A Mixed-Methods Evaluation of the Child-Dog Relationship in Healthy Weight and Overweight/Obese Children

A thesis submitted by

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Abstract

Childhood obesity is a growing public health concern necessitating comprehensive treatment. The development of effective and sustainable interventions to treat obesity and the mental health effects of childhood obesity remain both a priority and a challenge. Previous studies show that dogs may provide social support in overweight adults, but the child-dog relationship is not as well understood. The goal of this study was to improve knowledge of the child-dog relationship among children to inform future childhood obesity interventions including dogs. A sequential mixed-methods approach utilized a cross-sectional survey study to test the hypothesis that overweight children are more attached to their pet dogs and have less perceived social support compared to healthy weight children, and also utilized semi-structured interviews in an exploratory method to better understand the child-dog relationship and engage stakeholders of potential future interventions. Children aged 8-13 with a dog in the household were surveyed on dog attachment (Pet Relationship Scale), perceived social support (Child and Adolescent Social Support Scale), and had height and weight measurements taken. A parent demographic survey was also conducted. Semi-structured interviews with child-parent dyads further investigated the child-dog relationship and perceptions about potential child-dog activity programs. The results of the survey showed that overweight/obese children ($\geq 85^{th}$ body mass index percentile) had greater attachment to their dog (p=0.039) and less perceived social support (p=0.016) compared to healthy weight children. Semi-structured interviews revealed that child-parent dyads were positive and enthusiastic about child-dog physical activity programs. Perceived barriers for programs included safety concerns in child-dog and dog-dog interactions. Perceived

facilitators for programs included components that strengthen the child-dog bond, such as the addition of education, behavior training, or agility components. In conclusion, overweight/obesity in children was associated with greater dog attachment and less perceived social support, supporting the concept that pet dogs play a different role in overweight/obese children's social support networks. Children and parent/legal guardians support child-dog activity programs that are safe and enrich the child-dog relationship. Future studies are warranted to evaluate the impact of including pet dogs as additional mental health support in novel childhood obesity interventions.

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BMI: Body Mass Index

CASSS: Child and Adolescent Social Support Scale

CPET: Children Parents and Pets Exercising Together

PPET: People and Pets Exercising Together

PRS: Pet Relationship Scale

Introduction

Childhood obesity has tripled in incidence in the past 3 decades, with almost 1 in 3 children aged 2-19 years being overweight or obese in 2012 (Ogden et al, 2012). Obese children are at high risk of being obese as adults with a concomitant increase in diabetes, orthopedic disease, and cardiac conditions (Whitaker et al, 1997). The medical, psychological, and economic impacts from obesity are staggering. For the first time, our current generation of children may have lower life expectancy while facing an ever-increasing economic burden due to costs associated with obesity (Wang et al, 2002). Additional challenges include anxiety, depression, and other mental health challenges, which may hinder obesity treatment (Vander Wal et al, 2011; Verdejo-Garcia et al, 2010). Given this health burden, it is imperative that childhood obesity be effectively managed and that treatment meets the unique needs of pediatric populations.

The development of effective and sustainable interventions to treat childhood obesity, and the mental health effects of obesity, remain both a priority and a challenge, as attrition in obesity interventions hampers success (Dhaliwal et al, 2014). Behavior modification within this population must be comprehensive and sustainable, which requires an element of enjoyment to maintain engagement (Epstein et al, 1998; Epstein et al, 2010; Alberga et al, 2013). For example, overweight children often prefer physically inactive activities like computer games or watching television (Maffeis, 2000; Kreuser et al, 2013).

Furthermore, systematic reviews note the limitations of existing evidence and most interventions focusing on physical activity alone have only modest and short-term impact (van Sluijs EMF et al, 2011; Dobbins et al, 2009; Reilly JJ et al, 2005). It is also

critical that children are provided with mental health assistance, such as social support, to provide enjoyment and motivation during weight management programs (Goldschmidt et al, 2014). Thus, one significant barrier to treating childhood obesity is designing comprehensive programs for children that are enjoyable, feasible, and sustainable.

Human-Animal Interaction

Interactions with pets or visitation from therapy animals has been associated with numerous mental and physical health benefits (Friedman et al, 2009). Children often demonstrate high levels of attachment to their pets and frequently consider them family members (Albert and Bulcroft, 1988). Human-animal interaction has been shown to improve sustained focus, emotional stability, attitudes towards learning, and progress on individual goals—essential qualities for establishing and maintaining lifestyle behavior changes (Barker et al, 2008).

Furthermore, human-animal interaction also has numerous mental health benefits (e.g., improved depression and anxiety) and physical health benefits (e.g., improved cortisol and blood pressure, Friedmann et al, 2009). When these benefits are applied to obesity interventions in adults, studies suggest that human-animal interaction has the potential to provide enjoyment, motivation, and increased physical activity (Wohlfarth et al, 2013; Kushner et al, 2006; Morrison et al, 2013).

In parallel to human obesity, pet obesity is also a serious and growing concern, with up to 60% of the United States cat and dog population being overweight or obese (Courcier, O'Higgins et al, 2010; Courcier, Thomson et al, 2010). There are many similarities in the treatment of dog and childhood obesity, including education on the

impacts of obesity on health, nutrition and physical activity behavior change, physical versus emotional hunger, and the influence of media on food selection.

Given these parallels, pet dogs have the potential to provide a positive impact if partnered with children who are overweight not only to provide social support, but also to potentially act as an indirect method of modelling healthy behavior without stigma (e.g., discussing how obesity can lead to diseases in dogs can illustrate the negative impact of obesity without inducing guilt or blame in children).

Furthermore, there is evidence to show that simply petting a dog can reduce stress and improve mood (Friedman et al, 2009), which could help children enjoy physical activity more. For example, children may not engage in physical activity for fear of peer ridicule, which could be mitigated by a program emphasizing a dog's non-judgmental attitude toward playing with them thus increasing their bond and positive mood.

A similar methodology of providing a non-judgmental atmosphere with dogs was used in a study evaluating a canine-assisted reading program in a school in a low socioeconomic community in South Africa (Le Roux et al, 2014). The authors did not look at health outcomes, however, the main objective of the study tested whether dogs could help to change attitudes about reading in children, which they hypothesized would lead to more enjoyment of reading and thus better reading skills for children treated with animal therapy. They specifically assessed changes in reading skills in children who were classified as poor readers after a 10-week program reading to dogs, then compared these changes to children who read to human volunteers and teddy bears. Reading comprehension was shown to be significantly improved for those in the canine-assisted reading group, which supported their hypothesis, and also highlights the different role

animals can play in providing a non-judgmental environment and social support, which may be unique from human and peer support. However, while promising, more work is warranted before pet dogs can be incorporated successfully as a psychosocial supportive aspect of a comprehensive intervention that includes diet, environment, and exercise to increase sustainable healthy behaviors in children.

This novel enhancement of including human-animal interaction in treatment programs could help address the need for comprehensive interventions that provide additional social support through the human-animal bond. Standard obesity interventions that focus on only one risk factor for obesity are not enough to promote significant and sustainable change in overweight children. Programs that simply focus on the tangible aspects of physical activity do not address the needs of the whole individual, which include psychosocial and physical health aspects (Epstein et al, 1998; Epstein et al, 2010). Additionally, successful programs for children must be fun and varied, individualized, and multidisciplinary in nature (Alberga et al, 2013). Human-animal interaction has the potential to fill this need in obesity interventions.

