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Dog-walking in dense compact areas: The role of neighbourhood built environment

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A B S T R A C T

There is a dearth of evidence about how high-density living may influence dog-walking behaviour. We examined associations between neighbourhood built environment attributes and dog-ownership and dog-walking behaviour in Japan. Data from 1058 participants were used. The dog-ownership was 18.8%. All neighbourhood built attributes (excluding availability of parks) were negatively associated with dog-ownership. Among dog-owners, these same attributes were positively associated with any dog-walking in a usual week and with achieving 150-min per week of physical activity through dog-walking alone. These findings provided evidence on the importance of neighbourhood built environment attributes on dog-ownership and dog-walking behaviour in dense and compact areas. The urban design and public health implication of these findings is that the built environment attributes in high-density living areas may have different impacts on dog-ownership and dog-walking: while living in a walkable neighbourhood may not be conducive to dog-ownership, it may support dog-walking in such areas. Programs targeting dog-owners in high-density areas might be needed to encourage them to walk their dogs more. If successful, these programs could contribute to higher physical activity levels among dog-owners.

1. Introduction

There is a growing body of evidence demonstrating that dog-ownership is associated with physical activity across the life-course (Christian et al., 2013; Salmon et al., 2010; Wu et al., 2017). A cross-sectional study conducted in Australia found that dog-ownership was associated with children's physical activity (Salmon et al., 2010). A review of 29 published studies (1990–2010) found that dog-ownership in adults was associated with increased physical activity (Christian et al., 2013). A recent study undertaken in the UK found dog-ownership to be associated with older adults' objectively-measured physical activity (Wu et al., 2017). Dog-owners accumulate physical activity via walking their dogs. Notably, dog-walkers are more likely to engage in physical activity compared with non-dog-walkers (Christian et al., 2018; Soares et al., 2015). For example, dog-walkers are over 2.5 times likely to achieve the recommended weekly level of moderate-to-vigorous physical activity compared with non-dog-walkers (Soares et al., 2015). Similar to many western countries (e.g., Australia, Canada, and the USA) where dog-ownership makes-up a significant proportion of the population (American Pet Products Association; Animal Health Alliance, 2016; Perrin, 2009), in Japan, approximately 17% of households own a pet dog (Growth from Knowledge, 2016). Promoting and encouraging

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dog-walking have the potential to influence physical activity levels in this super-aged society, where more than half the population do not currently engage in the recommended level of physical activity (Oka and Shibata, 2012; Shibata et al., 2012). According to the national data, the number of daily steps of Japanese older adults (over 65 years old) is only 5597 steps for men, 4726 steps for women in 2017 (Ministry of Health Labour and Welfare Japan, 2017). A study using objective accelerometer data also found only about 31% and 21% of their sample of Japanese older men and women met the recommendation of 150 min of moderate to vigorous physical activity per week, respectively (Amagasa et al., 2017).

The role of the neighbourhood built environment as a barrier or facilitator for dog-ownership and dog-walking has been investigated by several studies (Christian et al., 2010; Coleman et al., 2008; Engelberg et al., 2016; McCormack et al., 2011, 2016; Richards et al., 2013). Some built environment attributes including street layout (McCormack et al., 2011), neighbourhood walkability (characterised by connected streets, high density, and land-use mix) (Engelberg et al., 2016), and access to parks (Christian et al., 2010) have been found to be associated with dog-walking behaviour. For example, McCormack et al. (2011) found that those dog-owners who lived in a grid street pattern were less likely to engage in dog-walking compared with those in less connected neighbourhoods. Another study found that having access to a dog-supportive park was associated with dog-walking, adjusting for other socio-demographic covariates (Christian et al., 2010). Despite almost a decade of interest on this topic, few studies have investigated the relations between the built environment and dog-walking. Notably, it remains unknown as to how built environment attributes such as sidewalk availability and space syntax metrics influence dog-ownership and dog-walking.

More importantly, most studies investigating the associations between the built environment and dog-walking are undertaken in sprawled lower density geographical areas in Australia, Canada, and the USA. There is a dearth of evidence about how high-density living (e.g., ultra-high population density) may influence dog-walking behaviour. There has been a worldwide increase in people living in urban areas with more than half of world's population are living in cities. By 2050, one in three people will likely live in cities and urban centres, according to the United Nations report (United Nations, 2018). Therefore, high-density living will become even more prevalent in the next decades. For humans to continue to gain the health and social benefits of owning and walking a dog, better understanding of the relationships between the built environment and dog-ownership and dog-walking in the context of dense and compact areas such as Japan are necessary.

