Social, cognitive, behavioural and neighbourhood characteristics associated with sedentary time in men and women living in deprived neighbourhoods

Journal:	*European Journal of Sports Science*
Manuscript ID	TEJS-2016-0748
Manuscript Type:	Original Paper
Keywords:	Sedentary living, Health, Behavior

Abstract

Background

Multiple individual and neighbourhood characteristics are theorised to influence adult sedentary behaviour. The aim of this study was to examine associations between individual and neighbourhood-level characteristics in forty deprived neighbourhoods in London, UK.

Methods

A cross-sectional design was utilised with baseline data from the *Well London* Cluster Randomised Controlled Trial in forty deprived neighbourhoods in London. Multilevel linear regression was used to examine associations between individual characteristics (measured by household survey), neighbourhood characteristics (neighbourhood audit, GIS and routinely available datasets) and sedentary behaviour (sitting time).

Results

Individual-level positive mental wellbeing and health behaviours were associated with sedentary time. Individual-level social networks were associated with increased sedentary time in men and reduced sedentary time in women. Neighbourhood-level measures of social networks and perceived neighbourhood quality were associated with reduced sedentary time. Fifteen percent of the variance in sedentary time was attributable to differences at the neighbourhood-level (intra-class correlation coefficient = 0.15).

Conclusion

These findings suggest that social networks at the individual and neighbourhood-levels, collective perceptions of neighbourhood quality, individual-level positive mental wellbeing and other health behaviours may be important components of interventions developed to reduce sedentary time in deprived populations.

Keywords: sedentary living; health, behaviour

Background

Sedentary behaviour has been identified as a key risk factor for all-cause mortality and cardiovascular diseases (Biddle et al., 2016; Biswas et al., 2015; Thorp, Owen, Neuhaus, & Dunstan, 2011; Tremblay, Colley, Saunders, Healy, & Owen, 2010). Operationally defined as any waking behaviour in which the amount of energy expenditure is ≤1.5 metabolic equivalent units (METS) while in a sitting or reclining posture (Cart, 2012), sedentary behaviour should be considered separately from inadequate physical activity because it has an independent contribution to adverse health outcomes (Shuval et al., 2014). Sedentary behaviour has become a major public health issue as it has recently been reported that most adults are physically active for only 3% of their waking hours, but are sedentary for 50-60% of this time (Healy, Matthews, Dunstan, Winkler, & Owen, 2011). Current guidance from the Chief Medical Officer in the UK is that the amount of time adults spend sitting should be kept to a minimum (Department of Health, 2011).

Socio-ecological models propose that factors contributing to sedentary behaviours operate at multiple levels (Owen et al., 2011; Sallis, Owen, & Fisher). For example, neighbourhood-level factors (also known as environmental or ecological-level factors) may include the aesthetic quality or walkability of the outdoor neighbourhood environment, or the availability of resources such as sport and leisure facilities (O'Donoghue et al., 2016; Owen et al., 2011). Household-level factors may include the availability of electronic entertainment or labour-saving devices and individual-level factors may include demographic, social and cognitive characteristics (Owen, Salmon, Koohsari, Turrell, & Giles-Corti, 2014; Owen et al., 2011).

In a recent systematic review, Rhodes et al. (2012) found that associations between individual-level socio-demographic characteristics (age, gender, ethnicity, and employment status), behavioural characteristics (physical activity, smoking status) and sedentary behaviour were consistently reported across several studies. There is limited evidence for associations between social capital or perceptions of the neighbourhood environment and physical activity. Owen et al. (2014) suggest that there is a need for better understanding, from a multilevel perspective, of the role of perceived social capital in individuals and the role of collective social capital.

There is emerging evidence to suggest that aspects of the neighbourhood built environment, urban form, and access to green spaces and other resources for physical activity may be important determinants of sedentary behaviour (Sugiyama, Healy, Dunstan, Salmon, & Owen, 2008; Delfien Van Dyck et al., 2012). However, compared to research on socio-demographic and behavioural characteristics there is a relative dearth of information on social, cognitive and neighbourhood correlates of sedentary behaviour (Rhodes et al., 2012). This information may be useful in the development of more effective interventions or policy initiatives to reduce levels of sedentary behaviour in adults (Owen et al., 2011).

Owen and colleagues (2011) have suggested that as associations between neighbourhood characteristics and physical activity vary by domains of physical activity (e.g. work vs leisure) it is likely that neighbourhood characteristics that influence sedentary time will be specific to domains of sedentary time. However, there is very little theory available to suggest the ways in which neighbourhood characteristics may influence sedentary time. In a recent paper, Owen et al (2014) adapted a socio-ecological model of physical activity, suggesting that determinants of physical activity may also be relevant to sedentary behaviours. However, little is known about neighbourhood determinants of sedentary time and whether they differ from neighbourhood determinants of physical activity.

