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The relationship of physical activity and overweight to objectively measured green space accessibility and use

Abstract

This study examines the association between objectively measured access to green space, frequency of green space use, physical activity, and the probability of being overweight or obese in the city of Bristol, England. Data from the Bristol Quality of Life in your Neighbourhood survey for 6,821 adults were combined with a comprehensive GIS database of neighbourhood and green space characteristics.. A range of green space accessibility measures were computed. Associations between accessibility and the odds of respondents achieving a recommended 30 minutes or more of moderate activity five times a week, or being overweight or obese, were examined using logistic regression. Results showed that the reported frequency of green space use declined with increasing distance. The study also found that respondents living closest to the type of green space classified as a Formal park were more likely to achieve the physical activity recommendation and less likely to be overweight or obese. The association with physical activity, but not with overweight or obesity, remained after adjustment for respondent characteristics, area deprivation, and a range of characteristics of the neighbourhood environment. The findings suggest that the provision of good access to green spaces in urban areas may help promote population physical activity.

Introduction

Despite the well recognised health benefits of regular physical activity and its role in reducing obesity, many people fail to achieve recommended activity levels; currently, only 37% of men and 24% of women in England and Wales meet the Chief Medical Officer's guidelines of 30 minutes of moderate exercise at least five days a week (Department of Health, 2005). Furthermore, over 25% of adult men and women are currently obese or overweight in the UK, for which physical inactivity is a well established risk factor (Pietiläinen, Kaprio, Borg, Plasqui, Yki-Järvinen, Kujala, et al., 2008). These figures are predicted to rise to over 50% in 2050 if current trends continue (Butland, Jebb, Kopelman, McPherson, Thomas, Mardell, et al., 2007).

There is increasing evidence that the environment may play a role in influencing physical activity levels (Jones, Benthams, Foster, Hillsdon, & Panter, 2007). In particular, recent research has suggested that the provision of open spaces, such as parks and other green spaces, for recreation may provide an important place for people to be active (Macintyre, Macdonald, & Ellaway, 2008), especially in urban areas where gaining access to the open countryside can be difficult (Maas, Verheij, Spreeuwenberg, & Groenewegen, 2006). Mitchell & Popham (2008), recently highlighted lower levels of circulatory and all-cause mortality amongst English populations with the most green space in their surroundings, and a number of recent policy documents have promoted their potential benefits (e.g. CAGE, 2004; National Heart Forum, 2007).

Several studies have examined the relationship between distance to green spaces and participation in physical activity. Giles-Corti, Broomhall, Knuiman, Collins, Douglas, Ng, et al. (2005) found that proximity to public open space was associated with higher levels of walking amongst residents in Perth, Australia. However, Hoehner, Brennan Ramirez, Elliott, Handy, & Brownson (2005) found no relationship between living within a 5 minute walk from a green space and meeting physical activity guidelines in the USA, and Hillsdon, Panter, Foster, & Jones (2006) found no relationship between distance to green spaces and self reported leisure time physical activity amongst a cohort of adults in an English city. Studies that have measured the availability of green space within the neighbourhoods of participants, have drawn similarly equivocal conclusions; in the Netherlands, Maas, Verheij, Spreeuwenberg, & Groenewegen (2008) found no association between green space area and physical activity levels in adults, whilst Roemmich, Epstein, Raja, Yin, Robinson, & Winiewicz (2006) identified a strong relationship for children in the USA. Conflicting findings have also emerged from studies that have examined the correlation between green space availability and bodyweight. For example, Potwarka, Kaczynski, & Flack (2008) found no relationship between proximity to parks and overweight in Canadian children, while Nielsen & Hansen (2007) identified a significant association for Danish adults. These conflicting findings might reflect the diverse and complex influences on bodyweight, which include dietary behaviours as well as physical activity.

