, researchers and practitioners currently do not
88 know whether – and to what extent – targeting owners' behaviour is an effective way to reduce
89 overweight and obesity among companion dogs. The primary aim of the present review then,
90 was to estimate the effectiveness of interventions targeting owners' behaviour.

91 **Behaviour Change Techniques**

92 It is also unclear what specific techniques have been used to modify owners' behaviour
93 and whether the use of particular techniques is linked to the effectiveness of the intervention.
94 Around 10 years ago, there was a similar problem in health psychology with many
95 interventions designed to promote health behaviour among humans being unclear about the
96 specific intervention techniques that they used. As a consequence, it was difficult to reach
97 conclusions about the best way to intervene (i.e., to identify which components of the
98 intervention were effective and might be taken forward to subsequent interventions). To
99 facilitate the accumulation of evidence, replication of interventions, and evaluation of
100 behaviour change interventions, researchers attempted to classify Behaviour Change
101 Techniques (or BCTs, defined as 'reliable components of an intervention designed to alter or
102 redirect causal processes that regulate behaviour', Michie, Abraham, et al., 2011) according to
103 their content (Abraham & Michie, 2008; Michie, Abraham et al., 2011), culminating in the
104 Behaviour Change Techniques Taxonomy (BCTTv1, Michie et al., 2013). A second aim of the
105 present review then, was to use this taxonomy to describe the BCTs used in interventions
106 designed to help the owners of overweight and obese dogs to manage the weight of their dogs
107 and attempt to link the use of specific BCTs to effectiveness. So doing should not only help to
108 describe the current 'state of the art' (e.g., what do these interventions typically do?), but also

109 help to identify which BCTs are effective in promoting changes in relevant outcomes (as well
110 as those that are less effective).

111 **Other factors that may influence the effectiveness of interventions**

112 It is also important to consider the extent to which interventions and the use of particular
113 BCTs has been informed by theory. For example, theoretical models such as Control Theory
114 (Carver & Scheier, 1982) would suggest that selecting BCTs that target the three putative
115 processes involved in regulating behaviour (namely, goal setting, goal monitoring, and goal
116 operating) might be particularly effective. However, whether interventions that are informed
117 by a theory are more effective than interventions that are not informed by a theory remains an
118 open question and, to date, a large proportion of interventions are not based on theory
119 (Prestwich et al., 2015). Therefore, the present review aimed to identify the extent to which
120 interventions designed to help dog owners to change their behaviour with respect to their dog
121 are informed by theory and whether this influences their effectiveness. Finally, the present
122 review aimed to evaluate the impact of other factors that could influence – or moderate – the
123 effectiveness of interventions targeting owners' behaviour. For example, the inclusion of an
124 additional nutritional interventions alongside interventions designed to change owners'
125 behaviour may produce a larger effect on relevant outcomes than interventions that only target
126 the owners' behaviour. Similarly, methodological characteristics such as the duration of the
127 intervention, design of the study (e.g., between vs. within designs, duration of the follow-up),
128 risk of bias (e.g., methodological quality of the study and source of funding) and type of
129 outcome reported (e.g., the dog's weight, body fat, or body condition, owners' behaviour) may
130 influence the actual, or apparent, effect of the interventions on these outcomes.

131 **The Present Review**

132 The primary aim of the present review was to estimate the effect of interventions that
133 target owners' behaviour on the owner's behaviour or on the weight or body condition of the

134 dog. The review also had three secondary aims – (i) to describe the BCTs used in interventions
135 designed to help owners to manage the weight of their dogs and attempt to link the use of
136 specific BCTs to effectiveness, (ii) to identify the extent to which interventions designed to
137 help dog owners to change their behaviour are informed by theory and whether this influences
138 their effectiveness, and (iii) to evaluate the impact of other factors that could influence – or
139 moderate – the efficacy of interventions targeting owners’ behaviour.

140 **Material and Methods**

141 **Inclusion criteria**

142 There were four inclusion criteria for the review. First, the study needed to evaluate an
143 intervention that was intended to help owners to make changes to their behaviour in an effort
144 to manage the weight of their companion dog. As this review focused on the effects of
145 interventions targeting owners’ behaviour, studies evaluating weight loss interventions for
146 dogs living in research facilities (e.g., kennel dogs) were excluded. Second, the intervention
147 had to contain at least one BCT designed to change owners’ behaviour with regards to feeding,
148 exercising and / or other weight management behaviours (e.g., weighing the dog), with BCTs
149 defined as those included in the BCTTv1 taxonomy (Michie et al., 2013). Third, the study had
150 to measure at least one relevant outcome, defined as (i) the dog’s body weight, percentage
151 change in dog’s body weight, amount of body fat or body condition, or (ii) a measure of the
152 owner’s behaviour (e.g., time spent walking the dog, number of treats given to the dog). We
153 included both randomized controlled trials and quasi experimental studies (i.e., studies with
154 between participants’ designs), as well as studies that measured outcomes before and after the
155 intervention (i.e., studies with within participant designs). Finally, studies needed to report
156 sufficient information for us to be able to compute an effect size representing the effect of the
157 intervention on relevant outcome(s), or this information needed to be available from the
158 authors. Studies published in peer-reviewed journals, reports, book chapters as well as

159 unpublished data (including university dissertations), written in any language (provided that an
160 English version of the abstract was available) were considered for inclusion.

