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

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1
2
3 **1 Abstract**

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6 **2 Background**

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8 Multiple individual and neighbourhood characteristics are theorised to influence adult
9
10 sedentary behaviour. The aim of this study was to examine associations between
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12 individual and neighbourhood-level characteristics in forty deprived neighbourhoods
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14 in London, UK.

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17 **7 Methods**

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19 A cross-sectional design was utilised with baseline data from the *Well London*
20
21 Cluster Randomised Controlled Trial in forty deprived neighbourhoods in London.
22
23 Multilevel linear regression was used to examine associations between individual
24
25 characteristics (measured by household survey), neighbourhood characteristics
26
27 (neighbourhood audit, GIS and routinely available datasets) and sedentary
28
29 behaviour (sitting time).

30
31
32 **14 Results**

33
34 Individual-level positive mental wellbeing and health behaviours were associated
35
36 with sedentary time. Individual-level social networks were associated with increased
37
38 sedentary time in men and reduced sedentary time in women. Neighbourhood-level
39
40 measures of social networks and perceived neighbourhood quality were associated
41
42 with reduced sedentary time. Fifteen percent of the variance in sedentary time was
43
44 attributable to differences at the neighbourhood-level (intra-class correlation
45
46 coefficient = 0.15).

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48
49 **22 Conclusion**

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51 These findings suggest that social networks at the individual and neighbourhood-
52
53 levels, collective perceptions of neighbourhood quality, individual-level positive
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55 mental wellbeing and other health behaviours may be important components of
56
57 interventions developed to reduce sedentary time in deprived populations.
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27 Keywords: sedentary living; health, behaviour

28

29 Background

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

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

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

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3 60 There is emerging evidence to suggest that aspects of the neighbourhood built
4 61 environment, urban form, and access to green spaces and other resources for
5 62 physical activity may be important determinants of sedentary behaviour (Sugiyama,
6 63 Healy, Dunstan, Salmon, & Owen, 2008; Delfien Van Dyck et al., 2012). However,
7 64 compared to research on socio-demographic and behavioural characteristics there is
8 65 a relative dearth of information on social, cognitive and neighbourhood correlates of
9 66 sedentary behaviour (Rhodes et al., 2012). This information may be useful in the
10 67 development of more effective interventions or policy initiatives to reduce levels of
11 68 sedentary behaviour in adults (Owen et al., 2011).

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19 69 Owen and colleagues (2011) have suggested that as associations between
20 70 neighbourhood characteristics and physical activity vary by domains of physical
21 71 activity (e.g. work vs leisure) it is likely that neighbourhood characteristics that
22 72 influence sedentary time will be specific to domains of sedentary time. However,
23 73 there is very little theory available to suggest the ways in which neighbourhood
24 74 characteristics may influence sedentary time. In a recent paper, Owen et al (2014)
25 75 adapted a socio-ecological model of physical activity, suggesting that determinants
26 76 of physical activity may also be relevant to sedentary behaviours. However, little is
27 77 known about neighbourhood determinants of sedentary time and whether they differ
28 78 from neighbourhood determinants of physical activity.

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37 79 Furthermore, Owen et al. (2014) highlighted a need for research that examines
38 80 whether associations between neighbourhood-level characteristics and sedentary
39 81 time are moderated by socio-demographic characteristics. For example, whether
40 82 these associations differ by gender or age. In this context, the aim of this study is to
41 83 answer the following research questions:

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46 84 1) Are individual-level and neighbourhood-level characteristics of deprived
47 85 neighbourhoods in London associated with individual-level sedentary
48 86 behaviour (total daily sitting time)?
49
50 87 2) What proportion of variance in sedentary behaviour can be attributed to
51 88 variance between individuals and to variance between neighbourhoods?
52
53 89 3) Do socio-demographic characteristics moderate associations between
54 90 individual and neighbourhood level characteristics and sedentary behaviour?
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91 **Methods**

92 *Overview of methods*

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

104 *Neighbourhood selection*

105 The forty neighbourhood units used this study were defined as census Lower Super
106 Output Areas (LSOAs) which cover approximately 5-6 streets and contain between
107 1000 and 1500 residents. These forty LSOAs were selected for inclusion in the *Well*
108 *London* CRCT as they were ranked in the top 11% for deprivation in London.
109 Further details about the neighbourhood selection process are available elsewhere
110 (Wall et al., 2009).

111 *Household Survey*

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

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3 120 *Outcome variable*

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5 121 Individual-level data on total time spent sitting on a week day was obtained using a
6
7 122 single item from the International Physical Activity Questionnaire - Short Form
8
9 123 (IPAQ-SF) which asks respondents to recall the total time they have spent sitting at
10 124 any time on a weekday (Craig et al., 2003).

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13 125 *Socio-demographic characteristics*

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15 126 The Well London household survey was used to collect information on socio-
16
17 127 demographic characteristics (age, gender, ethnicity, occupation, education and ease
18 128 of managing on household income).