Overall, there is some evidence to suggest that improving access to green space in urban areas could provide public health benefits by encouraging greater participation in physical activity and thus reducing risks for obesity. However, many of the studies from which the current research evidence is drawn suffer from a number of key limitations. First, research findings have often been based solely on the perceived accessibility of green spaces, whilst perceptions have recently been shown not to correlate well with objective measures (Macintyre et al., 2008). Second, several studies have been limited by the lack of a comprehensive database on publicly accessible green space locations and hence have been unable to measure the potential opportunities for green space use amongst their participants. Third, few researchers have been able to capture information on the attributes of green spaces and in particular, the types of activity that each may be particularly suitable for. Finally, very few studies have recorded the frequency with which participants actually make use of the green spaces in their area.

This study aims to provide new evidence on the association between objectively measured access to green space, frequency of green space use, physical activity levels, and the probability of being overweight or obese by combining information from the Bristol Quality of Life in your Neighbourhood Survey, undertaken amongst a large sample of adults from the city of Bristol, UK with a comprehensive database of green space locations and characteristics within the city.

Methods

The survey

Data from the 2005 Quality of Life in your Neighbourhood Survey, a cross-sectional postal survey used to facilitate planning within Bristol (UK) were accessed. The survey includes information on residents' perceptions and opinions about their local community, their lifestyle, health, and also some personal details including their home postcode. The study population was selected from the 393,900 adults resident in Bristol (Bristol City Council, 2005), an area with a mix of inner-city and suburban, and affluent and more socio-economically deprived neighbourhoods. By employing the Electoral Register for Bristol (a list of all individuals eligible to vote) a single-stage sampling frame was developed based on the 35 electoral wards (medium sized census tracts) in the city. An equal size population

from each ward was sampled (380 persons), with the exception of the 12 most deprived wards which were oversampled (950 persons) due to an anticipated lower response rate (Bristol City Council, 2005). This provided a total sample of 20,140 individuals. Although the electoral register does not contain the age of respondents, only those aged over 16 appear on it, so the sample excluded children. No information on household membership was available, so more than one member of some households may have been approached. Each person was sent a questionnaire to complete and return by post, and there was one postal reminder which included a duplicate questionnaire. Overall there were 6,821 respondents, equating to a response rate of 34%.

Outcomes

Survey respondents were requested to state their frequency of green space use (“How often do you visit Bristol’s parks and green spaces?”) with response frequency categories ranging from “5 times a week or more” to “less than once a year”. They were also asked about participation in sport (“How often do you take part in active sport for 30 minutes or more?”), with response categories ranging from “5 times a week or more” to “never”, and moderate physical activity (“How often do you take part in moderate exercise where you are active for 30 minutes or more, or in two 15 minute sessions?”). Examples of moderate exercise given were brisk walking, gardening, heavy housework or DIY, and the same response categories were offered. In addition they were asked to report their height and weight, and these were used to calculate their Body Mass Index (BMI). Three main outcomes were examined in this study: (i) the frequency with which visits were made to green space, (ii) the odds of achieving the Chief Medical Officer’s (CMO) guidelines for physical activity (at least 5 sessions of 30 minutes or more a week), and (iii) the odds of being overweight or obese.

As it is frequent exercise that has been shown to have health benefits, for outcome (i), the response scale was collapsed into a dichotomous variable where respondents were coded as “1” if they visited a green space at least once a week and “0” otherwise. For the computation of outcome (ii), the two measures of physical activity participation were combined to produce a single variable which was coded as “1” where respondents participated in either sport or moderate physical activity at least 5 times a week and “0” otherwise. For outcome (iii), respondents were classified as being overweight or obese if they had a calculated BMI of 25 or above, based on recommendations of the World Health Organisation (1995), and normal weight otherwise.

Explanatory variables

Respondent characteristics—Information on age, gender, and self rated health, which was rated as ‘good’, ‘fairly good’, or ‘not good’, was obtained from the questionnaire. Respondent’s individual socioeconomic position was derived from their education level and employment status. The survey recorded highest education level attained and this was used to group respondents according to whether they had no qualifications, had completed GCSEs (aged 16), A-levels (aged 18), or a university degree. Employment status was reported as full time employment, part time employment (16 to 30 hours per week), retired, or ‘other’, which included students, those looking after the home or caring for another person with an illness, and the unemployed. These categories were combined to produce a dichotomous variable which was coded as ‘1’ for those in either full or part time employment, or ‘0’ otherwise.

