The Great Outdoors: Fenced Yards and Their Impact on Companion Dog Activity and Adoption

Lauren Tsao

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Erica N. Feuerbacher (Chair)

Christy L. Hoffman

Allison Andrukonis

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ABSTRACT

Despite the prevalence of requiring a fenced yard to adopt a dog in the United States, there is little research investigating this adoption policy or its impact on companion dog welfare and behavior. Using observational methods, previous studies have shown dogs engage in a variety of behaviors while in their yards. However, differences in their activity levels when they are in the yard versus when they are not have not been measured through more objective means. In this study, I first conducted an analysis of publicly available data from the pet adoption website, PetFinder.com to show how many United States rescues/shelters are requiring fenced yards to adopt a dog. In the second part of the study, I fitted AX3 accelerometers to 12 companion dogs with regular fenced yard access to investigate the activity levels of dogs when in a fenced yard and when not in a fenced yard. The results indicate that shelters and rescues required fenced yards for dog adoption in over 20% of the United States adoption profiles analyzed and that fenced yard access increased dog activity level in some dog participants.

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DEDICATION

I dedicate this thesis to the four strongest souls I have ever known. First and foremost, my beloved project dog, Beretta. My continued pursuit of further education in the field of animal behavior is completely her fault. Next, my paternal grandfather, Bobby Jack “PawPaw” Parks and my maternal grandmother, Oda Louise Elliot “MawMaw” Pendergrass who both taught me to show kindness and tenderness to all animals. Finally, my friend and teacher, Liza “Liz” Martin whose life was cut short by cancer. She is my daily inspiration to persevere in the face of uncertainty.

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INTRODUCTION

1.1 United States Shelter and Rescue Statistics & Policies

The American Society for the Prevention of Cruelty to Animals (ASPCA) estimates that approximately 3.1 million dogs enter United States shelters annually. Each year approximately 390,000 of these shelter dogs are euthanized and 2 million are adopted (ASPCA, 2019). According to the American Pet Products Association (APPA), there are 78 million dogs owned in the United States, with 44% of households owning a dog. Of these dogs, 23% are obtained from shelters, while 34% are purchased from breeders. The ASPCA's National Rehoming Survey results show that pet problems (e.g., aggressive behaviors, growing larger than expected, and health problems) are the most common reasons for rehoming a dog and accounted for 47% of rehomed dogs (ASPCA, 2019).

Given the high number of dogs euthanized in United States shelters (ASPCA, 2019), understanding what factors enhance or hinder dog adoption and adoption retention is critical. Extensive research on dog-centric factors that can impact adoptions has been conducted. Appearance (e.g., Siettou et al., 2014; Protopopova & Wynne, 2016), size (e.g., Weiss et al., 2012; Brown et al., 2013; Siettou et al., 2014), and age (e.g., Weiss et al., 2012; Brown et al., 2013; Siettou et al., 2014) have all been found to be important considerations for dog adoption. Additionally, a dog's behavior can impact adoption. For example, some in-shelter behaviors are correlated with longer lengths of shelter stay. Dogs presenting back and forth motion, leaning or rubbing on enclosure walls, facing away from possible adopters, or making contact with the enclosure, increased a dog's length of stay at the shelter (Protopopova et al., 2014). Furthermore, Protopopova & Wynne (2014) discovered that adopters report not adopting certain dogs because they deemed the dogs too active. Given this information it is not surprising that return rates can

be affected by a dog's activity level too. Wells and Hepper (2000) found that 90% of adopters at a Northern Ireland shelter reported a behavioral problem within the first month of adoption, which led to them returning the dog. The two most common behavioral problems cited were hyperactivity and fearfulness, which were also common reasons for relinquishment in a separate study (New et al., 2000).

Adoption satisfaction and retention are commonly attributed to the aspects of the new pet, like the pet's personality, compatibility, and behavior, rather than adopter demographic differences, type/location of home, or the adoption setting (Neidhart & Boyd, 2002; Duxbury et al., 2003). However, adopter-centric factors and policies can impact adoption success as well. Owner behavior and traits found to correlate with increased adoption retention and owner attachment are the duration of time spent with the dog, co-sleeping with the dog, and whether or not the owner and dog have complementing personalities (Neidhart & Boyd, 2002; Curb et al., 2015; Väätäjä et al., 2021). While spending quality time with the dog and being able to appreciate the individual dog for who they are seem to be important, education of adopters could also be promising in increasing adoption success. Neidhart & Boyd (2002) conducted surveys over a one-year period with dog and cat owners who had adopted their pets in three different settings: a Luv-A-Pet location, an Adopt-a-thon, or a traditional shelter. Their findings suggest that factors that improved adopter perception of their new pets and the adoption process in general included the shelter providing educational information about pet health and behaviors and adoption counseling (Neidhart & Boyd, 2002). However, mixed results with adopter education have been reported (Weng et al., 2006; Gunter et al., 2017).

Another possible avenue for increasing adoption retention could be adopters attending training classes with their new dog. Puppies that attend socialization classes before four months

of age have been reported to stay in their adoptive homes more often than those that have not (Duxbury et al., 2003). However, no effect was reported if the dogs were older than four months (Duxbury et al., 2003), which suggests that socialization during critical periods for puppies might be an important component to reducing relinquishment as well. Furthermore, owners who received behavior and training information from a veterinary behaviorist reported fewer undesirable behaviors like house soiling, mouthing, and aggression directed towards dogs and people (Gazzano et al., 2008).

Given that both dog and adopter factors play into successful adoptions, how we make appropriate matches (Curb et al., 2015) could be more important for adoption retention than using demographics or location (Neidhart & Boyd, 2002; Duxbury et al., 2003) to approve adopters. A study on adopter selection found 31 characteristics that could exclude a person from adoption, but only eight of those characteristics had evidence supporting them in the scientific lecture relating to human safety risk and risk factors for relinquishment (Griffin et al., 2020). Pre-adoption home visits were the most commonly used method to determine who would be a suitable adopter, while self-administered questionnaires were the most standardized method (Griffin et al., 2020). Despite these policies and exclusions being common, it is possible they are not having the intended impact on adoption retention because they have not been confirmed as truly problematic adopter characteristics. With 390,000 dogs being euthanized yearly in the United States (ASPCA, 2019), ensuring that the factors used to exclude a person from adopting are useful and not excluding appropriate adopters is critical. Of the 31 characteristics, 23 of them have no scientific evidence supporting them (Griffin et al., 2020). The scientifically backed eight characteristics were related to human safety and risk of relinquishment. Out of these characteristics for adoption exclusion, four were related to having children or having children of certain ages. The

remaining four were related to limited financial means, living in a flat or apartment, being under 21 years old, and having no outdoor kennels or buildings/dog must live indoors. Not a single scientifically backed characteristic could be associated with dog welfare (Griffin et al., 2020). Further, studies surrounding return rate of adopted dogs report 14%-15% of dogs being returned (Diesel et al., 2010; Marston et al., 2004), which suggests that improvements could be made in identifying adopter characteristics for improved retention as well.

One adopter characteristic category that was found to have no scientific backing, but was required most often by United Kingdom (UK) dog rehoming organizations, was the yard-related characteristic category (Griffin et al., 2020). Sometimes the organizations additionally required specific fence heights ranging from four to five feet to approve an adopter for dog adoption (Griffin et al., 2020). However, the prevalence of United States fenced yard requirements is unknown given that the prevalence of yard requirements has not been collected in any of the United States shelter/rescue data collection efforts. There are many possible pros and cons concerning fenced yard requirements' impacts on owner retention and satisfaction, dog welfare, and owner-dog relationship. Previous research has reported that 91.2% of the 2,806 dogs the researchers documented being surrendered to shelters had a yard and only 5.9% did not (Diesel et al., 2010), which implies that yard access alone may not be the key to increase adoption retention. While fenced yard access might provide enrichment opportunities for the dog (Kobelt et al., 2007) and it is also reasonable to assume that fenced yards provide an extra layer of escape prevention, it has been documented that fenced yard access might have negative welfare impacts as well. Yard access has been linked to negative impacts on the amount and type of exercise the dog receives (Robertson, 2003; Kobelt et al., 2003; Schofield et al., 2005; Tatschl et al., 2006; Scheibeck et al., 2011) and higher obesity rates in comparison to dogs who are walked (Bland et al., 2008).

This begs the question as to whether some shelter policies and adopter requirements are positively or negatively affecting dog adoption rates. If the bar for adoption is set too high, it is possible that potential adopters might find other avenues for acquiring a pet, such as a breeder or pet store. Successfully identifying which adopter characteristics correlate with adoption retention is a key component to designing more effective adoption programs for dogs and their adopters, but these findings (Griffin et al., 2020) suggest we have yet to fully understand how best to do this.

1.2 Dog Activity Levels

A Google search of PetFinder.com/dog/ (which will search only the dog category of PetFinder) for the search terms “highly active”, “high energy”, “energetic”, and “hyper” collectively returns 29,700 results. Many of these same results make mention of a fenced yard requirement for approved adoption. These results could imply that shelters and rescues have fenced yard requirements because they are attempting to place dogs that they believe to be highly active into homes that can provide physical activity for these dogs easily, though whether this approach provides the desired outcomes has not been established.

Clearly, identifying certain behaviors in dogs up for adoption, such as activity level, is a necessary part of the adoption process. However, human accuracy when it comes to self-reporting our own activity levels varies (Fjeldsoe, 2012). It is possible that people are similarly inaccurate when observing dog activity levels because a study investigating dog ADHD-like (attention-deficit/hyperactivity disorder) symptoms found that dog trainers and owners only moderately agreed on individual dog ratings for hyperactivity/impulsivity (Csibra et al., 2022). Adding further difficulty to assessing dog activity level, both high and low activity levels have been linked to stress in shelter dogs (Jones, 2010), which could interfere with accurate assessment in a shelter

setting and suggest that shelter assessments may not accurately predict behavior in the home. This could indicate that current shelter/rescue methods of assessing dog activity level are flawed and could lead to inaccurate labeling of dogs. Additionally, whether or not an animal is too active or inactive is a rather subjective notion which could vary from person to person, making it challenging to rank and measure in a way that is useful to adopters.

Not only is it difficult to assess activity level by merely observing dogs, dog activity level is a far more complex subject than one would first assume. To date, research has indicated that dog activity levels are influenced by a multitude of factors like breed (Hoppe et al., 2017; Pickup et al., 2017; Hall et al., 2021; Li et al., 2022), sex (Li et al., 2022; Csibra et al., 2022; Salonen et al., 2022), neuter status (Hoppe et al., 2017; Griss et al., 2021), age (Siwak et al., 2003; Brown et al., 2010; Griss et al., 2021; Csibra et al., 2022; Li et al., 2022), physical fitness (Brown et al., 2010; Morrison et al., 2014; Griss et al., 2021), diet (Zanghi et al., 2012), training level (Csibra et al., 2022), environmental influences like weather, temperature, season, and foliage (Kobelt et al., 2007; Temple et al., 2011; Hall et al., 2021; Li et al., 2022), time of day (Delude, 1986; Adams et al., 1995; Dow et al., 2009; Zanghi et al., 2012; Piccione et al., 2012, 2014; Banerjee & Bhandra, 2019; Hoffman et al., 2019; Woods et al., 2020; Griss et al., 2021, Li et al., 2022), and human/animal presence (Hughes et al., 1989; Aslaksen & Aukrust, 2003; Frank et al., 2007; Kobelt et al., 2007; Dow et al., 2009; Vestrum, 2009; Rehn & Keeling, 2011; Piccione et al., 2012, 2014; Hoppe et al., 2017; Griss et al., 2021; Li et al., 2022). Even disorders similar to human attention deficit hyperactivity disorder (ADHD) (Hejjas et al., 2007; Hejjas et al., 2009; Vas et al., 2010; Hoppe et al., 2017; Bonvicini et al., 2020; Sulkama et al., 2021; Csibra et al., 2022; Salonen et al., 2022) and obsessive-compulsive disorder (OCD; Overall, 2000; Tang et al., 2014; Noh et al., 2017) are being investigated in dogs and could affect activity levels. Additionally,

there are other possible factors that impact dog activity that have not been thoroughly researched yet like yard access, kennel/crate usage, neighboring humans/animals, barrier frustration, and even fencing material (i.e., fencing giving more or less outside visual access).

Not only is dog activity level impacted by many variables we cannot easily modify, increasing and decreasing dog activity purposefully is a slippery slope, making matching owner-dog activity levels a possibly important factor for successful adoptions. Previous research has reported the more active a dog is, the higher their owner reported perceiving dog attachment to at least one family member, dog attentiveness, continuous companionship of the dog, and time spent together relaxing (Väätäjä et al., 2021). Dog walking (Panizzolo & Sergi, 2019) has also been reported to decrease some problematic behaviors and has been negatively correlated with problem behaviors like hyperactivity and barking (Kobelt et al., 2003) in some dogs, but the owner is an active participant during dog walking unlike fenced yard access.