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21 129 *Individual-level health/wellbeing*

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23 130 The Adult Hope Scale (Snyder et al., 1991) was used to measure positive mental
24
25 131 wellbeing and an item asking respondents to report feelings of anxiety or depression
26
27 132 was adapted from the EQ-5D (Rabin & de Charro, 2001) to record negative domains
28
29 133 of mental health. Other survey items asked respondents to report mobility problems,
30
31 134 problems with usual activities and visits to a general practitioner about being anxious
32
33 135 or depressed or about a mental, nervous or emotional problem (including stress).

34
35 136 *Individual-level health behaviours*

36
37 137 *Well London* survey items asked respondents to report smoking behaviour, alcohol
38
39 138 consumption, fruit and vegetable consumption, consumption of takeaway meals at
40
41 139 home and physical activity levels (IPAQ-SF).

42
43 140 *Individual-level social and cognitive characteristics*

44
45 141 Social support and social networks scales were created using items from the Office
46
47 142 of National Statistics Social Capital Harmonised Questionnaire (Green & Fletcher,
48
49 143 2003). The social support scale included items asking about the number of people
50
51 144 respondents could rely on to help with money, shopping and advise/support. The
52
53 145 social networks scale consisted of items that asked about frequency of contact with
54
55 146 friends, relative and neighbours in person, by phone and in writing (including letters,
56
57 147 texting and social media). To assess the individual-level perceptions of the
58
59 148 neighbourhood environment (attractive buildings, attractive environment, quiet and
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149 peaceful, parks and open spaces, children's play areas, transport, youth and leisure

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3 150 services and shops), a scale was created from items adapted from the British
4 151 Household Panel Survey (Prentice-Lane, 2010). Full details of methods used for
5 152 scale construction are provided by Bertotti et al. (2013) and in the supplemental file.

8
9 153 *Neighbourhood characteristics*

10
11 154 Access to greenspaces (at least 2 hectares) was measured using ArcGIS Version
12 155 9.1 (Environmental Systems Research Institute, 2010). The postcodes of survey
13 156 respondents were geo-coded and access points to the greenspaces were identified
14 157 using Google Earth and Ordnance Survey maps. Ordnance Survey Centre
15 158 Alignment of Roads (OSCAR) data was used to calculate the shortest walking
16 159 distance from the respondents' postcode to the nearest access point to a
17 160 greenspace. Data collected using a neighbourhood environmental audit tool
18 161 designed for the *Well London* programme was used to record items relating to
19 162 walkability, cyclability, presence of large parks, small greenspaces, incivilities. Two
20 163 trained fieldworkers visited each the 40 LSOAs on two separate occasions to
21 164 complete the audit. A street connectivity index was constructed by counting three-
22 165 way and four-way junctions in each LSOA and adjusting for the size of the LSOA
23 166 (Smith & Davey, 2009) Full details of the methods used to collect these data have
24 167 been previously published (Wall et al., 2009; Watts et al., 2013)

25
26 168 Walking time in minutes to the nearest leisure centres and sports facilities from the
27 169 centre of the LSOAs were obtained using Sport England's Active Places Power
28 170 Strategic Planning Tool (<http://www.activeplacespower.co.uk>). UK Department of
29 171 Transport Core Accessibility Measures were used to calculate the walking distance
30 172 from the respondent's place of residence to the nearest fast food outlet and food
31 173 store/town centre (Department for Transport, 2008). Transport for London's Public
32 174 Transport Accessibility Level indicator was used to measure accessibility, frequency
33 175 and reliability of bus and rail services (Greater London Authority, 2008). Levels of
34 176 crime in each neighbourhood (theft, burglaries, violence and criminal damage) were
35 177 recorded using the English Indices for Multiple Deprivation crime indicator
36 178 (Neighbourhood Renewal Unit, 2008).

37
38 179 To derive neighbourhood-level measures of social networks, social support and
39 180 neighbourhood perceptions we calculated the proportion of individuals in each
40 181 neighbourhood who had high scores on the individual-level scales. Specifically, we

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3 182 calculated the percentage of respondents in each neighbourhood whose score on
4 183 the individual-level scales was in the top quintile (top 20%) of the scores for all
5 184 respondents. These percentages were used as neighbourhood-level indicators of
6 185 social networks, social support and neighbourhood perceptions. Further details of
7 186 the data collection using the household survey, neighbourhood audit, geographical
8 187 information systems and routine sources are available online as supplementary
9 188 material.

10 11 12 13 14 15 189 *Statistical Analysis*

16
17 190 All data analyses were conducted using Stata v11. The sedentary time outcome
18 191 variable was log transformed to obtain a normal distribution and continuous variables
19 192 were mean centred. Multiple imputation was used to account for missing household
20 193 survey data; full details of the imputation models used for this dataset have been
21 194 published previously (Watts et al., 2013). Random-intercept linear regression
22 195 models were used to examine associations between individual-level and
23 196 neighbourhood-level independent variables and the sedentary time outcome.
24 197 Estimates are presented for models adjusted for individual-level age, gender,
25 198 ethnicity and job category and for models additionally adjusted for physical activity
26 199 levels and problems with mobility. An intra-class correlation coefficient for a model
27 200 adjusted for individual-level age, gender and ethnicity and job category was used to
28 201 examine the partitioning of variance in the sedentary behaviour (Merlo, 2003).