Green space access measures—Respondent’s home locations were mapped using the ArcGIS 9.2 Geographical Information System (GIS) package (ESRI, California). Home locations were identified based on postcodes using the Ordnance Survey Code-Point database (Ordnance Survey, 2009a). The measure of green space accessibility computed in

the GIS was the distance by road from the residential location of each respondent to the nearest green space of each type considered (Table 1).

The locations of all public green spaces within Bristol were mapped using a GIS database of their locations and attributes provided by Bristol City Council. This included details of the area and type of each green space. Green spaces were grouped into five typological categories. These were: Formal (those with an organised layout and structured path network, and generally well maintained), Informal (those with an informal design and less managed feel), Natural (habitats such as heathland or woodland), Young People's (areas designed for use by children or teenagers), and Sports (areas such as playing fields and tennis courts). These were broadly based on those described in UK Planning Policy Guidance Note 17 (Department for Communities and Local Government, 2006a). Where a green space fell into more than one category, the area of each was delineated separately. The GIS database was cross referenced with high resolution aerial photography of Bristol to ensure that no spaces were omitted or erroneously included. Only spaces of at least 2 hectares in size were included in the analysis, as areas smaller than this were considered unsuitable for use by adults for the purpose of being physically active. Using the Ordnance Survey Meridian database (Ordnance Survey, 2009b), the shortest path through the road network between each home location and an access point (public entrance) to a qualifying green space was identified, and the length computed. Distances were used rather than vehicle travel times as many visitors to green spaces visit on-foot (Jones, Brainard, Bateman, & Lovett, 2009).

Neighbourhood characteristics—The neighbourhood surrounding each respondent's home was delineated as the area within 800 metres along the road network from that point. This distance equates to an approximate 10 minute walk, and is comparable to that used in other recent research (e.g. Van Dyck, Deforche, Cardon, & De Bourdeaudhuij, 2008; Heinrich, Lee, Suminski, Regan, Reese-Smith, Howard, et al., 2007). Based on this 800 metre range, a number of neighbourhood characteristics which may independently affect physical activity levels and BMI were calculated, and are listed in Table 1.

Road density was computed in the GIS by identifying the total length of roads in each respondent's neighbourhood and dividing this by the total neighbourhood area. To provide a measure of traffic density, the density of A-roads, which are the busiest roads in the city, was calculated. Neighbourhoods containing higher densities of A-roads were considered more heavily trafficked.

Several measures of street connectivity, representing the ease of pedestrian movement through each neighbourhood, were also generated. They included the number of junctions per kilometre of road and the ratio of junctions to cul-de-sacs (dead ends). For both of these variables, higher values are assumed to indicate a more connected road network. A measure of the effective walkable area of each neighbourhood was also calculated. This was the ratio of the area of land in the respondent's neighbourhood, delineated using 800m distances along the road network, divided by the total area of land within an 800m straight line radius of their home. Values close to unity represent a more walkable neighbourhood with smaller values representing poorer walkability.

Information on land use in Bristol was derived from Ordnance Survey MasterMap (Ordnance Survey, 2009c) and Centre for Ecology and Hydrology (CEH) Land Cover Map of Great Britain datasets (Centre for Ecology and Hydrology, 2009). These provided details of the spatial extent of a variety of land uses including building locations, areas of other built land, roads and pavements, private gardens, farmland, grassland, woodland, and beaches. An indicator of land use diversity was calculated using the Herfindahl-Hirschmann Index (HHI) (Cowell, 2008). The formula used was $HHI = \sum (P^*100)^2$, where P is the proportion of each

land use in the neighbourhood. The higher the index value, the lower the levels of land use diversity. The density of buildings within neighbourhoods and the types of buildings present (percentage of residential and commercial buildings) were also estimated.