Therefore, the aim of this study was to examine associations between objectively-measured neighbourhood built environment attributes and dog-ownership and dog-walking behaviour in a sample of Japanese adults.

2. Methods

2.1. Study and sample

This study was part of the Healthy Built Environment in Japan (HEBEJ) project, an observational study examining associations of environmental attributes with health behaviours and outcomes among middle-to-older aged adults in Japan. The study design and methodology has been fully described elsewhere (Ishii et al., 2013). Briefly, a random cross-section of residents (40–69 years old) of two areas (Nerima Ward and Kanuma City) in Japan participated in this study (n = 1, 076, response rate = 35.9%). Nerima Ward is one of the 23 Special Ward of Tokyo and an example of highly populated residential district within a metropolitan area (721,722 persons in 2015). While Kanuma City in Tochigi Prefecture is a typical example of Japanese middle-size regional city (98,374 persons in 2015), its population density (639 persons per square kilometre) is still larger than those of many Western cities. A postal survey (from February through March 2010) captured information about dog-walking, socio-demographic, and health-related characteristics. The Institutional Ethics Committee of Waseda University approved this study (2010-238).

2.2. Measures

Dog-walking. Participants who owned a dog responded to the question "In a usual week do you walk with your dog(s)?" Those who responded "Yes" then reported weekly frequency and minutes of their dog-walking. These items have good reliability (Cutt et al., 2008). The duration of dog-walking was dichotomised into whether or not dog-walkers met physical activity recommendations of at least 150 min of physical activity in the last week (Centers for Disease Control and Prevention, 2016).

Neighbourhood built environment attributes. Six neighbourhood built environment attributes including population density (number of residents per km^2), intersection density (number of three-way or more intersections per km^2), street integration (mean value of street integration), availability of sidewalks (length of roads with sidewalks per km^2), availability of destinations (number of 27 types of destinations), and number of parks were objectively calculated using geographic information systems (GIS). Two measures of street connectivity were included in this study. While both intersection density and street integration reflect street connectivity, they depict different metric and topological aspects of street layout; and they do have their independent effects on walking behaviours (Koohsari et al., 2016b). Street integration reflects the number of turns (changes in direction) needed to travel from one location to all other locations in a defined area. Additionally, we estimated the space syntax walkability index (SSW). Recently, street integration has been combined with neighbourhood population density to create a novel walkability index, SSW (Koohsari et al., 2016a). SSW is a resourceful approach for estimating built characteristics compared with traditional neighbourhood walkability index, because the former is estimated from network and population data that are readily available. The SSW is associated with walking (Koohsari et al., 2016a) but unlike previous walkability indices (Maghelal and Capp, 2011), SSW employs readily-available geographic data. Spatial GIS data layers were from the Environmental Systems Research Institute (ESRI) Japan data 2011. Similar to previous studies among middle-to-older aged adults (Nagel et al., 2008), an 800 m (half a mile) circular (as the crow flies) buffer around participants' geocoded residential addresses was used to calculate neighbourhood built environment attributes in HEBEJ study.

Socio-demographic and health-related covariates. Participants reported their age, gender, education (tertiary or higher, below tertiary), employment status (employed, unemployed), household income (<¥5,000,000; ≥ ¥5,000,000), dog-ownership (yes, no), and self-rated health (healthy, not healthy).

2.3. Analysis

Descriptive analyses were used to calculate means and standard deviations for all variables in three groups of non-dog-owners, non-dog-walkers, and dog-walkers. Covariate-adjusted binary logistic regression estimated odds ratios (OR) and 95 percent confidence intervals (95CI) for the associations between neighbourhood built attributes and dog-ownership (n = 1058). For dog-owners only, covariate-adjusted binary logistic regression also estimated the associations between neighbourhood built attributes and dog-walking (any versus none, and; ≥150 versus <150 min, respectively) in a usual week (n = 199 and n = 137, respectively). Covariate-adjusted Zero-truncated Poisson regression estimated the associations (unstandardized beta: β and 95CI) between neighbourhood built attributes and the log count of dog-walking frequency in a usual week (n = 137). All neighbourhood built environment attributes were standardized (i.e., z-scores) prior to the regression analysis. We also checked the categorised exposures to assess possible non-linear relations but we could not identify clear non-linear trends (results not shown). Analyses were conducted using Stata 15.0 (Stata Corp, College Station, Texas) and the level of significance was set at $p < 0.05$.