Furthermore, Owen et al. (2014) highlighted a need for research that examines whether associations between neighbourhood-level characteristics and sedentary time are moderated by socio-demographic characteristics. For example, whether these associations differ by gender or age. In this context, the aim of this study is to answer the following research questions:

1) Are individual-level and neighbourhood-level characteristics of deprived neighbourhoods in London associated with individual-level sedentary behaviour (total daily sitting time)?
2) What proportion of variance in sedentary behaviour can be attributed to variance between individuals and to variance between neighbourhoods?
3) Do socio-demographic characteristics moderate associations between individual and neighbourhood level characteristics and sedentary behaviour?

Methods

Overview of methods

This study utilised a cross-sectional design with household survey and neighbourhood observational audit data collected in forty deprived London neighbourhoods at baseline (prior to implementation of interventions) of the *Well London* cluster randomised controlled trial (CRCT). Multilevel linear regression analyses of household survey data were used to examine associations between individual-level sedentary behaviour and a range of demographic, social, cognitive, and behavioural characteristics. In addition, associations between neighbourhood characteristics and individual-level sedentary behaviour were examined using neighbourhood-level data collected using Geographical Information Systems (GIS), routinely available data and the neighbourhood observational audit. Multiple imputation was used to account for missing household survey data.

Neighbourhood selection

The forty neighbourhood units used this study were defined as census Lower Super Output Areas (LSOAs) which cover approximately 5-6 streets and contain between 1000 and 1500 residents. These forty LSOAs were selected for inclusion in the *Well London* CRCT as they were ranked in the top 11% for deprivation in London. Further details about the neighbourhood selection process are available elsewhere (Wall et al., 2009).

Household Survey

The survey respondents were adults (16 years and above) residing in the selected LSOAs (N= 4107, mean 104 per LSOA). The addresses within each LSOA were selected at random by using Post Office Address files and in 2008 interviewer-administered surveys were conducted by trained fieldworkers in responding households. Informed consent in writing was obtained from all respondents. For respondents aged 16 or 17, written informed consent was obtained from the respondent as well as a parent or guardian. All residents of the selected addresses aged over 16 were eligible for participation in the study (Wall et al., 2009).

Outcome variable

Individual-level data on total time spent sitting on a week day was obtained using a single item from the International Physical Activity Questionnaire - Short Form (IPAQ-SF) which asks respondents to recall the total time they have spent sitting at any time on a weekday (Craig et al., 2003).

Socio-demographic characteristics

The Well London household survey was used to collect information on socio-demographic characteristics (age, gender, ethnicity, occupation, education and ease of managing on household income).

Individual-level health/wellbeing

The Adult Hope Scale (Snyder et al., 1991) was used to measure positive mental wellbeing and an item asking respondents to report feelings of anxiety or depression was adapted from the EQ-5D (Rabin & de Charro, 2001) to record negative domains of mental health. Other survey items asked respondents to report mobility problems, problems with usual activities and visits to a general practitioner about being anxious or depressed or about a mental, nervous or emotional problem (including stress).

Individual-level health behaviours

Well London survey items asked respondents to report smoking behaviour, alcohol consumption, fruit and vegetable consumption, consumption of takeaway meals at home and physical activity levels (IPAQ-SF).

Individual-level social and cognitive characteristics

Social support and social networks scales were created using items from the Office of National Statistics Social Capital Harmonised Questionnaire (Green & Fletcher, 2003). The social support scale included items asking about the number of people respondents could rely on to help with money, shopping and advise/support. The social networks scale consisted of items that asked about frequency of contact with friends, relative and neighbours in person, by phone and in writing (including letters, texting and social media). To assess the individual-level perceptions of the neighbourhood environment (attractive buildings, attractive environment, quiet and peaceful, parks and open spaces, children's play areas, transport, youth and leisure

services and shops), a scale was created from items adapted from the British Household Panel Survey (Prentice-Lane, 2010). Full details of methods used for scale construction are provided by Bertotti et al. (2013) and in the supplemental file.

Neighbourhood characteristics

Access to greenspaces (at least 2 hectares) was measured using ArcGIS Version 9.1 (Environmental Systems Research Institute, 2010). The postcodes of survey respondents were geo-coded and access points to the greenspaces were identified using Google Earth and Ordnance Survey maps. Ordnance Survey Centre Alignment of Roads (OSCAR) data was used to calculate the shortest walking distance from the respondents' postcode to the nearest access point to a greenspace. Data collected using a neighbourhood environmental audit tool designed for the *Well London* programme was used to record items relating to walkability, cyclability, presence of large parks, small greenspaces, incivilities. Two trained fieldworkers visited each the 40 LSOAs on two separate occasions to complete the audit. A street connectivity index was constructed by counting three-way and four-way junctions in each LSOA and adjusting for the size of the LSOA (Smith & Davey, 2009) Full details of the methods used to collect these data have been previously published (Wall et al., 2009; Watts et al., 2013)

Walking time in minutes to the nearest leisure centres and sports facilities from the centre of the LSOAs were obtained using Sport England's Active Places Power Strategic Planning Tool (http://www.activeplacespower.co.uk). UK Department of Transport Core Accessibility Measures were used to calculate the walking distance from the respondent's place of residence to the nearest fast food outlet and food store/town centre (Department for Transport, 2008). Transport for London's Public Transport Accessibility Level indicator was used to measure accessibility, frequency and reliability of bus and rail services (Greater London Authority, 2008). Levels of crime in each neighbourhood (theft, burglaries, violence and criminal damage) were recorded using the English Indices for Multiple Deprivation crime indicator (Neighbourhood Renewal Unit, 2008).