Finally, a range of measures from the 2001 UK Census of Population and the 2004 Index of Multiple Deprivation (IMD) was used to profile the socio-demographic characteristics of neighbourhoods. The IMD scores provide an indicator of material deprivation based on several components including income, employment, health, education, housing, environment, and crime (Office of the Deputy Prime Minister, 2004). High IMD scores indicate high levels of deprivation.

Statistical analysis—Binary logistic regression was used to examine the relationship between access to green space and the three outcomes studied. Age, gender, socioeconomic status, self rated health, and area deprivation were included within all regression models to account for any confounding effects of these factors. Other variables were added to the models and retained if the relationship they exhibited with the outcome was in the expected direction, and they showed a statistically significant relationship at least at the $p < 0.05$ level. Tests for trend across categories were made by fitting the categorical variables as continuous measures and noting the p-value. All analyses were undertaken using the SPSS for Windows software package version 16.

Results

Sample characteristics

In total, out of the 6,821 responses received, a home location was derived from the postcode for all but 18, leaving a final sample of 6,803 for analysis. Compared to the population of Bristol at the 2001 Census, respondents were more likely to be female (59% sample vs 51% Bristol), not in employment (55% vs 60%), retired (27% vs 15%) and owner-occupiers 73% vs 63%). Ethnic minorities were under-represented (4.4% vs 6.8%). Although information on the actual prevalence of adult obesity in Bristol is not available, survey respondents were less likely to be obese than estimates for Bristol suggest (16% survey vs 22.5% estimate) (Office for National Statistics, 2009).

Access to green space

Overall, the majority of respondents had good access to green space, with 55% of people living within 300 metres of one, the target distance within which the Government agency Natural England recommends all members of the population should have access to a green space from their home. When access was examined by green space type, disparities became apparent; mean distances were 2207m for Young People's, 1758m for Formal, 1082m for Sports, 570m for Natural, and 481m for Informal green space types. Whilst 30% of respondents lived within 300m of Informal and Natural green spaces, less than 10% lived within 300m of Young People's and Sports green spaces.

Green space use, physical activity and overweight

In total, 31% of respondents reported visiting a green space at least once a week, while 18% visited less than once a year. Overall, 39% of respondents reported achieving the CMO recommended physical activity levels, while 43% were identified as being either overweight or obese.

Table 2 shows the odds of visiting a green space at least once a week, achieving physical activity guidelines, and being overweight or obese, by distance to green spaces. All are adjusted for respondent characteristics. The results demonstrate a statistically significant

decline in the odds of visiting with increasing distance for all green space types, except for Young People's. The distance decay was particularly strong for Formal green spaces where respondents living in the furthest quartile were approximately 36% less likely to visit weekly compared to those in the nearest. Furthermore, there was a particularly strong and statistically significant decrease in odds of achieving physical activity recommendations and increase in odds of being overweight or obese associated with increasing distance to Formal green space.

Table 3 shows the direction of effect for those neighbourhood covariates where a statistically significant association with each outcome was identified. The associations for green space use, physical activity and bodyweight are generally in the direction expected with residents of more walkable and less socio-economically deprived neighbourhoods being more likely to visit green spaces, more likely to meet physical activity guidelines, and less likely to be overweight or obese. The associations with A-road density are more counter-intuitive and most likely reflect the higher walkability (e.g. more pavements, fewer cul-de-sacs) of neighbourhoods with many major roads, rather than the effects of heavier traffic flows.

In order to determine the robustness of observed relationships, a further set of models (Table 4) was fitted which controlled for all the neighbourhood characteristics found to be statistically significant in Table 3. For brevity only the model for Formal green spaces is detailed in Table 4 as no statistically significant trends in each of the outcomes were observed for other green space types (all $p > 0.05$). After this adjustment the associations with green space use and physical activity were somewhat attenuated but remained, whilst the trend with bodyweight was no longer apparent.