29 30 31 32 33 34 35 36 37 202 *Ethical Approval*

38
39 203 Ethical approval for this study was granted by the University of East London Ethics
40 204 Committee in line with declaration of Helsinki.

41 42 43 205 **Results**

44 45 206 *Household Survey*

46
47 207 The *Well London* baseline adult household survey was completed by 4107
48 208 individuals. The mean response rate at the household-level was 73.3 % (standard
49 209 deviation: 13.9; range: 40.5% - 99%). The mean individual-level (within the
50 210 household) response rate was 61 %. The mean number of participants per
51 211 household was 1.65 (range 1 to 8, standard deviation 0.99). Further information
52 212 about the survey respondents have been published previously (Phillips et al., 2012).

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3 213 *Associations between socio-demographic characteristics and sedentary time*

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5 214 The overall mean daily sitting time reported by respondents was 392 minutes (six
6
7 215 hours 32 minutes). Associations between socio-demographic characteristics and
8
9 216 sitting time are presented in Table 1. Females reported significantly lower mean
10
11 217 sedentary time than males. Respondents aged 16-24 years old reported the highest
12
13 218 mean sedentary time, however, there was no observable association between age
14
15 219 group and mean sedentary time. Asian respondents reported a higher mean
16
17 220 sedentary time than other ethnic groups, but this difference was not statistically
18
19 221 significant. Respondents who worked less than 30 hours per week, were retired, ill
20
21 222 or unable to work were significantly more sedentary than respondents who were
22
23 223 employed and working for at least 30 hour per week but did not specify their
24
25 224 occupation. Respondents in skilled manual and elementary occupations were
26
27 225 significantly less sedentary than those working 30 hours or more per week in
28
29 226 unspecified occupations (see Table 1).

27 [TABLE 1 ABOUT HERE]

28
29 228 *Associations between individual-level health/ wellbeing and sedentary time*

30
31 229 Higher levels of positive mental wellbeing measured using the Hope scale were
32
33 230 associated with less sedentary time (see Table 2). Respondents reporting some
34
35 231 problems with walking also reported more sedentary time compared to respondents
36
37 232 with no problems walking. Other measures of health and wellbeing were not
38
39 233 associated with sedentary time.

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41 234 *Associations between individual-level health behaviours and sedentary time*

42
43 235 Higher fruit and vegetable consumption and physical activity levels were both
44
45 236 associated with reduced sedentary time. Levels of alcohol consumption and
46
47 237 frequency of buying takeaways to eat at home were associated with increased
48
49 238 sedentary time (see Table 2).

48 [TABLE 2 ABOUT HERE]

50
51 240 *Associations between individual-level social and cognitive characteristics and sedentary time*

52
53 241 The social networks, social support and perceived quality of environment scales
54
55 242 were not associated with sitting time. Ownership of a mobile phone and access to
56
57 243 the internet at home were not associated with sedentary time (see Supplemental
58
59 244 File).

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3 245 *Neighbourhood characteristics and sedentary behaviour*

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5 246 Higher street connectivity was associated with increased sedentary time (opposite to
6
7 247 the theorised direction). Living in a neighbourhood where a high proportion of
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9 248 respondents had high social networks scores was associated with decreased
10
11 249 sedentary time. Living in a neighbourhood where a high proportion of respondents
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13 250 had positive perceptions of the neighbourhood environment was also associated with
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15 251 decreased sedentary time. Other neighbourhood characteristics were not
16
17 252 associated with sedentary time (see Table 3).

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253 [TABLE 3 ABOUT HERE]

254 *Partitioning of variance*

255 After adjusting for individual-level age, gender and ethnicity and job category, fifteen
256 percent of the variance in sedentary behaviour between neighbourhoods was
257 attributable to variance at the neighbourhood-level (Intraclass Correlation Coefficient
258 = 0.15).

259 *Associations between individual characteristics and sedentary time moderated by age and*
260 *gender*

261 There was little evidence that gender or age moderated the associations reported
262 above. With only one exception, interaction terms fitted to examine the moderating
263 role of gender or age were not statistically significant. The exception was the social
264 networks scale, for which the interaction with gender was statistically significant ($p =$
265 <0.00). Subgroup analyses presented in Table 4 show that the associations
266 between social networks and sedentary time for men and women were in opposing
267 directions. Higher social networks were associated with decreasing sedentary time
268 in men and with increasing sedentary time for women.