In contrast, a positive correlation between walks and ADHD-like symptoms in dogs has been reported, which could suggest that leash walking could cause overstimulation and problematic side effects in some dogs, especially those who are already overtly active or that the owners of these dogs rely on leash walking more often (Hoppe et al., 2017). Therefore, it is worth considering whether matching dogs and owners based on similar activity levels could be beneficial to both parties. Uncovering whether or not owner presence or additional activity is helpful for dogs will be a challenging problem to solve because dog activity level increases in human presence, (Hughes et al., 1989; Aslaksen & Aukrust, 2003; Frank et al., 2007; Kobelt et al., 2007; Dow et al., 2009; Vestrum, 2009; Rehn & Keeling, 2011; Piccione et al., 2012, 2014; Hoppe et al., 2017; Griss et al., 2021; Li et al., 2022) making it challenging to assess these factors separately from one another. Studying dog activity during fenced yard access could possibly unravel

this question because dogs can reasonably participate in this activity with or without their owner present.

1.3 Fenced Yards and Their Impacts on Dog Behavior

To determine whether requiring a fenced yard for dog adoption is beneficial, we should evaluate how and if yards are used when available, and their effects on dog behavior and welfare. Past research suggests that most dogs are exercised away from their home and own yard (Schofield et al., 2005; Tatschl et al., 2006), with one study reporting only 12% of dogs are exercised in their own backyards (Robertson, 2003). This could imply that owners are rarely using their yards to exercise their dogs. There is concern that dog owners with yards might be using fenced yard access as their dog's only form of outside world contact and that this could result in negative behavioral consequences (Thornton, K. C., 2007). Former San Francisco SPCA president Jan Mchugh-Smith stated her concerns about fenced yard requirements: ""[Some organizations] have this mandatory fence policy when really what's the best quality time you can spend with your dog? On a leash, walking your dog, giving your dog exercise and you getting exercise and training your dog. So, I always worry that by having policies like requiring a fenced yard, are we sending that wrong message of having your dog live in the backyard?" (Thornton, K. C., 2007).

In line with these thoughts, Wójcik and Powierża (2021) compared housing conditions and undesirable behaviors in ancient dog breeds and found that dogs living indoors with backyard access had a higher percentage of owner-reported aggressive behavior, when compared to those living indoors, outdoors unconfined, and confined to an outdoor kennel. Additional undesirable behaviors were most common in dogs living indoors without backyard access (47.19%)

and those living indoors with backyard access (46.98%), which suggests that occasional yard access did not have a great effect on improving behavior (Wójcik and Powierża, 2021). However, it should be noted that owner bias could play a role in these results. It is possible that owners of dogs living solely outdoors were less likely to notice certain behaviors in their dogs simply because they were not present when the behaviors occurred. Other past research has reported owner-reported behavioral concerns in Labrador retrievers with regular yard access which included digging, chewing, and jumping up on people, although the frequency of these owner-reported behaviors was found to be low (Kobelt et al., 2007).

According to Wójcik and Powierża (2021) their ancient breed behavior findings could be attributed to housing conditions, like dogs living indoors and dogs living indoors with backyard access. These housing conditions may allow limited living space that led to low levels of physical activity. This could imply that physical activity and larger living space positively impact at least some behaviors that owners may find undesirable, like excessive barking. However, the study did not measure physical activity which makes drawing these conclusions more difficult, as the relative activity levels of these different dog populations is still unknown. Wójcik and Powierża (2021) further explain this decrease in barking was possibly due to indoor dogs with backyard access and outside dogs having more stimulating environments.

Further complicating matters, in contrast, other research findings (Kobelt et al., 2007) suggest that larger yards with more foliage increase barking. Additionally, dogs moved from smaller enclosures to larger ones display increased activity, barking, social interaction, and exploration (Normando et al., 2014). In direct conflict with all the results aforementioned, another study found that size of enclosure did not significantly affect dog behavior (Hefts et al., 1992). The conflict between the current research we have makes drawing many connections between

yard access and behavioral impacts challenging and leaves us with additional questions that need to be answered before drawing conclusions.

In regards to dog health and exercise, there is little known about the impacts of fenced yard access. However, dogs confined to yards as their exercise regime, rather than walked, are significantly more likely to be overweight (Bland et al., 2008). Additionally, dogs with yards are less likely to get leash walks (Kobelt et al., 2003, 2007; Scheibeck et al., 2011); consequently, dogs with yards may be less likely to get the reported benefits of leash walking, like decreased barking and decreased hyperactivity.

While dogs' physical health does not seem to benefit from yard access, it is possible that having a yard could still be beneficial if it serves as environmental enrichment. Kobelt et al. (2007) reported larger yards with more foliage were related to increased yard exploring in Labrador retrievers. The hypothesis that larger yards increase exploration is further supported by other findings that suggest dogs moved from smaller areas to bigger areas display more exploration and social interaction (Normando et al., 2014). While we cannot separate out yard-size from foliage amount using the study results (Kobelt et al., 2007), it is possible that increased exploration was at least partly due to more foliage, which could trap additional odors or attract more wildlife, all of which could provide additional enrichment.

The impact of yards on dog behavior and welfare might be affected by the presence or absence of the owner in the yard as well. Kobelt et al. (2007) suggested that dogs were more active in the backyard if humans were present, but did not find this same effect with the presence of other dogs. More specifically, dogs were also more likely to play, even when with another dog, if a human was present, and peaks in dog activity correlated with peaks in human activity (Kobelt et al., 2007). This is in harmony with other research showing dog activity levels increase

in human presence (Hughes et al., 1989, Dow et al., 2009; Piccione et al., 2012, 2014; Griss et al., 2021; Li et al., 2022) and decrease when the dog is home alone (Aslaksen & Aukrust, 2003; Frank et al., 2007; Vestrum, 2009; Rehn & Keeling, 2011).

While these studies give us some insight on how yard access might impact dog behavior and welfare, there is not enough information to paint a clear picture at this point. There is also a fair amount of missing puzzle pieces, like how do owners actually utilize fenced yards when it comes to dog ownership (i.e., how long do dogs stay outside each day and do owners tend to stay outside with their dog) and if we objectively measured dog activity in yards instead, how might this impact our results. The variety in research results and variables measured shows that this topic is likely just as complex as general dog activity. Far more research and information are needed to draw firm conclusions on how fenced yards impact behavior in dogs as individuals and as a group.

Based on our current knowledge, it could be more beneficial to focus on the amount of time the adopter is willing to spend with the dog instead of fenced yard ownership. More owner-active activities such as dog walking (Kobelt et al., 2003; Bland et al., 2008; Westgarth et al., 2014; Panizzolo & Sergi, 2019), dog sports participation (Baldwin & Norris, 1999; Hultsman, 2012; Farrell et al., 2015; Zilocchi et al., 2016), training classes, and/or other enrichment activities (Clark & Boyer, 1993; Jagoe & Serpell, 1996; Duxbury et al., 2003; Bennet & Rohlf, 2007; Gazzano et al., 2008; Hakanen et al., 2020; Puurenen et al., 2020; Fernandez, 2022) are already correlated with behavioral, social, and/or health benefits in companion dogs. Therefore, we should consider whether we are excluding adopters who are willing to provide these activities in exchange for adopters with access to an environment which has not been shown to necessarily increase dog welfare. With the small amount of knowledge, we have on fenced yards and their

impacts on dog ownership, welfare, and adoption retention, assumptions about whether or not fenced yard ownership makes someone a more ideal adopter should be made with caution.

The purpose of this study was to 1) identity the percentage of United States shelters and rescues applying fenced yard requirements, and 2) evaluate how fenced yards are used by dogs that have access to them, and to quantify dog activity levels when in their fenced yard and when not in their fenced yard, as well as how time of day, and day of the week impacts activity levels. I collected activity level data from companion dogs with fenced yard access using accelerometers, while owners kept logs of their dogs' daily activities, to record when they were or were not in the yard.

METHODS

2.1 PetFinder Fenced Yard Requirement Data Collection

To determine the prevalence of yard requirements for adoptions, I collected data from 4,940 United States PetFinder.com dog adoption profiles and analyzed how many shelters/rescues were requiring fenced yards for adoption of dogs. I collected data from 10 different shelters/rescues listed on PetFinder in each of the 50 United States from February 10th, 2022 through April 22nd, 2022. I turned off PetFinder's "Out-of-Town" search feature to further ensure that dogs were not being counted twice because they were listed in two or more states at a time.

From each of these shelters/rescues, I analyzed 100 dog adoption profiles that included a description and photo of the dog for any fenced yard requirements. The only exception is Hawaii which had 40 profiles collected because Hawaii only had four shelters listed on PetFinder. I divided this data into three categories; profiles that required a fenced yard for adoption, profiles that mentioned there was no yard requirement for adoption, and profiles that did not mention either way. I also analyzed the shelter/rescue's PetFinder profile description to ensure they did not list any fenced yard related requirements there. I considered profiles with a fenced yard requirement profiles with statements like, "For this dog, a fenced yard is must.", "A secure yard is required.", or in the case of profiles written from the dog's perspective stating, "I would do best in a home with a fenced yard." I also included profiles requiring certain fence heights and profiles that stated no apartments would be considered for that specific dog. It should be noted that the no-apartment listings only accounted for a total of six of the fenced yard required adoption profiles.

For profiles that specifically stated that the dog could live in an apartment setting or did not require a fenced yard, they were included in the count of no-yard requirement. All other profiles in the "did not mention" category were listed as such because I did not check individual shelter/rescue websites or contact the shelters/rescues to confirm if there were truly no requirements to adopt that specific dog. So, it is possible these dogs also had requirements which were not mentioned on their PetFinder profiles. Additionally, I collected reasons shelters and rescues gave within the profiles for requiring fenced yards when applicable, as well as any specific fence height requirements mentioned.

After collecting this data, I calculated the percentages of adoption profiles that fell into each of the three categories, as well as how many shelters/rescues had at least one profile listed with a fenced yard requirement. Additionally, I divided the United States into four regions (Southern, Northeast, Midwest, and Western) using the US Census format and individual states to further analyze the data to see if state or region made any difference in the case of fenced yard requirements.

2.2 Recruitment

With the input of focus groups, members of which were professional dog trainers, dog owners, veterinarians, and other canine researchers, I created the Research Interest Questionnaire (See Table 1). The focus groups of two to four members met twice in order to develop a questionnaire which would help raise awareness to a dog participant's fitness for this specific study, which would allow for dogs to be excluded from the study should they not meet criteria. This questionnaire was used in recruitment and given to all owners to help determine if their dog met the study criteria based on the dog's age, location, fenced yard access, and health status. To be included, the dogs had to 1) be healthy with no pre-existing medical conditions that could affect

their ability to exercise; 2) have access to a fenced yard; 3) have no contraindications to daily physical activity; and 4) be comfortable wearing collars. I recruited participants from a variety of sources including dog training facilities, dog daycare facilities, veterinary clinics, and social media across the state of Mississippi in the United States.

The Research Interest Questionnaire consisted of 22 questions relating to 1) the dog's routine and environment; 2) the dog's daily behaviors; 3) any medical concerns that could keep the dog from performing certain activities, such as exercise or wearing a collar; 4) any behavioral disorders their dog has been diagnosed with by a veterinary professional; and 5) contact information for the owner. After the questionnaire was launched, sixteen completed questionnaires on sixteen dogs were submitted by their owners, fourteen of which were entered into the study after meeting criteria, and twelve dogs completed the study. Of the participants, two dogs were removed from the study due to one dog receiving a diagnosis for heart worms and the second dog's usual routine being interrupted due to inclement weather during their data collection period.

2.3 Accelerometers and Behavior Logs

After the owner completed the Research Interest Questionnaire and their dog was determined to be eligible for the study, each owner received an Axivity (Newcastle upon Tyne, UK) accelerometer and an email on how to mount the accelerometer collars on their dogs properly. I attached the Axivity accelerometers to nylon collars using duct tape, with the Axivity logo side up. Each owner was instructed to put the collar onto their dog immediately after delivery to ensure maximum data collection and battery life for the 14-day period. The owner placed the collar onto their dog allowing room for two fingers under the collar, as suggested in previous research using these accelerometers for recording dog activity (Martin et al., 2016; Onsen et al., 2016). I

recorded activity for 14 days for each dog. One week into having the devices, I contacted participants to make sure the accelerometers were charged, if necessary. In order to do this, the duct tape on the collars was folded in a way in which participants could unfold the tape on one end without removing the accelerometer from the collar. The USB end on the device was marked on the tape so, participants knew which end to unfold to plug in the device charger. This step was only required of four participants who received the devices over long distances or in the mail to ensure the battery would remain charged through the two-week data collection period. Once two weeks of data were collected, participants mailed the accelerometers back to me or set up a time for me to collect the device.