Table 5 shows the association between reported frequencies of green space use and the physical activity and bodyweight outcomes, both unadjusted and adjusted for age, sex, socioeconomic status, self-rated health, area deprivation, and the neighbourhood characteristics from Table 3. Both before and after adjustment, the likelihood of achieving the physical activity recommendations declined strongly with decreasing frequency of use. Before adjustment the likelihood of being obese or overweight increased with decreasing frequency, although the trend did not remain after adjustment.

Discussion

Respondents who lived further from urban green spaces in this study were less likely to visit them than those nearby, and this effect was particularly strong for Formal green spaces. Respondents living further from green spaces were also less likely to meet guideline physical activity levels and more likely to be overweight or obese, even after adjustment for the walkability of respondent's neighbourhoods, their socioeconomic status, and area deprivation. Importantly, when the outcomes were examined against frequency of green space use, trends were apparent whereby more frequent green space users were more physically active and less likely to be overweight or obese. The robustness of these associations was tested by controlling for a wide range of characteristics of the areas around respondent's homes which were hypothesised to potentially be associated with each outcome. Subsequent associations were mostly attenuated but persistent, except for those with bodyweight which generally disappeared. This may reflect the particularly varied nature of the personal, societal, and environmental influences on weight.

The reasons for the apparent importance of Formal green spaces warrant some attention. The associations with Formal green space use could be artefactual if respondents were more likely to consider this type of green space when they completed the survey, which asked

them to state how often they visited a 'green space or park' but did not define these terms. However, this would not explain our observed associations with the physical activity and bodyweight outcomes. It may be therefore that the attributes of Formal green spaces make them particularly suitable for physical activity. They often have a good path network, which provides a basis for a range of activities including walking, cycling and jogging (Kaczynski, Potwarka, & Saelens, 2008), and the presence of paths may also encourage active forms of travel as people may be more inclined to walk or cycle to destinations if they can incorporate a green environment into part of their journey (Giles-Corti et al., 2005). In addition, these spaces are often well maintained and are sometimes lit, and this may improve perceptions of their safety. Finally, the diverse nature of Formal green spaces means they tend to offer a suitable environment for a broad range of people, whilst those provided for sport for example are often specialised, housing specific facilities, and are used by a small proportion of the population (Handy & Neimeier, 1997).

Our findings have implications for urban planning. Although UK planning policies such as Planning Policy Statement 3 (Department for Communities and Local Government, 2006b) now stipulate that green spaces should be incorporated into urban planning, there are currently no minimum requirements to ensure these guidelines are sufficiently met. Nevertheless, there have been some recommendations for the level of green space provision that might be appropriate. These suggest that people in urban areas should be able to access a green space of at least 2 hectares in size within 300m or a 5 minute walk of their home (English Nature, 1995). Our results suggest that better access to green spaces may be associated with higher use and in turn greater participation in physical activity which could reduce levels of obesity. Our finding of particularly strong associations with access to Formal parks suggests that the green spaces should be well maintained and suitable for use by a broad spectrum of the population, both key characteristics of this type of space.

Our study has a number of strengths and weaknesses. One of the strengths was the large sample size of almost 7,000 respondents. In addition, the sample purposively included a mix of respondents of different socioeconomic status, being representative of the overall population of Bristol. We had information on actual green space use amongst respondents and detailed information on the provision of green space in the city. We also had details of both the physical activity and bodyweight of respondents.

