Landscape and Urban Planning 174 (2018) 18–23

Contents lists available at ScienceDirect

Landscape and Urban Planning

journal homepage: www.elsevier.com/locate/landurbplan

Research Paper

Neighbourhood greenspace is related to physical activity in England, but only for dog owners

Mathew P. White*, Lewis R. Elliott, Benedict W. Wheeler, Lora E. Fleming

European Centre for Environment & Human Health (ECEHH), University of Exeter Medical School, England, United Kingdom

ARTICLE INFO

Keywords:
Greenspace
Physical activity
Dog-ownership
Health promotion

ABSTRACT

Evidence supporting a positive association between neighbourhood greenspace and physical activity is equivocal. Using data from a large, nationally representative survey in England (n = 280,790), we found that while a positive relationship between the amount of neighbourhood greenspace and the odds of achieving recommended weekly physical activity existed for dog owners, no relationship was found for non-dog owners. The findings highlight the importance of neighbourhood greenspaces for supporting physical activity through dog walking in the UK context, but also raise the issue of how to encourage non-dog owners to use greenspaces in health-promoting ways. The results may also help to explain previously mixed findings in the international evidence base, and emphasise the need to adequately account for dog-ownership in future research exploring the relationship between greenspaces and physical activity.

1. Introduction

Although regular physical activity is beneficial for health (National Institute for Health, 2008; World Health Organization, 2009), the majority of adults in England do not meet guidelines of at least 150 min of moderate-intensity activity a week (Health and Social Care Information Centre, 2017). Attempts to increase physical activity have targeted known determinants at the individual, social and environmental level, with mixed success (Ding et al., 2012; National Institute for Health, 2012; Ogilvie et al., 2007). This study advances the field by focusing on the way in which two different determinants, neighbourhood greenspace and dog-ownership, interact to possibly explain some of the ambiguities in previous research.

Evidence that greater neighbourhood greenspace, by itself, is associated with more physical activity including walking and cycling is equivocal. While some studies report a positive relationship (Astell-Burt, Feng, & Kolt, 2014; Coombes, Jones, & Hillsdon, 2010; Giles-Corti et al., 2005; Richardson, Pearce, Mitchell, & Kingham, 2013; Wendel-Vos et al., 2004), others find no effect (Hillsdon, Panter, Foster, & Jones, 2006; Maas, Verheij, Spreeuwenberg, & Groenewegen, 2008; Ord, Mitchell, & Pearce, 2013), or even a negative relationship (Triguero-Mas et al., 2015). Even among positive relationship studies, many only find significant differences between the most and least green areas, rather than a 'dose-response' pattern (Astell-Burt et al., 2014; Duncan & Mummery, 2005; Perchoux, Kestens, Brondeel, & Chaix, 2015). Inconsistencies have been explained in terms of differing operationalisations of greenspace (Klompmaker et al., 2018; Mytton, Townsend, Rutter, & Foster, 2012) and/or physical activity (Lachowycz & Jones, 2011), and variation in included confounders (James, Banay, Hart, & Laden, 2015). Within the confines of utilising the measures of greenspace, physical activity and common confounders available, the current research focused on dog ownership as a potentially important confounder that has been under-researched to date.

The relationship between dog-ownership and physical activity, independent of local greenspace, is clear, with several reviews reporting a positive relationship (Christian et al., 2013; Toohey & Rock, 2011). Although the effect is generally small (Westgarth, Christley, & Christian, 2014), longitudinal work supports a causal relationship (Cutt, Giles-Corti, Knuiman, & Burke, 2007). Crucially for the current study, 'walking the dog' is the most frequent greenspace activity in England, accounting for over 44% of all visits ≥0 min (approx. 580 million annually; (White et al., 2016)). Given that dog owners walk their dogs for, on average, 160 min a week (Toohey & Rock, 2011), and that most dog walking takes place within 2 miles of home (Elliott, White, Taylor, & Herbert, 2015), some of the ambiguity in previous findings investigating the relationship between greenspace and physical activity might be due to not having fully accounted for dog-ownership.

The current work explored this issue using data from the Monitor of Engagement with the Natural Environment (MENE) survey, a repeat cross-sectional survey running in England since 2009. Our central hypothesis was that any positive relationship between the amount of neighbourhood greenspace and achieving physical activity

* Corresponding author at: ECEHH, University of Exeter Medical School, Knowledge Spa, Royal Cornwall Hospital Treliske, Truro, Cornwall, TR1 3HD England, United Kingdom.
E-mail address: mathew.white@exeter.ac.uk (M.P. White).

https://doi.org/10.1016/j.landurbplan.2018.01.004
Received 10 May 2017; Received in revised form 11 January 2018; Accepted 14 January 2018

recommendations would be stronger for dog owners than non-dog owners because neighbourhood greenspace is an important facilitator of regular dog walking, itself a contributor to physical activity. Although dogs in public spaces may also inhibit activity and enjoyment amongst non-dog owners (Christian et al., 2013; Toohey & Rock, 2011; Westgarth et al., 2014), we did not explore this possibility here.