While the dogs wore the activity monitors, owners were required to maintain two logs. In one, they noted any time their dog went into their fenced yard (and when they left the fenced yard). Due to the accelerometers only recording activity data, this log was needed to understand when the dog was in the fenced yard and when they were not, so the data could be analyzed by location of the dog. In the second log, owners noted any time they removed the accelerometer collars for specific reasons like bathing their dog, attending daycare, vet/groomer visits, or water-related activities like swimming, as instructed to prevent damage. In order to ensure owner compliance, owners were given the option to log digitally or on paper. It was recommended they keep their logs near the door to their yard so, logging would be convenient. Owner compliance for logging was high and some owners provided additional information about what activities their dog was engaging in during certain periods of time, as well as some weather information without being prompted.

2.4 Dog Activity Cut Point Development

To analyze the data by activity level (sedentary, moderate activity, and high activity), I determined cut points for the Axivity AX3 accelerometers for these three activity level categories. To do this, I compared the Mean Single Vector Magnitude (SVM) per minute from accelerometer data files from the accelerometers that I accessed using the program OMGUI, to videos I recorded of three different sized dogs (small, medium, and large sized dogs) performing three different levels of activity (sedentary, moderate activity, and high activity) for five minutes each while wearing the accelerometers in the same manner as the participant dogs.

Sedentary behavior consisted of sleeping or other activities, like laying down, idly chewing on chew treats, and sitting or standing still. During sedentary behavior the device did not log more than 0.100000 Mean SVM per minute. Moderate activity consisted of behaviors such as walking, during which the accelerometer logged a Mean SVM per minute in the range of 0.100000 through 0.349999. High activity consisted of behaviors such as jumping, fetching toys, running, or jogging, during which the accelerometer logged a Mean SVM greater than 0.350000 or equal to. Thus, Mean SVM per minute <0.100000 was considered sedentary behavior, Mean SVM per minute 0.100000 < 0.349999 was considered moderate activity, and Mean SVM per minute >= 0.350000 was considered high activity.

2.5 Data Analysis

After I created the activity cut points, I exported the data (Mean SVM) from the Axivity accelerometers worn by dog participants, into Comma Separated Value (CSV) files using the program OMGUI. I then applied the dog activity cut points I had created to determine if the dogs were engaged in sedentary, moderate or high activity for each minute of recorded data.

Using the owners' logs, I was able to determine if the dog was not wearing the collar and I excised that data from further analysis. Additionally, I compared whether activity levels differed between yard time and non-yard time (using owner logs), time of day (Morning: 5am - 12pm; Afternoon: 12:01pm - 5pm; Evening: 5:01pm - 9pm; and Night: 9:01pm - 4:59am), and day of the week (weekday vs. weekend). Because dogs wore the collars for different amounts of time depending on whether the collar was removed for any length of time and the exact time of application and removal of the collar at the beginning and end of the 14-day period, I normalized all overall data by dividing by total number of minutes the dog wore the collar to produce percentage of overall time spent in each activity level. For yard versus non-yard time, time of day, and day of the week analyses, I normalized by the total number of minutes of data obtained during which they were in yard or not, total number of minutes of data obtained from each time of day bin, or total number of minutes of data obtained from weekdays and weekends, respectively. Thus, I had a percentage of time spent in each activity level for those different analyses. From the fenced yard logs, I also calculated the number of trips to the fenced yard each dog took, the duration of these yard trips, and what percentage of the dog's overall collar-wearing time was spent in the fenced yard.

I ran Wilcoxon signed rank tests comparing percentage of time spent sedentary, moderate, and high activity levels for all participants when in the yard compared to when not in the yard. A Wilcoxon rank test comparing percentage of time spent sedentary on weekends versus weekdays, percentage of time spent in the yard on weekends versus weekdays, and number of yard trips per day on weekends versus weekdays was also conducted. To discover any differences in activity levels during the overall collar-wear period, I ran a Friedman test comparing the percentage of time spent in the sedentary, moderate, and high activity levels for all participants

during the overall collar-wear duration to discover if there were any significant differences. Because the Friedman test showed a significant difference, I ran another set of Wilcoxon signed rank tests comparing each overall percentage of time spent sedentary, moderate, and high activity levels by all dog participants, to each other to determine where the differences between activity levels were. The *p* values reported reflect the *p* values collected from the Friedman and Wilcoxon signed rank tests, because the results remained significant after applying a Benjamini-Hochberg correction.

RESULTS

3.1 PetFinder Adoption Profile Fenced Yard Requirements

Each dog adoption profile had a photo and a biography about the individual dog on the pet adoption listing search engine PetFinder.com. The adoption profiles were selected at random from several cities around each state. Dogs of any age, breed, sex, and health status were included in the sample. Of the 4,940 United States dog adoption profiles I evaluated, 20.69% required a fenced yard to adopt the listed dog out (Figure 1). That is 1 in 5 adoption profiles that listed having a fenced yard as an adoption requirement. Only 0.65% directly mentioned that the dog in the profile did not require a fenced yard for adoption. Of the profiles sampled, 78.66% did not mention whether there was a fenced yard requirement to adopt the dog or not.

Additionally, I analyzed this same data by United States regions (Southern, Northeast, Midwest, and Western as per the US Census) and by state (Figure 2) to discover any differences between regions or states. The by-region analysis shows, in order of most to least, that Midwest states require fenced yards for adoption in 23% of their profiles, Southern states require it in 22.25%, Western states require it in 19.92%, and lastly, Northeast states require it in 15.89% of their profiles. As for stating in profiles that a fenced yard would not be required, from most to least, Northeast states stated this in 1.22% of dog adoption profiles in their region, Southern states mentioned this in 0.69%, Midwest states in 0.67%, and lastly, Western states in 0.16%. The by-state analysis shows that the state of Mississippi required fenced yards most often with 40% of their profiles mentioning a fenced yard requirement and Texas, Rhode Island, and Vermont tied for requiring fenced yards the least with only 5% of profiles stating this was a requirement for adoption.

Shelters and rescues included a variety of reasons for including a fenced yard requirement in the adoption profiles for certain dogs. These reasons included the dog having a history of escaping, the dog's breed/breed mix, the dog being deemed not walkable on leash for behavioral or training reasons, the dog being deemed highly active, and medical issues like deafness, blindness, or difficultly walking. Some profiles also mentioned fence height requirements between four to ten feet tall.

3.2 Dog Participants and Sample Demographic

My sample demographic of dog participants wearing the Axivity accelerometers for the activity level monitoring portion of the study included twelve dogs ranging from the ages of 10 months old to 9 years old from the state of Mississippi (see Table 2 for dog demographics). All dogs were clear of contraindications for inclusion in the study, such as inability to exercise daily or inability to wear a collar comfortably. Three dogs were under two years old, eight dogs were in the two to five year range, and one dog was over five years old. Two dogs who started study were later excluded; one due to weather disrupting his normal activity patterns and the second for being diagnosed with heart worms.

3.3 Overall Accelerometer Collar-Wear Results

The overall accelerometer activity results include activity during the entire time period the dog wore the Axivity accelerometer collar; that is when in a fenced yard access and when not. The dogs wore the collar for a median of 19,410 minutes (N = 12, Mdn = 19410, CI [19170, 19670]). For overall time worn, the dogs were sedentary 91.70% of the time (N = 12, Mdn = 91.70, CI [88.19, 92.99]), moderately active 7.87% of the time (N = 12, Mdn = 7.87, CI [6.486, 10.25]), and highly active 0.62% of the time (N = 12, Mdn = 0.62, CI [0.371, 1.729]). A Friedman test on the dogs' percentage of time spent in each activity level overall indicated that there

was a significant difference in percentage of time spent engaging in the three activity levels (p <.001). Because this difference was found to be significant, Wilcoxon signed rank tests comparing each overall percentage of time spent sedentary, moderate, and high activity levels to each other to determine where the differences were was conducted. All Wilcoxon signed rank tests showed a significant difference between all activity levels when compared to each other. A Wilcoxon signed rank test indicated that the percentage of time spent sedentary by the dogs was statistically significantly higher than the percentage of time spent moderately active (Z = 3.48, p <.001). A Wilcoxon signed rank test indicated that the percentage of time spent sedentary by the dogs was statistically significantly higher than the percentage of time spent highly active was significantly different (Z = 3.48, p <.001). A Wilcoxon signed rank test indicated that the percentage of time spent moderately active by the dogs was statistically significantly higher than the percentage of time spent highly active was significantly different (Z = 3.48, p <.001).

On weekdays, the dogs were sedentary for 92.27% of the observation period (N = 12, *Mdn* = 92.27, CI [88.76, 93.32]), moderately active for 7.17% of the observation period (N = 12, *Mdn* = 7.17, CI [6.177, 9.663]), and highly active for 0.5% of the observation period (N = 12, *Mdn* = 0.5, CI [0.3328, 1.747]). In contrast, on weekends, the dogs were sedentary for 90.15% of the observation period (N = 12, *Mdn* = 90.15, CI [86.51, 92.21]), moderately active for 9.33% of the observation period (N = 12, *Mdn* = 9.33, CI [7.209, 11.95]), and highly active for 0.91% of the observation period (N = 12, *Mdn* = 0.91, CI [0.4646, 1.675]) (See Figure 3). A Wilcoxon signed rank test indicated that the dogs' percentage of time spent sedentary on weekdays was statistically significantly higher than the percentage of time spent sedentary on weekends (Z = 2.41, p = .016).

The dogs were sedentary for the greatest percentage of time during the night (9:01pm - 4:59am), spending 98.42% of the night sedentary (*N* = 12, *Mdn* = 98.42, CI [96.07, 98.93]). The dogs were sedentary for the lowest percentage of time in the evening (5:01pm - 9pm) being sedentary 85.89% of evening (*N* = 12, *Mdn* = 85.89, CI [80.37, 88.57]). They were moderately active for the greatest percentage of time in the evening (5:01pm - 9pm) being moderately active 13.13% of the evening (*N* = 12, *Mdn* = 13.13, CI [10.6, 17.76]). The dogs were moderately active for the lowest percentage of time during the night (9:01pm - 4:59am) being moderately active 1.49% of the night (*N* = 12, *Mdn* = 1.49, CI [1.012, 3.808]). And lastly, the dogs were highly active for the greatest percentage of time in the afternoon (12:01pm - 5pm) spending 1.02% of the afternoon highly active (*N* = 12, *Mdn* = 1.02, CI [0.7074, 3.333]). The dogs were highly active for the lowest percentage of time during the night (9:01pm - 4:59am) with 0.05% of the night being highly active (*N* = 12, *Mdn* = 0.05, CI [0.03776, 0.1622]) (See Figure 4).

3.3a. Overall Time by Age Group

When dividing the dogs up into age brackets and evaluating their overall time budget, Under Two Years Old group was sedentary for 89.59% of the observation period (*n* = 3, *Mdn* = 89.59, CI [83.37, 92.59]), moderately active for 9.61% of the observation period (*n* = 3, *Mdn* = 9.61, CI [6.27, 14.35]), and highly active for 1.71% of the observation period (*n* = 3, *Mdn* = 1.71, CI [0.8613, 2.559]). The Two Through Five Years Old group was sedentary 91.71% of the time (*n* = 8, *Mdn* = 91.71, CI [88.26, 93.42]), moderately active 7.87% of the time (*n* = 8, *Mdn* = 7.87, CI [6.341, 10.14]), and highly active 0.45% of the time (*n* = 8, *Mdn* = 0.45, CI [0.04302, 1.817]). The Over Five Years Old group was sedentary 96.40% of the time (*n* = 1, *Mdn* = 96.40), moderately active 3.57% of the time (*n* = 1, *Mdn* = 3.57), and highly active 0.03% of the time (*n* = 1, *Mdn* = 0.03) (See Figure 5).

3.3b. Weekday Versus Weekend Time by Age Group

On weekdays, the Over Five Years Old age group spent the greatest percentage of time sedentary with 96.78% of their time spent sedentary (*n* = 1, *Mdn* = 96.78). The Two Years to Five Years spent 92.50% of their weekdays sedentary (*n* = 8, *Mdn* = 92.50, CI [88.86, 93.66]). The Under Two Years Old age group spent the lowest percentage of time sedentary on weekdays with 90.51% of their time spent sedentary (*n* = 3, *Mdn* = 90.51, CI [84.04, 93]).

For moderate activity, the Under Two Years Old age group spent the greatest percentage of time moderately active on weekdays with 8.79% of their weekday time spent moderately active (*n* = 3, *Mdn* = 8.79, CI [5.943, 13.64]). The Two Year to Five Year group was moderately active 7.17% of their weekday time (*n* = 8, *Mdn* = 7.17, CI [6.14, 9.48]). The Over Five Years Old age group spent the lowest percentage of time moderately active on weekdays being moderately active 3.22% of the time (*n* = 1, *Mdn* = 3.22).