In terms of weaknesses, one of the limitations of the study was that the outcome measures of green space visits, physical activity, and weight were all based on simple self-report. There are a number of consequences of this. Firstly, we are not able to determine whether reported frequency of green space use was a valid measure of actual use, or if that use actually took place in those spaces for which we calculated objective accessibility measures, although the fact it was found to be strongly associated with our objectively computed measure of green space accessibility in the manner expected is reassuring. Furthermore, we were unable to validate our measure of physical activity participation, and it is noteworthy that reported physical activity levels were somewhat high compared to overall population estimates, with 39% of our sample reporting undertaking physical activity at least 5 times a week. Nevertheless we are reassured by the fact that Jackson, Morrow, Bowles, Fitzgerald, & Blair (2007) have recently shown acceptable levels of validity in a single item report measure similar to that used here. We were also unable to validate our measure of BMI and there is evidence that the use of self-reported height and weight for the calculation of BMI can lead to under-reporting of weight in particular, although research evidence also suggests that self report based measures are valid (e.g. Elgar & Stewart, 2008) and we have no reason to believe that any under-reporting would be associated with access to green spaces, and thus bias our results.

Whilst the response rate of 34% was typical of postal surveys, it may be that respondents were not typical of those who did not reply, although the focus of the survey was not specifically on the outcomes studied so non-response bias may have been small. A further limitation is that the study is cross sectional in nature and hence it is difficult to determine if the relationships we have observed are causal. In particular, it may be that those members of the population who are more active in general choose to reside in areas with better access to green space, in which case the presence of the green spaces may not be encouraging physical activity *per se*. However, it is noteworthy that the relationships were generally apparent after adjustment for both individual and area socio-demographic factors. We also tested their robustness by controlling for a particularly wide variety of neighbourhood measures. We delineated neighbourhoods based on an 800m distance from respondent's homes. Whilst this distance compares with that used by other researchers, it may be that our results are sensitive to the definition used, although a sensitivity analysis on the road connectivity variable using radii of 400m and 1600m showed that the associations observed with the three outcomes were stable. Furthermore, although we had information on the types of green space present in Bristol we did not have detail on the specific features of each. A valuable extension to this work would be to better understand which features might be acting to encourage physical activity, as this insight could be used to inform the design of new green spaces and the regeneration of existing ones.

This study has provided new evidence that good access to urban green spaces is associated with higher use, higher physical activity levels, and a lower likelihood of being overweight or obese. Informal physical activity is an important component of overall activity levels, and provision of facilities such as green spaces which can be used for a wide range of physical activities, has population wide benefits. It is important that supportive environments are available to facilitate active lifestyles, and our findings suggest that green spaces may provide a valuable resource in urban areas.

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Table 1

Environmental and neighbourhood socio-demographic characteristics examined. Neighbourhood is defined as the area within 800m along the road network from each respondent's home.

Variable group	Variable name	Mean	Min	Max	Data source
Access to green space	Road distance to nearest green space (metres)	334.1	0.0	1682.7	Bristol Green Space Database; OS Meridian
Road density	Road density (length of roads in neighbourhood (km) divided by neighbourhood area (km ²))	11.3	2.7	20.0	OS Meridian
	A-road density (length of A-roads in neighbourhood (km) divided by neighbourhood area (km ²))	0.8	0.0	5.2	
Street connectivity	Number of junctions per km of road	5.0	0.8	7.7	OS Meridian
	Road connectivity (ratio of junctions to cul-de-sacs)	0.9	0.3	1.0	
	Effective walkable area (ratio of actual neighbourhood area (km ²) to potential neighbourhood (km ²))	0.5	0.1	0.8	
Land use	Land use diversity (HHI: measure of the number and area of land uses in each neighbourhood)	2194.6	1281.7	4794.2	OS MasterMap; OS Address Layer 2; CEH Land Cover Map of Great Britain
	Density of buildings (% area of land covered by buildings in each neighbourhood)	17.1	1.5	40.5	
	Percentage of residential buildings in neighbourhood	70.2	0.4	93.3	
	Percentage of commercial buildings in neighbourhood	17.2	0.0	78.1	
Demographic measures	Age structure (% population over 60 years)	20.0	4.5	37.1	2001 UK Census of Population, ODPM
	Ethnicity (% non-white population)	8.3	0.7	44.5	
	Levels of employment (% population unemployed)	3.2	0.7	9.7	
	Home ownership (% population who own their own home)	65.1	19.3	96.1	
	Car ownership (% population who own a car)	46.3	32.5	57.5	
	Levels of active travel (% population who walk or bike to work)	18.5	3.3	55.1	
	Limiting Long-Term Illness (% population with LLTI)	18.9	8.8	37.9	
	Neighbourhood deprivation (IMD score for neighbourhood)	29.0	4.8	65.9	