2. Method

2.1. Participants

Participants were 280,790 individuals from the first six waves (2009/10-2014/15) of the MENE survey. The survey is commissioned by Natural England, a government body promoting public understanding of the natural environment, and is part of a face-to-face, nationally representative omnibus survey conducted across England throughout the year to reduce geographical and seasonal biases. Details on sampling protocols, to ensure representativeness, are available elsewhere (Natural England, 2017).

2.2. Physical activity

Physical activity was derived from the question: *"In the past week, on how many days have you done a total of 30 min or more physical activity which was enough to raise your breathing rate? This may include sport, exercise, and brisk walking or cycling for recreation or to get to and from places, but should not include housework or physical activity that may be part of your job"* (Natural England, 2017; p. 50). This single item has good test-retest reliability and correlates well with more detailed measures (Milton, Bull, & Bauman, 2011). As UK guidelines are for a minimum of 150 min of moderate physical activity a week and one way of achieving this is ≥5 days of 30 min (Bull and The Expert Working Groups, 2010), our outcome variable was whether or not the individual reported engaging in ≥5 days of ≥30 min of leisure- or transport-related physical activity (LTPA) in the last week (White, Wheeler, Herbert, Alcock, & Depledge, 2014).

2.3. Neighbourhood greenspace and covariates

Neighbourhoods were defined as the Lower-layer Super Output Area (LSOA) of respondent residence, where each LSOA (n = 32,482 in England) contains approximately 1500 people and has an average size of 4 km^2. Neighbourhood greenspace was derived from the Generalised Land Use Database which categorises the total land use in each LSOA, at a resolution of 10 m^2, into nine types: greenspace, domestic gardens, fresh water, domestic buildings, nondomestic buildings, roads, paths, railways, and other (Department for Communities and Local Government, 2007). 'Greenspace' (excluding domestic gardens) includes, playing fields, parks, woodlands and farmland, and on average, accounts for 40.5% of LSOA land use in our sample. To aid interpretation, we structured this into 5 equal bands of greenspace for each LSOA: 0–19.99%; 20–39.99%; 40–59.99%; 60–79.99% and 80–100%. LSOA data were missing for 2.7% of the sample, so final analyses included n = 271,071 participants.

Based on Census definitions, LSOAs are categorised as 'Urban' (LSOAs situated within a conurbation of > 10,000 inhabitants), 'Town & Fringe' (within peri-urban areas and smaller conurbations), or 'Rural' (within villages, hamlets and sparsely populated areas). We collapsed the first two categories into a single 'urban-peri-urban' category to have the widest spread of greenspace availability in the non-rural category. This aggregation also results in inclusion of relatively similar types of greenspace access within the 'urban' category (primarily parks, public gardens etc. in urban, peri-urban and town settings, as opposed to wider 'countryside' availability in more sparsely populated rural settings). This resulted in 92.8% of the sample categorised as urban-peri-urban and 7.2% as rural. The socio-economic characteristics of each LSOA (including unemployment, education and crime) were taken from the 2004 Indices of Deprivation (Department for Communities and Local Government, 2008). We used the total Index of Multiple Deprivation (IMD) score, divided by ten to aid interpretation of regression coefficients (White et al., 2014).

2.4. Dog-ownership

Dog-ownership was assessed with the question: "*Do you have a dog?", 'Yes' or 'No'*.

2.5. Individual & time-related control variables

Individual level control variables included: sex (male = *reference*), age (16–34 years = *reference*, 35–64 years, ≥65 years), Socio-economic status (SES) classification based on occupation (A/B = high/intermediate managerial, professional; C1 = supervisory, clerical, junior managerial; C2 = skilled manual worker; D/E = semi, unskilled manual worker = *reference*), employment status (full-time, part-time, in education, not working, retired, unemployed/not working = *reference*), marital status (married/cohabiting vs. single/separated/divorced/widowed = *reference*), children in the household (≥1 vs. 0 = *reference*), ethnicity (White British vs. other = *reference*), long standing work/mobility limiting health issue (No vs. Yes = *reference*), and access to own car/van (Yes vs. No = *reference*). These factors have all been associated with physical activity (Giles-Corti & Donovan, 2002; Lachowycz & Jones, 2011; White et al., 2014) and/or dog-ownership (Westgarth et al., 2014) in previous research. We also controlled for season and survey year in case there was variance across season as a function of dog-ownership (Lail, McCormack, & Rock, 2011; Temple, Rhodes, & Higgins, 2011; Wu, Luben, & Jones, 2017).

2.6. Analysis strategy

Analyses were conducted in SPSS v23 and constituted a series of logistic regressions estimating the odds of an individual achieving ≥5 (vs. < 5) days of LTPA a week. Three core models were run: a) an unadjusted model of the relationship between neighbourhood greenspace and LTPA; b) the same relationship controlling for dog-ownership and area, individual and temporal controls; and c) a model including the interactions between dog-ownership and greenspace. Additional models were stratified by season (presented in Supplementary Materials) and run for urban settings only (because the vast majority of rural dwellers were already in the highest quintile of greenspace coverage).