High activity on weekdays follows the same trend with the Under Two Years Olds spending the greatest percentage of time highly active on weekdays with 1.72% of their time spent highly active (*n* = 3, *Mdn* = 1.72, CI [0.786, 2.574]). The Two to Five Year Olds spent 0.47% of their weekday time highly active (*n* = 8, *Mdn* = 0.47, CI [-0.01549, 1.855]). The Over Five Years Olds spent the lowest percentage of time highly active on weekdays with 0.01% of their weekdays spent highly active (*n* = 1, *Mdn* = 0.01). The Under Two Years Olds spent the greatest percentage of time highly active on weekdays with 1.72% of their time spent highly active (*n* = 3, *Mdn* = 1.72, CI [0.786, 2.574]).

On the weekends, the Over Five Years Old age group spent the greatest amount of time sedentary at 95.47% of their weekend time spent sedentary (*n* = 1, *Mdn* = 95.47). The Two To Five Year Olds were sedentary 90.15% of their weekend time (*n* = 8, *Mdn* = 90.15, CI [86.43,

92.95]). The Under Two Years Old age group spent the lowest percentage of time sedentary with 87.06% of their weekend time spent sedentary (*n* = 3, *Mdn* = 87.06, CI [81.20, 91.64]).

For moderate activity on weekends, the Under Two Years Old age group spent the greatest percentage of time moderately active with 11.89% of the weekend time spent moderately active (*n* = 3, *Mdn* = 11.89, CI [7.036, 16.56]). The Two To Five Year Olds were moderately active 9.33% of their weekend time (*n* = 8, *Mdn* = 9.33, CI [6.747, 12.01]). The Over Five Years Old age group spent the lowest percentage of time moderately active with 4.44% of their weekend time spent moderately active (*n* = 1, *Mdn* = 4.44).

The Under Two Years Old age group spent the greatest amount of time highly active with 1.68% of their time spent highly active on the weekends (*n* = 3, *Mdn* = 1.68, CI [1.067, 2.493]). The Two To Five Year Olds were highly active 0.57% of their weekend time (*n* = 8, *Mdn* = 0.57, CI [0.1608, 1.699]). While the Under Five Years Old age group spent the lowest percentage of time highly active on weekends with 0.09% of their weekend time spent highly active (*n* = 1, *Mdn* = 0.09).

3.3c. Time of Day By Age Group

For Time of Day by Age Group, all age groups spent the greatest percentage of time sedentary during the night time range (9:01pm - 4:59am). The Under Two Years Old age group spent 98.33% of the night time sedentary (*n* = 3, *Mdn* = 98.33, CI [96.76, 99.64]), while the Two Through Five Years Olds spent 98.27% of the time sedentary (*n* = 8, *Mdn* = 98.27, CI [95.05, 99.03]), and the Over Five Years Olds spent 99.07% of the time sedentary (*n* = 1, *Mdn* = 99.07).

Two age groups spent the greatest percentage of time moderately active during the Evening time range (5:01pm - 9:00pm). The Under Two Years Olds spent 21.01% of evening moderately active (*n* = 3, *Mdn* = 21.01, CI [11.39, 23.89]), while the Two Through Five Years Olds

spent 13.13% of the evening moderately active (n = 8, Mdn = 13.13, CI [10.29, 18.03]). However, the Over Five Years Olds only spent 3.96% of evening moderately active (n = 1, Mdn = 3.96) and their greatest percentage of time was spent moderately active in the Morning (5am - 12pm) with 6.13% of the morning spent moderately active (n = 1, Mdn = 6.13).

All age groups spent the greatest percentage of time highly active during the Afternoon time range (12:01pm - 5:00pm). The Under Two Years age group spent 3.59% of the afternoon time highly active (n = 3, Mdn = 3.59, CI [1.264, 6.176]), the Two Through Five Years Old group spent 0.85% of their afternoon time highly active (n = 8, Mdn = 0.85, CI [0.1232, 3.117]), and the Over Five Year Olds group spent 0.12% of their afternoon time highly active (n = 1, Mdn = 0.12).

3.4 Fenced Yard Activity Results

The dogs spent 4.05% of their time in their fenced yards out of the total accelerometer collar-wear time period (N =12, Mdn = 4.05, CI [3.71, 10.93]). While in the yard, dogs spent 61.65% of their time sedentary (N = 12; Mdn = 61.65, CI [43.69, 68.85]), 32.95% of their time moderately active (N = 12, Mdn = 32.95, CI [26.25, 43.67]), and 2.92% of their time highly active (N = 12, Mdn = 2.92, CI [1.197, 16.38]). Wilcoxon signed rank tests comparing each percentage of time spent sedentary, moderately active, and highly active showed a significant difference in all activity levels when in the yard versus when not in the yard. A Wilcoxon sign ranked test indicated that the percentage of time spent sedentary by the dogs when not in the yard was statistically significantly higher than the percentage of time spent sedentary when in the yard (Z = 3.48, p <.001). A Wilcoxon signed rank test indicated that the percentage of time spent moderately active in the yard was statistically significantly higher than the percentage of time spent

moderately active when not in the yard ($Z = 3.48$, $p < .001$). A Wilcoxon signed rank test indicated that the percentage of time spent highly active in the yard was statistically significantly higher than the percentage of time spent highly active when not in the yard ($Z = 3.48$, $p < .001$).

The dogs spent 3.75% of their weekday time in the yard ($N = 12$, *Mdn* = 3.75, CI [2.957, 9.203]) and 5.05% of their weekend time in the yard ($N = 12$, *Mdn* = 5.05, CI [4.285, 10.21]). A Wilcoxon signed rank test indicated that the dogs' percentage of time spent in the yard on weekends and weekdays was not statistically significantly different. ($Z = 1.03$, $p = .30$).

3.4a. Fenced Yard Activity by Age Group

When considering age groups, the Two To Five Years Old age group spent the greatest percentage of time in their fenced yards with 5.43% of their overall collar-wear spent in the yard (n = 8, *Mdn* = 5.43, CI [3.166, 11.27]). The Under Two Years spent 4.46% of their time in their fenced yards (n = 3, *Mdn* = 4.46, CI [-0.2693, 17.95]). The Over Five Years Old age group spent the lowest percentage of time in their fenced yard with 3.62% of their overall collar-wear time spent in the yard (n = 1, *Mdn* = 3.62).

For sedentary yard time, each group spent over 50% of their yard time sedentary. Under Two Year Olds spent the greatest percentage of time sedentary in the yard at 64.21% (n = 3, *Mdn* = 64.21, CI [15.34, 80.46]), with Two Through Five Years Olds close behind them at 61.50% (n = 8, *Mdn* = 61.50, CI [45.25, 72.85]). Over Five Year Olds spent the lowest percentage of time sedentary in the yard at 59.09% (n = 1, *Mdn* = 59.09).

For moderate activity in the yard, Over Five Olds had the greatest percentage of time spent moderate activity with 40.08% of their time spent moderately active (n = 1, *Mdn* = 40.08), followed by Under Two Years Olds spent 32.90% of the time moderately active (n = 3, *Mdn* = 32.90, CI [24.66, 42.22]). Two Through Five Years Olds had the lowest percentage of time spent

moderately active inside the yard with 31.59% of the observation time spent moderately active (n = 8, *Mdn* = 31.59, CI [22.32, 47.46]).

For high activity in the yard, Under Two Years spent the greatest percentage of time highly active in the yard with 3.76% of the time spent highly active (n = 3, *Mdn* = 3.76, CI [-5.884, 43.20]), followed by Two to Five Years Olds with 2.80% of their time spent moderately active (n = 8, *Mdn* = 2.80, CI [1.60, 10.58]). The lowest percentage of time spent highly active in the yard was shown by the Over Five Year Olds with 0.83% of their yard time spent highly active (n = 1, *Mdn* = 0.83) (See Figure 6).

On weekdays, the Under Two Year Olds spent the greatest percentage of time in the yard out of the other age groups with 4.39% of their weekday time spent in the yard (n = 3, *Mdn* = 4.39, CI [0.9229, 12.40]). The Over Five Year Olds spent the lowest percentage of time in the yard during the weekdays with 3.17% of their weekday time spent in the yard (n = 1, *Mdn* = 3.17). The Two To Five Years Old spent a similar amount of time in the yard on weekdays with 3.75% of their weekday time spent in the yard (n = 8, *Mdn* = 3.75, CI [2.139, 10.26]).

In contrast, on weekends, the Two To Five Year Olds spent the greatest percentage of time in the yard out of the other age groups with 8.29% of their weekend time spent in the yard (n = 8, *Mdn* = 8.29, CI [4.576, 12.68]). The Under Two Year Olds spent the lowest percentage of time in the yard on the weekends with 4.67% of their weekend time spent in the yard (n = 3, *Mdn* = 4.67, CI [2.332, 6.428]). The Over Five Year Olds spent 4.77% of their weekend time in the yard (n = 1, *Mdn* = 4.77).

3.5 Outside of Fenced Yard Time Activity Results

The dogs spent around 95.96% of their overall collar-wear time not in their fenced yards (*N* = 12, *Mdn* = 95.96, CI [89.07, 96.29]). During this time, they were 93.70% sedentary (*N* =

12, *Mdn* = 93.70, CI [90.31, 95.39]), 5.87% moderately active (*N* = 12, *Mdn* = 5.87, CI [4.392, 9.608]), and 0.23% highly active (*N* = 12, *Mdn* = 0.23, CI [0.1651, 1.195]). All dogs as individuals spent over 80% of their time not in their fenced yard sedentary.

3.5a. Outside of Fenced Yard By Age Group

All age groups spent over 90% of their overall collar-wear time outside of their fenced yards with Under Two Year Olds spending 95.54% of their time not in the yard (*n* = 3, *Mdn* = 95.54, CI [82.05, 100.30]), Two Through Five Olds spending 94.58% of their time not in the yard (*n* = 8, *Mdn* = 94.58, CI [88.74, 96.84]), and Over Five Years Olds spending 96.37% of their time not in the yard (*n = 1*, *Mdn* = 96.37).

All age groups spent over 90% of time outside the fenced yard sedentary with the Over Five Years Old age group spending the 97.80% of this time sedentary (*n = 1*, *Mdn* = 97.80). The Two Through Five Years Old age group spent the lowest percentage of this time sedentary with 93.35% of their non-yard time spent sedentary (*n* = 8, *Mdn* = 93.35, CI [90.47, 95.51]). Under Two Years Olds had similar findings with them spending 93.62% of their time not in the yard sedentary (*n* = 3, *Mdn* = 93.62, CI [84.97, 97.28]).

In the moderate activity and high activity ranges across the board, every age group spent less time active while not in their fenced yard versus when in their fenced yard after considering the amount of time each dog had access to each respected area. For moderate activity outside of the yard, Two Through Five Years Olds spent the greatest percentage of time moderately active at 6.54% (*n* = 8, *Mdn* = 6.54, CI [4.112, 10.35]), while the Over Five Years Olds spent the lowest percentage of time moderately active at 2.20% (*n = 1*, *Mdn* = 2.20). The Under Two Year Olds spent 5.61% of their time outside of the yard moderately active (*n* = 3, *Mdn* = 5.61, CI [2.618, 13.32]).

For high activity outside of the fenced yard, the Under Two Years spent the greatest percentage of time highly active at 0.77% (n = 3, Mdn = 0.77, CI [0.07973, 2.32]), and the Under Five Olds spent the lowest percentage of time highly active at 0% (n = *1*, Mdn = 0). The Two Through Five Year Olds spent 0.18% of their time outside of the yard highly active (n = 8, Mdn = 0.18, CI [-0.01208, 1.152]) (See Figure 6).

3.6 Fenced Yard Trips Analysis Results

The dogs took a median of 61 trips to the fenced yard during the duration of the study (N = 12, Mdn = 61, CI [55.58, 85.26]). The dogs took 4.39 trips per day to the fenced yard (N = 12, Mdn = 4.39, CI [3.926, 6.054]). The duration of a fenced yard trip was 11.41 minutes (N = 12, Mdn = 11.41, CI [9.113, 34.09]). On the weekdays, dogs went to the fenced yard 4.52 times (N = 12, Mdn = 4.52, CI [4.019, 6.021]) and on weekends, dogs went to the fenced yard 4.43 times (N = 12, Mdn = 4.43, CI [3.767, 6.233]). A Wilcoxon signed rank test indicated that the dogs' number of yard trips per day on weekends and weekdays was not statistically significantly different (Z = .78, p = .44).

When considering age groups, Over Five Years Olds took the greatest number of trips to the fenced yard with 90 trips total (n = 1, Mdn = 90). Two to Five Years Olds took 67.50 trips total (n = 8, Mdn = 67.50, CI [55.6, 94.38]), and Under Two Years Olds took 48 trips total (n = 3, Mdn = 48, CI [38.86, 64.48]). Yard trips per day by age group, Under Two Year Olds went the least number of times a day at 3.20 trips (n = 3, Mdn = 3.20, CI [2.659, 4.561]). Two Through Five Years Olds went 4.67 trips a day (n = 8, Mdn = 4.67, CI [3.951, 6.709]). Over Five Years Olds went the greatest number of times a day with 6.42 trips (n = 1, Mdn = 6.42).