161 **Literature search strategy**

162 Figure 1 shows the flow of studies through the review. The first author searched Web
163 of Science and ProQuest (which covers ProQuest Dissertation and Theses) in December 2016
164 using predefined search filters (i.e., FILTER 1 - Dogs': Dog* OR Canine* OR Pet OR Pets OR
165 'Companion animal*'; FILTER 2 - 'Weight management behaviours': Walk* OR Exerc* OR
166 'Physical activity' OR Diet* OR Food OR Weight OR Overweight OR Obes*; FILTER 3 -
167 'Interventions': Intervention* OR Program* OR Management OR Control OR Trial OR Study
168 OR Restriction OR Treatment). This yielded 8,071 papers (excluding duplicates). Four
169 additional studies were identified by looking through lists of studies cited by potentially eligible
170 articles for additional studies published up to December 2016 (i.e., an ancestry approach,
171 Johnson, 1993). The titles and abstracts of these papers were then examined for eligibility and
172 clearly ineligible studies were excluded. Reference management software (e.g., EndNote X7)
173 was used to identify duplicates and to store the citations and the electronic copies of the
174 identified papers.

175 Forty-three papers were then screened in detail by reading the full text. Studies were
176 rejected at this stage if they did not report the effects of an intervention designed to promote
177 weight loss or management among companion dogs (33% of studies, e.g., Laflamme et al.,
178 1997) or did not include a BCT as part of the intervention (28% of studies, e.g., Floerching et
179 al., 2015, reported the effects of a nutritional intervention). Finally, three studies (7%) did not
180 provide enough information to enable computation of the effect sizes (e.g., Carciofi et al.,
181 2015). This was mostly the case for studies that employed a within participant design as these
182 studies typically only reported the percentage change in the dog's weight at the end of the
183 intervention, from which it was not possible to calculate an effect size (as there was nothing to

184 compare this value to). In each case, the respective authors were emailed to request the required
185 data (e.g., the average weight of the dogs and respective standard deviation at the beginning
186 and at the end of the intervention). In total, $k = 14$ studies, from 13 papers were included in the
187 review. Table 1 provides a list of these studies and their characteristics.

188 **Coding of the study characteristics**

189 The characteristics of each study were coded by the first and second authors
190 independently using a data extraction sheet that was specified a priori. Disagreements were
191 resolved jointly by discussion. Information on the design of the study was coded into two
192 categories: (i) studies with between participant designs (i.e., where outcomes were assessed for
193 participants in experimental and control conditions, such as in quasi experimental designs and
194 in randomized controlled trials) or (ii) studies with within participants designs (i.e., where
195 outcomes were assessed for the same participants at the beginning and at the end of the
196 intervention). The duration of the intervention and length of the longest follow-up was coded
197 in terms of the number of weeks, respectively. We also identified sample characteristics for
198 owners (namely, age and gender) and for dogs (namely, body weight at the beginning of the
199 intervention, sex, neutering status, and most common breed). The source of funding was
200 divided into commercial (typically pet food manufacturers such as WALTHAM or Purina),
201 non-commercial (e.g., University, foundation, funding council), or not specified. Finally, we
202 assessed the methodological quality of the study using Downs and Black's Quality Index (QI,
203 Downs & Black, 1998), on which scores can range from 0 to 32 with higher scores indicating
204 higher quality). We scored item 27 on statistical power by computing the minimum number of
205 participants required in the intervention condition to detect a medium-sized effect (i.e., $d =$
206 0.50) at $p < .05$. Studies that provided $< 80\%$ power were scored 0, those with 80% power were
207 scored 1, those with 85% power were scored 2, those with 90% power were scored 3 those with
208 95% power were scored 4, and those with 99% power were scored 5.

209 Three aspects of the interventions were coded. First, we coded the BCTs that were
210 employed by each of the interventions with respect to the 93 techniques listed in the BCTTv1
211 taxonomy (Michie et al., 2013). The BCTTv1 taxonomy defines 93 unique BCTs clustered into
212 16 categories. For example, goal setting (from the ‘goals and planning’ category) involves
213 setting or agreeing on a goal defined in terms of the behaviour or outcome to be achieved, while
214 comparative imagining of future outcomes (from the ‘comparison of outcomes’ category)
215 involves asking the person to compare the likely outcomes of changing versus not changing
216 their behaviour (Michie et al., 2013). Given the relatively small number of interventions that
217 have targeted the behaviour of dog owners to date, it was not possible to evaluate the impact
218 of specific BCTs on outcomes. We therefore compared interventions that used (vs. did not use)
219 BCTs in each of the 16 categories identified by the BCTTv1 taxonomy and then considered
220 whether the use of specific categories of BCTs was associated with outcomes. In addition, we
221 investigated whether there was a linear relationship between the number of BCTs employed in
222 the intervention (regardless of category) and outcomes.

223 Second, we used a coding scheme developed by Michie and Prestwich (2010) to
224 identify the extent to which the development of the intervention was informed by a theory of
225 behaviour change. Specifically, we used the first three categories from the coding scheme that
226 identify whether the intervention: (i) referred to underpinning theory, (ii) targeted one or more
227 relevant theoretical constructs, and (iii) used theory to select recipients and/or tailor the
228 intervention. Finally, we coded whether the owners were also provided with a nutritional
229 intervention (i.e., specific food) alongside the behavioural intervention.