3. Results

After excluding those with missing dog-ownership and dog-walking values (n = 18), data from 1058 participants were included in the analysis. In our sample, the median age was 56, less than half (48%) were female, more than half (53%) completed tertiary or higher education, and about 74% were employed. Our sample included 199 (18.8%) dog-owners, of which 137 participants (68.8%) walked their dog at least one time per week. Few differences in sociodemographic characteristics between non-dog-owners, non-dog-walkers, and dog-walkers were found (Table 1). Notably, non-dog-walkers had significantly ($p < 0.05$) higher household income compared with non-dog-owners and dog-walkers. Dog-owners walked their dogs, on average, 7.8 times per week and approximately one-half (55.5%) walked their dogs for at least 150 min per week. Table 2 shows the characteristics of neighbourhood built attributes.

Adjusting for covariates, all neighbourhood built attributes (excluding availability of parks) were negatively associated ($p < 0.05$) with dog-ownership (Table 3). Among dog-owners, these same attributes were positively associated ($p < 0.05$) with any dog-walking in a usual week ($p < 0.05$). Among dog-walkers, positive associations between street integration and SSW, and log count of dog-walking frequency were borderline significant ($\beta = 0.17$, 95% CI = −0.01, 0.35, $p = 0.07$; $\beta = 0.18$, 95% CI = −0.02, 0.39, $p = 0.08$, respectively). Except for the availability of parks, all neighbourhood built attributes were positively associated ($p < 0.05$) with achieving 150-min per week of physical activity through dog-walking alone.

4. Discussion

This was the first study, to our knowledge, to examine associations between neighbourhood built attributes and dog-ownership and dog-walking in the context of a dense and compact area in Asia. About 18% of our sample owned a pet dog. There are several explanations for the lower rate of dog-ownership in Japan versus other Western countries such as Australia, Canada, and the USA. Limited spatial space (in housing, neighbourhoods) is one of the main barriers to own a dog, especially in Japanese urban areas. As a super-aged society, the number of Japanese single-household elderlies is increasing (Koohsari et al., 2018); which limits the household ability to own a dog. About 70% of dog-owners walked their dog, similar to the 62–84% reported in previous studies involving western populations (Coleman et al., 2008; Engelberg et al., 2016; McCormack et al., 2016; Richards et al., 2013). We found that those people residing in more walkable areas were less likely to own a dog. High walkable and dense areas tend to have smaller dwellings (apartments and condominium), which are not typically convenient for dogs.

Similar to previous evidence (Coleman et al., 2008; Engelberg et al., 2016), our findings showed that higher population density, more connected and integrated street layouts, and better availability of sidewalks and destinations to be supportive for engaging in any dog-walking. These attributes appeared to be also important for dog-walkers to achieve the recommended weekly level of physical activity through dog-walking. Additionally, those dog-walkers who lived in areas with higher street integration did walk their dogs more frequently. Another study, conducted in Canada, found more-connected street layouts to be positively associated with the initiation of dog-walking, but not with more frequent dog-walking (McCormack et al., 2011). However, they assigned participants' residential postcode to three broad categories based on the street layout (grid, warped-grid or curvilinear) of the neighbourhood (administrative boundary). This approach may not accurately detect small variations in street layouts to which participants were exposed or that are within immediate walking distance from the participant's home (Koohsari et al., 2016a). In contrast to previous studies conducted in Western contexts (Christian et al., 2010; McCormack et al., 2011), availability of parks was not associated with dog-walking behaviours in our study. This may be due to our park availability measure which did not distinguish between different park types including dog parks. Availability of dog parks with dog-friendly equipment and furniture such as dog park benches, stepping cluster, and ramp were found to be supportive of dog-walking (McCormack et al., 2011). Future qualitative studies are needed to better understand how Japanese dog-walkers engage with their surrounding parks with

Table 1
Characteristics of study participants (n = 1058).