3. Results

Full descriptives are presented in Supplementary Table A. The simple (unadjusted) relationship between neighbourhood greenspace, dog-ownership and LTPA can be seen in Table 1. These unadjusted results suggest that those in the greenest areas were more likely to achieve LTPA guidelines (24.8%) than those in the least green areas (21.7%), as were dog owners (34.9%) compared to non-dog owners (19.1%). When stratified on dog-ownership, the relationship between greenspace and LTPA was positive for dog owners (from 33.4% in the least green neighbourhoods to 38.4% in the greenest), but not non-dog owners (from 19.2% to 18.8%).

Table 2 presents the logistic regression models. Model 2 shows that after all covariates are included, a significant relationship between greenspace and LTPA persists. This model also suggests that urban residents, females, older adults, those with a long-term illness or disability, and those in higher social grades were less likely to report meeting physical activity guidelines. White British participants, those unemployed/not working, and those interviewed in spring, summer and autumn (vs. winter) were more likely to report meeting guidelines.

Table 1
Number and percentage of individuals reporting ≥5 episodes of physical activity in the last 7 days as a function of neighbourhood greenspace and dog-ownership in England (2009/10-2014/15).

	Total (valid) sample		Physical activity			
	(N = 280,790)		< 5 per week (n = 217,259; 77.4%)		≥5 per week (n = 63,531; 22.6%)	
	N	%[a]	N	%[b]	N	%[b]
Neighbourhood greenspace						
80–100%	40,693	15.0	30,618	75.2	10,075	24.8
60–79.99%	31,917	11.8	24,463	76.6	7454	23.4
40–59.99%	43,731	16.1	33,662	77.0	10,069	23.0
20–39.99%	70,448	26.0	54,776	77.8	15,672	22.2
0–19.99%	84,282	31.1	65,991	78.3	18,291	21.7
Owns Dog						
Yes	63,454	22.6	41,328	65.1	22,126	34.9
No	217,336	77.4	175,931	80.9	41,405	19.1
Greenspace by dog-ownership						
80–100% x dog yes	12,422	4.4	7652	61.6	4770	38.4
60–79.99% x dog yes	8337	3.0	5315	63.8	3022	36.2
40–59.99% x dog yes	10,608	3.8	6924	65.3	3684	34.7
20–39.99% x dog yes	15,333	5.5	10,241	66.8	5092	33.2
0–19.99% x dog yes	14,899	5.3	9928	66.6	4971	33.4
80–100% x dog no	28,271	10.1	22,966	81.2	5305	18.8
60–79.99% x dog no	23,580	8.4	19,148	81.2	4432	18.8
40–59.99% x dog no	33,123	11.8	26,738	80.7	6385	19.3
20–39.99% x dog no	55,115	19.6	44,535	80.8	10,580	19.2
0–19.99% x dog no	69,383	24.7	56,063	80.8	13,320	19.2

[a] Column percentages (i.e.% of people in each greenspace/dog-ownership category).
[b] Row percentages (e.g.% of people within each greenspace/dog-ownership category).

These findings largely replicate earlier results (Giles-Corti & Donovan, 2002).

Model 3 adds dog-ownership and the interactions between greenspace and dog-ownership. Dog owners were twice as likely to report meeting guidelines as non-dog owners. Although it now appears that those in the greenest areas were less likely to achieve guidelines these results can only be interpreted with reference to the interaction terms and is clarified in the stratified models. Specifically, there was a clear, linear gradient concerning the interaction terms between greenspace and dog-ownership: as greenspace increased, dog-ownership became an increasingly important predictor of LTPA.

Model 4 shows this pattern was maintained even when only urban areas were explored. Full models for greenspace stratified by dog-ownership are presented in Supplementary Table B, and key findings presented in Fig. 1. Compared to living in an area with 0–19.99% greenspace, living in areas with: a) 20–59.99% greenspace was unrelated to the odds of achieving LTPA guidelines; but b) 60–100% greenspace was related to LTPA for dog owners, but not non-dog owners (although the ORs were < 1, the relationship was not significantly negative).

A further breakdown of results by dog-ownership, by season is presented in Supplementary Table C. Although there was some evidence that dog owners in greener areas were more likely to report recommended levels of PA in spring, the overall seasonal pattern was unclear.

4. Discussion

Supporting some previous work (Astell-Burt et al., 2014; Coombes et al., 2010; Giles-Corti et al., 2005; Richardson et al., 2013; Wendel-Vos et al., 2004), we found a positive relationship between neighbourhood greenspace and the odds of achieving recommended levels of physical activity, through leisure and travel-related activities (LTPA) alone. Extending previous findings, this relationship was found for dog owners, but not for non-dog owners. Given that: a) on average, dog owners walk their dogs for 160 min per week (Toohey & Rock, 2011); b) most dog walks are within a 2 mile radius of home (Elliott et al., 2015); and c) dog walks are the most frequent activity ≥30 min engaged in England's greenspaces (White et al., 2016), our findings support the contention that the positive association between local greenspace and LTPA in the MENE data, is largely accounted for by dog owners walking their dogs in these locations. Although we recognise the possibility that dog-ownership may be particularly good at motivating people to take exercise in inclement weather (e.g. winter; Lail et al., 2011; Temple et al., 2011; Wu et al., 2017), the current research found no clear relationship between physical activity, greenspace, dog-ownership and season.