269 [TABLE 4 ABOUT HERE]

270 **Discussion**

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

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3 276 social networks were associated with reduced sedentary time and for women higher
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5 277 levels of social support were associated with increased sedentary time.
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7 278 Higher street connectivity was associated with increased sedentary time (opposite to
8
9 279 the theorised direction). Evidence from previous research on the influence of
10
11 280 objectively measured neighbourhood characteristics on sedentary time is equivocal.
12
13 281 A study in Australia found that individuals living in high-walkable neighbourhoods are
14
15 282 less sedentary. However, a study of Belgian adults found that people living in high-
16
17 283 walkable neighbourhoods are more sedentary (Van Dyck, Deforche, Cardon, & De
18
19 284 Bourdeaudhuij, 2009). We hypothesised that levels of public transport accessibility
20
21 285 may explain the observed association between street connectivity and sitting time.
22
23 286 However, after adjusting models for public transport accessibility the association
24
25 287 remained. Our findings suggest that objectively measured street connectivity
26
27 288 represents a component of neighbourhood-walkability that promotes sedentary time.
28
29 289 This is in contrast with consistently reported associations between street connectivity
30
31 290 and increased physical activity and therefore indicates that neighbourhood correlates
32
33 291 of sedentary behaviour are not the same as neighbourhood correlates of physical
34
35 292 activity (O'Donoghue et al., 2016).

36
37 293 The observed association between sedentary time and physical activity is consistent
38
39 294 with many previous studies and supports the theory that physical activity may
40
41 295 displace sedentary time (Ekelund et al., 2016). However, the finding that sedentary
42
43 296 time is associated with eating habits and alcohol consumption, but not with smoking
44
45 297 differs from the findings of several previous studies included in a recent systematic
46
47 298 review (Rhodes et al., 2012). Rhodes et al. (2012) reported that four out of 12
48
49 299 studies reported an association between eating behaviour sedentary time, one out of
50
51 300 15 studies reported a positive association between alcohol consumption and
52
53 301 sedentary time and sedentary time and 16 out of 21 studies reported an association
54
55 302 between smoking and sedentary time. The differences in our observations and
56
57 303 trends in relationships reported in these previous studies may be explained by the
58
59 304 use of total sitting time as an outcome measure, whereas most previous studies
60
305 have examined TV viewing time as the main outcome measure. Furthermore,
306
307 previous studies have not sought to examine sedentary time specifically in deprived
populations.

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3 308 Positive mental wellbeing, measure using the Snyder hope scale (Snyder et al.,
4 309 1991) has not previously been examined in relation to sedentary time, however, our
5 310 findings suggested that positive mental wellbeing may be important in achieving a
6 311 less sedentary lifestyle. We also found that while individual-level perceptions of
7 312 neighbourhood quality were not associated with sedentary time, collective positive
8 313 perceptions of neighbourhood quality was associated with reduced sitting time. A
9 314 recent study using pooled data from Australia, Belgium and the US found that
10 315 individual-level perceptions of neighbourhood attributes predicted motorised travel
11 316 time, but findings for overall sedentary time were less clear (Delfien Van Dyck et al.,
12 317 2012). Our findings suggest that collective perceptions of neighbourhood quality
13 318 should be considered when planning interventions or changes to neighbourhoods
14 319 designed to reduce sedentary time.

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24 320 With the exception of street connectivity, objective measures of neighbourhood
25 321 characteristics were not associated with sedentary time. These findings may
26 322 indicate that these neighbourhood characteristics, as measured in this study, are not
27 323 important determinants of sedentary time in deprived neighbourhoods. An
28 324 alternative explanation for these findings may be the lack of variation in objectively
29 325 measured neighbourhood characteristics across the forty neighbourhoods. The
30 326 neighbourhood units selected for this study were selected based on homogenous
31 327 neighbourhood deprivation scores. Owen et al. (2014) have recently suggested that
32 328 research across more heterogeneous units of study where there is greater variation
33 329 in neighbourhood characteristics may be needed in order for correlates to be
34 330 identified.

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43 331 This study has a number of strengths including the use of perceived as well and
44 332 objective measures of neighbourhood characteristics. Analyses of the partitioning of
45 333 variance in sedentary time between the neighbourhood and individual levels and
46 334 analyses of the moderating role of socio-demographic characteristics has provided
47 335 information not previously available in reports of correlates of sedentary time.

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51
52 336 The approach to analysis also enabled examination of associations between
53 337 individual and neighbourhood characteristics and sedentary time, whilst accounting
54 338 for the potential confounding influence of physical activity levels. Social-ecological
55 339 models often do not distinguish between characteristics theorised to reduce

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3 340 sedentary time and characteristics theorised to increase levels of physical activity
4 341 (Giles-Corti, Timperio, Bull, & Pikora, 2005). The approach to analyses in this study
5 342 follows a more recently developed model of determinants of sedentary behaviour
6 343 (Owen et al., 2014) and has allowed examination of correlates of sedentary
7 344 behaviour, distinct from correlates of physical inactivity. Correlates of physical
8 345 activity in this population have been reported previously (Watts et al., 2013).