OS = Ordnance Survey, CEH = Centre for Ecology and Hydrology, ODPM = Office of the Deputy Prime Minister

Table 2

Odds Ratios (ORs) of visiting a green space at least once a week, achieving physical activity guidelines,¹ and being overweight or obese by distance to green space type. All values are adjusted for age, sex, socioeconomic status, self-rated health, and area deprivation. Significance values represent the results from a test of trend across the quartiles of accessibility.

Distance measure	Visiting green space at least once a week		Achieving physical activity guidelines ¹		Being overweight or obese ²	
	OR	95% CI	OR	95% CI	OR	95% CI
All green spaces						
quartile 1 (nearest <100m)	1.00	-	1.00	-	1.00	-
quartile 2	0.87	(0.74-1.01)	0.95	(0.82-1.01)	0.93	(0.80-1.07)
quartile 3	0.79	(0.68-0.92)	1.01	(0.87-1.17)	0.95	(0.82-1.10)
quartile 4 (furthest >500m)	0.64 ^{**}	(0.55-0.75)	0.95 ^{ns}	(0.81-1.10)	0.83 [*]	(0.72-0.96)
Formal green spaces						
quartile 1 (nearest <830m)	1.00	-	1.00	-	1.00	-
quartile 2	0.73	(0.63-0.85)	0.87	(0.76-1.01)	1.00	(0.86-1.16)
quartile 3	0.73	(0.63-0.85)	0.72	(0.62-0.84)	1.18	(1.02-1.37)
quartile 4 (furthest >2250m)	0.64 ^{**}	(0.55-0.75)	0.76 ^{**}	(0.65-0.88)	1.27 ^{**}	(1.09-1.47)
Informal green spaces						
quartile 1 (nearest <200m)	1.00	-	1.00	-	1.00	-
quartile 2	0.80	(0.69-0.93)	0.96	(0.82-1.11)	0.95	(0.82-1.10)
quartile 3	0.70	(0.60-0.82)	0.97	(0.83-1.12)	0.96	(0.83-1.11)
quartile 4 (furthest >680m)	0.80 ^{**}	(0.68-0.93)	0.98 ^{ns}	(0.84-1.15)	0.83 [*]	(0.72-0.97)
Natural green spaces						
quartile 1 (nearest <250m)	1.00	-	1.00	-	1.00	-
quartile 2	1.03	(0.88-1.20)	1.04	(0.89-1.20)	1.05	(0.91-1.22)
quartile 3	0.85	(0.73-0.99)	1.04	(0.89-1.20)	0.94	(0.81-1.08)
quartile 4 (furthest >800m)	0.80 ^{**}	(0.68-0.94)	1.05 ^{ns}	(0.91-1.22)	0.97 ^{ns}	(0.84-1.13)
Young People's green spaces						
quartile 1 (nearest <1300m)	1.00	-	1.00	-	1.00	-
quartile 2	1.07	(0.92-1.30)	1.06	(0.92-1.23)	0.90	(0.78-1.05)
quartile 3	0.98	(0.84-1.14)	0.91	(0.79-1.06)	0.98	(0.85-1.14)
quartile 4 (furthest >2800m)	0.95 ^{ns}	(0.81-1.11)	0.91 ^{ns}	(0.78-1.06)	1.06 ^{ns}	(0.92-1.23)
Sports green spaces						
quartile 1 (nearest <640m)	1.00	-	1.00	-	1.00	-
quartile 2	0.94	(0.81-1.10)	1.09	(0.94-1.26)	0.96	(0.83-1.11)
quartile 3	0.89	(0.77-1.04)	1.05	(0.91-1.22)	1.09	(0.94-1.26)
quartile 4 (furthest >1470m)	0.87 [*]	(0.74-1.02)	1.10 ^{ns}	(0.95-1.28)	0.94 ^{ns}	(0.81-1.09)