The current findings may help explain some of the previously equivocal results concerning the relationship between neighbourhood greenspace and physical activity, at least in the UK and countries with similar cultures of dog-ownership and dog-walking. It seems possible that dog-ownership might also help explain mixed findings in the association between greenspace and social relations (Dadvand et al., 2016; de Vries, van Dillen, Groenewegen, & Spreeuwenberg, 2013; Maas, van Dillen, Verheij, & Groenewegen, 2009; Weinstein et al., 2015). Dog walking has been found to promote social contact (Wood, Giles-Corti, & Bulsara, 2005), in part by enhancing feelings of one's own safety (Westgarth et al., 2014); therefore, it may be that dog-ownership moderates the relationship between greenspaces and social contact, in the same way as we have found for greenspace and LTPA. Further research could explore this possibility.

Several limitations with the present study should be noted. First, LTPA was based on self-reports which are sensitive to over-reporting (National Institute for Health & Care Excellence, 2008). This may be of less concern than usual, however, since only 22.6% of our sample reported meeting guidelines compared to 34% in the Health Survey for England (Bélanger, Townsend, & Foster, 2011), perhaps because the MENE's focus was not on health and there were fewer incentives to give inflated responses. We recognise however that this measure also did not differentiate between indoor and outdoor physical activity which future studies would need to do since dog walking necessitates being outside. Second, it might be argued that dog walking is not sufficiently intense to count as 'moderate-to-vigorous physical activity' and thus conducive to health benefits (McCormack, Graham, Swanson, Massolo, & Rock, 2016). While dog walking is generally considered a relatively low-intensity activity, considerable public health benefits and associated healthcare cost savings could be accrued through dog walking at the population level (Bauman, Russell, Furber, & Dobson, 2001). Importantly, activity accumulated through dog walking could serve to benefit demographic groups typically at risk of inactivity such as older adults (Dalton, Wareham, Griffin, & Jones, 2016; Toohey, McCormack, Doyle-Baker, Adams, & Rock, 2013) and those with chronic diseases (Peel, Douglas, Parry, & Lawton, 2010). Third, our cross-sectional data cannot address issues of causality: for instance there may be selective migration of physically active dog walkers to areas with more greenspace (Astell-Burt et al., 2014). Further, longitudinal work, could explore this issue by monitoring physical activity levels of dog owners moving home to greener areas to see whether having more local greenspace does indeed lead to higher levels of physical activity.

To conclude, our findings support the contention that local planners and greenspace managers can help promote public health by being sensitive to the needs of dog owners as key users of local greenspace,

Table 2
The relationship between neighbourhood green space, dog-ownership and likelihood of reporting ≥5 days of 30 min or more leisure and transport related physical activity in the last 7 days in England (2009/10-2014/15).