13
14 346 There are also several limitations to the methods used this study including the cross-
15 347 sectional design, which prevents inferences about the causal direction of the
16 348 associations reported. In addition, the measure of overall sitting time in this study
17 349 may be less sensitive than domain-specific measures of sitting time. Evidence from
18 350 the physical activity literature suggests that outcome measures of that are specific to
19 351 work, leisure or neighbourhood-based behaviours may be more strongly associated
20 352 with social, cognitive, behavioural and neighbourhood characteristics. The
21 353 neighbourhood units (census LSOAs) used in this study were selected due to the
22 354 available information on neighbourhood characteristics that is routinely available at
23 355 this level of geography. However, LSOAs may not always correspond to the
24 356 respondents' conceptions of their lived neighbourhoods (Weiss, Ompad, Galea, &
25 357 Vlahov, 2007). It should also be noted that with multiple comparisons of variables
26 358 there is increased likelihood of type I errors (incorrectly reporting significant
27 359 relationships) as these relationships may have been observed by chance (Feise,
28 360 2002).

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40 361 Our findings suggest that collective perceptions of neighbourhood quality and high
41 362 levels of social networks within neighbourhoods may form important components of
42 363 neighbourhood-level interventions to reduce sedentary time. At the individual-level
43 364 efforts to reduce sedentary time through the promotion of social networks may need
44 365 to consider gender differences in the relationships between social networks and
45 366 physical activity. The social network scale used in these analysis includes a
46 367 measure of how often respondents speak on the phone and/or write to relatives and
47 368 friends. One interpretation of these findings could be that as women speak and
48 369 write messages through social networking applications more often than men
49 370 (Thelwall, 2008) and this is most often done while sitting down, sedentary time is
50 371 higher in women with more social networks. For men increased social networks

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3 372 alone may be effective in reducing sedentary time, but for women it may be
4 373 necessary to provide interventions that aim to promote non-sedentary social
5 374 activities.

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9 375 Individual-level correlates of sedentary behaviour identified in these deprived
10 376 neighbourhoods are similar to those reported in previous studies, in particular the
11 377 behavioural characteristics (Rhodes et al., 2012). This suggests that interventions
12 378 targeting multiple health behaviours including, sedentary time, physical activity, and
13 379 health eating may be effective. Further research on the extent to which these health
14 380 behaviours are clustered and the determinants of clustered health behaviours in
15 381 deprived populations is needed. Future research may also include examination of
16 382 more heterogeneous populations and examination of individual and neighbourhood
17 383 characteristics that specifically relate to different domains of sedentary time in these
18 384 populations. For example, examination of associations between sedentary time at
19 385 work, at home or during leisure time outside the home and conceptually matched
20 386 social, cognitive, behavioural and neighbourhood characteristics.

21 387 **Acknowledgements**

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23 389 of the household survey data. We would also like to thank members of the Well
24 390 London evaluation team for their contributions to the data collection and preparation
25 391 processes.

26 392 **References**

- 27 393 Bertotti, M., Watts, P., Netuveli, G., Yu, G., Schmidt, E., Tobi, P., . . . Renton, A.
28 394 (2013). Types of social capital and mental disorder in deprived urban areas: a
29 395 multilevel study of 40 disadvantaged London neighbourhoods. *PLoS one*,
30 396 *8*(12), e80127.
- 31 397 Biddle, S. J., Bennie, J. A., Bauman, A. E., Chau, J. Y., Dunstan, D., Owen, N., . . .
32 398 van Uffelen, J. G. (2016). Too much sitting and all-cause mortality: is there a
33 399 causal link? *BMC Public Health*, *16*, 635. doi:10.1186/s12889-016-3307-3
- 34 400 Biswas, A., Oh, P. I., Faulkner, G. E., Bajaj, R. R., Silver, M. A., Mitchell, M. S., &
35 401 Alter, D. A. (2015). Sedentary time and its association with risk for disease
36 402 incidence, mortality, and hospitalization in adults: a systematic review and
37 403 meta-analysis. *Annals of Internal Medicine*, *162*(2), 123-132.
- 38 404 Cart, L. (2012). Letter to the editor: standardized use of the terms "sedentary" and
39 405 "sedentary behaviours". *Appl. Physiol. Nutr. Metab.*, *37*(3), 540.
- 40 406 Craig, C. L., Marshall, A. L., Sjostrom, M., Bauman, A. E., Booth, M. L., Ainsworth, B.
41 407 E., . . . Oja, P. (2003). International physical activity questionnaire: 12-country