To derive neighbourhood-level measures of social networks, social support and neighbourhood perceptions we calculated the proportion of individuals in each neighbourhood who had high scores on the individual-level scales. Specifically, we

calculated the percentage of respondents in each neighbourhood whose score on the individual-level scales was in the top quintile (top 20%) of the scores for all respondents. These percentages were used as neighbourhood-level indicators of social networks, social support and neighbourhood perceptions. Further details of the data collection using the household survey, neighbourhood audit, geographical information systems and routine sources are available online as supplementary material.

Statistical Analysis

All data analyses were conducted using Stata v11. The sedentary time outcome variable was log transformed to obtain a normal distribution and continuous variables were mean centred. Multiple imputation was used to account for missing household survey data; full details of the imputation models used for this dataset have been published previously (Watts et al., 2013). Random-intercept linear regression models were used to examine associations between individual-level and neighbourhood-level independent variables and the sedentary time outcome. Estimates are presented for models adjusted for individual-level age, gender, ethnicity and job category and for models additionally adjusted for physical activity levels and problems with mobility. An intra-class correlation coefficient for a model adjusted for individual-level age, gender and ethnicity and job category was used to examine the partitioning of variance in the sedentary behaviour (Merlo, 2003).

Ethical Approval

Ethical approval for this study was granted by the University of East London Ethics Committee in line with declaration of Helsinki.

Results

Household Survey

The *Well London* baseline adult household survey was completed by 4107 individuals. The mean response rate at the household-level was 73.3 % (standard deviation: 13.9; range: 40.5% - 99%). The mean individual-level (within the household) response rate was 61 %. The mean number of participants per household was 1.65 (range 1 to 8, standard deviation 0.99). Further information about the survey respondents have been published previously (Phillips et al., 2012).

Associations between socio-demographic characteristics and sedentary time

The overall mean daily sitting time reported by respondents was 392 minutes (six hours 32 minutes). Associations between socio-demographic characteristics and sitting time are presented in Table 1. Females reported significantly lower mean sedentary time than males. Respondents aged 16-24 years old reported the highest mean sedentary time, however, there was no observable association between age group and mean sedentary time. Asian respondents reported a higher mean sedentary time than other ethnic groups, but this difference was not statistically significant. Respondents who worked less than 30 hours per week, were retired, ill or unable to work were significantly more sedentary than respondents who were employed and working for at least 30 hour per week but did not specify their occupation. Respondents in skilled manual and elementary occupations were significantly less sedentary than those working 30 hours or more per week in unspecified occupations (see Table 1).

[TABLE 1 ABOUT HERE]

Associations between individual-level health/ wellbeing and sedentary time

Higher levels of positive mental wellbeing measured using the Hope scale were associated with less sedentary time (see Table 2). Respondents reporting some problems with walking also reported more sedentary time compared to respondents with no problems walking. Other measures of health and wellbeing were not associated with sedentary time.

Associations between individual-level health behaviours and sedentary time

Higher fruit and vegetable consumption and physical activity levels were both associated with reduced sedentary time. Levels of alcohol consumption and frequency of buying takeaways to eat at home were associated with increased sedentary time (see Table 2).

[TABLE 2 ABOUT HERE]

Associations between individual-level social and cognitive characteristics and sedentary time

The social networks, social support and perceived quality of environment scales were not associated with sitting time. Ownership of a mobile phone and access to the internet at home were not associated with sedentary time (see Supplemental File).

Neighbourhood characteristics and sedentary behaviour

Higher street connectivity was associated with increased sedentary time (opposite to the theorised direction). Living in a neighbourhood where a high proportion of respondents had high social networks scores was associated with decreased sedentary time. Living in a neighbourhood where a high proportion of respondents had positive perceptions of the neighbourhood environment was also associated with decreased sedentary time. Other neighbourhood characteristics were not associated with sedentary time (see Table 3).

[TABLE 3 ABOUT HERE]

Partitioning of variance

After adjusting for individual-level age, gender and ethnicity and job category, fifteen percent of the variance in sedentary behaviour between neighbourhoods was attributable to variance at the neighbourhood-level (Intraclass Correlation Coefficient = 0.15).