	Model 1			Model 2			Model 3			Model 4 (Urban only)		
	OR	95% CIs		OR	95%CIs		OR	95% Cis		OR	95% CIs	
		Lower	Upper		Lower	Upper		Lower	Upper		Lower	Upper
Neighbourhood green space												
80–100%	1.19***	1.16	1.22	1.07***	1.03	1.11	0.92***	0.88	0.96	0.95*	0.90	0.99
60–79.99%	1.10***	1.07	1.13	1.05**	1.01	1.08	0.95*	0.92	0.99	0.95*	0.91	0.98
40–59.99%	1.08***	1.05	1.11	1.05**	1.02	1.08	1.00	0.96	1.03	1.00	0.97	1.03
20–39.99%	1.03**	1.01	1.06	1.02	0.99	1.04	1.00	0.97	1.03	1.00	0.97	1.03
0–19.99%	–	–	–	–	–	–	–	–	–	–	–	–
Owns dog (ref = no)	–	–	–	–	–	–	2.06***	1.98	2.14	2.05***	1.97	2.14
Greenspace × dog												
80–100% × dog	–	–	–	–	–	–	1.28***	1.20	1.36	1.20***	1.11	1.30
60–79.99% × dog	–	–	–	–	–	–	1.17***	1.09	1.25	1.18***	1.10	1.26
40–59.99% × dog	–	–	–	–	–	–	1.07*	1.00	1.14	1.06	1.00	1.13
20–39.99% × dog	–	–	–	–	–	–	1.00	0.94	1.06	1.00	0.95	1.06
0–19.99% × dog	–	–	–	–	–	–	–	–	–	–	–	–
Urban (ref = rural)	–	–	–	0.89***	0.85	0.92	0.94***	0.90	0.98	–	–	–
Area deprivation	–	–	–	1.00	0.99	1.01	0.99***	0.98	1.00	0.99***	0.98	1.00
Female (ref = male)	–	–	–	0.79***	0.78	0.81	0.77***	0.76	0.79	0.78***	0.76	0.79
Age												
18-34yrs (ref)	–	–	–	–	–	–	–	–	–	–	–	–
35-64yrs	–	–	–	1.00	0.97	1.02	1.00	0.97	1.02	0.99	0.97	1.02
65 + yrs	–	–	–	0.77***	0.73	0.80	0.82***	0.79	0.86	0.82***	0.79	0.86
Socioeconomic status												
AB, High	–	–	–	0.94***	0.91	0.96	0.92***	0.90	0.95	0.93***	0.90	0.95
C1, Mod high	–	–	–	0.97*	0.94	1.00	0.92***	0.89	0.95	0.93***	0.90	0.96
C2, Mod low	–	–	–	0.88***	0.85	0.90	0.83***	0.81	0.86	0.83***	0.81	0.86
DE, low (ref)	–	–	–	–	–	–	–	–	–	–	–	–
Ethnicity 'White British' (ref = other)	–	–	–	1.45***	1.41	1.49	1.22***	1.19	1.26	1.24***	1.21	1.27
Employment status												
Full-time (ref)	–	–	–	–	–	–	–	–	–	–	–	–
Part-time	–	–	–	1.03	1.00	1.06	1.03	1.00	1.06	1.02	0.99	1.06
In education	–	–	–	0.99	0.95	1.03	0.96*	0.91	1.00	0.96*	0.92	1.00
Not working	–	–	–	1.06***	1.03	1.09	1.04*	1.01	1.07	1.03*	1.00	1.07
Retired	–	–	–	0.97	0.93	1.01	1.02	0.98	1.06	1.01	0.97	1.05
Married/cohabiting (ref = other)	–	–	–	0.99	0.97	1.01	0.97***	0.94	0.99	0.96***	0.94	0.98
Long-term illness (ref = no)	–	–	–	0.68***	0.66	0.70	0.66***	0.64	0.68	0.67***	0.65	0.69
Children in household (ref = no)	–	–	–	1.00	0.98	1.03	0.99	0.97	1.01	1.00	0.98	1.02
Owns car (ref = no)	–	–	–	1.01	0.99	1.04	1.07***	1.04	1.09	1.08***	1.05	1.10
Season												
Spring	–	–	–	1.13***	1.10	1.16	1.13***	1.10	1.16	1.12***	1.09	1.16
Summer	–	–	–	1.19***	1.16	1.22	1.19***	1.16	1.22	1.19***	1.16	1.23
Autumn	–	–	–	1.12***	1.09	1.14	1.12***	1.09	1.15	1.12***	1.09	1.15
Winter (ref)	–	–	–	–	–	–	–	–	–	–	–	–
Year/wave												
Year 1 (ref)	–	–	–	–	–	–	–	–	–	–	–	–
Year 2	–	–	–	0.93***	0.90	0.96	0.93***	0.90	0.96	0.92***	0.89	0.95
Year 3	–	–	–	0.95**	0.92	0.98	0.94***	0.92	0.97	0.94***	0.91	0.97
Year 4	–	–	–	0.90***	0.88	0.93	0.89***	0.87	0.92	0.88***	0.86	0.91
Year 5	–	–	–	0.93***	0.90	0.96	0.91***	0.89	0.94	0.91***	0.88	0.94
Year 6	–	–	–	0.97	0.94	1.01	0.96*	0.93	0.99	0.96**	0.92	0.99
Constant	0.28			0.31			0.29			0.27		
Nagelkerke R^2	0.00			0.02			0.05			0.05		
N	271,038			271,038			271,038			251,452		

OR = Odds Ratio; CI = Confidence Intervals; Socio-economic status is based on job classifications with AB being e.g. managerial and DE being e.g. unskilled.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

and by supporting dog walking as a key contributor to population level physical activity. The findings also suggest that neighbourhood greenspaces can be an important venue for community physical activity, and that opportunities to capitalise upon this for non-dog owners should also be pursued. At the same time they, and dog owners themselves, need to be sensitive to other groups for whom dog fouling and fear of aggressive dogs can inhibit enjoyment or use of local greenspace for physical activity (Christian et al., 2013; Toohey & Rock, 2011; Westgarth et al., 2014). Above all, the current results may help explain previously equivocal findings concerning neighbourhood greenspace and physical activity, and highlight the need to account for dog-ownership in future related research.