230 **Computing effect sizes**

231 Effect sizes (Cohen’s d) were calculated for each study. For studies with between
232 participant designs, the outcomes for experimental versus control groups were compared. For
233 studies with within participant designs, the relevant outcomes were compared before versus

234 after the intervention. Given that studies adopting within participants designs can produce
235 different estimates of the effect size than studies with between participant designs (Dunlap et
236 al., 1996), we converted effect sizes into a common metric before conducting the meta-analysis,
237 using the approach proposed by Morris and DeShon (2002).

238 Five types of outcomes were considered: (i) the dog's body weight (in kg), (ii) the
239 percentage change in the dog's body weight, (iii) the proportion of body fat that the dogs had,
240 (iv) the dog's body condition score (BCS; Laflamme et al., 1997), and / or (v) owners'
241 behaviours that could influence the dog's weight (i.e., exercising, feeding, and weighing the
242 dog). When more than one outcome was reported, we calculated an effect size for each outcome
243 and then computed an average effect size across the available outcomes to enter into the meta-
244 analysis (this procedure retains as much data as possible while ensuring the independence of
245 effect sizes that is crucial to the validity of meta-analysis).

246 **Meta-analytic strategy**

247 SPSS Version 23 and David Wilson's Macros for meta-analysis were used to conduct
248 the analyses (Lipsey & Wilson, 2001). A random effects model was used, as we expected
249 significant variation in our effect sizes that was unlikely to be attributable to systematic
250 differences in the samples, methods, or interventions (Borenstein et al., 2010). Each effect size
251 was weighted by its inverse sampling variance, which was calculated using the technique
252 recommended by Morris and DeShon (2002). Effect sizes were interpreted using Cohen's
253 recommendations, where $d = 0.20$, 0.50 , and 0.80 indicate small, medium, and large effect
254 sizes, respectively (Cohen, 1992) and $p < .05$ was used as the threshold for determining
255 statistical significance throughout.

256 To test the moderating effects of categorical variables (i.e., the design of the study, the
257 type of outcome measured, use of behaviour change theory or specific BCTs) the studies were
258 divided into levels of the categorical moderator (e.g., those with between vs. within participant

259 designs) and separate meta-analysis were conducted for each level to calculate and compare
260 the average effect sizes for each level of the moderator. To ensure the validity of the
261 comparisons, we only compared levels of the moderators that were represented by at least two
262 effect sizes from the primary studies. The average effect sizes across levels were then compared
263 using the homogeneity Q statistic (Cooper, 1986). The influence of continuous moderators (i.e.,
264 number of BCTs, duration of the intervention, age of the sample) on effect sizes was assessed
265 using meta-regression (Sutton & Higgins, 2008).

266 **Results**

267 **Overall effect of the interventions on outcomes**

268 The (adjusted) effect sizes derived from the primary studies varied from $d = -0.20$ to d
269 $= 1.80$ with a weighted average effect size of $d_+ = 0.59$ (95% CI: 0.23 to 0.96), based on $k = 14$
270 studies and a total sample of 384 dogs / owners (Table 2). This finding suggests that, on
271 average, the interventions had a medium sized effect on outcomes, although it is notable that
272 only two of the studies had significant effects (based on 95% CIs) when evaluated individually,
273 in part because individual studies were typically underpowered to detect statistical significance
274 (none of the primary studies provided 80% power to detect a medium-sized effect, according
275 to our calculations). Effect sizes did not differ significantly across the primary studies, $Q(13)$
276 $= 12.10$, $p = .52$.

277 **Categorical moderators of the effect of interventions on outcomes**

278 Table 3 shows the effect of the categorical moderators on effect sizes.

279 **Type of study design.** There was no difference between the effect sizes for the 6 studies
280 that employed between participants designs ($d_+ = 0.49$) and the 8 studies that employed within
281 participant designs ($d_+ = 0.66$), $Q(1) = 0.21$, $p = .65$.

282 **Type of outcome.** In order to evaluate whether the nature of the outcome variable
283 influenced the effect of the interventions, we compared the effects of the interventions on the

284 different outcome variables.² The average effect size ranged from very small for outcomes
285 reflecting the dog's body fat and weight ($d_+ = 0.07$ and 0.04 , respectively) to large for outcomes
286 reflecting the owners' behaviour ($d_+ = 0.96$) or the dogs' body condition ($d_+ = 0.91$). The
287 difference between the effects of the interventions on the different outcomes did not, however,
288 differ significantly, $Q(4) = 6.36$, $p = .17$, and only the effect of the interventions on the owners'
289 behaviour and the dogs' body condition reached statistical significance.

290 **Use of theory.** In order to examine whether the use of theory influenced the
291 effectiveness of the intervention, the studies were divided into those that reported using theory
292 (2 studies) and those studies that did not report that they used theory (12 studies). The average
293 effect size for studies that reported using theory ($d_+ = 1.07$) and those that did not ($d_+ = 0.52$)
294 did not differ significantly, $Q(1) = 0.98$, $p = .32$.