Yard trip duration, Under Two Years Olds spent the most amount of time per trip at 19.77 minutes per trip (n = 3, Mdn = 19.77, CI [-1.681, 69.88]). Two Through Five Years Olds

spent 11.41 minutes per trip (n = 8, Mdn = 11.41, CI [7.558, 29.98]). Over Five Years Olds spent the least amount of time per trip at 6.78 minutes per trip (n = 1, Mdn = 6.78).

3.6a. Fenced Yard Trips on Weekdays Versus Weekends

All age groups, except the Two Through Five Years Olds, went for fewer trips to the yard on weekdays than weekends. Under Two Years Olds had the fewest number of yard trips on weekdays with 3.10 trips (n = 3, Mdn = 3.10, CI [2.797, 4.403]). The Two Through Five Years Old had 4.87 trips on weekdays (n = 8, Mdn = 4.87, CI [4.131, 6.709]). The greatest number of trips on the weekdays were the Over Five Years Old with 6 trips (n = 1, Mdn = 6).

For weekends, the Under Two Years went the fewest number of trips with 3.40 trips to the fenced yard on average (n = 3, Mdn = 3.40, CI [2.227, 5.033]). The Two Through Five Years Olds went for 4.50 trips to the yard on weekends (n = 8, Mdn = 4.50, CI [3.641, 6.759]). The Over Five Years went for the greatest number of trips to the yard on weekends with 7.5 trips (n = 1, Mdn = 7.5).

DISCUSSION

4.1 General Overview of Findings

Several factors explored showed significant differences in activity level when analyzed. During the overall collar-wear duration, the dogs spent statistically significantly more time engaged in sedentary activity than high or moderate activity and more time engaged in moderate activity than high activity. As for activity in the fenced yard, the dogs spent statistically significantly more time moderately and highly active, and therefore less time sedentary, when in the yard than when not in the yard. The dogs showed a variable range of time spent in the yard during the two-week period as well. The dogs spent statistically significantly less time sedentary on weekends compared to weekdays. The dogs were more likely to be sedentary at night (9:01pm - 4:59am), moderately active in the evening (5:01pm - 9:00pm), and highly active in the afternoon (12:01pm - 5pm). The findings suggest that various factors could influence dog activity level such as fenced yard access, day of the week, and time of day.

4.2 Fenced Yard Requirements by Location

I investigated United States (US) shelters and rescues that had PetFinder dog adoption profiles requiring fenced yards for adoption approval. A little over 20% of the dog adoption profiles sampled required a fenced yard for adoption. That means 1 in 5 adoption profiles listed having a fenced yard as an adoption requirement. Only 0.65% of adoption profiles sampled directly mentioned that the dog in the profile did not require a fenced yard for adoption. Previous research in United Kingdom reported that yard-related requirements were the most commonly required adopter characteristic category in their country (Griffin et al., 2020). My results give us insight into these same requirements within the United States. Shelters and rescues in the United States mentioned fence height requirements ranging from four feet to ten feet, while in the

United Kingdom fence height requirements between four to five feet have been reported (Griffin et al., 2020).

Despite possible variability in access to affordable fenced yards across the United States, these results did not vary much between United States census regions. All United States regions still required a fenced yard for adoption in over 15% of the profiles for their respected region. This means the factors impacting shelters and rescues implementing a fenced yard requirement could be more complex than whether or not fenced yards are common within the region. However, because no entity has collected data on the prevalence of fenced yards through the United States, it is impossible to correlate fenced yard availability with frequency of a fenced yard as an adoption requirement.

Despite regions making little difference in how often fenced yards were required, individual states did differ from 5% to 40% of adoption profiles requiring fenced yard requirements. It is possible the variety between states is due to internal influences within the shelter/rescue communities, local laws, or dog transportation laws that make placing adoptable dogs outside of their origin state more difficult.

4.3 Reasons for Fenced Yard Requirements

While I did not perform a formal analysis on reasons shelters gave for including a fenced yard requirement, common reasons given by shelters and rescues included the dog being a certain breed/breed mix, being a larger size, or having certain medical issues. Additional behavioral reasons given were the dog having limited or no leash training, escaping in the past, or being high energy/highly active. Being highly active or high energy was the most common reason and was mentioned in over 100 adoption profiles. Given that activity is such a common reason for

fenced yard requirements, understanding how dogs use fenced yards is critical for being able to assess the utility of such an adoption requirement.

Another common reason for fenced yard requirements was breed/breed mix. This seems related to the requirement for highly active dogs, as fenced yard requirements were commonly applied to adoption profiles of herding, terrier, hound and livestock guardian breeds. Many of these breeds are often labeled as highly active or high energy in their American Kennel Club breed standards (*American Kennel Club*, 2022).

4.3a Age and Fenced Yard Requirements

Further considering fenced yard requirements, other than shelters and rescues with organization-wide fenced yard requirements, no adoption listing that I sampled required a fenced yard for a puppy under six months of age. Adopters of younger dogs might be less likely to have fenced yards due to this inconsistency in adoption policy, which could impact adoption retention. The findings indicate that dogs under the age of two years old were the most highly (1.68% of their time spent highly active) and moderately active (11.89% of their time spent moderately active) age group. Previous research indicates that younger dogs score higher on hyperactivity/impulsivity ratings than older dogs (Csibra et al., 2022), making this lapse in policy is worth noting. Additionally, puppies with more play time opportunities under six months of age have shown a decrease in hyperactivity and motor activity as adults (Hoppe et al., 2017). Because play often ended up being ranked as high activity, it is possible that because dogs showed an increase in high activity during fenced yard time, that puppies under six months would benefit from fenced yard access in some way. If fenced yard access does increase adopter satisfaction, play, or dog welfare for more active dogs, this age group might be the ideal age group to recommend fenced yard access to.

4.4 Overall Dog Activity Levels

The overall Axivity accelerometer collar-wear results, which include both fenced yard and non-fenced yard time, showed that dogs were sedentary over 91% of the time, moderately approximately 7% of the time, and highly active only 0.62% of the time. Because similar findings on time spent in each activity level have been previously reported (Morrison et al., 2014), it is possible this is typical of companion dog's sedentary activity levels. Possible causes of differences in the sedentary levels seen in the dogs in my study could be due to individual differences between dogs influenced by human activity patterns (Hughes et al., 1989, Kobelt et al., 2007, Dow et al., 2009; Piccione et al., 2012, 2014; Griss et al., 2021; Li et al., 2022) and/or the age of the dog (Siwak et al., 2003, Brown et al., 2010; Li et al., 2022).

Additionally, visual analysis suggested that older dogs displayed decreased high activity and increased sedentary activity. Previous studies on aging and dog activity that show dogs tend to show at least a decrease in high activity as they age (Siwak et al., 2003; Brown et al., 2010; Griss et al., 2021; Li et al., 2022). However, the Over Five Year Old age group in my study only had one dog participant. Therefore, a larger sample size would be required to detail exactly how fenced yard access for aging dogs impacts activity levels.

4.4a Overall Activity Levels on Weekdays Compared to Weekends

My findings suggest that dog activity is likely interlinked with the owner's activity, as suggested by past research (Hughes et al., 1989; Aslaksen and Aukrust, 2003; Frank et al., 2007; Kobelt et al., 2007; Dow et al., 2009; Vestrum, 2009; Rehn and Keeling, 2011; Piccione et al., 2012, 2014; Griss et al., 2021; Li et al., 2022). The dogs spent statistically significantly more time sedentary on weekdays (92.27%) than weekends (90.15%). Additionally, there was a trend for dogs to be more highly active on weekends than weekdays (0.91% on weekends compared to

0.5% on weekdays). These differences could be accounted for by the owner's schedule allowing for increased presence or human activity on weekends. Because activities like running, playing, fetching, and roughhousing registered as high activity, this could suggest that owners were playing, or at least directly interacting with, their dogs more often on weekends than weekdays. It is also possible that owners were more likely to take the dog for a walk as well, as there was a trend for moderate activity to also be increased on weekends (9.33% compared to 7.17% on weekdays).

These findings are in agreement with previous research showing dogs display higher moderate and high activity on weekends (Dow et al., 2009; Piccione et al., 2014; Li et al., 2022); the authors of these papers also suggested that the owners' schedule likely impacted the dogs' activity levels. Furthering this conclusion, my findings indicated that the number of yard trips per day and percentage of time spent in the yard were not statistically significantly different on weekends compared to weekdays. This could further suggest that something about owner presence or activity on weekends accounts for the decreased sedentary dog activity on weekends.

4.4b Overall Activity Levels and Time of Day

Unsurprisingly, dogs spent the greatest amount of time sedentary during the night time (9:01pm - 4:59am), with over 98% of the night time spent sedentary. These findings are in line with our knowledge about companion dog circadian activity patterns, which reports dogs exhibit sleep/wake and rest/activity behavior patterns (Zanghi et al., 2012) and the results are also in harmony with past research showing most moderate and high dog activity occurs during daylight hours (Piccione et al., 2012; Li et al., 2022). While many studies conclude that dogs are diurnal (i.e., active during the day; Adams et al., 1995; Zanghi et al., 2012; Banerjee and Bhandra, 2019;

Hoffman et al., 2019), there is also evidence of dogs possibly being cathemeral (i.e., active during the day and night; Delude, 1986; Bulter & Toit, 2002; Woods et al., 2020). As such, it is possible that the high percentage of sedentary behavior at night is because companion dogs are matching the diurnal activity patterns of humans, not because they are naturally diurnal themselves.

Most dogs were most likely to be moderately active (13.13%) during the evening time frame (5:01pm - 9:00pm). These findings are in agreement with previous research showing dogs limit most of their moderate activity to the morning and evening time periods (Beck, 1975; Daniels, 1983; Griss et al., 2021). Furthermore, a study on off-leash dog park visitation showed dog park visitation peaked in the early morning and evening, as well as on weekends (Lee et al., 2009), which could imply a human component to this finding as well. Owners in my study could have been arriving home from work leading to the dog greeting them (Rehn & Keeling, 2011) or the owners could have more present during this time frame leading to increased activity (Hughes et al., 1989, Kobelt et al., 2007, Dow et al., 2009; Piccione et al., 2012, 2014; Griss et al., 2021; Li et al., 2022). Another consideration is that dinner is commonly served during this time frame. Dogs could become more active when they smell or hear food being prepared in the household because previous research has reported free-ranging dogs will often scavenge (Bulter & Toit, 2002; Bhadra & Bhadra, 2014; Bhadra et al., 2016) and beg for food from familiar humans (Bhadra & Bhadra, 2014; Majumder et al., 2014).

Previous research (Beck, 1975; Daniels, 1983; Griss et al., 2021) has reported that free-roaming urban dogs and free-roaming owned dogs limit their activity to early mornings and later evenings to possibly avoid the heat of the day. However, my findings showed all age groups were most highly active during the afternoon (12:01pm - 5pm) time period. Previous research

(Griss et al., 2021) reported a similar finding: a mid-day peak in activity that changed from day-to-day in family dogs. Furthermore, Beck (1975) reported an absence of activity during midday through summer months in free-roaming domestic dogs as well. These differences could be because my data collection period was through winter to spring or because the dogs were domestic dogs in households instead of free-roaming dogs. The dogs could also be influenced by their owner's schedule in some way, which influenced these results, but data on owner schedule were not collected. More research into this time period is needed to draw firmer conclusions on whether this is a natural peak activity time for dogs or if the high activity level was influenced by the owners.

4.4c Overall Activity Level and Dog Breed

While I did not perform a formal analysis based on breed due to the small sample size, I did rank all dogs by greatest percentage of time spent in each activity level to uncover any possible differences between breeds or individuals. The two Border Collie participants' high activity levels ranked among the Under Two Year Olds age group's high activity levels when ranked by greatest percentage of time spent highly active. This is notable because the Border Collies were four and five year olds and were more similar in percentage of time spent highly active to the Under Two Year Olds age group than their own age group. Breeds having different levels of activity is supported by previous studies that have shown differences in activity levels in some breeds (Hoppe et al., 2017; Li et al., 2022), particularly in Border Collies (Pickup et al., 2017; Hall et al., 2021). While the sample size is too small to conclude if this is unique to these dogs, there could be merit to some breeds being more active in some respects than others. In the future, adding more of each individual breed to the sample demographic would help evaluate whether breed is a factor on activity level.

4.5 Fenced Yard versus Outside Fenced Yard Activity

My findings suggest dogs are more likely to be both moderately and highly active when logged as inside a fenced yard than when not logged in the fenced yard. Even though dogs spent little time in their fenced yards, with the dogs only spending a little over 4% of their time in the fenced yard, they spent most of their highly and moderately active moments within the fenced yard. The dogs spent almost all their time sedentary when not in the yard (over 93% of non-yard time) and only spent around 61% of their yard time sedentary in comparison. Furthermore, the dogs were more likely to be moderately active (over 32% of yard time) and highly active (over 2% of yard time) when in the fenced yard versus when not in the fenced yard (moderately active over 5% of non-yard time and highly active 0.23% of non-yard time).