Associations between individual characteristics and sedentary time moderated by age and gender

There was little evidence that gender or age moderated the associations reported above. With only one exception, interaction terms fitted to examine the moderating role of gender or age were not statistically significant. The exception was the social networks scale, for which the interaction with gender was statistically significant ($p = <0.00$). Subgroup analyses presented in Table 4 show that the associations between social networks and sedentary time for men and women were in opposing directions. Higher social networks were associated with decreasing sedentary time in men and with increasing sedentary time for women.

[TABLE 4 ABOUT HERE]

Discussion

In this study, collective positive perceptions of neighbourhood quality and high levels of neighbourhood social networks were associated with lower individual-level sedentary time. At the individual-level, positive mental wellbeing was associated with reduced sedentary time and negative health behaviours were associated with increased sedentary time. Subgroup analyses provided evidence that for men, high

social networks were associated with reduced sedentary time and for women higher levels of social support were associated with increased sedentary time.

Higher street connectivity was associated with increased sedentary time (opposite to the theorised direction). Evidence from previous research on the influence of objectively measured neighbourhood characteristics on sedentary time is equivocal. A study in Australia found that individuals living in high-walkable neighbourhoods are less sedentary. However, a study of Belgian adults found that people living in high-walkable neighbourhoods are more sedentary (Van Dyck, Deforche, Cardon, & De Bourdeaudhuij, 2009). We hypothesised that levels of public transport accessibility may explain the observed association between street connectivity and sitting time. However, after adjusting models for public transport accessibility the association remained. Our findings suggest that objectively measured street connectivity represents a component of neighbourhood-walkability that promotes sedentary time. This is in contrast with consistently reported associations between street connectivity and increased physical activity and therefore indicates that neighbourhood correlates of sedentary behaviour are not the same as neighbourhood correlates of physical activity (O'Donoghue et al., 2016).

The observed association between sedentary time and physical activity is consistent with many previous studies and supports the theory that physical activity may displace sedentary time (Ekelund et al., 2016). However, the finding that sedentary time is associated with eating habits and alcohol consumption, but not with smoking differs from the findings of several previous studies included in a recent systematic review (Rhodes et al., 2012). Rhodes et al. (2012) reported that four out of 12 studies reported an association between eating behaviour sedentary time, one out of 15 studies reported a positive association between alcohol consumption and sedentary time and sedentary time and 16 out of 21 studies reported an association between smoking and sedentary time. The differences in our observations and trends in relationships reported in these previous studies may be explained by the use of total sitting time as an outcome measure, whereas most previous studies have examined TV viewing time as the main outcome measure. Furthermore, previous studies have not sought to examine sedentary time specifically in deprived populations.

Positive mental wellbeing, measure using the Snyder hope scale (Snyder et al., 1991) has not previously been examined in relation to sedentary time, however, our findings suggested that positive mental wellbeing may be important in achieving a less sedentary lifestyle. We also found that while individual-level perceptions of neighbourhood quality were not associated with sedentary time, collective positive perceptions of neighbourhood quality was associated with reduced sitting time. A recent study using pooled data from Australia, Belgium and the US found that individual-level perceptions of neighbourhood attributes predicted motorised travel time, but findings for overall sedentary time were less clear (Delfien Van Dyck et al., 2012). Our findings suggest that collective perceptions of neighbourhood quality should be considered when planning interventions or changes to neighbourhoods designed to reduce sedentary time.

With the exception of street connectivity, objective measures of neighbourhood characteristics were not associated with sedentary time. These findings may indicate that these neighbourhood characteristics, as measured in this study, are not important determinants of sedentary time in deprived neighbourhoods. An alternative explanation for these findings may be the lack of variation in objectively measured neighbourhood characteristics across the forty neighbourhoods. The neighbourhood units selected for this study were selected based on homogenous neighbourhood deprivation scores. Owen et al. (2014) have recently suggested that research across more heterogeneous units of study where there is greater variation in neighbourhood characteristics may be needed in order for correlates to be identified.

This study has a number of strengths including the use of perceived as well and objective measures of neighbourhood characteristics. Analyses of the partitioning of variance in sedentary time between the neighbourhood and individual levels and analyses of the moderating role of socio-demographic characteristics has provided information not previously available in reports of correlates of sedentary time.

The approach to analysis also enabled examination of associations between individual and neighbourhood characteristics and sedentary time, whilst accounting for the potential confounding influence of physical activity levels. Social-ecological models often do not distinguish between characteristics theorised to reduce

sedentary time and characteristics theorised to increase levels of physical activity (Giles-Corti, Timperio, Bull, & Pikora, 2005). The approach to analyses in this study follows a more recently developed model of determinants of sedentary behaviour (Owen et al., 2014) and has allowed examination of correlates of sedentary behaviour, distinct from correlates of physical inactivity. Correlates of physical activity in this population have been reported previously (Watts et al., 2013).