Human-animal interaction is an emerging field that intersects naturally with health and wellness interventions to provide a unique and engaging part of a comprehensive intervention for childhood obesity. Children consider pets members of the family, and pets can provide a trust and social support that is not always possible from human conspecifics, even friends or family members (Albert and Bulcroft, 1988). Building on this trust and enthusiasm, integrating dogs into comprehensive interventions could provide psychosocial support missing from many standard interventions in a truly novel and exciting approach.

Preliminary and Pilot Studies

        Preliminary studies are promising in the field of human-animal interaction with respect to obesity interventions. However, these preliminary studies did not show significant health benefits to participants potentially because the complexity of the human-animal relationship was not known nor integrated into the studies. Two feasibility studies have evaluated the effect of incorporating dogs into obesity interventions in adults or families. The Pets and People Exercising Together (PPET) study evaluated overweight adults and their dogs in a year-long joint physical activity intervention (Kushner et al, 2006). In children, the Children, Parents and Pets Exercising Together (CPET) exploratory study based in Scotland evaluated the feasibility of including pet dogs in a 10-week family-based physical activity intervention (Morrison et al, 2013). Both studies support feasibility of the concept of including dogs in physical activity programs and interventions. Additionally, both studies supported the notion that dogs can act as social support during the weight loss period. In the PPET study, consistent themes were that dogs acted as initiators, sources of enjoyment, and buddies supporting motivation and encouragement for participants. Focus groups in the CPET study highlighted that the children enjoyed taking part and they felt they increased their physical activity. Beyond feasibility, however, both studies failed to show clinically meaningful health benefits for participants such as weight loss improvement compared to those participating without dogs.

        Even though there is evidence to support the feasibility of dogs in obesity interventions, both the CPET and PPET studies only showed promising but not

statistically significant results. Treatment groups in which participants were paired with dogs did not have a statistically significant change in their body mass index (BMI) compared to the control group who did not engage their dog in the intervention. Additionally, the CPET study was designed to be a pilot study to assess feasibility, and not necessarily powered to explore and test this difference the way a randomized clinical trial would have.

What is lacking in the current literature is a comprehensive obesity intervention based on in-depth knowledge of the child-dog relationship. Systematic reviews of weight management programs show that focusing only on physical activity or dog walking does not provide the comprehensive intervention necessary for sustained change (Epstein et al, 1998; Epstein et al, 2010; Alberga et al, 2013). Both PPET and CPET implemented a physical activity program with dogs without prior in-depth study of the mechanism through which dogs would enable improvement beyond standard obesity programs. Therefore, what is needed is further investigation into the child-dog relationship and how exactly that relationship could and should be leveraged to provide improvement over currently available obesity treatment interventions.

The dog-owner therapeutic relationship has been initially explored in overweight adult populations, and preliminary studies suggest that overweight adults have different relationships with dogs compared to healthy weight adults. One study found that overweight dog owners had less perceived social support and were more attached to dogs than healthy weight individuals (Stephens et al, 2012). However, this has not been studied in overweight children.

To further understand the child-dog relationship, preliminary data was collected through a currently established adolescent weight management program. This program enrolls adolescent children who are overweight (BMI percentile $\geq 85^{th}$ percentile) with a comorbidity or obese (BMI percentile $\geq 95^{th}$ percentile). Children aged 11-18 participate in a 2-hour, 10-week structured group program that helps them practice healthy eating and physical activity habits. Preliminary information was obtained from participants who had pet dogs in this program to help design the current study. When given a modified Lexington Attachment to Pets Scale survey (Johnson et al, 1992), participants had a median score of 4.15 (standard deviation, 0.53), where 1: Strongly disagree and 5: Strongly agree to questions such as 'My animal understands me' and 'I confide in my animal.' Although there was no control group in this preliminary assessment, the strong bond between overweight children and their dogs is supported by these data.

These preliminary data supported the design of the current study to further assess the child-dog relationship, how it differs between overweight and healthy weight children, and to investigate how this bond might have the potential to assist in healthy lifestyle interventions to increase efficacy of obesity treatment. The published studies mentioned and our preliminary data support the need for more psychosocial support in overweight individuals and suggest that dogs may provide that support due to a strong human-animal bond. Although this need is more clearly identified in adults, it is not well-studied beyond preliminary data in children. In addition, unique challenges associated with incorporating dogs into obesity interventions with children have not been studied. Therefore, more in-depth knowledge is needed to understand the child-dog

relationship and how relationships with dogs may be leveraged to increase physical activity in children, especially those children who are overweight/obese.

Study Objectives

Therefore, the **goal** of the study was to improve knowledge of the child-dog relationship to inform future childhood obesity interventions with the following specific aims:

Specific Aim 1: To increase knowledge of the child-dog relationship in overweight/obese and healthy weight children, we evaluated the associations between body mass index (BMI) percentile (categorized dichotomously into overweight/obese and healthy weight status), dog attachment, and perceived social support.

> Hypothesis 1: We hypothesized that children's weight status would be positively associated with dog attachment and negatively associated with perceived social support.
>
> Hypothesis 2: We hypothesized that perceived social support would be negatively associated with dog attachment.

Specific Aim 2: To further examine the child-dog relationship, we performed semi-structured interviews to develop a conceptual framework of factors which are influential to the child-dog relationship in healthy weight and overweight/obese children.

Specific Aim 3: To explore strategies for and perceptions of future childhood obesity interventions, we performed semi-structured interviews in healthy weight and overweight/obese children and their parent/legal guardians.

Materials and Methods

Rationale for Study Methods

The current study utilized a sequential mixed-methods study design. A quantitative component was conducted with a cross-sectional survey study, followed by a qualitative component with semi-structured interviews. The quantitative component allowed for initial hypothesis testing and informed the sampling framework of the qualitative component (i.e., if a significant difference was seen between overweight/obese and healthy weight children, then weight status would be taken into account for determining appropriate dyads to enroll). Sequential mixed-methods study designs similar to those in the current study have been successfully applied in a population of children aged 9-11 years in the United Kingdom to inform pediatric health interventions with animals in previous studies (Morrison et al, 2013).

The rationale for a sequential, mixed methods study was to facilitate complementary analyses that leverage the strengths of the respective methods and develop a broad knowledge base of the child-dog relationship. The quantitative surveys allowed for hypothesis testing and provided information on dog attachment and perceived social support in children. Finally, the qualitative and quantitative components both provided information to enhance future studies, not only in the generation of new hypotheses, but also to develop an intervention program that best incorporates dogs to increase healthy behaviors in overweight/obese children.

Quantitative Component

Children aged 8-13 that visited the Boston Museum of Science with their parent or legal guardian between the months of April 2015 through October 2015 during data collection sessions were eligible to participate in the study. There were age requirements, but no gender or weight requirements. Exclusion criteria included children without a dog in the household at the time of the study or children visiting the museum without a parent/legal guardian (e.g., with a school trip). Additionally, children and parent/legal guardians who were not fluent in English or could not understand the assent and consent form without the help of a translator were excluded. Ethical approval was obtained from the Social, Behavioral and Educational Institutional Review Board of Tufts University and the Ethical Review Board of the Museum of Science.