¹Defined as 30 minutes of at least moderate activity 5 times a week or more;

²Defined as a Body Mass Index of 25 or above

* p< 0.05,

^{**}
p < 0.01, ns = not statistically significant

Table 3

Direction of effect (+ positive, – negative) for neighbourhood variables exhibiting a statistically significant relationship with each outcome studied. Significance values represent the results from a test of trend across the quartiles of each variable.

Independent variable	Visiting green space at least once a week	Achieving physical activity guidelines ¹	Being overweight or obese ²
Road density	+ **	+ **	– **
A-road density	+ ns	+ **	– *
Number of junctions per km road	+ **	+ **	– **
Ratio of junctions to cul-de-sacs	+ *	+ **	– ns
Age structure: % population >60 yrs	– **	– **	+ **
% Non-white population	+ **	+ **	– **
% Population who walk/bike to work	+ **	+ **	– **
% Population with LLTI	– **	– **	+ **
Neighbourhood deprivation	– **	– **	+ **

¹Defined as 30 minutes of at least moderate activity 5 times a week or more;

²Defined as a Body Mass Index of 25 or above

*
p<0.05,

**
p<0.01, ns = not statistically significant

Table 4

Odds ratios for visiting a green space at least once a week, achieving physical activity recommendations, and being overweight or obese, by distance to Formal green space. All values are adjusted for age, sex, socioeconomic status, self-rated health, area deprivation, and the neighbourhood variables found to exhibit an association with each outcome. Significance values represent the results from a test of trend across the quartiles of accessibility.

Distance to Formal green space	Visiting green space at least once a week		Achieving physical activity guidelines ¹		Being overweight or obese ²	
	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI
quartile 1 (nearest <830m)	1.00	-	1.00	-	1.00	-
quartile 2	0.73	(0.62-0.85)	0.87	(0.75-1.01)	1.00	(0.86-1.16)
quartile 3	0.81	(0.69-0.96)	0.81	(0.69-0.95)	1.01	(0.85-1.18)
quartile 4 (furthest >2250m)	0.76 ^{**}	(0.62-0.93)	0.88 ^{**}	(0.73-1.06)	0.98 ^{ns}	(0.83-1.20)

¹ Defined as 30 minutes of at least moderate activity 5 times a week or more;

² Defined as a Body Mass Index of 25 or above

^{**} p<0.01, ns = not statistically significant

Table 5

Odds ratios for achieving physical activity recommendations and overweight or obese, by frequency of reported green space use. Values are adjusted for age, sex, socioeconomic status, self-rated health, area deprivation, and the neighbourhood variables found to exhibit an association with each outcome. Significance values represent the results from a test of trend across the quartiles of accessibility.

Independent variable	Achieving physical activity guidelines ¹		Being overweight or obese ²	
	Odds ratio	95% CI	Odds ratio	95% CI
Unadjusted:				
At least once a week	1.00	-	1.00	-
At least twice a month	0.59	(0.52-0.67)	1.32	(1.17-1.50)
At least once a year	0.50	(0.44-0.57)	1.39	(1.22-1.58)
Less frequently	0.39 ^{**}	(0.33-0.45)	1.44 ^{**}	(1.25-1.66)
Adjusted:				
At least once a week	1.00	-	1.00	-
At least twice a month	0.54	(0.47-0.62)	1.30	(1.14-1.49)
At least once a year	0.48	(0.42-0.55)	1.28	(1.12-1.48)
Less frequently	0.45 ^{**}	(0.38-0.53)	1.05 ^{ns}	(0.90-1.24)

¹ Defined as 30 minutes of at least moderate activity 5 times a week or more;

² Defined as a Body Mass Index of 25 or above

^{**} p<0.01, ns = not statistically significant