There are also several limitations to the methods used this study including the cross-sectional design, which prevents inferences about the causal direction of the associations reported. In addition, the measure of overall sitting time in this study may be less sensitive than domain-specific measures of sitting time. Evidence from the physical activity literature suggests that outcome measures of that are specific to work, leisure or neighbourhood-based behaviours may be more strongly associated with social, cognitive, behavioural and neighbourhood characteristics. The neighbourhood units (census LSOAs) used in this study were selected due to the available information on neighbourhood characteristics that is routinely available at this level of geography. However, LSOAs may not always correspond to the respondents' conceptions of their lived neighbourhoods (Weiss, Ompad, Galea, & Vlahov, 2007). It should also be noted that with multiple comparisons of variables there is increased likelihood of type I errors (incorrectly reporting significant relationships) as these relationships may have been observed by chance (Feise, 2002).

Our findings suggest that collective perceptions of neighbourhood quality and high levels of social networks within neighbourhoods may form important components of neighbourhood-level interventions to reduce sedentary time. At the individual-level efforts to reduce sedentary time through the promotion of social networks may need to consider gender differences in the relationships between social networks and physical activity. The social network scale used in these analysis includes a measure of how often respondents speak on the phone and/or write to relatives and friends. One interpretation of these findings could be that as women speak and write messages through social networking applications more often than men (Thelwall, 2008) and this is most often done while sitting down, sedentary time is higher in women with more social networks. For men increased social networks

alone may be effective in reducing sedentary time, but for women it may be necessary to provide interventions that aim to promote non-sedentary social activities.

Individual-level correlates of sedentary behaviour identified in these deprived neighbourhoods are similar to those reported in previous studies, in particular the behavioural characteristics (Rhodes et al., 2012). This suggests that interventions targeting multiple health behaviours including, sedentary time, physical activity, and health eating may be effective. Further research on the extent to which these health behaviours are clustered and the determinants of clustered heath behaviours in deprived populations is needed. Future research may also include examination of more heterogeneous populations and examination of individual and neighbourhood characteristics that specifically relate to different domains of sedentary time in these populations. For example, examination of associations between sedentary time at work, at home or during leisure time outside the home and conceptually matched social, cognitive, behavioural and neighbourhood characteristics.

Acknowledgements

We are very grateful for the contributions of numerous fieldworkers to the collection of the household survey data. We would also like to thank members of the Well London evaluation team for their contributions to the data collection and preparation processes.

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Table 1. Associations between socio-demographic characteristics and sitting time.

Individual Characteristics				Adjusted model[1]		
	N	%	Mean daily sitting mins	β coef	LCI	UCI
Sex						
Male	1,815	45.0	404.9	Ref		
Female	2,220	55.0	381.2	**-0.070**	**-0.130**	**-0.011**
Age Group						
16-24 years	776	21.0	410.7	Ref		
25-34 years	1,018	27.5	402.9	-0.038	-0.131	0.055
35-44 years	807	21.8	402.2	-0.086	-0.185	0.013
45-54 years	454	12.3	377.6	-0.062	-0.172	0.049
55-64 years	288	7.8	364.7	-0.119	-0.254	0.016
65 years and older	359	9.7	401.3	-0.005	-0.175	0.166
Ethnicity						
White	1,787	44.6	394.1	Ref		
Black	1,226	30.6	376.9	-0.04	-0.112	0.027
Asian	601	15.0	448.8	0.06	-0.033	0.156
Mixed	191	4.8	330.6	-0.11	-0.240	0.021
Other	199	5.0	340	-0.09	-0.233	0.048
Job Category						
Unspecified working (30+ hours per week)	759	19.8	394.9	Ref		
Unspecified working (Under 30 hours)	123	3.2	519.1	**0.100**	**0.077**	**0.470**
Unpaid housework	210	5.5	308.2	-0.087	-0.216	0.042
Full-time education	489	12.8	425.5	0.066	-0.052	0.183
Unemployed	221	5.8	423.6	-0.023	-0.191	0.145
Retired	396	10.3	396.8	**0.184**	**0.026**	**0.342**
Unable, ill or disabled	217	5.7	411.5	**0.227**	**0.089**	**0.364**
Managerial, professional and sales	1,075	28.1	427.7	0.077	-0.006	0.161
Skilled manual and elementary	267	7.0	330.3	**-0.148**	**-0.273**	**-0.023**

[1]Adjusted for age, gender, ethnicity and job category. LCI = Lower confidence interval; UCI = Upper confidence interval

Table 2. Associations between physical and mental health/wellbeing, health behaviours and sitting time.