295 **Inclusion of an additional nutritional intervention.** There was no difference between
296 the effect sizes associated with studies that did not include a nutritional intervention in addition
297 to the behavioural intervention (6 studies, $d_+ = 0.49$), and those that did include an additional
298 nutritional intervention (8 studies, $d_+ = 0.66$), $Q(1) = 0.20$, $p = .64$.

299 **Nature of the behaviour change techniques used.** Table 1 lists the BCTs that were
300 used in each of the primary studies. The primary studies used BCTs from 11 of the 16 categories
301 identified by the BCTTv1 taxonomy: (i) goals and planning, (ii) feedback and monitoring, (iii)
302 social support, (iv) shaping knowledge, (v) natural consequences, (vi) comparison of
303 behaviour, (vii) associations, (viii) repetition and substitution, (ix) comparison of outcomes,
304 (x) reward and threat, and (xi) antecedents. There was, however, no statistical differences in

² The effect size from studies that reported the effects of an intervention on more than one outcome (i.e., Byers et al., 2014, German et al., 2007, Vitger et al., 2016, Yaissle et al., 2004) was disaggregated prior to this analysis (recall that it was averaged prior to inclusion in the main dataset to ensure that the effect sizes were independent).

305 the effect sizes associated with interventions that reported using (versus not using) BCTs from
306 the various categories of techniques.

307 **Source of funding.** Nine studies (64%) were funded by pet food companies or other
308 commercial interests, 3 (21%) were funded by non-commercial organisations (e.g.,
309 Universities, Foundations, or Research Councils) and 2 (14%) did not report the source of
310 funding. The effect sizes between studies that were funded ($d_+ = 0.69$) versus not funded by
311 commercial organisations ($d_+ = 0.71$) did not differ significantly from one another, or from the
312 effect sizes for studies that did not report the source of funding ($d_+ = 0.06$), $Q(2) = 1.53$, $p =$
313 0.46 .

314 **Continuous moderators of the effect of interventions on outcomes**

315 **Number of behaviour change techniques.** On average, the interventions used 7 BCTs
316 ($SD = 5$, range = 1 to 19); however, the number of BCTs that were used was not associated
317 with the magnitude of effect sizes ($\beta = 0.09$, $p = .75$).

318 **Duration of the intervention.** The mean duration of the interventions evaluated in the
319 primary studies was about 3 and a half months ($M = 15.61$ weeks, $SD = 9.30$, range: 0 [i.e., the
320 entire intervention took place at one time point] to 28.70 weeks). The duration of the
321 intervention was not associated with the magnitude of effect sizes ($\beta = 0.04$, $p = .89$).

322 **Length of follow-up.** The length of follow-up in the primary studies was 22.75 weeks,
323 $SD = 24.42$, range: 7.57 to 104 weeks). The length of follow-up was not associated with the
324 magnitude of effect sizes ($\beta = -0.35$, $p = .18$).

325 **Characteristics of the sample.** Only a relatively small proportion of studies reported
326 the baseline characteristics of the owners in the sample (e.g., only 4 studies reported the
327 owner's age and 3 studies reported owner's gender at baseline) and their dogs (11 studies
328 reported the dog's weight and 9 reported the dogs age at baseline). There was little variation in
329 the mean age of owners at baseline across the primary studies (47.05 years, $SD = 2.52$, range

330 of means: 44.80 to 49.70) or the percentage of female participants in the samples ($M = 87$, SD
331 $= 5$, range of means: 82 to 90), and so we did not test whether this moderated the effect of the
332 interventions. The mean age of the dogs at baseline across the primary studies was 6.15 years
333 ($SD = 1.06$, range of means: 3.70 to 7.60) and, on average, the dogs weighed 32.52kg at baseline
334 ($SD = 5.70$, range of means: 22.68 to 40.63). Neither characteristic of the dogs moderated the
335 effect of the interventions on outcomes (betas = 0.06 and -0.15, for age and weight,
336 respectively, $ps = .89$ and $.63$).

337 **Quality of the study.** The mean QI score across studies was 15.93 (out of a possible
338 32, $SD = 3.08$, range: 9 to 21). There was no evidence that the methodological quality of the
339 study was associated with the magnitude of the effect sizes reported by the primary studies
340 (beta = 0.19, $p = .50$).

341 **Discussion**

342 The present review sought to evaluate the effectiveness of interventions designed to
343 help owners to change their behaviour so as to manage the weight of their companion dogs.
344 Overall, the findings suggest that targeting owners' behaviour is an effective way to promote
345 changes in relevant outcomes; having on average medium-sized effect on outcomes, reflecting
346 a large-sized effect of the interventions on owners' behaviour and the body condition of the
347 dogs, a medium-sized effect on weight, and (very) small or null effects on the dogs' weight
348 and body fat (although it should be noted that the magnitude of effects did not differ
349 significantly across the different outcomes). A medium-sized effect of interventions targeting
350 dog owners' behaviour on relevant outcomes is comparable to effects reported in other domains
351 (e.g., on physical activity among humans, Olander et al., 2013) and reviews focusing on
352 specific BCTs (e.g., planning, Gollwitzer & Sheeran, 2006, or self-monitoring, Harkin, Webb
353 et al., 2016) It was also notable that the effect sizes from the primary studies were relatively
354 homogenous and that the nature of the intervention, methodological, and sample characteristics

355 did not moderate the effect sizes. The implication is that interventions that target owners'
356 behaviour can be an effective way to reduce overweight and obesity among companion dogs
357 and could and should form the basis of holistic interventions to manage this problem.