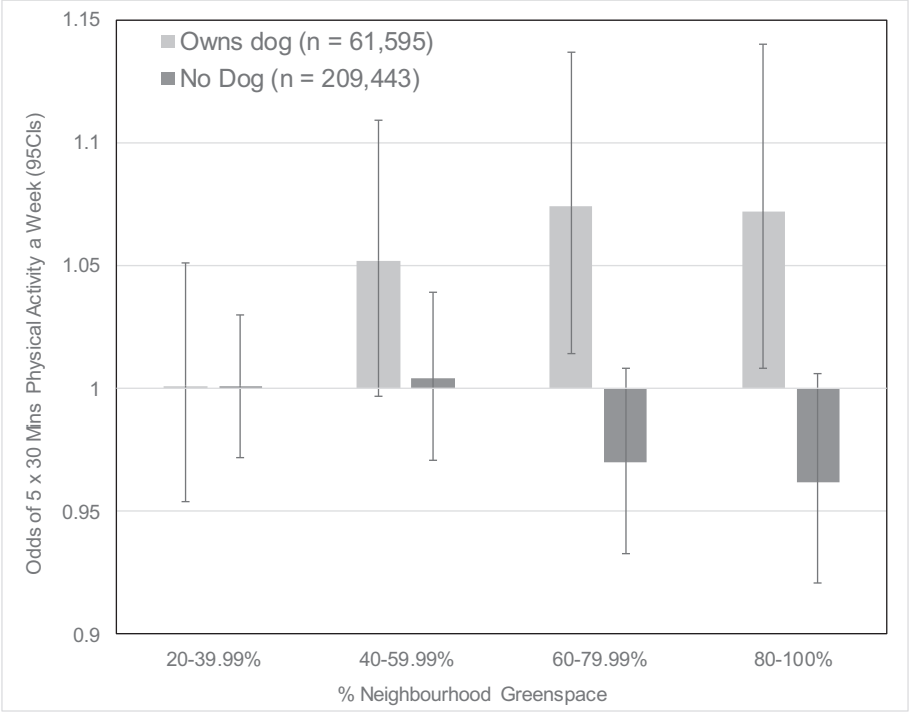

Fig. 1. The odds of reporting recommended physical activity levels of 5 × 30 min a week as a function of neighbourhood greenspace (ref = 0–19.99%) and dog-ownership (controlling for area, individual and temporal factors).

Acknowledgements

We would like to thank the editor and four reviewers for their helpful suggestions and comments on a previous version of this manuscript. This work was supported by the National Institute for Health Research Health Protection Research Unit (NIHR HPRU) in Environmental Change and Health at the London School of Hygiene and Tropical Medicine in partnership with Public Health England (PHE), and in collaboration with the University of Exeter, University College London, and the Met Office. The funders had no role in the study design, analysis, interpretation of data, or decision to submit the article for publication. The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR, the Department of Health, or Public Health England.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.landurbplan.2018.01.004.

References

Astell-Burt, T., Feng, X., & Kolt, G. S. (2014). Green space is associated with walking and moderate-to-vigorous physical activity (MVPA) in middle-to-older-aged adults: Findings from 203 883 Australians in the 45 and Up Study. *British Journal of Sports Medicine, 48*(5), 404–406. http://dx.doi.org/10.1136/bjsports-2012-092006.

Bauman, A. E., Russell, S. J., Furber, S. E., & Dobson, A. J. (2001). The epidemiology of dog walking: An unmet need for human and canine health. *The Medical Journal of Australia, 175*(11), 632–634.

Bélanger, M., Townsend, N., & Foster, C. (2011). Age-related differences in physical activity profiles of English adults. *Preventive Medicine*. http://dx.doi.org/10.1016/j.ypmed.2011.02.008.

Bull, F. C. The Expert Working Groups. (2010). *Physical activity guidelines in the UK: Review and recommendations.* School of Sport, Exercise and Health Sciences, Loughborough University Retrieved from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/213743/dh_128255.pdf.

Christian, H. E., Westgarth, C., Bauman, A., Richards, E. A., Rhodes, R. E., Evenson, K. R., ... Thorpe, R. J., et al. (2013). Dog ownership and physical activity: A review of the evidence. *Journal of Physical Activity and Health, 10*(5), 750–759. http://dx.doi.org/10.1123/jpah.10.5.750.

Coombes, E., Jones, A. P., & Hillsdon, M. (2010). The relationship of physical activity and overweight to objectively measured green space accessibility and use. *Social Science & Medicine, 70*(6), 816–822. http://dx.doi.org/10.1016/j.socscimed.2009.11.020.

Cutt, H., Giles-Corti, B., Knuiman, M., & Burke, V. (2007). Dog ownership, health and physical activity: A critical review of the literature. *Health & Place, 13*(1), 261–272. http://dx.doi.org/10.1016/j.healthplace.2006.01.003.

Dadvand, P., Bartoll, X., Basagaña, X., Dalmau-Bueno, A., Martinez, D., Ambros, A., ... Nieuwenhuijsen, M. J., et al. (2016). Green spaces and general health: Roles of mental health status, social support, and physical activity. *Environment International, 91*, 161–167. http://dx.doi.org/10.1016/j.envint.2016.02.029.

Dalton, A. M., Wareham, N., Griffin, S., & Jones, A. P. (2016). Neighbourhood greenspace is associated with a slower decline in physical activity in older adults: A prospective cohort study. *SSM – Population Health, 2*, 683–691. http://dx.doi.org/10.1016/j.ssmph.2016.09.006.

de Vries, S., van Dillen, S. M. E., Groenewegen, P. P., & Spreeuwenberg, P. (2013). Streetscape greenery and health: Stress, social cohesion and physical activity as mediators. *Social Science & Medicine, 94*, 26–33. http://dx.doi.org/10.1016/j.socscimed.2013.06.030.

Department for Communities and Local Government. (2007). *Generalised Land Use Database Statistics for England 2005*. London: Crown Copyright. Retrieved from: http://www.andywightman.com/docs/GLUD_2005.pdf.

Department for Communities and Local Government. (2008). *The English Indices of Deprivation 2007*. London: Queen's Printer and Controller of Her Majesty's Stationery Office. Retrieved from: http://geoconvert.mimas.ac.uk/help/imd-2007-manual.pdf.