Individual Characteristics	Partially adjusted model[1]			Fully adjusted model[2]		
	β coef	LCI	UCI	β coef	LCI	UCI
Hope scale	**-0.061**	**-0.100**	**-0.021**	**-0.044**	**-0.084**	**-0.003**
Mobility Problems						
No problems walking	Ref					
Some problems walking	**0.144**	**0.053**	**0.235**	**0.122**	**0.024**	**0.220**
Confined to bed	**0.600**	**0.066**	**1.134**	0.478	-0.074	1.029
Problems with usual activities						
No problems with usual activities	Ref					
Some problems with usual activities	**0.111**	**0.014**	**0.208**	0.086	-0.018	0.190
Unable to perform usual activities	**0.283**	**0.030**	**0.535**	0.152	-0.103	0.407
Portions of fruit and veg (previous day)	**-0.008**	**-0.016**	**-0.001**	**0.009**	**-0.016**	**-0.002**
Takeaway at least once a week	**0.066**	**0.006**	**0.125**	**0.070**	**0.011**	**0.130**
Alcohol consumption (none - heavy)	**0.027**	**0.004**	**0.050**	**0.025**	**0.002**	**0.048**
Smoker	0.004	-0.062	0.071	0.016	-0.050	0.082
Physical Activity (weekly MET minutes)	**-0.002**	**-0.003**	**0.001**	**-0.001**	**-0.002**	**0.001**

[1]Adjusted for age, gender, ethnicity and job category; [2]Adjusted for age, gender, ethnicity and job category, hope scale, mobility problems, problems with usual activities and physical activity

Table 3. Associations between neighbourhood characteristics and sitting time

Neighbourhood Characteristics	Partially adjusted model[1]			Fully adjusted model[2]		
	B coef	LCI	UCI	B coef	LCI	UCI
Count of large parks within neighbourhood	0.221	-0.769	1.212	0.263	-0.771	1.297
Count of greenspaces within neighbourhood	-0.010	-0.045	0.025	-0.010	-0.046	0.026
Walkability Index	-0.003	-0.017	0.011	0.000	-0.014	0.014
Cyclability Index	0.003	-0.059	0.064	0.005	-0.060	0.069
Street connectivity index	**1.575**	**0.021**	**3.130**	**1.784**	**0.185**	**3.384**
Public Transport Accessibility Level	-0.006	-0.179	0.006	-0.005	-0.178	0.007
IMD Crime Score	-0.008	-0.153	0.137	-0.037	-0.187	0.114
Count of incivilities within neighbourhood	0.001	-0.127	0.129	-0.008	-0.141	0.125
High neighbourhood perceptions	**-0.899**	**-1.477**	**-0.321**	**-0.919**	**-1.519**	**-0.319**
High neighbourhood social networks	**-0.808**	**-1.435**	**-0.182**	**-0.736**	**-1.394**	**-0.077**
High neighbourhood social support	0.286	-0.475	1.048	0.457	-0.329	1.243
Travel time to nearest food store	-0.012	-0.049	0.025	-0.014	-0.052	0.025
Travel time to nearest sport/leisure facility	0.004	-0.029	0.037	0.009	-0.025	0.044
Travel time to nearest town centre	0.017	-0.004	0.038	0.020	-0.001	0.042
Walking distance to greenspace	-0.001	-0.001	0.001	-0.001	-0.001	0.001

[1]Adjusted for age, gender, ethnicity and job category; [2]Adjusted for age, gender, ethnicity and job category, hope scale, mobility problems, problems with usual activities and physical activity

Table 4. Associations between social networks and sitting time, moderated by gender

Individual Characteristics	Fully adjusted model without interaction terms[1]			Fully adjusted model with interaction terms[1]		
	B coef	**LCI**	**UCI**	**B coef**	**LCI**	**UCI**
Gender*Social networks scale				**0.014**	**0.003**	**0.025**
Social networks scale	-0.002	-0.008	0.004	**-0.009**	**-0.018**	**-0.001**
Subgroup analyses						
Social networks scale (men only)	**-0.008**	**-0.012**	**-0.005**			
Social networks scale (women only)	**0.005**	**0.002**	**0.009**			

[1]Adjusted for age, gender, ethnicity and job category, hope scale, mobility problems, problems with usual activities and physical activity

Supplemental File

Household survey data

The *Well London* household survey was used to collect data on gender, age, ethnicity, education, employment status and ease of managing on household income. The survey also included a measure of positive mental wellbeing (Snyder Hope Scale (Snyder et al., 1991) and self-reported measures of: mobility problems; problems performing usual activities; pain/discomfort; and depression/anxiety from the Euroqol questionnaire (Rabin & de Charro, 2001) Questions taken from the Office for National Statistics social capital harmonised question set (Green & Fletcher, 2003) asked participants to report how often they meet with friends and how often they speak to neighbours (see table below). Likert scale style responses were used to record participants' perceptions of the quality of buildings, the environment, parks and open spaces, and youth and leisure services.

Current smoking behaviour was ascertained by a simple yes/no question "are you a daily smoker?", as commonly used in the Health Survey for England (NHS Information Centre, 2008). Validated measures of healthy eating were also adapted from the Health Survey for England. Self-reported alcohol consumption and frequency of take-away consumption were recorded using items from previous studies of health behaviours in London (Clark et al., 2007). The international physical activity questionnaire – short form (Craig et al., 2003) was used to generate a measure of physical activity MET minutes.