358 Caution is however needed considering the relatively small number of primary studies
359 that were available for review (just 14 studies to date) and the varied, but generally low,
360 methodological quality of the primary studies; although, again, it should be noted that the
361 methodological quality of the studies did not influence effect sizes. In short, there is still work
362 to be done to improve the evidence base and produce high quality studies evaluating
363 interventions that use BCTs to influence owners' behaviour. Specifically, studies should recruit
364 samples that provide sufficient power to detect potentially relatively small-sized effects. We
365 would also note that, while reporting changes in the dog's weight at the end of the intervention
366 seems to be an established practice, change scores can be problematic (Peter et al., 1993) and
367 we were not able to calculate effect sizes for studies that only reported this outcome measure.
368 Future studies should, therefore, consider measuring and reporting several outcomes (e.g.,
369 owners' behaviour, dogs' body weight, fat or condition), especially as the intervention may
370 have different effects on each. We would also appeal to researchers to consider how theory
371 (including theoretical models of human behaviour and how it can be influenced) can help to
372 inform the design of interventions. Although the present review found no difference in the
373 effectiveness of interventions that reported using theory versus those that did not, only two
374 studies reported using theory and research in other domains has found clear evidence that using
375 theory is associated with more effective interventions (for a review, see Prestwich et al., 2015);
376 particularly if used in a systematic way (e.g., in accordance with the intervention mapping
377 approach, Bartholomew et al., 1998).

378 Which behaviour change techniques are effective?

379 One of the key objectives of this review was to identify which Behaviour Change
380 Techniques (or BCTs) are most effective in helping owners' to managing the weight of their
381 dogs. The most commonly used techniques involved setting goals with regards to behaviour
382 (e.g., walking the dog five times a week for half an hour, giving the dog no more than one treat
383 per day) and / or outcomes (e.g., helping the dog to lose 2.5% of its body mass each week),
384 techniques to shape knowledge (e.g., instructions on how best to feed or exercise the dog), self-
385 monitoring behaviour (e.g., using a wallchart to record when the dog is fed) or the provision of
386 feedback on behaviour or the outcomes of that behaviour (e.g., weekly visits to the veterinary
387 practice where owners' are briefed about changes in their dog's weight). However, the present
388 review found no evidence that including such strategies or, indeed, BCTs involving social
389 support, comparison of behaviour or outcomes, repetition or substitution etc. were associated
390 with more effective interventions. This does not necessarily mean that these BCTs do not help
391 owners' make changes to their behaviour. This is a field in its infancy and our analyses were
392 based on a relatively small number of studies. Therefore, more (high quality) evidence is
393 probably needed to evaluate the effectiveness of different BCTs with more certainty. It was
394 also notable that only about half of the BCTs listed in the BCTv1 taxonomy have been
395 employed thus far in interventions targeting overweight and obesity among companion
396 animals. There is, therefore, the opportunity for studies in the future to try other techniques and
397 other combinations of techniques. For example, techniques such as modelling (e.g., showing a
398 video of a person performing the desired behaviour) and relapse prevention (e.g., helping
399 people to adopt a self-compassionate approach to slips) have been found to influence peoples'
400 behaviour with regards to their own health (Webb et al., 2010; Sirois et al., 2015).

401 Limitations and future directions

402 There are a number of limitations to the present review that may help to inform future
403 research into behavioural interventions to address the problem of obesity in companion
404 animals. First, the review is based on a relatively small number of studies, pointing to a need
405 for additional evaluations of weight loss interventions targeting owners' behaviour. It was
406 frustrating, for example, not to be able to include studies that reported the effect of an
407 intervention targeting owners' behaviour on changes in dogs' weight over time (i.e., using a
408 within participant design) in the present review. We therefore appeal to scientists and
409 researchers conducting these sorts of studies to report descriptive statistics for relevant
410 outcomes at baseline and at follow-up in addition to change scores, so that these data can be
411 included in subsequent reviews. Second, while there is a general agreement that randomized
412 controlled trials constitute the most reliable and valid evidence on the effects of interventions
413 on outcomes and should form a basis for meta-analysis, due to the relatively small number of
414 available studies we also included studies with non-randomized designs including between and
415 within participant designs (e.g., Marshall et al., 2009; Vitger et al., 2016). Third, the
416 methodological quality of the included studies was often low which might impact the reliability
417 of our findings. Several guidelines exist with regards to the design and evaluation of
418 interventions in the area of human health (e.g., CONSORT guidelines for randomized
419 controlled trials, Moher et al., 2010) that could be used to guide reporting of veterinary studies,
420 along with guidelines on reporting animal research (e.g., ARRIVE guidelines, Kilkenny et al.,
421 2010). Finally, we were not always able to fully extract details of the intervention from the
422 reports and therefore may not have fully identified the BCTs that they used. While we are aware
423 that space constraints mean that it is not always possible to include all of the relevant details,
424 we would echo appeals for more detailed reporting of interventions (e.g., Hoffman et al., 2014).
425 Possible ways of achieving this include using templates and guides for reporting (e.g., the

426 TIDieR checklist, Hoffman et al., 2014) and / or publishing a study protocol before collecting
427 data (Munafò, 2016).

