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

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In press at Landscape & Urban Planning March 2018

**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.

*Key Words*: Greenspace, Physical Activity, Dog-ownership, Health Promotion

*Research Highlights*:

1) Evidence of an association between neighbourhood greenspace and physical activity is equivocal.

2) The current analysis finds a positive relationship for dog owners but not for non-dog-owners.

3) Findings have implications for greenspace management and future research.

**Introduction**

Although regular physical activity is beneficial for health(National Institute for Health and Care Excellence, 2008; World Health Organization, 2009),the majority of adults in England do not meet guidelines of at least 150 minutes 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 and Care Excellence, 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 ≥30 minutes (approx. 580 million annually; (White et al., 2016)).Given that dog owners walk their dogs for, on average, 160 minutes 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 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),wedid not explore this possibility here.

**Method**

*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).

*Physical activity*

Physical activity was derived from the question: “*In the past week, on how many days have you done a total of 30 minutes 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 minutes of moderate physical activity a week and one way of achieving this is ≥5 days of 30 minutes (Bull & the Expert Working Groups, 2010),our outcome variable was whether or not the individual reported engaging in ≥5 days of ≥30 minutes of leisure- or transport-related physical activity (LTPA) in the last week (White, Wheeler, Herbert, Alcock, & Depledge, 2014).

*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 1,500 people and has an average size of 4km2. Neighbourhood greenspace was derived from the Generalised Land Use Database which categorises the total land use in each LSOA, at a resolution of 10m2, 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).

*Dog-ownership*

Dog-ownership was assessed with the question: “*Do you have a dog?”, ‘Yes’ or ‘No’*.

*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).

*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 gr*een*space coverage).

**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. 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 Figure 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.

**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 minutes 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 minutes 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 partby 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 and 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, 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.

**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.

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*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 | 7,454 | 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 | 7,652 | 61.6 | 4,770 | 38.4 |
| *60-79.99% x dog yes* | 8,337 | 3.0 | 5,315 | 63.8 | 3,022 | 36.2 |
| *40-59.99% x dog yes* | 10,608 | 3.8 | 6,924 | 65.3 | 3,684 | 34.7 |
| *20-39.99% x dog yes* | 15,333 | 5.5 | 10,241 | 66.8 | 5,092 | 33.2 |
| *0-19.99% x dog yes* | 14,899 | 5.3 | 9,928 | 66.6 | 4,971 | 33.4 |
|  |  |  |  |  |  |  |
| *80-100% x dog no* | 28,271 | 10.1 | 22,966 | 81.2 | 5,305 | 18.8 |
| *60-79.99% x dog no* | 23,580 | 8.4 | 19,148 | 81.2 | 4,432 | 18.8 |
| *40-59.99% x dog no* | 33,123 | 11.8 | 26,738 | 80.7 | 6,385 | 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).

*Table 2*: The relationship between neighbourhood green space, dog-ownership and likelihood of reporting ≥5 days of 30 minutes 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 |
| Owns dog (ref = no) | - | - | - |  | - | - | - |  | 2.06\*\*\* | 1.98 | 2.14 |  | 2.05\*\*\* | 1.97 | 2.14 |
| Greenspace x dog |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| *80-100% x dog* | - | - | - |  | - | - | - |  | 1.28\*\*\* | 1.20 | 1.36 |  | 1.20\*\*\* | 1.11 | 1.30 |
| *60-79.99% x dog* | - | - | - |  | - | - | - |  | 1.17\*\*\* | 1.09 | 1.25 |  | 1.18\*\*\* | 1.10 | 1.26 |
| *40-59.99% x dog* | - | - | - |  | - | - | - |  | 1.07\* | 1.00 | 1.14 |  | 1.06 | 1.00 | 1.13 |
| *20-39.99% x dog* | - | - | - |  | - | - | - |  | 1.00 | 0.94 | 1.06 |  | 1.00 | 0.95 | 1.06 |
| *0-19.99% x 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 R2 | 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.