Ding, D., Sallis, J. F., Conway, T. L., Saelens, B. E., Frank, L. D., Cain, K. L., et al. (2012). Interactive effects of built environment and psychosocial attributes on physical activity: A test of ecological models. *Annals of Behavioral Medicine, 44*(3), 365–374. http://dx.doi.org/10.1007/s12160-012-9394-1.

Duncan, M., & Mummery, K. (2005). Psychosocial and environmental factors associated with physical activity among city dwellers in regional Queensland. *Preventive Medicine, 40*(4), 363–372. http://dx.doi.org/10.1016/j.ypmed.2004.06.017.

Elliott, L. R., White, M. P., Taylor, A. H., & Herbert, S. (2015). Energy expenditure on recreational visits to different natural environments. *Social Science & Medicine, 139*, 53–60. http://dx.doi.org/10.1016/j.socscimed.2015.06.038.

Giles-Corti, B., Broomhall, M. H., Knuiman, M., Collins, C., Douglas, K., Ng, K., ... Donovan, R. J., et al. (2005). Increasing walking: How important is distance to, attractiveness, and size of public open space? *American Journal of Preventive Medicine, 28*(2), 169–176. http://dx.doi.org/10.1016/j.amepre.2004.10.018.

Giles-Corti, B., & Donovan, R. J. (2002). The relative influence of individual, social and physical environment determinants of physical activity. *Social Science & Medicine, 54*(12), 1793–1812. http://dx.doi.org/10.1016/S0277-9536(01)00150-2.

Health and Social Care Information Centre. (2017). *Statistics on Obesity, Physical Activity and Diet. England: 2017*. London: UK Government Statistical Service. Retrieved from: https://digital.nhs.uk/media/30781/Statistics-on-Obesity-Physical-Activity-and-Diet-England-2017-Report-/Any/obes-phys-acti-diet-eng-2017-rep.

Hillsdon, M., Panter, J., Foster, C., & Jones, A. (2006). The relationship between access and quality of urban green space with population physical activity. *Public Health,*