428

Conclusions

429 Owners' behaviour clearly contributes to the 'the obesity epidemic' among companion
430 dogs (Webb, 2015). Fortunately, behaviour can be changed and the present review suggests
431 that interventions designed to help owners to change their behaviour with respect to their dogs
432 can have beneficial effects on outcomes, particularly the condition of the dog. However, it is
433 also clear that the evidence base is in its infancy and could be improved in a number of ways.
434 We therefore propose that the present review serves as a starting point on which to base future
435 research. In particular, studies are needed that investigate the effectiveness of a range of BCTs
436 and that measure outcomes in a relatively large number of participants.

437

Acknowledgments

438

No third-party funding or support was received in connection with this study or the

439

writing or publication of the manuscript. Funding sources did not have any involvement in

440

the study design, data analysis and interpretation, or writing and publication of the

441

manuscript. The authors declare that there were no conflicts of interest.

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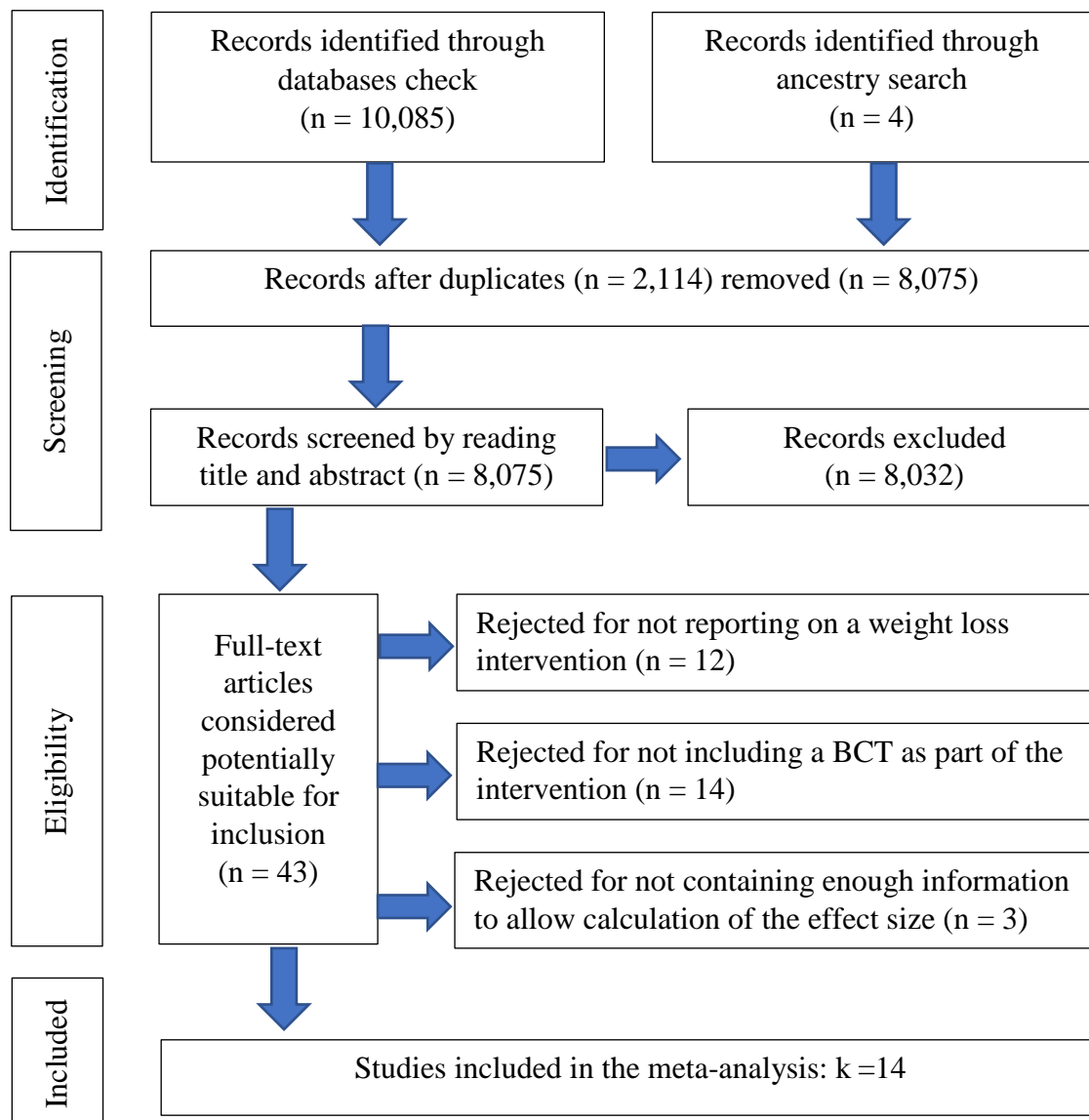
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653 **Figure 1**