The quantitative component of the study was conducted at the Boston Museum of Science Living Laboratory. This program allows for children who visit the museum with their parent/legal guardian to actively participate in research projects and learn about the research process. Data collection sessions occurred for 3 hours per week on a weekday in the spring and summer and a weekend day in the fall. As visitors walked by one section of the museum, the Living Laboratory, they were approached by study investigators, who explained the purpose of the Living Laboratory, summarized the study and protocol and asked if they would like to participate (if eligible). Children filled out surveys on dog attachment [modified Pet Relationship Scale (PRS), Lago et al, 1988] and perceived social support [Child and Adolescent Social Support Scale (CASSS), Malecki et al, 2002]. The PRS is a 22-item rating scale with a Likert-type format (from Strongly Disagree to Strongly Agree) that consists of three subscales measuring affectionate

companionship, equal family member status, and mutual physical activity (Lago et al, 1988). Subscales were scored by summing the Likert responses for each respective subscale; a total score combining all three subscales was then calculated to determine overall dog attachment. Participants were asked to answer this part of the survey with respect to their favorite pet dog (if they owned more than one). The CASSS is a 40-item scale measuring perceived social support from four sources: parent/legal guardians, teachers, classmates, and friends. For the purposes of this study, only relationships that occur year-round, the parent/legal guardians and friends subscales, were evaluated. Children responded by rating each item on frequency ratings, which included a six-point Likert scale from one (never) to six (always). Parent/legal guardian and close friend subscale scores were calculated by summing these respective frequency ratings, and then a total score combining both subscales was calculated to determine overall perceived social support. The CASSS has been validated for children aged 8-13, but the PRS has not. Therefore, the PRS was reviewed for readability for the target age group and modified for child-appropriate wording adjustments.

Child height and weight was also measured. Weight was measured in a semi-private manner to provide respect for privacy of information but not a removal from sight completely that might imply shame of the process. A stadiometer (Seca Model 213 Portable Stadiometer Height-Rod, Seca North America, Chino, CA, USA) measured height, and weight was captured by a blinded scale (Seca Clara Model 803 Digital Personal Scale, Seca North America, Chino, CA, USA) and recorded without visibility for visitors, though height and weight data recorded was shared with children and parent/legal guardians privately if requested. As a part of the study, parent/legal

guardians completed a brief demographic survey which included information on household information such as family income, number of children and pets in household, and pet demographic information..

Data are presented as mean ±standard deviation for normally distributed data and median (range) for data without a normal distribution, which was assessed graphically. All statistical analysis was performed using SPSS v.22.0 (IBM Corp., Armonk, NY, USA). The primary analysis for the study was assessing the association between weight status and dog attachment score. Body mass index percentile was calculated using the Center for Disease Control's BMI Percentile Calculator for Child and Teen Metric Version (Center for Disease Control, 2015). Weight status was defined by each participant's BMI percentile, which was categorized into two groups: overweight/obese ($\geq 85^{th}$ BMI percentile) and healthy weight children ($< 85^{th}$ BMI percentile). The primary analysis was performed using a two-sample independent t-test. Demographic data were compared between the overweight/obese and healthy weight groups using Mann Whitney U tests (for continuous data) and Chi-square tests (or Fisher's exact tests for variables with small cell size). Ordinal data was assessed for trend by using the Linear-by-Linear Association test. A p value <0.05 was considered statistically significant.

Secondary analysis assessed the association between weight status and perceived social support, as well as the association between dog attachment and perceived social support. Weight status was again defined by each participant's BMI percentile and categorized into overweight/obese and healthy weight groups. Comparisons of dog attachment and total and subscale perceived social support between the groups of healthy weight and overweight/obese children were performed using two-sample independent t-

tests. Associations between dog attachment and perceived social support (total and parent/legal guardian and close friend subscales) were analyzed using Pearson correlation.

An *a priori* power analysis was performed. Based on internal data from the Museum of Science, it was estimated that 30% of the visiting demographic was overweight/obese. Therefore a calculation was performed for unequal group sizes. A two-sided, two-sample t-test with group sample sizes of 247 healthy weight and 106 overweight/obese children achieved 80% power to detect a 5% difference in mean dog attachment score with a 0.05 significance level (alpha). The coefficient of variation was calculated conservatively as 0.2 based on information from previous validation studies using the PRS (Lago et al, 1988), which revealed a mean score of 21 and a standard deviation of 4.5. A previous study in 75 adults comparing BMI with dog attachment found a correlation with an r=-0.27 (Stephens et al, 2012). Using this anticipated r, 91 participants total would provide 80% power to detect a similar result. To obtain a sample size of 353 participants, it was planned to enroll an average of three child participants per hour in the Museum of Science Living Laboratory over the course of 48 weekly sessions of three hours each. Lower than expected enrollment rates prompted an unplanned interim analysis in October 2015, which was intended to generate a new sample size calculation and consider the addition of alternate sites to the study. Limitations of such an interim analysis which can increase the Type I error rate was considered by the primary investigator and discussed with the thesis committee. While the interim analysis unexpectedly found statistically significant results with a considerably smaller sample size (n=44) then calculated (n=353), the consensus of the committee was to cease data

collection and end the quantitative component of the study. This decision was based on the rationale that the original power analysis was performed as conservatively as possible and that a previous study in an adult population had statistically significant results with a similar participant size (n=75; Stephens et al, 2012).

Qualitative Component

Findings from the quantitative component informed the sampling framework of the qualitative component (i.e., the appropriate groups of dyads to enroll). As a result of the findings of significant differences between the overweight/obese and healthy weight children, two groups of children aged 8-13 who had a dog in the household were recruited to participate along with their parent/legal guardian (n=15 dyads per group): healthy weight children (BMI < 85th BMI percentile) and overweight/obese children (BMI ≥ 85th BMI percentile). Participants from the quantitative portion of the study conducted at the Museum of Science were notified that they were also eligible for future interview studies; however, no participants were enrolled from that recruitment strategy. The preplanned alternative recruitment strategy was then initiated, in which referral sampling, specifically snowball sampling and word of mouth, was utilized. A recruitment advertisement was developed and spread online through social media, in particular the Cummings School of Veterinary Medicine Facebook page. The post was shared by 620 people and had 46,900 views. Within 24 hours, over 200 interested parties had emailed expressing interest. All interested individuals were emailed a description of the study and a link to an eligibility screener. Over 180 interested parent/legal guardians completed the eligibility screener (a response rate of over 90%), which was a modified version of the

parent/legal guardian demographic survey used for the quantitative component at the Museum of Science. Self-report height and weight of the child was included in the eligibility screener and was used to determine weight status for enrollment (where healthy weight children were BMI < 85th BMI percentile and overweight/obese children were BMI ≥ 85th BMI percentile). From the eligibility screener, 15 overweight/obese children and 15 healthy weight children and their parent/legal guardians were invited to participate in interviews. Selection was based on keeping gender and age ratios equal between the groups and invitations were sent in order of response based on this self-report data from the eligibility screener (e.g., the first response with an 8 year old girl, then 8 year old boy, etc., were invited from both healthy weight and overweight/obese groups to represent each age from 8 to 13 years of age). All of those invited participated in the study with the exception of five families who had scheduling conflicts. Five additional families were invited to fill the remaining spots based on demographic information and in order of response, similar to the original invitees. Demographic information was confirmed and height and weight was measured in person at the interview.

The qualitative component included both semi-structured interviews and observations in the form of videotaped interview of each dyad consisting of the child, parent (no legal guardians enrolled in this component), and dog (i.e., 30 interviews were conducted, each with a child, parent, and dog).

The qualitative component of the study included semi-structured interviews that lasted approximately one hour and included questions for both the parent and the child. Interviews were performed in an examination room in the Foster Hospital for

Small Animals at Cummings School of Veterinary Medicine at Tufts University. The qualitative interviews included domains that were chosen to meet the goals of the study, which were (1) to develop a conceptual framework of factors which are influential to the child-dog relationship in healthy weight and overweight/obese children and (2) to explore strategies for and perceptions of future childhood obesity interventions. These domains included strength and quality of the child-dog relationship, perspectives on incorporating dogs into physical activity programs, and perceived facilitators and barriers to physical activity programs incorporating dogs. Interview questions were based on previous studies in similar fields of human-animal interaction and child physical activity programs. After the first 12 interviews, emergent themes were identified and incorporated into the interview guide for the remaining participants.