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



*Supplementary Table A*: Number and percentage of individuals in each covariate category.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Predictors | N | % |  | Predictors | N | % |
| *Neighbourhood green space* |  |  |  | *Employment status* |  |  |
| 80-100% | 40,693 | 15.0 |  | Full-time | 97,345 | 34.7 |
| 60-79.99% | 31,917 | 11.8 |  | Part-time | 36,183 | 12.9 |
| 40-59.99% | 43,731 | 16.1 |  | In education | 17,282 | 6.2 |
| 20-39.99% | 70,448 | 26.0 |  | Not working/ unemployed | 49,209 | 17.5 |
| 0-19.99% | 84,282 | 31.1 |  | Retired | 80,771 | 28.8 |
| *Owns Dog* |  |  |  | *Marital status* |  |  |
| Yes | 63,454 | 22.6 |  | Married/cohabiting | 158,565 | 56.5 |
| No | 217,336 | 77.4 |  | Other | 122,225 | 43.5 |
| *Residence type* |  |  |  | *Children in household* |  |  |
| Urban | 253,475 | 92.8 |  | Yes | 84,420 | 30.1 |
| Rural | 19,589 | 7.2 |  | No | 196,370 | 69.9 |
| *Area Index of Multiple Deprivation score/10a* | M = 2.38 | SD = 1.60 |  | *Owns car* |  |  |
| *Gender* |  |  |  | Yes | 197,095 | 70.2 |
| Female | 150,255 | 53.5 |  | No | 83,695 | 29.8 |
| Male | 130,535 | 46.5 |  | *Season* |  |  |
| *Age* |  |  |  | Spring | 72,637 | 25.9 |
| *18-34 years* | 84,350 | 30.0 |  | Summer | 70,859 | 25.2 |
| *35-64 years* | 126,575 | 45.1 |  | Autumn | 68,060 | 24.2 |
| *65+ years* | 69,865 | 24.9 |  | Winter | 69,234 | 24.7 |
| *Socio-economic classification* |  |  |  | *Wave/year* |  |  |
| *AB* | 51,153 | 18.2 |  | *Year 1* | 48,514 | 17.3 |
| *C1* | 73,913 | 26.3 |  | *Year 2* | 46,099 | 16.4 |
| *C2* | 57,326 | 20.4 |  | Year 3 | 47,418 | 16.9 |
| *DE* | 98,398 | 35.0 |  | Year 4 | 46,749 | 16.6 |
| *Ethnicity* |  |  |  | Year 5 | 46,785 | 16.7 |
| White British | 222,849 | 79.4 |  | Year 6 | 45,225 | 16.1 |
| Other | 57,941 | 20.6 |  |  |  |  |
| *Long-term illness/disability* |  |  |  |  |  |  |
| Yes | 59,430 | 21.2 |  |  |  |  |
| No | 221,360 | 78.8 |  |  |  |  |
| *a - IMD score is divided by 10 to aid interpretation of Odd Ratios, M = Mean; SD = Standard Deviation.* | | | | | | |