Sample characteristics[a]	Total (n = 1058)	Non-dog-owner (n = 859)	Non-dog-walkers (n = 62)	Dog-walkers (n = 137)
Age, years (median [IQR])	56.0 (15)	56.0 (15)	55.0 (15)	57.0 (11)
Gender				
Female	507 (48%)	409 (48%)	27 (44%)	71 (52%)
Education				
Tertiary or higher	559 (53%)	465 (54%)	27 (44%)	67 (49%)
Below tertiary	498 (47%)	393 (46%)	35 (56%)	70 (51%)
Employment status				
Employed	772 (74%)	622 (73%)	50 (83%)	100 (74%)
Unemployed	277 (26%)	231 (27%)	10 (17%)	36 (26%)
Household income (per annum)[b]				
<¥5,000,000	523 (49%)	430 (51%)	21 (35%)	72 (54%)
≥¥5,000,000	514 (49%)	414 (49%)	39 (65%)	61 (46%)
Self-rated health				
Healthy	889 (86%)	723 (86%)	48 (79%)	118 (88%)
Not healthy	150 (14%)	121 (14%)	13 (21%)	16 (12%)

[a] Variable distributions are reported as n (%) unless otherwise specified.
[b] Statistically significant difference ($p < 0.05$) based on Pearson's chi-square test.

Table 2
Characteristics of neighbourhood built attributes.

Neighbourhood built attributes	Mean (SD)			
	Total (n = 1058)	Non-dog owners (n = 859)	Non-dog walkers (n = 62)	Dog-walkers (n = 137)
Population density*	9448.4 (8068.2)	9848.3 (8210.8)[a]	6285.0 (7310.3)[a]	8372.7 (70.64)
Intersection density*	352.8 (231.2)	361.4 (229.9)[a]	259.9 (229.7)[a]	341.0 (231.8)
Street integration*	952.8 (787.2)	980.0 (787.2)[a]	611.1 (648.6)[ab]	937.7 (812.4)[b]
Availability of sidewalks*	12.2 (7.7)	12.4 (7.8)[a]	9.3 (7.5)[a]	11.6 (6.9)
Availability of destinations	61.8 (52.4)	63.4 (52.5)[a]	44.2 (48.7)[a]	59.5 (52.2)
Number of parks	0.2 (0.4)	0.2 (0.4)	0.1 (0.3)	0.1 (0.3)

* Statistically significant difference ($p < 0.05$) based on ANOVA test. Estimates with the same superscript are statistically significantly different ($p < 0.05$) based on Tukey's Least Significant Difference Test.
Neighbourhood built attributes within the buffer: Population density. the number of residents per km^2; Intersection density. the number of intersections per square km^2; Street integration. Mean value of street integration; Availability of sidewalks. km of roads with sidewalks per km^2; Availability of destinations. the number of 27 types of destinations; Number of parks. the number of parks.

Table 3
Associations between neighbourhood built attributes and dog-ownership, any dog-walking, achieving ≥150 min of dog-walking, and frequency of dog-walking in a usual week.

Neighbourhood built environment attributes	Dog-ownership[a]	Any dog-walking in a usual week[b]	Frequency of dog-walking in a usual week[c]	Achieving ≥150 min of dog-walking in a usual week[d]
	OR (95% CI)	OR (95% CI)	*B* (95% CI)	OR (95% CI)
Population density	0.76 (0.64, 0.91)*	1.57 (1.02, 2.41)*	0.15 (−0.05, 0.36)	2.19 (1.20, 3.98)*
Intersection density	0.83 (0.70, 0.98)*	1.59 (1.09, 2.30)*	0.16 (−0.05, 0.37)	1.99 (1.19, 3.32)*
Street integration	0.84 (0.70, 1.00)*	1.92 (1.25, 2.94)*	0.17 (−0.01, 0.35)[a]	2.06 (1.24, 3.44)*
Availability of sidewalks	0.82 (0.69, 0.97)*	1.48 (1.01, 2.17)*	0.09 (−0.02, 0.19)	1.77 (1.09, 2.85)*
Availability of destinations	0.85 (0.72, 1.02)[a]	1.45 (0.98, 2.16)[a]	0.06 (−0.07, 0.18)	1.89 (1.14, 3.13)*
Number of parks	0.93 (0.78, 1.10)	0.81 (0.57, 1.16)	−0.10 (−0.21, 0.02)	0.81 (0.50, 1.31)
Space syntax walkability	0.80 (0.67, 0.95)*	1.84 (1.22, 2.78)*	0.18 (−0.02, 0.39)[a]	2.21 (1.29, 3.78)*

