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

**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,[1,2] the majority of adults in England do not meet guidelines of at least 150 minutes of moderate-intensity activity a week.[3] Attempts to increase physical activity have targeted known determinants at the individual, social and environmental level, with mixed success.[4-6] 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[12]. While some studies report a positive relationship [7-11], others find no effect,[12-15] or even a negative relationship[16]. Even among positive relationship studies, many only find a significant difference between the most and least green areas, rather than a ‘dose-response’ pattern[17-19]. Inconsistencies have been explained in terms of differing operationalisations of greenspace[20, 21] and/or physical activity[22], and variation in included confounders[23]. 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.[24-25] Although the effect is generally small,[26] longitudinal work supports a causal relationship.[27] 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).[28] Given that dog owners walk their dogs for, on average, 160 minutes a week,[24]  and that most dog walking takes place within 2 miles of home, [29]  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 an contributor to physical activity. Although dogs in public spaces may also inhibit activity and enjoyment amongst non-dog owners,[24-26] 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.[30]

*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” (q21, p.39)*.[30]  This single item has good test-retest reliability and correlates well with more detailed measures.[31] 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,[32] 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.[33]

*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.[ 34]  ‘Greenspace’ (excluding domestic gardens) includes, playing fields, parks, woodlands and farmland, and on average, accounts for 40.5% of the total 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.

LSOAs are categorised as being Urban (>10,000 inhabitants), Peri-urban (‘Town & Fringe’), or Rural (‘Village, Hamlet’). 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 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.[35]  We used the total Index of Multiple Deprivation (IMD) score, divided by ten to aid interpretation of regression coefficients.[33]

*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[22,33,36]  and/or dog-ownership[26] in previous research. We also controlled for season and survey year in case there was variance across season as a function of dog-ownership.[37-39]

*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 further model also 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 in the highest quintile of greenspace 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.[36]

Model 3 adds dog-ownership and the interactions between greenspace and dog-ownership. asAlthough 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. (although the ORs were <1, the relationship was not significantly negative)

. 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,[7-11] 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;[24] b) most dog walks are within a 2 mile radius of home;[29] and c) dog walks are the most frequent activity ≥30 minutes engaged in England’s greenspaces,[28] 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)[37-39] , 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 by exploring the role of dog-ownership, 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.[40-44] Dog walking has been found to promote social contact,[45] in partby enhancing feelings of one’s own safety (especially among certain demographics)[26]; 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.[1] This may be of less concern than usual, however, since only 22.6% of our sample reported meeting guidelines compared to 43% of men and 32% of women in the Health Survey for England,[3] 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.[46] 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[47]. Importantly, activity accumulated through dog walking could serve to benefit demographic groups typically at risk of inactivity such as older adults[48-49] and those with chronic diseases[50]. 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.[19] 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 green space 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.[24-26] 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.

**References**

1. National Institute for Health Care Excellence (2008). Physical activity and the environment. *NICE Public Health Guidance 8*, London.

2. World Health Organization 2009). *Global Health Risks: Mortality and burden of disease attributable to selected major risks*. Geneva, Switzerland: World Health Organization.

3. Health and Social Care Information Centre (2015). *Statistics on Obesity, Physical Activity and Diet: England 2015*. UK Government Statistical Service: London. Downloaded on 7th May 2917 from: <http://www.hscic.gov.uk/catalogue/PUB16988/obes-phys-acti-diet-eng-2015.pdf>.

4. Ding D., Sallis J.F., Conway T.L., et al. (2012). Interactive effects of built environment and psychosocial attributes on physical activity: a test of ecological models. *Annals Behavioral. Medicine*, 44, 365-74.

5. National Institute for Health Care Excellence (2012). Walking and cycling: local measures to promote walking and cycling as forms of travel. *NICE Public Health Guidance 41*..

6. Ogilvie D., Foster C.E., Rothnie H., et al. (2007). Interventions to promote walking: systematic review. *BM*J, 334:1204-7.

7. Wendel-Vos, G. W., Schuit, A. J., De Niet, R., Boshuizen, H. C., Saris, W. H. M., & Kromhout, D. A. A. N. (2004). Factors of the physical environment associated with walking and bicycling. *Medicine and Science in Sports and Exercise*, 36(4), 725-730

8. Giles-Corti, B., Broomhall, M. H., Knuiman, M., Collins, C., Douglas, K., Ng, K., ... & Donovan, R. J. (2005). Increasing walking: how important is distance to, attractiveness, and size of public open space?. *American Journal of Preventive Medicine*, 28(2), 169-176.