*Supplementary Table B*: The relationship between neighbourhood greenspace and likelihood of reporting ≥5 days of 30 minutes or more leisure and transport related physical activity in the last 7 days in England (2009/10-2014/15) for dog owners and non-dog owners separately.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Owns dog | | |  | Does not own dog | | |
|  | OR | 95% CIs | |  | OR | 95% CIs | |
|  |  | Lower | Upper |  |  | Lower | Upper |
| Neighbourhood green space |  |  |  |  |  |  |  |
| *80-100%* | 1.07\* | 1.01 | 1.14 |  | 0.96 | 0.92 | 1.01 |
| *60-79.99%* | 1.07\* | 1.01 | 1.14 |  | 0.97 | 0.93 | 1.01 |
| *40-59.99%* | 1.05 | 1.00 | 1.11 |  | 1.00 | 0.97 | 1.04 |
| *20-39.99%* | 1.00 | 0.95 | 1.05 |  | 1.00 | 0.97 | 1.03 |
| *Urban (Ref = rural)* | 0.90\*\*\* | 0.84 | 0.96 |  | 0.98 | 0.93 | 1.04 |
| *Deprivation score/10* | 0.97\*\*\* | 0.96 | 0.98 |  | 1.00 | 0.99 | 1.01 |
| *Female* | 0.85\*\*\* | 0.82 | 0.88 |  | 0.74\*\*\* | 0.72 | 0.76 |
| *Age 35-64* | 1.13\*\*\* | 1.08 | 1.18 |  | 0.93\*\*\* | 0.91 | 0.96 |
| *Age 65+* | 1.00 | 0.92 | 1.09 |  | 0.76\*\*\* | 0.72 | 0.80 |
| *AB* | 0.91\*\*\* | 0.86 | 0.96 |  | 0.92\*\*\* | 0.89 | 0.95 |
| *C1* | 0.86\*\*\* | 0.82 | 0.91 |  | 0.94\*\*\* | 0.91 | 0.98 |
| *C2* | 0.80\*\*\* | 0.75 | 0.84 |  | 0.84\*\*\* | 0.81 | 0.87 |
| *White British (Ref = other)* | 1.11\*\* | 1.04 | 1.19 |  | 1.29\*\*\* | 1.25 | 1.32 |
| *Part-time* | 1.06\* | 1.01 | 1.12 |  | 1.01 | 0.97 | 1.05 |
| *In education* | 0.79\*\*\* | 0.73 | 0.86 |  | 1.02 | 0.97 | 1.07 |
| *Not working* | 1.01 | 0.96 | 1.06 |  | 1.07\*\*\* | 1.03 | 1.11 |
| *Retired* | 1.04 | 0.97 | 1.12 |  | 1.02 | 0.97 | 1.07 |
| *Married/cohabit (Ref = other)* | 1.02 | 0.98 | 1.06 |  | 0.94\*\*\* | 0.92 | 0.96 |
| *Long-term illness (Ref = no)* | 0.61\*\*\* | 0.59 | 0.64 |  | 0.68\*\*\* | 0.66 | 0.70 |
| *Children in household* | 0.92\*\*\* | 0.89 | 0.96 |  | 1.04\* | 1.01 | 1.07 |
| *Owns car (Ref = no)* | 1.02 | 0.98 | 1.07 |  | 1.08\*\*\* | 1.05 | 1.11 |
| *Spring* | 1.09\*\*\* | 1.04 | 1.14 |  | 1.15\*\*\* | 1.11 | 1.18 |
| *Summer* | 1.10\*\*\* | 1.04 | 1.15 |  | 1.24\*\*\* | 1.20 | 1.28 |
| *Autumn* | 1.01 | 0.96 | 1.06 |  | 1.17\*\*\* | 1.13 | 1.21 |
| *Year 2* | 0.95 | 0.90 | 1.01 |  | 0.92\*\*\* | 0.88 | 0.95 |
| Year 3 | 1.00 | 0.95 | 1.06 |  | 0.92\*\*\* | 0.89 | 0.96 |
| Year 4 | 0.93\* | 0.88 | 0.99 |  | 0.88\*\*\* | 0.84 | 0.91 |
| Year 5 | 0.94\* | 0.89 | 0.99 |  | 0.90\*\*\* | 0.87 | 0.94 |
| Year 6 | 0.96 | 0.91 | 1.02 |  | 0.96\* | 0.93 | 1.00 |
|  |  |  |  |  |  |  |  |
| Constant | 0.71 |  |  |  | 0.26 |  |  |
| Nagelkerke R2 | 0.02 |  |  |  | 0.02 |  |  |
| N | 61,595 |  |  |  | 209,443 |  |  |