One possibility for why dogs showed higher activity in the fence yard than when not in the fenced yard is that the dogs sampled were more likely to be kenneled/crated when not in their yard, which would make any activity levels besides sedentary impossible or unlikely depending on the size of the enclosure. Additionally, it is feasible that owners are more likely to play with or spend time with their dogs within their fenced yards because some owners did note on their yard time logs that they were playing frisbee or fetch with the dog and chasing the dog around in the yard. For moderate activity, dogs could be more moderately active in the fenced yard area because they are locating an area to use the bathroom or if the dog lives in a larger yard, they could be spending more time walking from one end of the yard to the other, as suggested by previous research (Kobelt et al., 2007).

The novelty of the area could also play a role in activity level (i.e., the longer the dog is denied access to an area, the more active they are when given access to the area or that owners could discourage their dog or send them into the yard when they are highly active inside the

home). If dogs were less likely to spend time in the yard, it is possible they would be more active once entering that space. Additional data about kennel/crate usage, owner engagement, and novelty should also be collected so it can be considered as a factor on fenced yard activity. Additionally, some owners noted on their yard time logs situations in which the dog would not get yard time that day or why they perceived the dog was not as active during a yard trip, like it raining outside or the ground being wet. Missing out on yard time for a period of time due to weather could also influence activity level in the following days.

When considering time outside of the fenced yard, it should be noted that I instructed owners not to change their daily routine with their dog, so the dogs were not restricted to just their homes during the duration of the study. The owners were told to log time within their fenced yards only. This means that non-fenced yard time does not necessarily mean the dog was indoors or even on their own property. The dogs could have been engaged in many activities outside of the home when outside of the fenced yard. For example, one owner did note when they took their dog for leashed walks outside of the yard.

Almost 96% of the entire group's total collar-wear time was spent outside of the fenced yard. As a group, the dogs spent over 93% of their non-yard time sedentary. Each individual dog spent at least 80% of their non-yard time sedentary. These findings highlight how dogs with fenced yard access, may spend most of their active moments when in their fenced yard. These findings could imply that these dog owners may not routinely walk their dogs or actively engage with the dogs in spaces outside of the fenced yard. Because only one owner of the twelve participants responded on the Research Interest Questionnaire that they walked their dog daily, this could be the case. Further logging of owner and dog activities is needed. An alternative circumstance could be some owners were using crates/kennels when their dog was not in the fenced

yard.

Another possibility is that when owners are home, they are more likely to spend time in the fenced yard with their dogs than outside of the fenced yard. With this being a possibility, dogs without routine fenced yard access, like dogs living in apartments, could be a useful population to compare to the current dogs. That is, do owners of dogs living in apartments find suitable supplements for fenced yard access or are these dogs more sedentary due to the lack of a fenced yard? Further research is needed on how often dog owners engage in activities with their dogs outside of the yard and whether or not human engagement of the dog, like play, mostly occurs in the fenced yard.

4.6 Fenced Yard Trips

During the two-week period, the dogs took a median of 61 trips to and from the fenced yard with around 4 yard trips per day. The median duration of each trip was around 11 minutes. After data collection, several owners mentioned noticing how little they were taking their dog into yard and that the dog was spending far less time in the yard than they originally imagined. These comments were similar to past research findings where owners reported an increased awareness about their dog's activities after activity monitoring (Nelson & Shih, 2016).

Several dogs were logged spending only a single minute in the fenced yard on multiple trips. This could be because these dogs were potty trained to go outdoors and they were only interested in using the bathroom on these shorter trips. Alternatively, it is conceivable that dogs ask to go outside just to look for enrichment opportunities, like neighboring dogs/humans, certain scents, or wildlife, and, when those opportunities are not present, they immediately want to return indoors. Similarly, some dogs could have been left outside alone and immediately wanted

access to their owner again, as Kobelt et al. (2007) found the dogs left outside alone in their backyards would stand at gates, windows, and doors waiting for humans to return.

As for age and yard trips, there was a trend that showed that as dogs increased in age they went for a higher number of yard trips on average, but average yard trip duration decreased. However, it should be noted that the individual dogs had visible variance in the overall amount of time spent within the yard which ranged from 1.94% to 20.57% of their total collar wear-time being inside the yard. This means that despite the differences in the number of yard trips and yard trip duration, the dogs did not spend an equal or similar amount of time within the yard as one another.

Considering weekend versus weekdays, there was no statistically significant difference between the number of yard trips taken. On weekdays, the dogs went on 4.43 trips to the fenced yard and on weekends they went on 4.52 trips. Therefore, it is unlikely that day of the week played a large role in how often the dogs were taken to and from their fenced yard. When the percentage of time the dogs could have access the yard on weekdays versus weekends is considered, the findings indicated that dogs did not spend a statistically significant different overall duration of time in the yard on weekends (5.05%) compared to weekdays (3.75%) either.

A plausible explanation for the similarities in yard trips and overall duration of yard time on weekends compared to weekdays could be that dogs are used to a schedule that fits with the human's weekday schedule and dogs do not stray from this schedule themselves to ask for additional trips to the fenced yard, even though through the owner might be more present. Further research should be conducted on how possible human interactions, days of the week, and reinforcement in the yard effects yard trips to further understand the lack of differences on a deeper level.

4.7 Barrier Requirements Creating Barriers to Adoption

Given that United States dog owners are more likely to purchase dogs from breeders than adopt dogs from shelters (ASPCA, 2019), one consideration is if dogs labeled for adoption to homes with fenced yards are more challenging to adopt out because of these requirements, especially in areas that may lack affordable fencing or yard space opportunities. Fenced yard requirements might serve as nothing more than additional barriers to dog adoption because no significant differences in adoption retention based on owner demographic, type of home, or location of home has been found (Duxbury et al., 2003). Previous research has also reported that 91.2% of the 2,806 dogs they documented being surrendered to shelters had a yard and only 5.9% did not (Diesel et al., 2010). Additionally, Robertson (2003) reported only 12% of dogs are exercised within their own backyards, so fenced yards may not be utilized by owners often when they are available. Shelters and rescues might want to focus on more researched areas for improving adoption retention like dog-owner matching (Curb et al., 2015), encouraging quality time with the dog (Neidhart & Boyd, 2002; Väätäjä et al., 2021), furthering adopter education (Neidhart & Boyd, 2002), and recommending dog training (Duxbury et al., 2003; Gazzano et al., 2008) until more research can be done on fenced yard impacts on dog welfare and adoption retention.

My findings show dogs spent over 2% of their fenced yard time highly active compared to 0.23% of their non-yard time. However, recent research has reported that dogs spend the lowest percentage of time in the highly active category, regardless of living conditions (Hoffman et al., 2019; Griss et al., 2021). Because I did not collect data on whether or not owners stayed outside with their dogs in their fenced yard, I cannot determine whether human presence was the reason behind activity increase, as shown in previous research (Hughes et al., 1989; Aslaksen

and Aukrust, 2003; Frank et al., 2007; Kobelt et al., 2007; Dow et al., 2009; Vestrum, 2009; Rehn and Keeling, 2011; Piccione et al., 2012, 2014; Griss et al., 2021; Li et al., 2022).

Further demonstrating that human presence could be an important component to the usefulness of fenced yard access is that dog behavioral improvements that have been reported from increasing moderate and high activity have stemmed from owner-involved activities, like leash walking and dog sports participation (Kobelt et al., 2003; Zilocchi et al., 2016; Panizzolo and Sergi, 2019; Kluess et al., 2021). Additionally, longer separation periods from the owner have been linked to undesirable behaviors (Hopee et al., 2017) and it is uncertain how having a fenced yard impacts the amount of time the owner spends with their dog. This suggests that more research needs to be conducted on how often dog owners utilize their fenced yards before we can conclude that fenced yard access could make dogs more behaviorally manageable for adopters and therefore improve adoption retention.

Due to negative impact of yard ownership on amount and type of exercise received (Robertson, 2003; Kobelt et al., 2003; Schofield et al., 2005; Tatschl et al., 2006; Bland et al., 2008; Scheibeck et al., 2011), focusing on reported ways to improve dog welfare and health first is something to consider. Shelters and rescues could focus on more owner-involved activities such as dog walking (Kobelt et al., 2003; Bland et al., 2008; Westgarth et al., 2014; Panizzolo and Sergi, 2019), dog sports participation (Baldwin and Norris, 1999; Hultsman, 2012; Farrell et al., 2015; Zilocchi et al., 2016), training classes, and/or other enrichment activities (Clark & Boyer, 1993; Jagoe & Serpell, 1996; Duxbury et al., 2003; Bennet & Rohlf, 2007; Hakanen et al., 2020; Puurenen et al., 2020; Fernandez, 2022) because no clear dog welfare benefit has been connected to dog owners owning fenced yards at this point. Additionally, no data exist to point to

whether matching active dogs with adopters with fenced yards would assure better matched pairs and increase adoption satisfaction.

More research will need to be conducted on matching dogs and owners to gather more information about the goals of shelters and rescues implementing fenced yard requirements and the effects on adoption outcomes. Shelters and rescues could be decreasing their adopter pool far more than they realize because the commonality of fenced yard requirements had not been previously assessed in the United States until now. Because fenced yard requirements seem to be relatively common and the number of fenced yards available in an area would be limited and no clear welfare benefit has been discovered yet, it might benefit adoption rates for shelters and rescues to only apply fenced yard requirements to dogs and adopters on an individual basis.

4.8 Limitations and Future Adjustments

A limitation of the study is that there is not a singular influence affecting companion dog activity levels. Factors like varying owner schedules, weather/temperature, breed, and age might be impacting dog activity level outcomes and it can prove challenging to separate these factors. Because previous research indicts a possible interaction with dog activity and these factors (Hughes et al., 1989; Aslaksen and Aukrust, 2003; Frank et al., 2007; Kobelt et al., 2007; Dow et al., 2009; Vestrum, 2009; Rehn and Keeling, 2011; Piccione et al., 2012, 2014; Hall et al., 2021; Li et al., 2022), collecting this information in future studies might be fruitful.

In terms of information to collect in the future, it should be noted that overweight dogs have been reported to have lower activity levels than ideal weight dogs (Brown et al., 2010; Morrison et al., 2014) and because I did not collect data on weight, I cannot confirm if weight impacted my participants' activity levels. However, more recent research did not find any impact on activity levels if the dog was overweight (Hoffman et al., 2018). Thus, the impact of weight

on activity remains undetermined. Furthermore, data could be collected about the weather or owner presence, because I did not collect this information, I could not measure any impacts these factors had on the dog's behavior.

Due to the limited number of subjects and all participants being from the same state, a larger sample size will be needed to increase the generalizability of the results. Different populations could help us gain a more circumspect view of what dogs experience, however this can present some additional challenges. Participants with doggie doors or similar such that the dog could come and go from the fenced yard freely, could be difficult for owners to accurately log yard access without modifying the dog's routine. I recommend these participants not be introduced into the subject demographic unless a video recording system can be used to monitor the dog coming and going from the yard to reduce human error. Additionally, collecting data about whether or not dogs are kenneled/crated when indoors also seems needed for future versions of this study in order to rule out crating/kenneling as a factor in the sedentary activity level outside of the fenced yard.

Overall, this area of research is prime for additional research to answer the remaining questions about the influences on dog activity levels both inside and outside of their fenced yards. The findings suggest that Axivity accelerometers can be used with custom cut points to collect comparable results to past research on dog activity levels. Additional research to validate these cut points by using a wider variety of breeds, ages, and sizes could be done to further assess their usefulness. All these challenges and limitations should be acknowledged to limit their impact in future projects.

CONCLUSIONS AND FUTURE DIRECTIONS

Dog activity is a complex topic with many variables that impact its presentation. Variables that impact dog activity include, but are not limited to, breed (Hoppe et al., 2017; Pickup et al., 2017; Hall et al., 2021; Li et al., 2022), sex (Li et al., 2022; Csibra et al., 2022; Salonen et al., 2022), neuter status (Hoppe et al., 2017; Griss et al., 2021), age (Siwak et al., 2003; Brown et al., 2010; Griss et al., 2021; Csibra et al., 2022; Li et al., 2022), physical fitness (Brown et al., 2010; Morrison et al., 2014; Griss et al., 2021), diet (Zanghi et al., 2012), training level (Csibra et al., 2022), environmental influences like weather, temperature, season, and foliage (Kobelt et al., 2007; Temple et al., 2011; Hall et al., 2021; Li et al., 2022), time of day (Delude, 1986; Adams et al., 1995; Dow et al., 2009; Zanghi et al., 2012; Piccione et al., 2012, 2014; Banerjee & Bhandra, 2019; Hoffman et al., 2019; Woods et al., 2020; Griss et al., 2021, Li et al., 2022), and human/animal presence (Hughes et al., 1989; Aslaksen & Aukrust, 2003; Frank et al., 2007; Kobelt et al., 2007; Dow et al., 2009; Vestrum, 2009; Rehn & Keeling, 2011; Piccione et al., 2012, 2014; Hoppe et al., 2017; Griss et al., 2021; Li et al., 2022). My study provides results that are comparable to previous studies on how age, human presence/routine, time of day, and day of the week impact dog activity levels. Additionally, my findings inform us on how fenced yard access impacted twelve dogs' activity levels over the two-week study period and adds to previous research on accelerometer use for dogs (Michel & Brown, 2011; Yam et al., 2011; Preston et al., 2012; Ladha et al., 2013; Yashari et al., 2015; Olsen et al., 2016; Westgarth & Ladha, 2017; Ladha & Hoffman, 2018).