Well London Household Survey: Independent variable measurement and item sources

Variables (Source)	Measurement / Categories / Scales
Independent variables	
Smoking (Health Survey for England)	Binary variable Are you a daily smoker? Yes/No
Alcohol consumption (Clark et al., 2007)	1) drink heavily 2) drink quite a lot 3) drink a moderate amount 4) drink a little 5) hardly drink at all 6) never drink alcohol
Continuous physical activity outcome (International Physical Activity Questionnaire)	Continuous measure in MET minutes
Take-away meal consumption (Clark et al., 2007)	Categorical variable 1) once a week or more than once a week 2) less than once a week
Hope scale (Snyder Hope Scale)	A continuous scale was derived from 8 items: 1) I can think of many ways to get out of a jam 2) I energetically pursue my goals 3) There are lots of ways around any problem 4) I can think of many ways to get the things in life that are most important to me 5) Even when others get discouraged, I know I can find a way to solve the problem 6) My past experiences have prepared me well for my future 7) I've been pretty successful in life 8) I meet the goals that I set myself Responses to each item were dichotomised as: 0= 'Definitely false', 'Mostly false', or 'Somewhat false' 1= 'Slightly true', 'Mostly true' or 'Definitely true'; 'Prefers not to say' was treated as missing. The responses from all items were combined to give a score from 0 to 8.
Perceived neighbourhood quality scale (British Household Panel Survey)	A Likert style item was used to record residents perceptions of the quality of each of the following characteristics: attractive buildings, attractive environment, quiet and peaceful, parks and open spaces, children's play areas, transport, youth and leisure services and shops. Categorical variable: 1) Very poor 2) Fairly poor 3) Neither good nor bad 4) Fairly good 5) Very good The scores from the Likert scale for each item was summed to create a scale.

Social Networks Scale (Office for National Statistics social capital harmonised question set)	A Likert style item was used to record a) Frequency of meeting friends and b) frequency of speaking to neighbours: 1) Never 2) Less often than once a month 3) Once or twice a month 4) Once a week or more 5) Most days The scores from the Likert scale for each item was summed to create a scale.
Social Support Scale (Office for National Statistics social capital harmonised question set)	An item was used to ask respondents how many people they could ask for the following kinds of help a) 'To go to the shop for groceries if you are unwell' b) 'To lend you money to see you through the next few days' c) 'To give you advice and support in a crisis' 1) None 2) One or Two 3) More than two The scores from the Likert scale for each item was summed to create a scale.

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Neighbourhood audit

Physical and structural neighbourhood characteristics were measured using a systematic social observation tool, designed for the *Well London* programme study following a review of previously validated tools (Boarnet, Day, Alfonzo, Forsyth, & Oakes, 2006; Clifton, Livi Smith, & Rodriguez, 2007) and the theoretical literature. Trained observers visited each of the 40 neighbourhoods to complete the audit tool proforma as they walked throughout each pre-defined segment of the neighbourhoods. Pre-defined segments were 'output areas', which the smallest level of geography used in the census (Neighbourhood Renewal Unit, 2008). Typically, these segments (output areas) covered the length of one street and around 125 households. The data collected in these segments were adjusted for their size when scales were calculated (see below).

Two observers completed the audit of each segments independently, compared their observations and agreed on the data to be entered into a database for analysis. A sample of these segments were cross-checked using Google Earth Street View (Clarke, Ailshire, Melendez, Bader, & Morenoff, 2010) once the audits were completed to identify any major discrepancies, but there was a good level of agreement between the physical audits and those using Street View. Therefore, the data originally collected in the audit was used for analysis. The final indices for each neighbourhood (LSOA) were created by summing the score for each index in each segment then adjusting for the size of the neighbourhoods in square meters to account for differences in the geographical size of the neighbourhoods.

Well London Neighbourhood audit: Independent variable measurement and item sources

Independent variables from the neighbourhood audit	Items included and index construction
Green spaces	Number of: 1) Communal green spaces 2) Large parks The counts of these items in each segment were examined separately as continuous variables
Cyclability	Count of: 1) Continuous cycle lanes 2) Non-continuous cycle lanes 3) Bicycle storage facilities The counts of the three items in each segment were summed to give an overall index to be analysed as a continuous variable.
Walkability	Number of: 1) Road crossing aids 2) Pedestrianised areas 3) Buffers between the road and pathway 4) Signposts for pedestrians The counts of the four items in each segment were summed to give an overall index to be analysed as a continuous variable.
Signs of social disorder and incivilities	Amount of (rated as 'None', 'Little', 'Moderate' or 'A lot'): 1) Litter and broken glass 2) Graffiti 3) Vandalised facilities 4) Broken windows 5) Security measures 6) Unattended dogs 7) Large items dumped in public areas 8) Dog foul 9) Needles/syringes/condoms 10) Empty alcohol bottles/cans The total number of items recorded as 'Moderate' or 'A lot' in each segment was summed to give an overall index to be analysed as a continuous variable.