- 1
2
3 408 reliability and validity. *Med Sci Sports Exerc*, 35(8), 1381-1395.
4 409 doi:10.1249/01.MSS.0000078924.61453.FB
5 410 Department For Transport. (2008). Transport connectivity and accessibility of key
6 411 services statistics. Retrieved from
7 412 [https://www.gov.uk/government/collections/transport-connectivity-and-](https://www.gov.uk/government/collections/transport-connectivity-and-accessibility-of-key-services-statistics)
8 413 [accessibility-of-key-services-statistics](https://www.gov.uk/government/collections/transport-connectivity-and-accessibility-of-key-services-statistics)
9
10 414 Ekelund, U., Steene-Johannessen, J., Brown, W. J., Fagerland, M. W., Owen, N.,
11 415 Powell, K. E., . . . Group, L. S. B. W. (2016). Does physical activity attenuate,
12 416 or even eliminate, the detrimental association of sitting time with mortality? A
13 417 harmonised meta-analysis of data from more than 1 million men and women.
14 418 *Lancet*, 388(10051), 1302-1310. doi:10.1016/S0140-6736(16)30370-1
15 419 Environmental Systems Research Institute. (2010). ArcGIS Desktop. Retrieved
16 420 from <http://help.arcgis.com/en/arcgisdesktop/10.0/help.htm>
17 421 Feise, R. J. (2002). Do multiple outcome measures require p-value adjustment?
18 422 *BMC Medical Research Methodology*, 2(1), 1.
19 423 Giles-Corti, B., Timperio, A., Bull, F., & Pikora, T. (2005). Understanding physical
20 424 activity environmental correlates: increased specificity for ecological models.
21 425 *Exercise and sport sciences reviews*, 33(4), 175.
22 426 Greater London Authority (2008). Public Transport Accessibility Levels. Retrieved
23 427 from [https://tfl.gov.uk/info-for/urban-planning-and-construction/planning-with-](https://tfl.gov.uk/info-for/urban-planning-and-construction/planning-with-webcat/webcat?scenario=2021%20(Forecast)&Type=PTAL)
24 428 [webcat/webcat?scenario=2021%20\(Forecast\)&Type=PTAL](https://tfl.gov.uk/info-for/urban-planning-and-construction/planning-with-webcat/webcat?scenario=2021%20(Forecast)&Type=PTAL)
25
26
27 429 Green, H., & Fletcher, L. (2003). *Social Capital Harmonised Question Set: A guide to*
28 430 *questions for use in the measurement of social capital*. Retrieved from
29 431 London:
30 432 Department of Health. (2011). Start Active, Stay Active: A report on physical activity
31 433 for health from the four home countries' Chief Medical Officers.
32 434 Healy, G. N., Clark, B. K., Winkler, E. A., Gardiner, P. A., Brown, W. J., & Matthews,
33 435 C. E. (2011). Measurement of adults' sedentary time in population-based
34 436 studies. *American journal of preventive medicine*, 41(2), 216-227.
35 437 Healy, G. N., Matthews, C. E., Dunstan, D. W., Winkler, E. A., & Owen, N. (2011).
36 438 Sedentary time and cardio-metabolic biomarkers in US adults: NHANES
37 439 2003–06. *European heart journal*, ehq451.
38 440 Merlo, J. (2003). Multilevel analytical approaches in social epidemiology: measures
39 441 of health variation compared with traditional measures of association. *J*
40 442 *Epidemiol Community Health*, 57(8), 550-552.
41 443 Neighbourhood Renewal Unit. (2008). The English Indices of Deprivation 2007.
42 444 doi:<http://www.communities.gov.uk/publications/communities/indicesdeprivati>
43 445 [on07](http://www.communities.gov.uk/publications/communities/indicesdeprivati)
44 446 O'Donoghue, G., Perchoux, C., Mensah, K., Lakerveld, J., van der Ploeg, H.,
45 447 Bernaards, C., . . . Consortium, D. (2016). A systematic review of correlates of
46 448 sedentary behaviour in adults aged 18-65 years: a socio-ecological approach.
47 449 *BMC Public Health*, 16, 163. doi:10.1186/s12889-016-2841-3
48 450 Owen, N., Salmon, J., Koohsari, M. J., Turrell, G., & Giles-Corti, B. (2014).
49 451 Sedentary behaviour and health: mapping environmental and social contexts
50 452 to underpin chronic disease prevention. *British journal of sports medicine*,