My results also found that fenced yard requirements for dog adoption are common in the United States; because of this, further research could focus on how these requirements impact of

adoption rate, owner retention, dog welfare, and owner satisfaction to answer additional questions about how fenced yard ownership impacts dog ownership. Given the common nature of fenced yard requirements in same states, shelters and rescues could consider adopters without fenced yards as way to place more dogs into homes.

In regards to dog activity, my findings show that dogs with regular fenced yard access spend a majority of their moderately and highly active moments within their fenced yards. Due to activity levels varying widely between each individual dog and previous research findings suggesting that dog owners with yard access are less likely to exercise their dogs (Robertson, 2003; Kobelt et al., 2003; Schofield et al., 2005; Tatschl et al., 2006; Scheibeck et al., 2011), factors like owner presence in the yard must be considered before concluding that fenced yard access alone is the cause of heightened activity levels.

Future research could focus on whether or not dog owners who have access to fenced yards are more likely to spend time engaging with their dog and if so, exactly how these owners are engaging their dogs. A research focus on the human psychological perspective could also be helpful to determine how fenced yard requirements impact adoption rates and retention. While additional research will be required to conclude if fenced yards benefit adoption rates, owner retention, and/or dog welfare, the importance of this future research has now been bought to the forefront. There is great potential and reason for expanding on our knowledge about how fenced yards interplay with dog adoption success and dog welfare.

Table 1

Research Interest Questionnaire

Question	Possible Answers
Q1. Dog Owner's Full Name	
Q2. Dog Owner's Shipping Address (for device shipment purposes)	
Q3. Dog's Name	
Q4. What sex is your dog?	Intact male; Intact female; Neutered male; Spayed Female
Q5. What breed is your dog? (Please state mixed if unsure)	
Q6. What age is your dog?	
Q7. Does your dog currently have any health conditions or injuries?	Yes or No
Q8. If you answered yes to the previous question, which health conditions or injuries does your dog have?	
Q9. Does your dog have any previous health conditions or injuries?	
Q10. If you answered yes to the previous question, which health conditions or injuries did your dog have?	
Q11. Does your dog currently have heart worms?	Yes or No
Q12. Is your dog currently pregnant or have a litter of puppies?	Yes or No
Q13. Is your dog currently in good health to your knowledge?	Yes or No

Q14. Does your dog have any conditions that would causes them to not be able to perform daily exercises like running, jogging, or walking on leash daily?	Yes or No
Q15. Is your dog able to participate in the full experiment length of two weeks?	Yes or No
Q16. Does your dog have daily access to a fenced-in yard for daily exercise?	Yes or No
Q17. If yes to the previous question, how long does your dog spend outside in the fenced-in yard each day usually?	Less than an hour; 1-2 hours; 2-4 hours; 4-6 hours; More than 6 hours/My dog lives outside in the yard.
Q18. Does your dog go for daily leash walks for exercise?	Yes or No
Q19. If yes to the previous question, how often are they walked per day and how long are these walks usually?	
Q20. Can your dog wear a regular nylon collar without issue?	Yes or No
Q21. Has your dog been diagnosed by a vet or vet behaviorist with any behavioral disorders? (Ex. Aggression, reactivity, separation anxiety, etc.)	Yes or No
Q22. If yes to the previous question, which behavioral disorders has your dog been diagnosed with?	

Table 1. Research Interest Questionnaire. Questionnaire given to owner participants to judge their dog's eligibility for participating in the research study.

Table 2

Dog Participants

Dog Name	Sex	Age	Breed
Mookie	Neutered Male	10 months	Unknown Mix
Gibbous	Intact Female	1 year	Icelandic Sheepdog
Gloria	Spayed Female	1 year	Miniature American Shepherd
Ginger	Spayed Female	2 years	Border Collie/Pit Bull mix
Murfee	Neutered Male	3 years	Miniature Australian Shepherd
Amos	Neutered Male	4 years	Labrador retriever
Bailey	Spayed Female	4 years	Border Collie
Dani	Spayed Female	4 years	Pit Bull mix
Alice	Spayed Female	5 years	Pit Bull mix
Oakley	Spayed Female	5 years	Border Collie
Riley	Spayed Female	5 years	Hound mix
Beretta	Spayed Female	9 years	Australian Kelpie

Table 2. Dog Participants. Demographic information about each dog who participated in the Axivity activity data collection portion of the research study.

Figure 1

Fenced Yard Requirements for Dog Adoptions on PetFinder

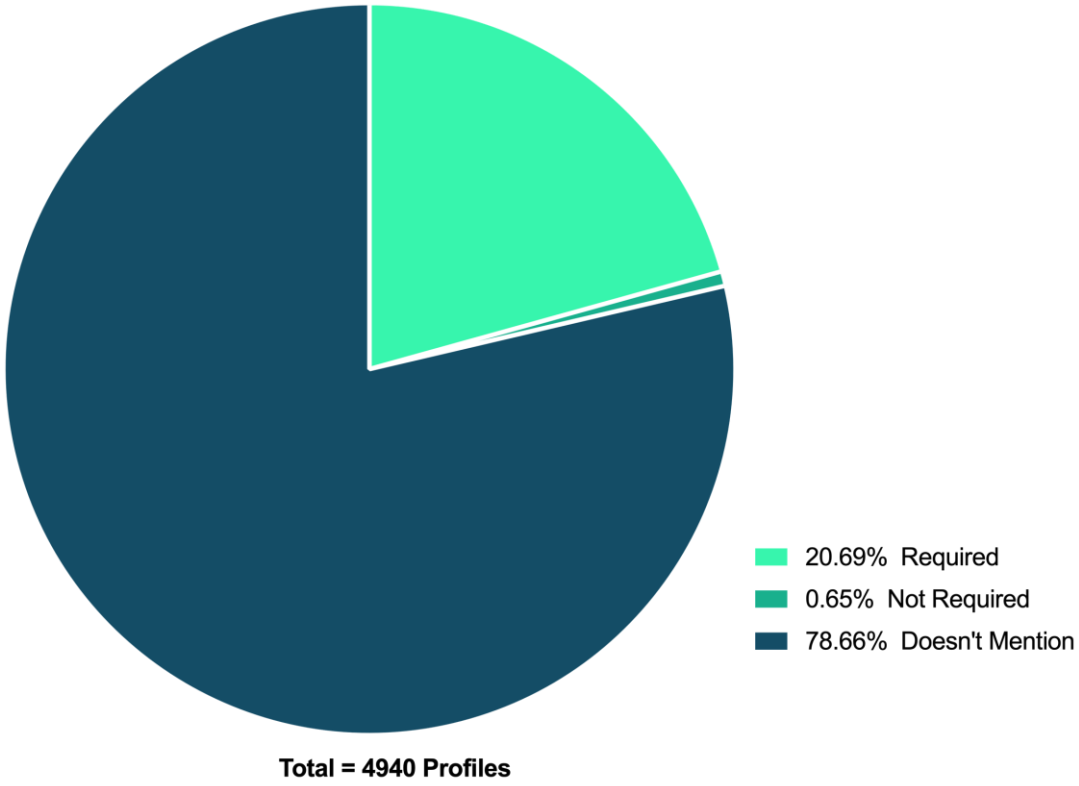


Figure 1. Fenced Yard Requirements for Dog Adoptions on PetFinder. Adoption listings were from PetFinder.com posted from all 50 United States between February 10th, 2022 to April 22nd, 2022.

Figure 2

Fenced Yard Requirements for Dog Adoption Per State

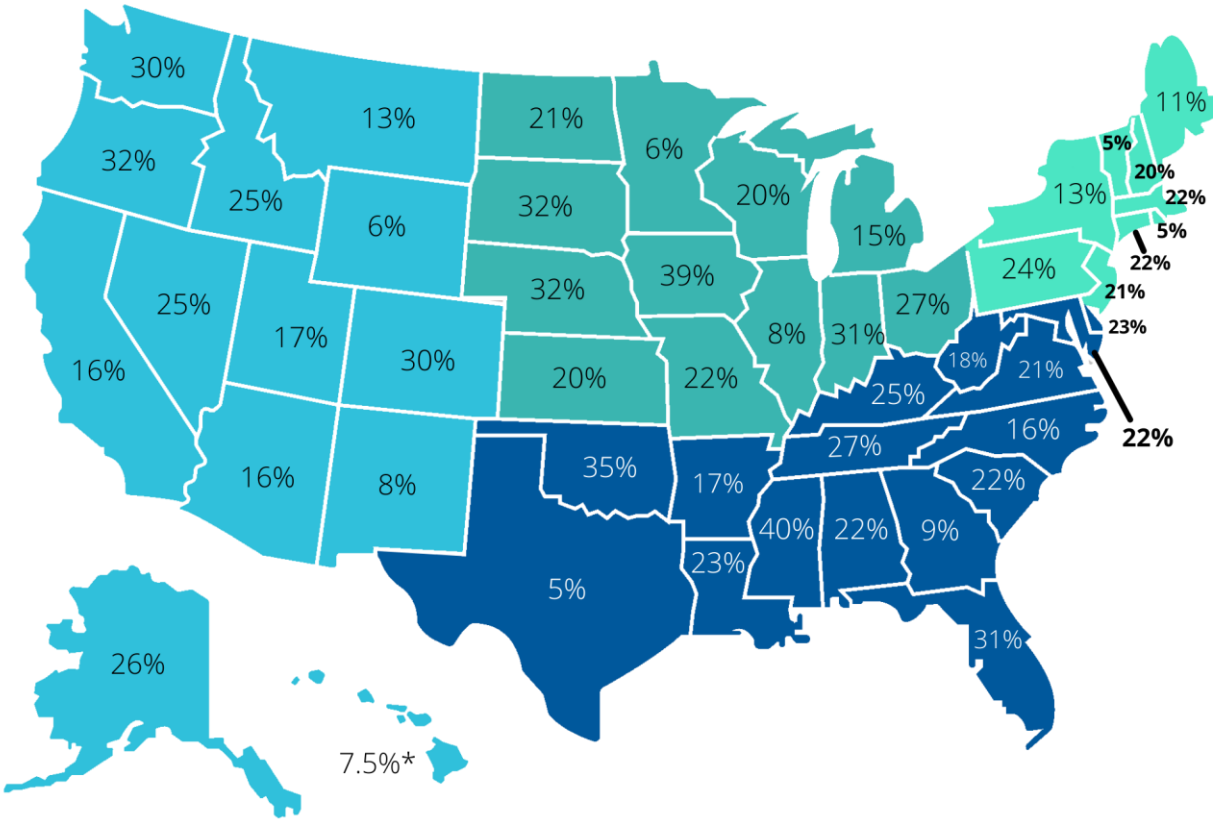


Figure 2. Fenced Yard Requirements for Dog Adoptions on PetFinder by State.