Participant observation was also conducted. Dogs were present at the interview with the child and parent and while there was no structured activity, behavioral observation was used to note interaction between the child, parent, and dog (e.g., child pet the dog, child looked to the dog when answering a question, etc.). This behavioral observation data collection was modified from an animal ethogram used to determine human-animal interaction in therapy dog visitations. The animal ethogram was originally developed by the American Humane Association for use in the Canines in Child Cancer Study, where behavior between therapy dogs and patients was recorded. It was modified by the addition of counts of behaviors because the current observation was longer in duration (one hour instead of 20 minutes) and the addition of behaviors based on the author's clinical experience as a veterinarian and member of an animal-assisted therapy

organization. The interviews were videotaped to allow for completion of the ethogram after the interviews were completed.

Audio files were transcribed by a professional transcription service and reviewed by the principal investigator for accuracy. Transcripts were coded by the principal investigator as well as by a research assistant with experience in qualitative data analysis. Coding was conducted using structural codes determined *a priori* coupled with emerging thematic coding (Barbour, 2001). Structural codes mirrored the structured questions in the interview guide. These codes included the domains: strength and quality of the child-dog relationship, child and parent perception of incorporating dogs into physical activity programs, and child and parent perception of facilitators and barriers to physical activity programs incorporating dogs. Additionally, emergent thematic coding was added, which included information that was unexpected and found through inductive analysis (e.g., educational component, or concern for dog safety, etc.). A subset of interviews (n = 3, 10%) was used to develop the final codebook by the principal investigator and research assistant. Once this codebook was finalized, a systematic analysis of all data from the interviews was performed by the principal investigator and research assistant using a consensus and constant comparison approach (Barbour, 2001; Armstrong, 1997). Inter-rater reliability was used for comparison between coding researchers (kappa = 0.76) with the software Dedoose v.6.2.21(SocioCultural Research Consultants, LLC, Manhattan Beach, CA, USA) and remaining discrepancies were resolved through consensus approach (Lombard et al, 2002). For participant observation from videos, counts and frequency of

behaviors noted in the interviews were compared between overweight/obese and healthy weight children and their parents.

Quantitative and Qualitative Ethical Considerations

As this was a one-time cross-sectional survey study for the quantitative component and a one-time interview for the qualitative component, and because parent/legal guardians were present with the children at all parts of the study, there was minimal anticipated risk to the participants. However, given their vulnerable status as children, additional precautions were taken to ensure parent/legal guardian informed consent and child assent. Ethical approval was obtained from the Social, Behavioral and Educational Institutional Review Board of Tufts University and the Ethical Review Board of the Museum of Science. Though compensation was not allowed by the Museum of Science, a reasonable stipend in the form of a $65 gift card was given to families for their time and travel to participate in the semi-structured interviews, which were conducted at Cummings School of Veterinary Medicine at Tufts University, in North Grafton, Massachusetts, a 45 minute drive outside of the Museum of Science site in Boston, Massachusetts.

Results

Quantitative Component

Of the 44 total child participants in the cross-sectional survey at the Museum of Science, 27% (n=12) were categorized as overweight/obese ($\geq 85^{th}$ BMI percentile) and 73% (n=32) were categorized as healthy weight ($< 85^{th}$ BMI percentile), Table 1. Child characteristics (child age, number of children in the household) were similar between the two groups, and participants in both groups were predominately female (overweight/obese group [92%, n=11], healthy weight group [66%, n=21]). Dog characteristics (dog neuter status, dog breed, dog gender, and parent/legal guardian-perceived body condition of the dog) were similar between the two groups, with the exception of older dogs in the overweight/obese group (p=0.002). Parent/legal guardian-reported demographics (parent/legal guardian age, parent/legal guardian race, family income) were also similar between groups, with the exception of parent/legal guardian education level, where the most common education level achieved in the overweight/obese group was high school (33%, n=4) and in the healthy weight group, all participants (100%, n=32; p=0.002) had achieved advanced degrees (Bachelor's degree or above). Ordinal data (family income) was assessed to have no trend by the Linear-by-Linear Association test (p=0.179).

Table 1. Subject characteristics of the quantitative cross-sectional survey participants expressed in median (range) or count (percentage) between overweight/obese and healthy weight groups.

Variable	Overweight/Obese	Healthy Weight	*P* value
n	12	32	---
Child Characteristics			
Body Mass Index	24.2 (19.7-35.4)	16.8 (14.8-20.6)	---
Body Mass Index Percentile	95.4 (88.6-99.2)	50.8 (3.4-84.0)	---
Age	10.5 (8-12)	11 (8-13)	0.765
Gender			
Male	1 (8%)	11 (34%)	0.132
Number of Children in the Household			0.153
1	3 (25%)	4 (13%)	
2	7 (58%)	20 (63%)	
3	0 (0%)	7 (22%)	
4	1 (8%)	1 (3%)	
5	1 (8%)	0 (0%)	
Parent/Legal Guardian Characteristics			
Age	46 (36-61)	43 (36-54)	0.193
Education Level			0.002
Some High School	0 (0%)	0 (0%)	
High School/GED	4 (33%)	0 (0%)	
Bachelor's Degree	3 (25%)	18 (56%)	
Master's/PhD/Doctorate	5 (42%)	14 (44%)	
Household Yearly Income Level			0.321

Less than $10,000	0 (0%)	0 (0%)	
$10,000-$29,999	1 (11%)	0 (0%)	
$30,000-$49,999	0 (0%)	1 (3%)	
$50,000-$74,999	1 (11%)	3 (9%)	
$75,000-$99,999	2 (22%)	4 (13%)	
$100,000+	5 (56%)	24 (75%)	
Race			0.375
White	12 (100%)	30 (94%)	
Hispanic/Latino	0 (0%)	0 (0%)	
Black/African American	0 (0%)	0 (0%)	
Native American	0 (0%)	0 (0%)	
Asian/Pacific Islander	0 (0%)	0 (0%)	
Other	0 (0%)	2 (6%)	

Dog Characteristics

Age	6.5 (4-11)	3 (1-14)	0.002
Number of Dogs in the Household			0.152
1	10 (91%)	23 (72%)	
2	0 (0%)	8 (25%)	
3	1 (9%)	1 (3%)	
Breed			
Purebred	3 (25%)	12 (38%)	0.500
Gender			

Male	5 (42%)	11 (36%)	0.707
Neuter Status			
Neutered	12 (100%)	27 (87%)	0.563
Owner-Perceived Dog Body Condition			0.246
Underweight	0 (0%)	1 (3%)	
Ideal Weight	8 (67%)	27 (84%)	
Overweight	4 (33%)	4 (13%)	

Overweight/obese children had significantly greater mean dog attachment scores compared to healthy weight children (p=0.039), Table 2. Overweight/obese children also had significantly lower mean total perceived social support scores compared to healthy weight children (p=0.016). On secondary analysis, when parent/legal guardian and subscales were evaluated separately, overweight/obese children had significantly lower mean perceived social support from close friends compared to healthy weight children (p=0.015). However, there was not a statistically significant difference in perceived social support from parent/legal guardians between overweight/obese children and healthy weight children (p=0.172). There also were no statistically significant correlations between dog attachment score and total perceived social support (r=-0.011, p=0.943), nor between dog attachment score and the parent/legal guardian or close friend subscales (r=0.005, p=0.976; r=-0.026, p=0.864, respectively).