654 Flow of Information through the Review

655



656 **Table 1**

657 Characteristics of the Studies Included in the Meta-Analysis

Study	Study design	Outcome(s)	Intervention				Sample size (exp. / control)	Effect size (Cohen's d) ^c
			Duration (in weeks)	(Behaviour Change Techniques (BCTs) ^a)	Intervention based on theory? ^b	Also includes nutritional intervention?		
Byers et al. (2014)	Between participant	Weight, body condition score, owners' behaviour	0	1.1 Goal setting 1.2 Problem solving 5.3 Information about social and environmental consequences	No	No	22/10	-0.03
Chauvet et al. (2011)	Within participant	Weight	12	1.1 Goal setting (behaviour) 1.5 Review of behaviour goal(s) 2.7 Feedback on the outcome(s) of behaviour 5.1 Information about health consequences 9.1 Credible source 10.10 Reward (outcome)	No	Yes	6/-	2.81
Gentry (1993)	Within participant	Weight	25	1.1 Goal setting (behaviour) 1.3 Goal setting (outcome) 2.7 Feedback on the outcomes of behaviour 3.1 Social support (unspecified) 4.1 Instructions on how to perform the behaviour 5.1 Information about health consequences 5.3 Information about social and environmental consequences 9.1 Credible source	No	Yes	15/-	0.27
German et al. (2007)	Within participant	Weight, body fat	25	1.1 Goal setting (behaviour) 1.2 Problem solving	No	Yes	19/-	0.44

				1.3 Goal setting (outcome) 1.5 Review of behaviour goal(s) 1.7 Review outcome goals 2.3 Self-monitoring of behaviour 3.1 Social support (unspecified) 4.1 Instructions on how to perform the behaviour 5.3 Information about social and environmental consequences 7.3 Reduce prompts / cues 8.2 Behaviour substitution					
Markwell et al (1990)	Within participant	Weight	12	1.1 Goal setting (behaviour) 1.3 Goal setting (outcome) 1.5 Review of behaviour goal(s) 2.7 Feedback on the outcomes of behaviour 5.3 Information about social and environmental consequences	No	Yes	24/-	2.23	
Marshall et al. (2010)	Within participant	Weight	16	1.1 Goal setting (behaviour) 4.1 Instructions on how to perform the behaviour	No	Yes	14/-	0.16	
Morrison et al. (2013)	Between participant	Owners' behaviour	10	1.1 Goal setting (behaviour) 1.2 Problem solving 1.5 Review of behaviour goal(s) 1.8 Behavioural contract 2.2 Feedback on behaviour 2.3 Self-monitoring of behaviour 3.1 Social support (unspecified) 3.2 Social support (practical) 3.3 Social support (emotional) 4.1 Instructions on how to perform the behaviour 6.1 Demonstration of behaviour 8.1 Behavioural practice/rehearsal 8.2 Behavioural substitution 9.1 Credible source 9.2 Pros and cons 10.3 Non-specific reward 12.1 Restructuring the physical environment 12.2 Restructuring the social environment	Yes	No	15/12	0.59	

Author(s)	Design	Outcome	n	Intervention components	Intervention	Control	n/N	Effect size
Rhodes et al. (2012)	Between participant	Owners' behaviour	0	12.5 Adding objects to the environment 1.1 Goal setting (behaviour) 4.1 Instructions on how to perform the behaviour 5.3 Information about social and environmental consequences 6.3 Information about others approval	No	No	30/28	0.08
Richards et al. (2015)	Between participant	Owners' behaviour	13	1.1 Goal setting (behaviour) 1.2 Problem solving 1.5 Review of behaviour goal(s) 2.3 Self-monitoring of behaviour 3.1 Social support (unspecified) 3.2 Social support (practical) 3.3 Social support (emotional) 4.1 Instruction on how to perform the behaviour 5.1 Information about health consequences 5.2 Salience of consequences 9.1 Credible source 12.2 Restructuring the social environment	Yes	No	23/24	1.47
Saker et al. (2005) Study 1	Within participant	Body condition score	14	1.1 Goal setting (behaviour) 1.3 Goal setting outcome 1.5 Review of behaviour goal(s) 4.1 Instructions on how to perform the behaviour 12.5 Adding objects to the environment	No	Yes	21/-	1.18
Saker et al. (2005) Study 2	Within participant	Body condition score	28	1.1 Goal setting (behaviour) 1.3 Goal setting outcome 1.5 Review of behaviour goal(s) 4.1 Instructions on how to perform the behaviour 12.5 Adding objects to the environment	No	Yes	39/-	2.60
Vitger et al. (2016)	Between participant	Weight, body fat, owners' behaviour	12	1.1 Goal setting (behaviour)	No	No	8/8	1.11

Wakshlag et al. (2012)	Within participant	Weight	27	1.1 Goal setting (behaviour) 1.5 Review of behaviour goal(s) 1.7 Review of outcomes goal(s) 2.3 Self-monitoring of behaviour 2.7 Feedback on the outcomes of behaviour 12.5 Adding objects to the environment	No	Yes	35/-	0.65
Yaissle et al. (2004)	Between participant	Weight, body condition score	26	4.1 Instruction on how to perform the behaviour 5.1 Information about health consequences 6.1 Demonstration of behaviour 9.1 Credible source	No	No	16/16	-0.21

658 ^a We intended to assess the extent to which the intervention was based on theory using a continuous measure developed by Michie and Prestwich
659 (2010). However, the majority of studies did not mention theory and so we converted the score into a binary measure indicating whether the
660 intervention was based on theory or not.