Routine data

The English Indices of Multiple Deprivation (IMD) Crime Indicator (Neighbourhood Renewal Unit, 2008) was used to examine neighbourhood-level crime rates: this indicator includes recorded rates of four categories of crime: burglaries; thefts; violence and criminal damage. As this indicator is published every three years, the 2007 data was used as it most closely matched the time period of the data collection for the *Well London* household survey data. A street connectivity index was created from counts of the three and four-way junctions within the neighbourhoods, adjusted for the size of the neighbourhoods by dividing the counts of junctions by the size of the neighbourhoods in square metres (Smith & Davey, 2009). The junctions were identified by examining Ordnance Survey maps of each LSOA from 2008.

The English Indices of Deprivation accessibility measures from 2008 were used as indicators of the neighbourhood average walking distances to the nearest available food store and town centre (Neighbourhood Renewal Unit, 2008). These measures use Ordnance Survey Centre Alignment of Roads (OSCAR) data. OSCAR data is generated by Ordnance Survey to provide vector data for streets and paths in the UK. OSCAR data is used by the government Department for Communities and Local Government with Geographical Information Systems (GIS) to calculate the quickest walking route from the centre of one postcode to the centre of another postcode. In this case the distance is calculated from the postcodes of residential addresses to the postcodes of the addresses of the nearest food store and town centre. The core accessibility measures provide the average distance that a resident of each LSOA would have to walk to reach the nearest food store or town centre.

Sport England's Active Places Power Strategic Planning Tool (http://www.activeplacespower.co.uk) was used to identify the number of sports and leisure facilities within ten minutes walking distance from the centre of the neighbourhoods. This tool also uses OSCAR data with GIS to calculate walking routes to the nearest facilities. Facilities were included in the final count only if they provided opportunities to be physically active and therefore leisure-only facilities (e.g. spas or saunas) were excluded.

Independent variables from routinely collected data sources

Independent variables from routinely available data	Data source
Percentage of LSOA classified as: 1) Greenspace 2) Residential 3) Transport 4) Commercial 5) Other (continuous variables)	Generalised Land Use Database
Land use mix index (continuous variable)	Generalised Land Use Database
Crime indicator (continuous variable)	English indices of Deprivation Crime Indicator (2007)
Street connectivity index (continuous variable)	Ordnance Survey
Average walking distance to nearest food store (continuous variable)	The English Indices of Deprivation core accessibility measures (2008)
Average walking distance to nearest town centre (continuous variable)	The English Indices of Deprivation core accessibility measures (2008)
Number of sport/leisure facilities within 10 minutes' walk (continuous variable).	Sport England's Active Places Power Strategic Planning Tool

Geographical information systems data

All postcodes within the 40 neighbourhoods were geocoded using Arc GIS Version 9.1. Publicly accessible and useable greenspaces in close proximity to each of the neighbourhoods were identified visually using aerial images from Google Earth and then the access points to the greenspaces were geocoded using Arc GIS. Only greenspaces larger than 2 hectares (20,000 square metres) were geocoded as areas smaller than this are often considered to be of inadequate size for adults to use to be physically active (Coombes, Jones, & Hillsdon, 2010). Judgements as to whether identified greenspaces were accessible and usable were made using the following criteria described by Natural England (2012) and Taylor et al (2011). To be judged accessible, the greenspaces had to be open to the public with at least one access point from a public road or path. To be judged usable, the greenspaces had to contain walkable paths and/or open, walkable surfaces. Usability was assessed using Google Earth aerial images of the parks. Google Earth Street View was used to identify access points by scanning the perimeter of each greenspace to visually identify access points which were then geocoded in the corresponding location in Arc GIS.

The shortest walking distance from each postcode to the nearest greenspace access point was calculated initially using OSCAR data. All walking routes were examined using Google Earth and Google Street View and subsequently modified if necessary to ensure that the shortest unobstructed walking route was accurately recorded. For example, in several cases it was clear that the shortest walking route to the nearest greenspace access point involved using a small path or alleyway that was not utilised in the route calculated using OSCAR data. Therefore, in order to capture the shortest walking distances as accurately as possible, walking distances were re-calculated manually where necessary to exploit the use of paths or alleyways. Walking distance to greenspace was examined by creating a categorical variable to compare participants who had access to at least one of these greenspaces within 300 metres to those who had access within 301-600, 601-900 or 900-1200 metres.

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Individual Characteristics	Partially adjusted model[1]			Fully adjusted model[2]		
	B coef	LCI	UCI	B coef	LCI	UCI
Social networks scale	0.001	-0.006	0.007	0.001	-0.005	0.007
Social support scale	-0.001	-0.014	0.013	-0.003	-0.017	0.012
Perceived quality of environment scale	0.004	-0.013	0.021	0.002	-0.016	0.019
Has a mobile phone	-0.066	-0.157	0.025	-0.091	-0.182	0.001
Has internet access at home	-0.066	-0.052	0.081	0.012	-0.056	0.079

[1]Adjusted for age, gender, ethnicity and job category; [2]Adjusted for age, gender, ethnicity and job category, hope scale, mobility problems, problems with usual activities and physical activity

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