Figure 3

Percentage of Time Engaged in Each Activity Level on Weekdays Versus Weekends

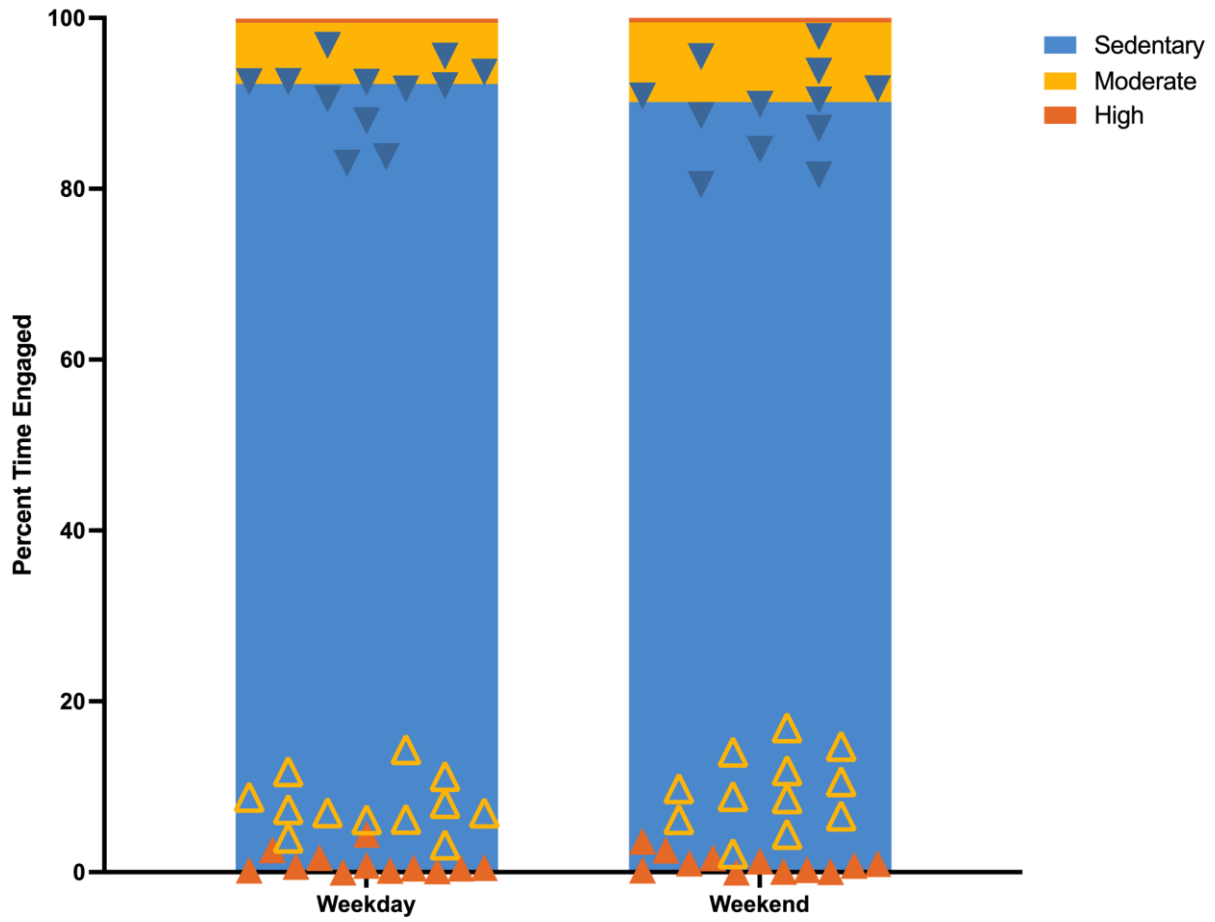
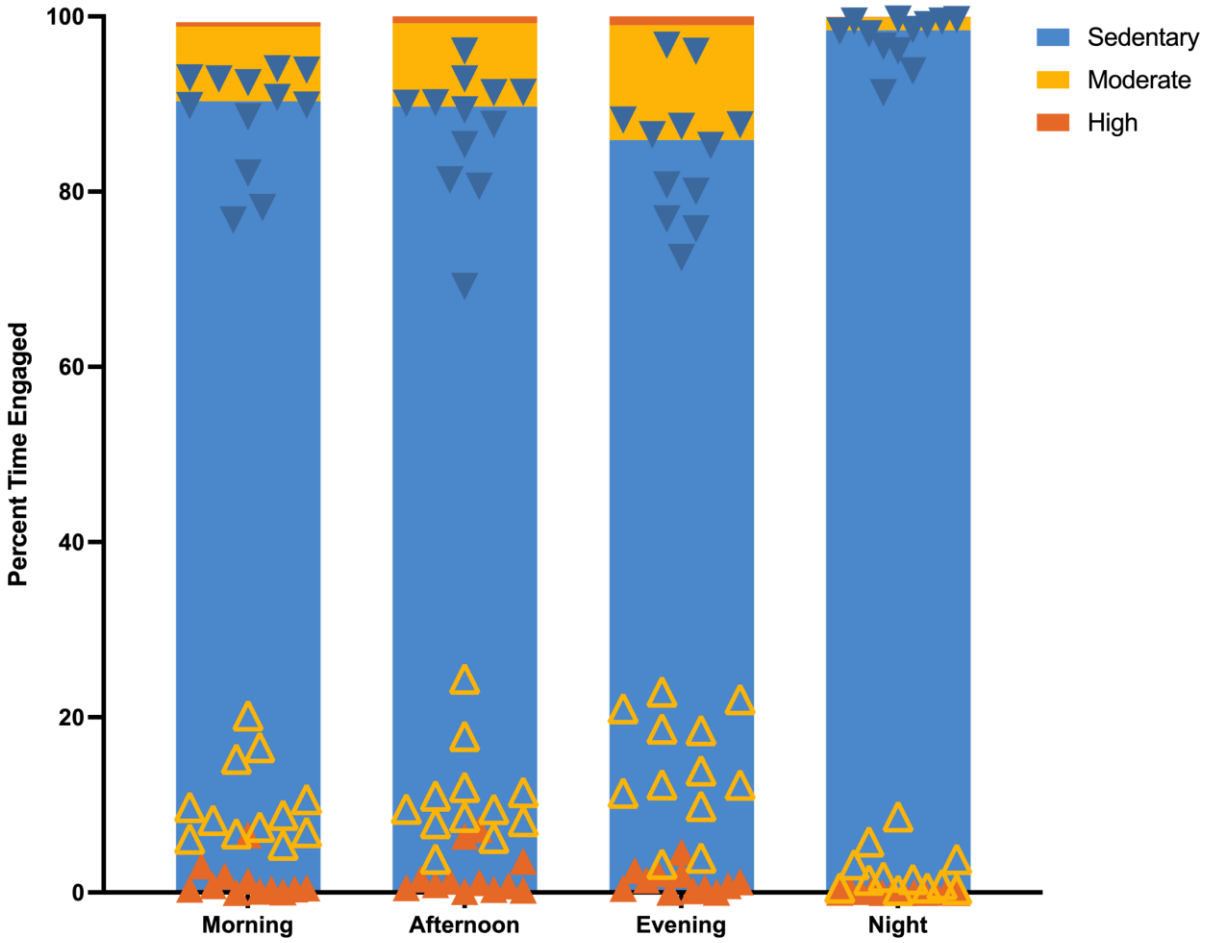


Figure 3. Percentage of Time Engaged in Each Activity Level on Weekdays Versus Weekends. Percentage of time dog participants engaged in each activity level on weekdays versus weekends.

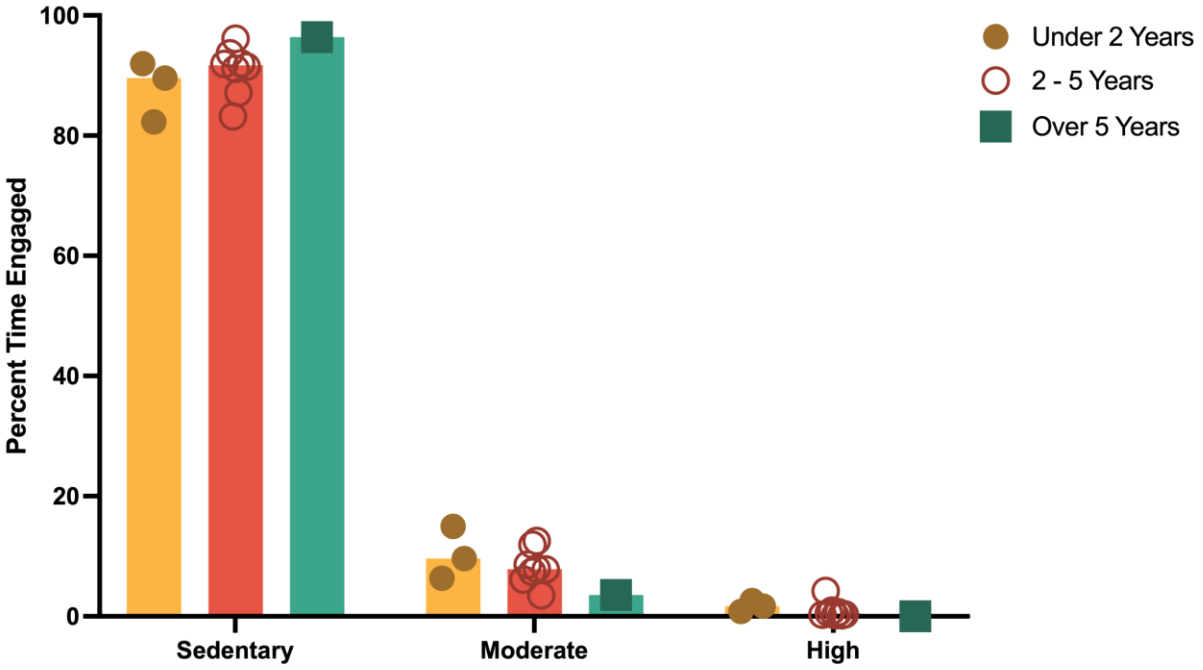
Figure 4



Percentage of Time Engaged in Each Activity Level During Different Times Of Day

Figure 4. Percentage of Time Engaged in Each Activity Level During Different Times Of Day. Percentage of time dog participants engaged in each activity level during different times of day.

Figure 5



Overall Percentage of Time Engaged in Activity Levels By Age

Figure 5. Overall Percentage of Time Engaged in Activity Levels By Age. Percentage of time dog participants engaged in each activity level by age group during overall collar-wear period.

Figure 6

Percentage of Time Engaged In Activity Levels In Fenced Yard Versus Outside Fenced Yard By Age

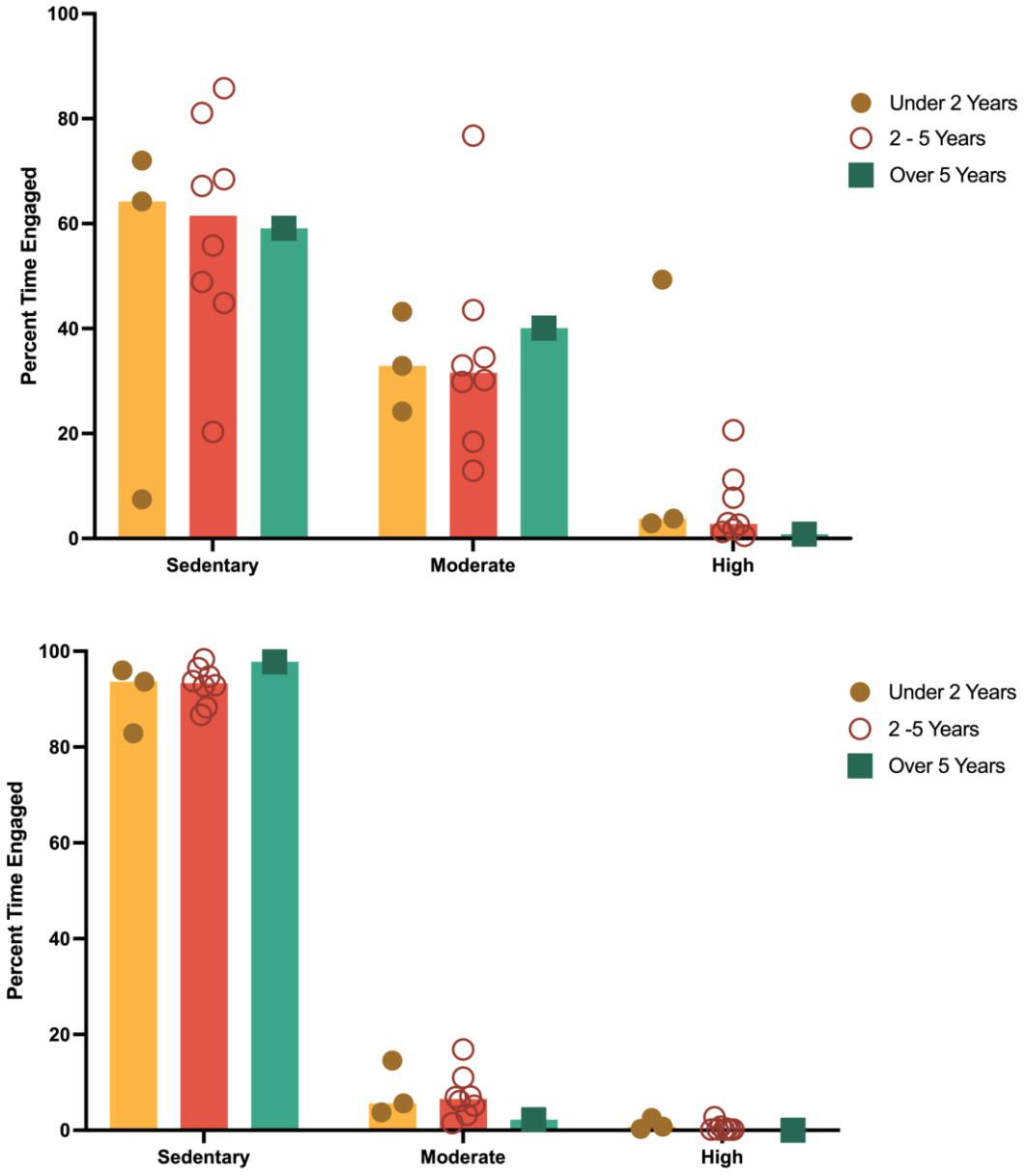


Figure 6. Percentage of Time Engaged In Activity Levels In Fenced Yard Versus Outside Fenced Yard By Age. Percentage of time dog participants engaged in each activity level by age group when in the fenced yard and when outside of the fenced yard.

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