9. 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.

10. 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.

11. 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.

12

13. 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.

14. 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), 206.

15. 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.

16. Triguero-Mas, M., Dadvand, P., Cirach, M., Martínez, D., Medina, A., Mompart, A., ... & Nieuwenhuijsen, M. J. (2015). Natural outdoor environments and mental and physical health: relationships and mechanisms. *Environment international*, 77, 35-41.

17. 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.

18. 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.

19. 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.

20. Klompmaker, J. O., Hoek, G., Bloemsma, L. D., Gehring, U., Strak, M., Wijga, A. H., van den Brink, C., Brunekreef, B., Lebret, E. & Janssen, N. A. (2018). Green space definition affects associations of green space with overweight and physical activity. *Environmental Research*, *160*, 531-540.

21. 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.

22. Lachowycz, K., & Jones, A. P. (2011). Greenspace and obesity: A systematic review of the evidence. *Obesity Reviews*, *12*, e183-189: <http://dx.doi.org/10.1111/j.1467-789X.2010.00827.x>

23. 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.

24. 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.

25. Christian, H. E., Westgarth, C., Bauman, A., Richards, E. A., Rhodes, R. E., Evenson, K. R., ... & Thorpe Jr, R. J. (2013). Dog ownership and physical activity: a review of the evidence. *Journal of Physical Activity and Health*, *10*(5), 750-759.

26. 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.

27. Cutt, H., Giles-Corti, B., Knuiman, M., Timperio, A., & Bull, F. (2008). Understanding dog owners’ increased levels of physical activity: results from RESIDE. *American Journal of Public Health*, *98*(1), 66-69.

28. White, M.P., Elliott, L.R., Taylor, T.J., Wheeler, B.W., Spencer, A., Bone, A., Depledge, M.H. & Fleming, L. (2016). Recreational physical activity in natural environments and implications for health: A population based cross-sectional study in England. *Preventive Medicine, 91, 383-388.*

29. 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.

30. Natural England (2015). *Monitor of Engagement with the Natural Environment. Technical Report 2013-14*. London: Natural England. Accessed June 30th, 2015 from: <http://publications.naturalengland.org.uk>

31. Milton, K., Bull, F. C., & Bauman, A. (2010). Reliability and validity testing of a single-item physical activity measure. *British Journal of Sports Medicine*, 45(3), 203-208

32. Bull, F.C. and the Expert Working Groups. (2010). *Physical Activity Guidelines in the U.K.: Review and Recommendations*. School of Sport, Exercise and Health Sciences, Loughborough University.

33. White, M.P., Wheeler, B.W., Herbert, S., Alcock, I. & Depledge, M.H. (2014). Coastal proximity and physical activity. Is the coast an underappreciated public health resource? *Preventive Medicine, 69, 135-140.*

34. Office of the Deputy Prime Minister. (2005). *Generalised Land Use Database Statistics for England*. London, England.

35. Department of Communities and Local Government (2008).*The English Indices of Deprivation 2007*. London: Communities and Local Government.

36. 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.

37. 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*, 11:148.

38. 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.

39. 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.

40. Dadvand, P., Bartoll, X., Basagaña, X., Dalmau-Bueno, A., Martinez, D., Ambros, A., ... & Nieuwenhuijsen, M. J. (2016). Green spaces and general health: roles of mental health status, social support, and physical activity. *Environment international*, *91*, 161-167.

41. de Vries, S., van Dillen, S. M., Groenewegen, P. P., & Spreeuwenberg, P. (2013). Streetscape greenery and health: stress, social cohesion and physical activity as mediators. *Social Science & Medicine*, *94*, 26-33.

42. Maas, J., Van Dillen, S. M., 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.

43. Sugiyama, T., Leslie, E., Giles-Corti, B., & Owen, N. (2008). Associations of neighbourhood greenness with physical and mental health: do walking, social coherence and local social interaction explain the relationships?. *Journal of Epidemiology and Community Health*, *62*(5), e9-e9.

44. 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.

45. Wood L., Giles-Corti B., Bulsara M. (2005). The pet connection: pets as a conduit for social capital? *Social Science & Medicine,* 61. 1159-1173.

46. 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.

47. 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(11-12), 632-634.

48. 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.

49. 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.

49. Peel, E., Douglas, M., Parry, O., & Lawton, J. (2010). Type 2 diabetes and dog walking: patients' longitudinal perspectives about implementing and sustaining physical activity. Br J Gen Pract, 60(577), 570-577.

*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.