Table 2. Comparison of mean dog attachment scores and perceived social support between overweight/obese and healthy weight children.

Variable (mean)	Overweight/Obese	Healthy Weight	*P* value
n	12	32	---
Dog Attachment Score	73.1±5.6	68.6±7.1	0.039
(Pet Relationship Scale; Lago et al, 1988)			
Perceived Social Support Scores			
(Child and Adolescent Social Support Scale; Malecki et al, 2002)			
Total Score	110.5±13.5	122.7±14.6	0.016
Parent/Legal Guardian Subscale	62.0±8.1	58.3±7.8	0.172
Close Friend Subscale	52.2±9.5	60.7±9.1	0.015

Qualitative Component

Based on the eligibility screener, participants were invited with the intent to achieve equal ratios of child age, BMI group (healthy or obese/overweight), and gender. Other demographic information was not considered in the selection process. Though similar between groups, 1:1 ratios were not achieved in all demographic categories due to inaccurate information from the eligibility screener (i.e., parents incorrectly reporting their child's gender or age, or reporting inaccurate height or weight of their child, which led to misclassification of their weight status upon invitation, though accurate information was obtained at the time of the interview). Of the 30 total child participants in the interview component, 40% (n=12) were categorized as overweight/obese (≥85th BMI percentile) and 60% (n=18) were categorized as healthy weight (<85th BMI

percentile), Table 3. Child, parent, and dog characteristics were similar between the two groups, with the exception of household income, with a higher yearly family income in the healthy weight group (p=0.012).

Table 3. Subject characteristics of the qualitative interview participants expressed in median (range) or count (percentage) between overweight/obese and healthy weight groups.

Variable	Overweight/Obese	Healthy Weight	*P* value
n	12	18	---
Child Characteristics			
Body Mass Index	24.3 (18.8-30.4)	17.4 (14.9-22.4)	---
Body Mass Index Percentile	96.3 (86.5-98.7)	61.9 (7.9-84.2)	---
Age	10.0 (8-13)	10.5 (8-13)	0.950
Gender			
Male	7 (58%)	9 (50%)	0.654
Number of Children in the Household			0.618
1	4 (33%)	4 (22%)	
2	6 (50%)	7 (39%)	
3	2 (17%)	4 (22%)	
4	0 (0%)	1 (6%)	
5	0 (0%)	2 (11%)	

Parent/Legal Guardian Characteristics

Education Level			0.277
Some High School	0 (0%)	0 (0%)	
High School/GED	4 (33%)	2 (11%)	
Bachelor's Degree	6 (50%)	10 (56%)	
Master's/PhD/Doctorate	2 (17%)	6 (33%)	
Household Yearly Income Level			0.012
Less than $10,000	0 (0%)	0 (0%)	
$10,000-$29,999	0 (0%)	0 (0%)	
$30,000-$49,999	1 (8%)	1 (6%)	
$50,000-$74,999	6 (50%)	1 (6%)	
$75,000-$99,999	3 (25%)	3 (17%)	
$100,000+	2 (17%)	13 (72%)	
Race			0.213
White	11 (92%)	18 (100%)	
Hispanic/Latino	0 (0%)	0 (0%)	
Black/African American	0 (0%)	0 (0%)	
Native American	0 (0%)	0 (0%)	
Asian/Pacific Islander	1 (8%)	0 (0%)	
Other	0 (0%)	0 (0%)	

Dog Characteristics

Age	3 (1-13)	4 (1-14)	0.787

Number of Dogs			0.307
1	5 (42%)	13 (72%)	
2	5 (42%)	4 (22%)	
3	1 (8%)	1 (6%)	
4	0 (0%)	0 (0%)	
5	0 (0%)	0 (0%)	
6	1 (8%)	0 (0%)	
Breed			
Purebred	8 (67%)	11 (61%)	1.000
Gender			
Male	3 (25%)	8 (44%)	0.440
Neuter Status			
Neutered	12 (100%)	17 (94%)	1.000
Owner-Perceived Dog Body Condition			0.329
Underweight	0 (0%)	1 (6%)	
Ideal Weight	8 (100%)	15 (83%)	
Overweight	0 (0%)	2 (11%)	

The first aim of this component of the study was to develop a conceptual framework of factors which are influential to the child-dog relationship in healthy weight and overweight/obese children. Overall, the child-dog relationship was very strong in both overweight/obese and healthy weight children and reflected a positive influence in the child's life, with 28/30 (93%) children noting that their pet made

them feel 'happy', further explained by one child:

> My dog, most of the time whenever I see his little face, I just can't
> help but smile all the time. He makes me happy, joyful, all the
> names of happy, he is that to me. (Boy, aged 10, overweight/obese
> group)

Children in both the healthy weight and overweight/obese groups described their pet as having a positive influence in their life and displayed a strong bond to their pet when describing their relationship. Both overweight/obese and healthy weight children described a strong emotional component to their relationship with their pet. One girl described how she and her pet understood each other's emotional state:

> She knows. If I come home and I'm sad she definitely knows, or if I'm
> angry or if I'm happy she definitely knows. I can tell when she's sad
> because she'll be acting differently and stuff. We're close. (Girl, aged 13,
> overweight/obese group)

Furthermore, children expressed that they perceived their pet to be a source of comfort and safety. One child noted that their dog provided physical protection as well as emotional support:

> He makes me feel really comfortable because like I said when he's
> so protective he makes me feel like no one could ever be able to
> get into our house. He makes me feel safe and happy. (Boy, aged
> 12, overweight/obese group)

Lastly, an emergent theme that was described by both healthy weight and overweight/obese children is the role of emotional support and unconditional love that their pets provide them. When asked what one girl liked about her dog, she

replied:

>That she'll always love you. (Girl, aged 9, overweight/obese group)

Another boy noted the role of emotional support his dog provides when he faces challenges:

>Life is just so much easier with him. Because you find something wrong. He's there. He won't move. He'll just lay there, 'You're going to give me a belly rub?' I don't care what's wrong. (Boy, aged 13, healthy weight group)

There was not an observable difference between healthy and overweight/obese children, and children from both groups reported their dogs provided companionship, love, and emotional support.

In describing the child-dog relationship, child-parent dyads reported various physical and non-physical activities that the children engaged in with their pets. The types and ways in which children actively played with their pets was quite varied, from more typical responses such as walking with their dog to activities not as commonly regarded as exercise, such as wrestling with the dog or with toys as one child described:

>He'd grab the hula hoop and he'd just pull it around the yard and we tried to chase him and get it back from him. (Girl, aged 10, healthy weight group)

Some children noted they enjoyed walking their dog, while others reported they did not like it because it was boring or because it was difficult to control their dog on a leash. There was no observed difference between responses of overweight/obese and

healthy weight children on dog walking.

Non-physical activities included dogs sleeping in children's beds, children reading to or with their dogs, and children providing a caregiver role, such as feeding or cleaning up after their dog. Furthermore, pet preference and the health condition of the dog often dictated the activities children engaged in with their dogs. One child-parent dyad described their geriatric dog's activities:

Child: She used to play. She doesn't anymore.
Parent: She's getting old now, so cuddling is probably her main activity.
Child: Yeah. That's pretty much it.
Interviewer: And how often do you do that with your dog?
Child: Everyday, 24/7.
(Girl, aged 9, healthy weight group)

Children enjoyed both physical and non-physical activities with their dogs, and these activities were part of the conceptual framework of factors that influenced the child-dog relationship.