Note: OR: odds ratio; CI = confidence interval; β = regression slope coefficient; All models adjusted for age, gender, education, employment status, household income, and self-rated health. Only one built environment variable was included per each model plus covariates. *$p < 0.05$; [a] $p < 0.08$.
[a] n = 1058.
[b] n = 199.
[c] n = 137.
[d] n = 137.

having different dog-friendly features.

This study had some limitations. The self-reported dog-walking measure may be subject to recall bias. Additionally, while not all dog-walking is necessarily undertaken inside the neighbourhood; self-reported dog-walking measures are not specific to neighbourhoods. Causal relationships cannot be drawn from this cross-sectional study. Our relatively small sample size of dog-owners did not allow us to conduct interaction analyses and may limit the interpretation of our results. We did not also take into account dog characteristics such as dog sizes and breeds (Degeling et al., 2012), owner-dog attachment bond (Westgarth et al., 2014), motivation/obligation from the dog to walk (Westgarth et al., 2014), and intention to walk the dog, which may influence dog-walking. Only one geographical buffer was used to calculate the built environment attribute. Future studies are needed to examine whether the observed associations between environmental attributes and dog-walking may vary across different neighbourhood buffers. The circular (as the crow flies) buffer (instead of network-based buffer) was also used which may not represent the actual neighbourhood environment accessible via walking. Furthermore, we did not take into account the potential residential self-selection: people who own dogs may seek out a certain type of housing (and neighbourhood) to accommodate a dog or seek out features that support dog-walking. Notably, however, our findings suggest that higher walkability might discourage dog-ownership, while also supporting dog-walking among dog-owners.

5. Conclusion

Creating a supportive built environment is one strategy in a multi-level approach to encourage dog owners to walk their dogs (Christian et al., 2018). Our findings provide preliminary evidence on the importance of neighbourhood built environment attributes for dog-ownership and dog-walking behaviour in dense and compact areas. While living in walkable neighbourhoods may negatively influence residents' dog-ownership, it may support dog-walking in such areas. Further research in the less-studied dense and compact areas are necessary to inform the urban design and public health fields with information on how high-density living may affect dog-walking.