661 ^b These are the BCTs that are unique to the experimental group. BCTs that are shared with the control group were not included as they cannot
662 explain any differences in outcomes between the studies.

663 ^c The effect sizes reported in this table are prior to adjustment for study design (e.g., using the procedures described by Morris & DeShon (2002)).

664 **Table 2**

665 Effect Sizes from the Primary Studies (ordered by the size of the effect, from large to small)

Study	Weight	Effect size (Cohen's d) ^a	Standard error	95% CI
Saker et al. (2005) Study 2)	2.41	1.80	0.64	0.54 to 3.06
Chauvet et al. (2011)	1.19	1.49	0.91	-0.31 to 3.28
Richards et al. (2015)	2.05	1.47	0.70	0.10 to 2.84
Markwell et al. (1990)	2.33	1.18	0.66	-0.10 to 2.46
Vitger et al. (2016)	1.36	1.11	0.86	-0.57 to 2.79
Saker et al. (2005) Study 1	2.23	0.82	0.67	-0.49 to 2.13
Morrison et al. (2013)	1.73	0.59	0.76	-0.90 to 2.08
Wakshlag et al. (2012)	2.46	0.16	0.64	-1.09 to 1.42
Rhodes et al. (2012)	2.14	0.08	0.68	-1.26 to 1.42
German et al. (2007)	2.33	0.08	0.66	-1.21 to 1.36
Gentry et al. (1993)	2.24	0.07	0.67	-1.24 to 1.38
Marshall et al. (2010)	2.21	0.04	0.67	-1.28 to 1.36
Byers et al. (2014)	1.77	-0.03	0.75	-1.51 to 1.44
Yaissle et al. (2004)	1.85	-0.20	0.74	-1.65 to 1.24
Sample weighted average effect size		0.59	0.19	0.23 to 0.96

666 ^a Note that the effect sizes for studies with within-participant designs have been adjusted
 667 (from those reported in Table 1) using the approach proposed by Morris and DeShon (2002).

668

669 **Table 3**

670 Categorical Moderators of the Effects of the Interventions on Outcomes

Moderator	k	n	95% CI	d ₊	Q	p-value
Study design					0.21	.65
Between participant	6	212	-0.11 to 0.81	0.49		
Within participant	8	172	0.19 to 0.95	0.66		
Type of outcome					6.36	.17
Owners' behaviour	5	180	0.31 to 1.61	0.96		
Body condition	4	124	0.17 to 1.66	0.91		
Percentage change in weight	4	77	-0.17 to 1.34	0.58		
Body fat	2	35	-0.96 to 1.09	0.07		
Weight	6	144	-0.53 to 0.61	0.04		
Theory					0.98	.32
Used	2	74	0.60 to 2.08	1.07		
Not used	12	310	0.13 to 0.92	0.52		
Nutritional intervention provided alongside the behavioural intervention					0.20	.64
Provided	8	172	0.19 to 1.13	0.66		
Not provided	6	212	-0.11 to 1.08	0.49		
Source of funding					1.53	0.46
Commercial	9	223	0.22 to 1.15	0.69		
Non-commercial	3	132	-0.10 to 1.52	0.71		
Not specified	2	29	-0.87 to 0.98	0.06		
BCT group 1 'Goals and planning' ^a						
Used	13	352	0.27 to 1.03	0.65		
Not used	1	32		-0.20		
BCT group 2 'Feedback and monitoring'					0.09	.77
Used	7	172	0.13 to 1.66	0.65		
Not used	7	212	0.01 to 1.14	0.54		
BCT group 3 'Social support'					0.32	.57
Used	3	89	-0.74 to 1.06	0.16		
Not used	11	295	0.05 to 0.84	0.44		
BCT group 4 'Shaping knowledge'					0.15	.70
Used	9	272	0.10 to 0.99	0.54		
Not used	5	212	0.05 to 1.35	0.70		
BCT group 5 'Natural consequences'					0.47	.49
Used	8	232	-0.01 to 0.97	0.47		
Not used	6	152	0.18 to 1.30	0.74		
BCT group 6 'Comparison of behaviour'					1.45	.22
Used	3	117	-0.78 to 0.96	0.70		
Not used	11	267	0.30 to 1.12	0.14		
BCT group 7 'Associations' ^a						
Used	13	365	0.26 to 1.02	0.08		
Not used	1	19		0.64		
BCT group 8 'Repetition and substitution'					0.41	.52
Used	2	46	-0.68 to 1.27	0.30		
Not used	12	338	0.25 to 1.04	0.64		

BCT group 9 'Comparison of outcomes'					0.37	.54
Used	6	150	0.15 to 1.31	0.73		
Not used	8	234	0.02 to 0.98	0.50		
BCT group 10 'Reward and threat'					0.43	.51
Used	2	32	-0.19 to 2.10	0.96		
Not used	12	352	0.16 to 0.94	0.55		
BCT group 12 'Antecedents'					2.55	.11
Used	5	169	0.38 to 1.57	0.97		
Not used	9	215	-0.11 to 0.83	0.36		

671 ^aThe impact of this moderator was not evaluated as one of the levels was only represented by
672 one study. However, the effect size is reported here for information.

673 Note. k = number of studies, n = number of participants, d₊ = sample weighted average effect
674 size.