The observational data from videos further supported the findings from the interviews. Healthy weight children, overweight/obese children, and their parents displayed many affectionate behaviors towards their dogs during the videotaped interviews. These behaviors displayed by both children and parents included activities such as talking to the dog, giving a treat or water to the dog, smiling at the dog, or petting the dog. Almost all parents (27/30, 90%) and children (28/30, 93%) interacted with their dog during the interview by petting them. There was no observed difference in affectionate behaviors displayed between weight groups.

The second aim of the qualitative component was to explore strategies for and perceptions of future childhood obesity interventions as described by healthy weight

and overweight/obese children and their parents. This aim was achieved by obtaining (1) barriers and perceived harms of an intervention, (2) facilitators and perceived benefits of an intervention, and (3) stakeholder intervention preferences, acknowledging children and their parents would be key stakeholders in such a program.

1. Barriers and Perceived Harms of Intervention

The most commonly reported barriers are listed in Table 4. All child-parent dyads, regardless of weight status, cited safety concerns for their dog as a barrier to a child-dog program (30/30, 100%). The most common safety concern was dog-dog aggression (29/30, 97%). Other frequently noted concerns included dogs getting loose (13/30, 43%), medical concerns for the dog due to over-exercising or engaging in physical activities that may be harmful to the pet (including exercise during weather extremes) (13/30, 43%), and breed concerns, such as large breed dogs causing intentional or unintentional injury to small dogs (11/30, 37%). One child participant noted concerns over her older dog:

> The only thing I'd worry about is his age being 12. I'd want to make
> sure that nothing happened to him during the program. I just want him
> to have fun and think, "Oh can I do this every day?" (Boy, aged 10,
> overweight/obese group)

Though not associated with pet safety, almost all children (24/30, 80%), regardless of weight status, noted barriers that involved their pet's preference, such as not wanting to engage in the program if they felt their dog wouldn't like the program or components of the program. For example, one girl noted she would prefer an outdoor

location with a lot of space based on her dog's preference:

> Probably more an outdoor community type thing…my dog can get kinda claustrophobic or like doesn't really enjoy being inside a place where she doesn't really know. (Girl, aged 12, healthy weight group)

Additional concerns that were mentioned by only a few participants included concern for disabled dogs or dogs with current medical conditions participating in such a program.

A commonly cited barrier among parents of both healthy weight and overweight/obese children was child safety concerns (24/30, 80%), particularly child-dog interaction which might result in injury such as dog bites (23/30, 77%). As one parent noted, child-dog interactions can be unpredictable:

> I had mentioned the safety thing. Again, you get a bunch of unknowns in the room with animals, no matter how well trained they are… (Parent of boy, aged 12, healthy weight group)

Almost all child-parent dyads, again regardless of weight status, noted logistical concerns as barriers to a child-dog program, such as scheduling (27/30, 90%) or, to a lesser extent, potential cost (5/30, 17%). One parent noted a sentiment mentioned by many participants that their lives are already very busy:

> Yeah. I think families that have so many like sports are such a focus. And everybody's running everywhere. That it's hard for families to set aside time unless it was really something to draw them in. (Parent of girl, aged 8, healthy weight group)

Additional concerns mentioned by a few participants included unsafe locations such as busy roads or unenclosed areas and children's physical activity limitations such as

asthma, allergies to dogs, and peanut allergy (an ingredient in some dog treats). One

barrier noted for the safety of both children and dogs was fear of communicable

disease if children or dogs were not vaccinated.

There were only two observed differences between healthy weight and

overweight/obese child-parent dyads with respect to barriers to a child-dog program.

More child-parent dyads of overweight/obese children (6/12, 50%) cited social

concerns as barriers to the child-dog program, while only 1 healthy weight child-

parent dyad (1/18, 6%) cited social concerns. This 1 healthy weight child reported

concerns about others perceiving their dog as not well trained as a barrier.

Overweight/obese child-parent dyads cited concerns over bullying, not wanting a

wide range of participants or genders participating, sibling rivalry concerns, and

parents wanting background checks from those would be interacting with their child.

One parent brought up potential for positive or negative interaction between children

in a social context:

> Being involved with others and have that interaction with others is
> always positive, unless, like they both get bullied. So that would be a
> negative outcome. (Parent of boy, aged 12, overweight/obese group)

The second observed difference between healthy weight and overweight/obese dyads

was when children were asked if they would prefer to have their friends join them in

the program or if they were prefer this to be alone time with their dog. More

overweight/obese children (4/12, 33%) did *not* want to have friends join them in the

program than healthy weight children (2/18, 11%); in other words, the

overweight/obese children were more likely to say that they would want a program

where it was just them and their dog. Healthy weight children cited safety concerns

for their dog as the reason for not wanting to participate in a group setting, while the

overweight/obese children who provided a reason noted that it was because they

specifically wanted more alone time with just their pet. One child in the

overweight/obese group further explained his reason for wanting time with his dog

instead of friends:

> My friend might say "Oh I don't think I want to do this because that
> doesn't seem fun or anything"…I'd do it for my dog, not just because of
> my friends…friends are family but then your dog would come first before
> your friends. (Boy, aged 12, overweight/obese group)

Perceived harms of the intervention were collapsed into the code for barriers as

all harms were noted as barriers as well and included child and dog safety concerns

exclusively.

2. Facilitators and Perceived Benefits of the Intervention

All children, regardless of weight status, had a positive response to the idea of a

program in which they would engage in healthy behaviors and physical activities with

their dog (30/30, 100%). The most commonly reported facilitators are shown in Table 4.

A noteworthy emergent theme for facilitators to such a program included an educational

component. All child-parent dyads, again regardless of weight status, stated that a

program which included a learning component would encourage them to participate

(30/30, 100%). Common topics participants cited as examples of possible learning

components included pet training (27/30, 90%), pet health and care information (19/30,

63%), and agility skills with their pet (16/30, 53%). One child described what types of

education she would want from a program:

> Learning about your dog more; learning how to take care of them, learning what they are like, their personalities, what they like to do, what you guys would like to do together, how to spend time with them that is enjoyable from both viewpoints, both perspectives; that would be good. (Girl, aged 13, overweight/obese group)

Many parents expressed an interest in engaging educational activities that strengthen the child-dog bond (Table 4). As one parent described:

> If his relationship with his dog would be even stronger than it already is, I would like that. There's something special that would be like between them, you know, and it would just be like, just build the relationship and strengthen the bond and get them active. (Parent of boy, aged 13, overweight/obese group)

Two additional emergent themes included pet preferences and variety/options in the program. Almost all (27/30, 90%) of child-parent dyads expressed facilitators to the program would be things they thought their dog would want, and one child noted he would want to do any type of program based on his pet's preference:

> It's up to my dog if she wants to do it. If she likes it and I don't know if I actually like it, then it's more about my dog and if she likes it. (Boy, aged 9, overweight/obese group)

Many child-parent dyads (13/30, 43%) noted that they would like to see variety in the program, particularly options or individualization due to their pet's needs, such as a medical condition or older age. There was no observed difference in facilitators between parents and children, or between healthy weight and overweight/obese children.