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References

Amagasa, S., Fukushima, N., Kikuchi, H., Takamiya, T., Oka, K., Inoue, S., 2017. Light and sporadic physical activity overlooked by current guidelines makes older women more active than older men. Int. J. Behav. Nutr. Phys. Act. 14, 59.
American Pet Products Association, APPA National Pet Owners Survey 2017–2018, Greenwich, CT: APPA.
Animal Health Alliance, 2016. Pet Ownership in Australia Summary 2016. AHA, Canberra, Australia.
Centers for Disease Control and Prevention, 2016. Physical Activity for Everyone: How Much Physical Activity Do Adults Need?.
Christian, H., Bauman, A., Epping, J.N., Levine, G.N., McCormack, G., Rhodes, R.E., Richards, E., Rock, M., Westgarth, C., 2018. Encouraging dog walking for health promotion and disease prevention. Am. J. Lifestyle Med. 12, 233–243.
Christian, H., Giles-Corti, B., Knuiman, M., 2010. "I'm Just a'-Walking the Dog" correlates of regular dog walking. Fam. Community Health 33, 44–52.
Christian, H.E., Westgarth, C., Bauman, A., Richards, E.A., Rhodes, R.E., Evenson, K.R., Mayer, J.A., Thorpe, R.J., 2013. Dog ownership and physical activity: a review of the evidence. J. Phys. Act. Health 10, 750–759.
Coleman, K.J., Rosenberg, D.E., Conway, T.L., Sallis, J.F., Saelens, B.E., Frank, L.D., Cain, K., 2008. Physical activity, weight status, and neighborhood characteristics of dog walkers. Prev. Med. 47, 309–312.
Cutt, H.E., Giles-Corti, B., Knuiman, M.W., Pikora, T.J., 2008. Physical activity behavior of dog owners: development and reliability of the Dogs and Physical Activity (DAPA) tool. J. Phys. Act. Health 5, S73–S89.
Degeling, C., Burton, L., McCormack, G.R., 2012. An investigation of the association between socio-demographic factors, dog-exercise requirements, and the amount of walking dogs receive. Can. J. Vet. Res. 76, 235–240.
Engelberg, J.K., Carlson, J.A., Conway, T.L., Cain, K.L., Saelens, B.E., Glanz, K., Frank, L. D., Sallis, J.F., 2016. Dog walking among adolescents: correlates and contribution to physical activity. Prev. Med. 82, 65–72.
Growth from Knowledge, 2016. Pet Ownership Global GfK Survey.
Ishii, K., Shibata, A., Oka, K., 2013. Sociodemographic and anthropometric factors associated with screen-based sedentary behavior among Japanese adults: a population-based cross-sectional study. J. Epidemiol. 23, 382–388.
Koohsari, M., Nakaya, T., Oka, K., 2018. Activity-friendly built environments in a super-aged society, Japan: current Challenges and toward a Research Agenda. Int. J. Environ. Res. Public Health 15, 2054.
Koohsari, M.J., Owen, N., Cerin, E., Giles-Corti, B., Sugiyama, T., 2016a. Walkability and walking for transport: characterizing the built environment using space syntax. Int. J. Behav. Nutr. Phys. Act. 13, 121.
Koohsari, M.J., Sugiyama, T., Mavoa, S., Villanueva, K., Badland, H., Giles-Corti, B., Owen, N., 2016b. Street network measures and adults' walking for transport: application of space syntax. Health Place 38, 89–95.
Maghelal, P.K., Capp, C.J., 2011. Walkability: a review of existing pedestrian indices. J. Urban . Reg. Inform. Syst. Assoc. 23.
McCormack, G.R., Graham, T.M., Christian, H., Toohey, A.M., Rock, M.J., 2016. Supportive neighbourhood built characteristics and dog-walking in Canadian adults. Can. J. Public Health 107, e245–e250.
McCormack, G.R., Rock, M., Sandalack, B., Uribe, F.A., 2011. Access to off-leash parks, street pattern and dog walking among adults. Public Health 125, 540–546.
Ministry of Health Labour and Welfare Japan, 2017. Summary Results of National Health and Nutrition Survey Japan.
Nagel, C.L., Carlson, N.E., Bosworth, M., Michael, Y.L., 2008. The relation between neighborhood built environment and walking activity among older adults. Am. J. Epidemiol. 168, 461–468.

Oka, K., Shibata, A., 2012. Prevalence and correlates of dog walking among Japanese dog owners. J. Phys. Act. Health 9, 786–793.
Perrin, T., 2009. The business of urban animals survey: the facts and statistics on companion animals in Canada. Can. Vet. J. 50, 48.
Richards, E.A., McDonough, M.H., Edwards, N.E., Lyle, R.M., Troped, P.J., 2013. Psychosocial and environmental factors associated with dog-walking. Int. J. Health Promot. Educ. 51, 198–211.
Salmon, J., Timperio, A., Chu, B., Veitch, J., 2010. Dog ownership, dog walking, and children's and parents' physical activity. Res. Q. Exerc. Sport 81, 264–271.
Shibata, A., Oka, K., Inoue, S., Christian, H., Kitabatake, Y., Shimomitsu, T., 2012. Physical activity of Japanese older adults who own and walk dogs. Am. J. Prev. Med. 43, 429–433.
Soares, J., Epping, J.N., Owens, C.J., Brown, D.R., Lankford, T.J., Simoes, E.J., Caspersen, C.J., 2015. Odds of getting adequate physical activity by dog walking. J. Phys. Act. Health 12, S102–S109.
United Nations, 2018. 2018 Revision of World Urbanization Prospects. United Nations Department of Economic and Social Affairs.
Westgarth, C., Christley, R.M., Christian, H.E., 2014. How might we increase physical activity through dog walking?: a comprehensive review of dog walking correlates. Int. J. Behav. Nutr. Phys. Act. 11, 83.
Wu, Y.-T., Luben, R., Jones, A., 2017. Dog ownership supports the maintenance of physical activity during poor weather in older English adults: cross-sectional results from the EPIC Norfolk cohort. J. Epidemiol. Community Health 71, 905–911.