120(12), 1127–1132. http://dx.doi.org/10.1016/j.puhe.2006.10.007.
James, P., Banay, R. F., Hart, J. E., & Laden, F. (2015). A review of the health benefits of greenness. *Current Epidemiology Reports, 2*(2), 131–142. http://dx.doi.org/10.1007/s40471-015-0043-7.
Klompmaker, J. O., Hoek, G., Bloemsma, L. D., Gehring, U., Strak, M., Wijga, A. H., ... Janssen, N. A. H., et al. (2018). Green space definition affects associations of green space with overweight and physical activity. *Environmental Research, 160*, 531–540. http://dx.doi.org/10.1016/j.envres.2017.10.027.
Lachowycz, K., & Jones, A. P. (2011). Greenspace and obesity: A systematic review of the evidence: Greenspace and obesity review. *Obesity Reviews, 12*(5), e183–e189. http://dx.doi.org/10.1111/j.1467-789X.2010.00827.x.
Lail, P., McCormack, G. R., & Rock, M. (2011). Does dog-ownership influence seasonal patterns of neighbourhood-based walking among adults? A longitudinal study. *BMC Public Health, 11*(1), 148. http://dx.doi.org/10.1186/1471-2458-11-148.
Maas, J., van Dillen, S. M. E., Verheij, R. A., & Groenewegen, P. P. (2009). Social contacts as a possible mechanism behind the relation between green space and health. *Health & Place, 15*(2), 586–595. http://dx.doi.org/10.1016/j.healthplace.2008.09.006.
Maas, J., Verheij, R. A., Spreeuwenberg, P., & Groenewegen, P. P. (2008). Physical activity as a possible mechanism behind the relationship between green space and health: A multilevel analysis. *BMC Public Health, 8*(1), http://dx.doi.org/10.1186/1471-2458-8-206.
McCormack, G. R., Graham, T. M., Swanson, K., Massolo, A., & Rock, M. J. (2016). Changes in visitor profiles and activity patterns following dog supportive modifications to parks: A natural experiment on the health impact of an urban policy. *SSM – Population Health, 2*, 237–243. http://dx.doi.org/10.1016/j.ssmph.2016.03.002.
Milton, K., Bull, F. C., & Bauman, A. (2011). Reliability and validity testing of a single-item physical activity measure. *British Journal of Sports Medicine, 45*(3), 203–208. http://dx.doi.org/10.1136/bjsm.2009.068395.
Mytton, O. T., Townsend, N., Rutter, H., & Foster, C. (2012). Green space and physical activity: An observational study using Health Survey for England data. *Health & Place, 18*(5), 1034–1041. http://dx.doi.org/10.1016/j.healthplace.2012.06.003.
National Institute for Health and Care Excellence. (2008). *Physical activity and the environment* (No. PH8). Retrieved from: https://www.nice.org.uk/guidance/ph8/resources/physical-activity-and-the-environment-pdf-55460874949.
National Institute for Health and Care Excellence. (2012). *Walking and cycling: local measures to promote walking and cycling as forms of travel or recreation* (No. PH41). Retrieved from: http://www.sustainabilitywestmidlands.org.uk/wp-content/uploads/walking_and_cycling_NICE.pdf.
Natural England. (2017). *Monitor of Engagement with the Natural Environment: Technical Report to the 2009-16 surveys* (No. Joint Report JP023). Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/612705/mene-technical-report-2015-16.pdf.
Ogilvie, D., Foster, C. E., Rothnie, H., Cavill, N., Hamilton, V., Fitzsimons, C. F., ... on behalf of the Scottish Physical Activity Research Collaboration (SPARColl). (2007). Interventions to promote walking: Systematic review. *BMJ, 334*(7605), http://dx.doi.org/10.1136/bmj.39198.722720.BE 1204–1204.
Ord, K., Mitchell, R., & Pearce, J. (2013). Is level of neighbourhood green space associated with physical activity in green space? *International Journal of Behavioral Nutrition and Physical Activity, 10*(1), 127. http://dx.doi.org/10.1186/1479-5868-10-127.
Peel, E., Douglas, M., Parry, O., & Lawton, J. (2010). Type 2 diabetes and dog walking: Patients' longitudinal perspectives about implementing and sustaining physical activity. *British Journal of General Practice, 60*(577), 570–577. http://dx.doi.org/10.3399/bjgp10X515061.
Perchoux, C., Kestens, Y., Brondeel, R., & Chaix, B. (2015). Accounting for the daily locations visited in the study of the built environment correlates of recreational walking (the RECORD Cohort Study). *Preventive Medicine, 81*, 142–149. http://dx.doi.org/10.1016/j.ypmed.2015.08.010.
Richardson, E. A., Pearce, J., Mitchell, R., & Kingham, S. (2013). Role of physical activity in the relationship between urban green space and health. *Public Health, 127*(4), 318–324. http://dx.doi.org/10.1016/j.puhe.2013.01.004.
Temple, V., Rhodes, R., & Higgins, J. W. (2011). Unleashing physical activity: An observational study of park use, dog walking, and physical activity. *Journal of Physical Activity and Health, 8*(6), 766–774. http://dx.doi.org/10.1123/jpah.8.6.766.
Toohey, A. M., McCormack, G. R., Doyle-Baker, P. K., Adams, C. L., & Rock, M. J. (2013). Dog-walking and sense of community in neighborhoods: Implications for promoting regular physical activity in adults 50 years and older. *Health & Place, 22*, 75–81. http://dx.doi.org/10.1016/j.healthplace.2013.03.007.
Toohey, A. M., & Rock, M. J. (2011). Unleashing their potential: A critical realist scoping review of the influence of dogs on physical activity for dog-owners and non-owners. *International Journal of Behavioral Nutrition and Physical Activity, 8*(1), 46. http://dx.doi.org/10.1186/1479-5868-8-46.
Triguero-Mas, M., Dadvand, P., Cirach, M., Martínez, D., Medina, A., Mompart, A., ... Nieuwenhuijsen, M. J., et al. (2015). Natural outdoor environments and mental and physical health: Relationships and mechanisms. *Environment International, 77*, 35–41. http://dx.doi.org/10.1016/j.envint.2015.01.012.
Weinstein, N., Balmford, A., DeHaan, C. R., Gladwell, V., Bradbury, R. B., & Amano, T. (2015). Seeing community for the trees: The links among contact with natural environments, community cohesion, and crime. *BioScience, 65*(12), 1141–1153. http://dx.doi.org/10.1093/biosci/biv151.
Wendel-Vos, G. C. W., Schuit, A. J., De Niet, R., Boshuizen, H. C., Saris, W. H. M., & Kromhout, D. (2004). Factors of the physical environment associated with walking and bicycling. *Medicine & Science in Sports & Exercise, 36*(4), 725–730. http://dx.doi.org/10.1249/01.MSS.0000121955.03461.0A.
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. *International Journal of Behavioral Nutrition and Physical Activity, 11*(1), 83. http://dx.doi.org/10.1186/1479-5868-11-83.
White, M. P., Elliott, L. R., Taylor, T., Wheeler, B. W., Spencer, A., Bone, A., ... Fleming, L. E., et al. (2016). Recreational physical activity in natural environments and implications for health: A population based cross-sectional study in England. *Preventive Medicine, 91*, 383–388. http://dx.doi.org/10.1016/j.ypmed.2016.08.023.
White, M. P., Wheeler, B. W., Herbert, S., Alcock, I., & Depledge, M. H. (2014). Coastal proximity and physical activity: Is the coast an under-appreciated public health resource? *Preventive Medicine, 69*, 135–140. http://dx.doi.org/10.1016/j.ypmed.2014.09.016.
Wood, L., Giles-Corti, B., & Bulsara, M. (2005). The pet connection: Pets as a conduit for social capital? *Social Science & Medicine, 61*(6), 1159–1173. http://dx.doi.org/10.1016/j.socscimed.2005.01.017.
World Health Organization. (2009). *Global health risks: mortality and burden of disease attributable to selected major risks*. Geneva, Switzerland.
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. *Journal of Epidemiology and Community Health, 71*(9), 905–911. http://dx.doi.org/10.1136/jech-2017-208987.