The strongest emergent theme throughout the interviews was the strong bond between children and their dogs, irrespective of weight status. Almost all child-parent dyads (27/30, 90%) cited a stronger bond between the child and the dog as a positive aspect of the program. When asked what the child would get as being a part of the program, one parent described:

> Take care of the dog. So it creates a stronger bond between them two. Well, then, you know, the program either through games or activities builds a stronger relationship. (Parent of boy, aged 12, overweight/obese group)

Other benefits of the program included perceived benefits to the dog's health by getting exercise (14/30, 47%), and parents of both overweight/obese and healthy weight children (9/30, 30%) noted that the program would increase their child's responsibility in the care of the dog. One child explained her reasoning for being in the program was for the benefits her dog would receive:

> The best reward would be your dog being fit. I don't think you need anything but having a loving relationship with your dog is enough. (Girl, aged 10, overweight/obese group)

The one difference found in term of perceived benefits between weight groups was perceptions on the impact of the intervention on children's health. Parents of overweight/obese and healthy weight children differed in their perception of the benefit to the child's health by getting exercise: more parents of overweight/obese children (7/12, 58%) noted this was a benefit of the program compared to parents of healthy weight children (4/18, 22%). Conversely, more healthy weight *children* perceived benefits to their health through exercise in the program (5/18, 28%) compared to only 1 child in the

overweight/obese group who noted perceived benefit; that is, more parents of overweight/obese children thought the program would be a benefit to their child's health through exercise, while and more healthy weight children cited exercise in the program as a benefit to their health.

3. Stakeholder Intervention Preferences

Respondents expressed a variety of preferences for the pragmatic aspects of a child-dog program. The preferred duration, frequency, and location for the program varied between both overweight/obese and healthy weight children and their parents, without any observed trends. Duration ranged from 15 minutes to a week-long camp experience, and frequency ranged from every day to a few times a year. Location was also varied and included indoor and outdoor locations, and different location preferences if the program was in the summer or winter months. When asked how families could be compensated for participating in the program, many respondents (16/30, 53%) reported that no compensation was necessary and that participating in the program itself was reward enough. When asked if there was something tangible they might want, (23/30, 77%) most preferred something for their pet, whether it be a dog toy or a gift card to a pet store. One child noted the time spent with the dog in the program would be the best reward:

> I would think it would be me getting a chance to be even closer with my
> dog, which I think is greater than any million dollar prize or anything.
> (Boy, aged 10, overweight/obese group)

The variation of responses highlighted convenience as a stakeholder preference in

terms of time and cost logistical concerns, though again, the child-dog bond was

highlighted as an emergent theme, even when discussing compensation and

preferences.

Discussion

The aims of the current study were (1) to evaluate the associations between weight status, dog attachment, and perceived social support, (2) to develop a conceptual framework of factors which are influential to the child-dog relationship, and (3) to explore strategies for and perceptions of future childhood obesity interventions. The findings of the current study support that overweight/obese had greater mean attachment to their dog and less perceived social support compared to healthy weight children, while there was no correlation found between dog attachment and perceived social support. A conceptual framework of factors that emerged from the child-parent dyad interviews included influences on the child-dog relationship such as the positive impact that the relationship had on the children, physical and non-physical activities that children and dogs engage in together, and the emotional support and perceived unconditional love that dogs provide to children. Perceptions of future interventions were positive and enthusiastic about child-dog physical activity programs. Strategies for future intervention included addressing perceived barriers such as safety concerns in child-dog and dog-dog interactions and highlighting perceived facilitators such as the addition of education, behavior training, or agility components that would strengthen the child-dog bond. Findings of the current study support the concept that partnering children and dogs might be useful for childhood obesity interventions. In addition, the results provide important information from stakeholders on how pet dogs could be included as social support which could potentially improve recruitment and attrition for such programs.

Results of the primary analysis supported the hypothesis that overweight/obese children are more attached to their pet dogs than healthy weight children. This finding is

consistent with a study in adults that found overweight adults were more attached to their pet dogs than healthy weight adults (Stephens et al, 2012). The mechanism behind this association is unknown, but it has been speculated that pet dogs may serve as a surrogate support network for their owners, particularly when the owners have less perceived social support from peers (Stephens et al, 2012). For example, in a study assessing a physical activity intervention for adult pet owners and their dogs participants reported themes of 'buddy' and 'consistent initiator' when describing the role of their dog in the intervention (Kushner et al, 2006). While sample size precludes adjustment of this potential confounder, it should be noted that dogs in the overweight group were older than those in the healthy weight group. Another consideration in interpretation of these results would include length of time the children had the dogs in the household affecting their attachment, where the overweight children had older dogs which presumably meant the children had longer duration of time with them. However, further studies are warranted to address this factor as older age of the dog does not necessarily equate to duration of dog ownership, as dogs can be adopted at any age.

The potential mechanism of a surrogate support network is supported by the secondary findings in the current study, as well as other childhood obesity literature, in which overweight/obese children have less perceived social support and other negative impacts on quality of life and peer networks compared to healthy weight children (Buttitta et al, 2014). Though the perceived social support results of this study are similar to findings in the childhood obesity literature, this is the first study to assess both dog attachment and perceived social support in the same population of children. Childhood obesity has been associated with numerous mental health concerns as well as a social

stigma. This concept of the social consequences of obesity is consistent with the findings in this and other studies where overweight children report less perceived social support from peers. However, because dog attachment was also measured in the same population, this study highlights a potential mechanism that explains a higher dog attachment in overweight/obese children, in which dogs could be taking the place of peer social support due to the unconditional love that children report is provided by their dogs.

Provision of a surrogate support network may be a rather complex mechanism, which could explain the results of the secondary analysis which was unable to identify a significant correlation between dog attachment and perceived social support in this population of children. This finding did not support the initial hypothesis that there would be a negative association between these two factors. Future studies with a larger sample size could be designed to address potential nuances of the complex support network in children and also whether an association between dog attachment and perceived social support differs in healthy weight and overweight/obese populations.

The qualitative component of the study, the semi-structured interviews with children and their parents, generated important information from stakeholders on how pet dogs could be included in child-dog programs and further understanding about the child-dog relationship. Noteworthy emergent themes regarding the child-dog relationship highlighted the strength of the bond between children and their dogs, regardless of weight status. Within this theme, dogs were described by children as providing emotional support, unconditional love, comfort, and safety. These emergent findings further define the results from the quantitative component of the study, however, the qualitative results support that both overweight/obese and healthy weight children described their dog as

emotionally reassuring. This was supported by observational data from the interviews that showed overweight/obese and healthy weight children both exhibited affectionate behaviors toward their dogs during the interview. This discrepancy where the quantitative results showed a greater distinction between overweight/obese and healthy weight children's dog attachment than the qualitative results could be explained by a strong attachment between healthy weight children and their dogs, but overweight/obese having an even stronger attachment. Another possible explanation is that the children and parents self-selected to be in the qualitative interviews and therefore may represent children that all have strong attachment to dogs. Lastly, while the qualitative interviews provide descriptive information about the child-dog relationship, the study was not designed to delineate possible nuanced levels of dog attachment between the groups in the same manner that a scored attachment measurement was able to in the quantitative component of the study.

Of note is that varied activities that defined children's relationship with their dogs. While previous studies piloting child-dog walking programs did not show statistically significant results, those studies only focused on walking to increase physical activity. Based on the emergent findings in interviews from the current study, both overweight/obese and healthy weight children engaged in physical activity with their dogs in many ways beyond walking. Additionally, factors such as the child perceiving walking as boring, having a dog that is hard to control on the leash, or a dog that cannot easily walk far due to health restrictions could impact the perceived benefit of dog-walking-only program. Addressing the varied activities was also reported in the interviews as facilitators to program. This suggests that interventions that address the

many ways in which children interact physically and non-physically with their dogs should be considered.