51 453 48(3), 174-177.
52 454 Owen, N., Sugiyama, T., Eakin, E. E., Gardiner, P. A., Tremblay, M. S., & Sallis, J. F.
53 455 (2011). Adults' sedentary behavior: determinants and interventions. *American*
54 456 *journal of preventive medicine*, 41(2), 189-196.
55
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2
3 457 Phillips, G., Renton, A., Moore, D. G., Bottomley, C., Schmidt, E., Lais, S., . . .
4 458 Frostick, C. (2012). The Well London program-a cluster randomized trial of
5 459 community engagement for improving health behaviors and mental wellbeing:
6 460 baseline survey results. *Trials*, 13(1), 105.
- 7 461 Prentice-Lane, E. (2010). *British Household Panel Survey User Manual Volume A:*
8 462 *Introduction, Technical Report and Appendices*. Colchester: University of
9 463 Essex.
- 11 464 Rabin, R., & de Charro, F. (2001). EQ-5D: a measure of health status from the
12 465 EuroQol Group. *Ann Med*, 33(5), 337-343.
- 13 466 Rhodes, R. E., Mark, R. S., & Temmel, C. P. (2012). Adult sedentary behavior: a
14 467 systematic review. *American journal of preventive medicine*, 42(3), e3-e28.
- 15 468 Sallis, J. F., Owen, N., & Fisher, E. B. Ecological models of health behavior.
16 469 *HEALTH BEHAVIOR*, 465.
- 17 470 Shuval, K., DiPietro, L., Skinner, C. S., Barlow, C. E., Morrow, J., Goldsteen, R., &
18 471 Kohl, H. W. (2014). 'Sedentary behaviour counselling': the next step in
19 472 lifestyle counselling in primary care; pilot findings from the Rapid Assessment
20 473 Disuse Index (RADl) study. *British journal of sports medicine*, 48(19), 1451-
21 474 1455.
- 22 475 Smith, G. R., & Davey, R. C. (2009). *Socio-Ecological Mapping of Physical Activity*
23 476 *Behaviours and Health Outcomes in Deprived Inner-City Communities*.
24 477 Retrieved from
- 25 478 Snyder, C. R., Harris, C., Anderson, J. R., Holleran, S. A., Irving, L. M., Sigmon, S.
26 479 T., . . . Harney, P. (1991). The will and the ways: development and validation
27 480 of an individual-differences measure of hope. *J Pers Soc Psychol*, 60(4), 570-
28 481 585.
- 29 482 Sport England Active Places Database [<http://www.activeplacespower.co.uk>].
- 30 483 Sugiyama, T., Healy, G. N., Dunstan, D. W., Salmon, J., & Owen, N. (2008). Is
31 484 television viewing time a marker of a broader pattern of sedentary behavior?
32 485 *Annals of Behavioral Medicine*, 35(2), 245-250.
- 33 486 Thelwall, M. (2008). Social networks, gender, and friending: An analysis of MySpace
34 487 member profiles. *Journal of the American Society for Information Science and*
35 488 *Technology*, 59(8), 1321-1330.
- 36 489 Thorp, A. A., Owen, N., Neuhaus, M., & Dunstan, D. W. (2011). Sedentary behaviors
37 490 and subsequent health outcomes in adults a systematic review of longitudinal
38 491 studies, 1996-2011. *Am J Prev Med*, 41(2), 207-215.
39 492 doi:10.1016/j.amepre.2011.05.004
- 40 493 Tremblay, M. S., Colley, R. C., Saunders, T. J., Healy, G. N., & Owen, N. (2010).
41 494 Physiological and health implications of a sedentary lifestyle. *Appl Physiol*
42 495 *Nutr Metab*, 35(6), 725-740. doi:10.1139/H10-079
- 43 496 Van Dyck, D., Cerin, E., Conway, T. L., De Bourdeaudhuij, I., Owen, N., Kerr, J., . . .
44 497 Sallis, J. F. (2012). Associations between perceived neighborhood
45 498 environmental attributes and adults' sedentary behavior: findings from the
46 499 USA, Australia and Belgium. *Social science & medicine*, 74(9), 1375-1384.
- 50 500 Van Dyck, D., Deforche, B., Cardon, G., & De Bourdeaudhuij, I. (2009).
51 501 Neighbourhood walkability and its particular importance for adults with a
52 502 preference for passive transport. *Health and Place*, 15(2), 496-504.
- 53 503 Wall, M., Hayes, R., Moore, D., Petticrew, M., Clow, A., Schmidt, E., . . . Renton, A.
54 504 (2009). Evaluation of community level interventions to address social and