OR = Odds Ratio; CI = Confidence Intervals

*Supplementary Table C:* The relationship between neighbourhood greenspace and likelihood of reporting ≥5 days of 30 minutes or more leisure and transport related physical activity in the last 7 days in England (2009/10-2014/15) stratified by dog-ownership and season.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Yes (owns) Dog | | |  | No (does not own) Dog | | |
|  | OR | 95% CIs | |  | OR | 95% CIs | |
|  |  | Lower | Upper |  |  | Lower | Upper |
| SPRING |  |  |  |  |  |  |  |
| Greenspace |  |  |  |  |  |  |  |
| *80-100%* | 1.14\* | 1.02 | 1.28 |  | 0.96 | 0.88 | 1.04 |
| *60-79.99%* | 1.18\*\* | 1.06 | 1.32 |  | 1.04 | 0.97 | 1.12 |
| *40-59.99%* | 1.03 | 0.93 | 1.14 |  | 1.03 | 0.96 | 1.10 |
| *20-39.99%* | 0.97 | 0.88 | 1.07 |  | 1.04 | 0.99 | 1.10 |
| *0-19.99%* |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
| Constant | 0.74 |  |  |  | 0.37 |  |  |
| Nagelkerke R2 | 0.03 |  |  |  | 0.02 |  |  |
| N | 16,372 |  |  |  | 54,561 |  |  |
|  |  |  |  |  |  |  |  |
| SUMMER |  |  |  |  |  |  |  |
| Green space |  |  |  |  |  |  |  |
| *80-100%* | 0.92 | 0.81 | 1.04 |  | 1.03 | 0.95 | 1.13 |
| *60-79.99%* | 0.96 | 0.85 | 1.07 |  | 0.98 | 0.90 | 1.05 |
| *40-59.99%* | 0.96 | 0.87 | 1.07 |  | 1.01 | 0.95 | 1.08 |
| *20-39.99%* | 0.86\*\* | 0.78 | 0.95 |  | 0.99 | 0.94 | 1.05 |
| *0-19.99%* |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
| Constant | 1.10 |  |  |  | 0.33 |  |  |
| Nagelkerke R2 | 0.02 |  |  |  | 0.02 |  |  |
| N | 15,405 |  |  |  | 52,190 |  |  |
|  |  |  |  |  |  |  |  |
| AUTUMN |  |  |  |  |  |  |  |
| Green space |  |  |  |  |  |  |  |
| *80-100%* | 1.13 | 1.00 | 1.29 |  | 0.96 | 0.88 | 1.05 |
| *60-79.99%* | 1.05 | 0.93 | 1.18 |  | 0.95 | 0.87 | 1.02 |
| *40-59.99%* | 1.06 | 0.95 | 1.18 |  | 1.02 | 0.96 | 1.09 |
| *20-39.99%* | 1.08 | 0.98 | 1.19 |  | 1.00 | 0.94 | 1.06 |
| *0-19.99%* |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
| Constant | 0.52 |  |  |  | 0.27 |  |  |
| Nagelkerke R2 | 0.02 |  |  |  | 0.02 |  |  |
| N | 15,065 |  |  |  | 51,414 |  |  |
|  |  |  |  |  |  |  |  |
| WINTER |  |  |  |  |  |  |  |
| Green space |  |  |  |  |  |  |  |
| *80-100%* | 1.11 | 0.98 | 1.26 |  | 0.89\* | 0.81 | 0.98 |
| *60-79.99%* | 1.12 | 0.99 | 1.26 |  | 0.91\* | 0.84 | 0.99 |
| *40-59.99%* | 1.17\*\* | 1.05 | 1.30 |  | 0.95 | 0.89 | 1.02 |
| *20-39.99%* | 1.12\* | 1.01 | 1.23 |  | 0.96 | 0.91 | 1.02 |
| *0-19.99%* |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
| Constant | 0.69 |  |  |  | 0.23 |  |  |
| Nagelkerke R2 | 0.03 |  |  |  | 0.02 |  |  |
| N | 14,753 |  |  |  | 51,278 |  |  |

\*Analyses controlling for Urban/rural, Area deprivation, gender, age, ethnicity, SES, marital status, employment status, disability status, children in household, car-ownership and survey wave.