The barriers to programs described by both children and parents, such as safety in child-dog interactions and dog-dog interactions, should also be addressed in future child-dog programs. Potential approaches include veterinary screening of dogs to avoid enrolling those with medical issues, separating dogs into large and small breed groups, or developing programs for children and their dogs one-on-one for additional safety precautions. The fact that many parents reported scheduling as a barrier suggests that individual sessions or personalized programs would be important to address.

Factors reported by the participants that would facilitate an overweight/obesity program incorporating dogs support many previous findings, in which parents and children supported the idea of the program and felt the pet and the child would benefit from receiving exercise and improve their health. However, the current study was able to obtain information not gathered from previous studies, which further describes children and parents' interest in having programs that are varied or personalized, as well as engaging children in novel methods, such as educational components which strengthen the child-dog bond. This has not previously been incorporated into a child-dog obesity intervention and could prove to be useful for improving outcomes. As children noted, they engaged with their pet physically in many ways beyond walking, and future pilot programs could assess if educational components foster enthusiasm and provide motivation for children to stay in programs and continue healthy behaviors after the conclusion of programs for increased sustainability.

Differences noted in the qualitative interviews between the overweight/obese and healthy weight groups could explain some of the findings from the quantitative portion of the study about dog attachment and perceived social support. While both overweight/obese and healthy weight children described strong emotional bonds with their dogs, healthy weight children appeared to include dogs in their social support group along with other people, while overweight/obese children appeared to replace peers with their dogs for social support. This could potentially be due to the unconditional love and non-judgmental attitude provided by dogs described by many in the child-dog relationship portion of the interview. Further studies are warranted to better describe how overweight/obese children view their dogs and their friends as part of their support network. Interventions could leverage this relationship to possibly broaden and increase children's ability to interact and form positive relationships with their peers by having their dogs with them as social support and providing a common interest among participants.

A strength of the quantitative component of the study is the involvement with the Museum of Science Living Laboratory. Due to the nature of the study design, individuals who may never have considered participating in research were invited and had the opportunity to provide data on a subset of the population that has not previously been evaluated. While the Museum of Science does allow for a more varied socioeconomic background, it only reflects those parent/legal guardians who chose to visit a museum focusing on science education, which is a value that not all families in the greater Boston area may share or be able to afford. However, demographic results showed that a variety of individuals from varied socioeconomic backgrounds participated, which suggests that

the results may reflect the general population of the children in the greater Boston area who have dogs in their households.

A strength of the qualitative component of the study was the strong interest in enrollment, and the ability to screen interested individuals to have participants of every age from 8-13 and controllable ratios of gender and weight status. Social media as a recruitment tool should be considered for future studies and for intervention programs due to the positive response in this particular study, as well as response from participants that that is the method they would want to be contacted in the future for such programs.

In addition to the strengths of the current study, there are also limitations that are important to note. The eligibility criteria for the quantitative component of the study led to lower than expected enrollment numbers. Many children were visiting the museum with a school group or summer camp group without a parent/legal guardian or legal guardian present, which excluded them from participation in the study. Having a data collection on a weekday in the spring while school is typically in session also led to lower than anticipated eligible participate. Other reasons for ineligibility were visitors outside the age range of 8-13 years of age and families without dogs. Refusal rate was not calculated and refusal rationale was not asked. However, many families voluntarily noted time and other scheduled activities, such as seeing a film in the museum theatre, as reasons for not wanting to participate even if eligible. Additionally, if only one child in a family or group was eligible, some participants voluntarily noted they did not want to participate alone and others in the group often opted not to wait (e.g., impatient or crying younger siblings). This lower than expected enrollment led to an unplanned interim analysis, which was intended to generate a new sample size calculation and consider the

addition of alternate sites to the study. Though the interim analysis provided statistically significant results, these results should be interpreted with caution as unplanned analyses can increase the type-I error. However, this risk is highest when investigators request formal analysis after they already informally see a potential treatment difference (Pocock et al, 1986). Due to the nature of the study, study investigators were not able to note a clinical difference, as would be possible in a clinical trial, and thus the intention of the unplanned analysis was not to confirm a potential informally noted finding, lowering this cause of risk. Furthermore, the original power analysis was performed very conservatively and resulted in a much higher sample size (n=353), then was necessary in a previous study that addressed this association in adults (n=75, Stephens et al, 2012). While the enrollment is considerably smaller than the original sample size calculated and results should be interpreted with caution due to this early cessation of the study, comparison to previous studies and a conservation calculation may lessen concern about the sample size bias. Nonetheless, additional research with larger populations is warranted to confirm these results.

The children were categorized for analysis and for the interviews into healthy weight and overweight/obese dichotomous groups. This does not allow for distinction between overweight and obese children. The study was not designed to analyze subgroups within each weight category. However, given the differences noted between the groups, future studies could investigate whether overweight and obese children have differences in attachment to dogs, perceived social support, or in their preferences for a child-dog program.

Another limitation of the quantitative component of the study is the specific age range selected for this study, 8-13 year old children, and the requirement for a dog in the household, which limits the generalization of the results to a broader group of children outside this age range and without dogs. Early interventions for childhood obesity are recommended, and children aged 8-13 years are commonly targeted. This age range is our target population for future interventions to maximize the number of activities that children are able to do with their dogs, but minimize the effects of puberty and gender disparities in social support as children enter middle school. Additionally, this greater Boston geographic location is also within the anticipated target population for planned future interventions. Future studies could expand the study population to consider other companion animals that serve as pets and potential social support, as well as larger age ranges, and a larger geographic population.

A limitation of the qualitative component of the study is the pre-determined sample size of 15 child-parent dyads per weight group for interviews, instead of sampling until saturation of themes. Interviews were completed before analysis could be initiated in order to capitalize on the success and interest in online recruitment, though this could be a limitation in that more dyads than necessary may been interviewed with this method. An additional limitation is modification of the behavioral observation data collection based on author experience, which weakens the validity of this method. While this is a limitation, no other validated ethograms exist for observational data collection between children and their pets, therefore, this modified method could be used and further validated in future studies. Another limitation for the qualiatative component of the study is the potential bias for enrollment. Those who volunteer for this type of study are self-

selecting and thus may represent a population of families that has a strong child-dog attachment. Additionally, children without dogs (either by family choice, losing a dog to illness, or medical restrictions such as allergies) were not represented in this sampling. However, the target population of a future intervention would include children who have a strong relationship with dogs currently in their household and thus the results from this component of the study are still useful in defining future interventions.

Conclusions and Future Directions

Overall, the study findings reveal that dogs play an important role in the social support network of children, particularly in overweight/obese children. The findings support the concept of incorporating dogs into childhood obesity interventions, but results also show the importance of tailoring programs to the special relationship each child has with his or her dog. Safety concerns, such as separating out small and large breed dogs, or pre-screening animals, is important to alleviate fears of parents and children over perceived harms of such an interventions. Variety and enhanced programming that strengthens the child-dog bond should be incorporated into programs to address the many ways in which children interact with their dogs in active and healthy ways. The positive response from participants as well as the interest shown by the general public to participate in the interviews support stakeholder enthusiasm and potential for including dogs in future interventions and studies to better understand the child-dog relationship. Given the positive reception and positive support that dogs provide for both healthy weight and overweight/obese children, future studies could determine the role of dogs in weight loss interventions or preventive programs to encourage more physical activity for

all children. However, the concept supported by the current study, that dogs play a different role in the social network of overweight/obese children, warrant pilot studies specifically addressing the potential impact of dogs on overweight/obese children in weight loss interventions. Future childhood obesity interventions incorporating dogs could have the potential to improve enthusiasm, motivation, and health impact on participants if designed with consideration for the complex, but also intensely positive relationship between children and their dogs.

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