- 1
2
3 505 structural determinants of health: a cluster randomised controlled trial. *BMC*
4 506 *public health*, 9(1), 207.
5 507 Watts, P., Phillips, G., Petticrew, M., Hayes, R., Bottomley, C., Yu, G., . . . Frostick,
6 508 C. (2013). Physical activity in deprived communities in London: examining
7 509 individual and neighbourhood-level factors. *PloS one*, 8(7), e69472.
8 510 Weiss, L., Ompad, D., Galea, S., & Vlahov, D. (2007). Defining neighborhood
9 511 boundaries for urban health research. *American journal of preventive*
10 512 *medicine*, 32(6), S154-S159.

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For Peer Review Only

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

¹Adjusted 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

¹Adjusted for age, gender, ethnicity and job category; ²Adjusted 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

¹Adjusted for age, gender, ethnicity and job category; ²Adjusted 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			

¹Adjusted 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.

23 **Well London Household Survey: Independent variable measurement and item**
 24 **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.

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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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3 27 **Neighbourhood audit**
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5 28 Physical and structural neighbourhood characteristics were measured using a
6 29 systematic social observation tool, designed for the *Well London* programme study
7 30 following a review of previously validated tools (Boarnet, Day, Alfonzo, Forsyth, &
8 31 Oakes, 2006; Clifton, Livi Smith, & Rodriguez, 2007) and the theoretical literature.
9 32 Trained observers visited each of the 40 neighbourhoods to complete the audit tool
10 33 proforma as they walked throughout each pre-defined segment of the
11 34 neighbourhoods. Pre-defined segments were 'output areas', which the smallest level
12 35 of geography used in the census (Neighbourhood Renewal Unit, 2008). Typically,
13 36 these segments (output areas) covered the length of one street and around 125
14 37 households. The data collected in these segments were adjusted for their size when
15 38 scales were calculated (see below).
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24 39 Two observers completed the audit of each segments independently, compared their
25 40 observations and agreed on the data to be entered into a database for analysis. A
26 41 sample of these segments were cross-checked using Google Earth Street View
27 42 (Clarke, Ailshire, Melendez, Bader, & Morenoff, 2010) once the audits were
28 43 completed to identify any major discrepancies, but there was a good level of
29 44 agreement between the physical audits and those using Street View. Therefore, the
30 45 data originally collected in the audit was used for analysis. The final indices for each
31 46 neighbourhood (LSOA) were created by summing the score for each index in each
32 47 segment then adjusting for the size of the neighbourhoods in square meters to
33 48 account for differences in the geographical size of the neighbourhoods.
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3 50 **Well London Neighbourhood audit: Independent variable measurement and**
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5 51 **item sources**
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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.

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3 54 **Routine data**

4 55 The English Indices of Multiple Deprivation (IMD) Crime Indicator (Neighbourhood
5 56 Renewal Unit, 2008) was used to examine neighbourhood-level crime rates: this
6 57 indicator includes recorded rates of four categories of crime: burglaries; thefts;
7 58 violence and criminal damage. As this indicator is published every three years, the
8 59 2007 data was used as it most closely matched the time period of the data collection
9 60 for the *Well London* household survey data. A street connectivity index was created
10 61 from counts of the three and four-way junctions within the neighbourhoods, adjusted
11 62 for the size of the neighbourhoods by dividing the counts of junctions by the size of
12 63 the neighbourhoods in square metres (Smith & Davey, 2009). The junctions were
13 64 identified by examining Ordnance Survey maps of each LSOA from 2008.

14 65 The English Indices of Deprivation accessibility measures from 2008 were used as
15 66 indicators of the neighbourhood average walking distances to the nearest available
16 67 food store and town centre (Neighbourhood Renewal Unit, 2008). These measures
17 68 use Ordnance Survey Centre Alignment of Roads (OSCAR) data. OSCAR data is
18 69 generated by Ordnance Survey to provide vector data for streets and paths in the
19 70 UK. OSCAR data is used by the government Department for Communities and
20 71 Local Government with Geographical Information Systems (GIS) to calculate the
21 72 quickest walking route from the centre of one postcode to the centre of another
22 73 postcode. In this case the distance is calculated from the postcodes of residential
23 74 addresses to the postcodes of the addresses of the nearest food store and town
24 75 centre. The core accessibility measures provide the average distance that a resident
25 76 of each LSOA would have to walk to reach the nearest food store or town centre.

26 77 Sport England's Active Places Power Strategic Planning Tool
27 78 (<http://www.activeplacespower.co.uk>) was used to identify the number of sports and
28 79 leisure facilities within ten minutes walking distance from the centre of the
29 80 neighbourhoods. This tool also uses OSCAR data with GIS to calculate walking
30 81 routes to the nearest facilities. Facilities were included in the final count only if they
31 82 provided opportunities to be physically active and therefore leisure-only facilities (e.g.
32 83 spas or saunas) were excluded.

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85 **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

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60**88 Geographical information systems data**

89 All postcodes within the 40 neighbourhoods were geocoded using Arc GIS Version
90 9.1. Publicly accessible and useable greenspaces in close proximity to each of the
91 neighbourhoods were identified visually using aerial images from Google Earth and
92 then the access points to the greenspaces were geocoded using Arc GIS. Only
93 greenspaces larger than 2 hectares (20,000 square metres) were geocoded as
94 areas smaller than this are often considered to be of inadequate size for adults to
95 use to be physically active (Coombes, Jones, & Hillsdon, 2010). Judgements as to
96 whether identified greenspaces were accessible and usable were made using the
97 following criteria described by Natural England (2012) and Taylor et al (2011). To be
98 judged accessible, the greenspaces had to be open to the public with at least one
99 access point from a public road or path. To be judged usable, the greenspaces had
100 to contain walkable paths and/or open, walkable surfaces. Usability was assessed
101 using Google Earth aerial images of the parks. Google Earth Street View was used
102 to identify access points by scanning the perimeter of each greenspace to visually
103 identify access points which were then geocoded in the corresponding location in Arc
104 GIS.

105 The shortest walking distance from each postcode to the nearest greenspace access
106 point was calculated initially using OSCAR data. All walking routes were examined
107 using Google Earth and Google Street View and subsequently modified if necessary
108 to ensure that the shortest unobstructed walking route was accurately recorded. For
109 example, in several cases it was clear that the shortest walking route to the nearest
110 greenspace access point involved using a small path or alleyway that was not
111 utilised in the route calculated using OSCAR data. Therefore, in order to capture the
112 shortest walking distances as accurately as possible, walking distances were re-
113 calculated manually where necessary to exploit the use of paths or alleyways.
114 Walking distance to greenspace was examined by creating a categorical variable to
115 compare participants who had access to at least one of these greenspaces within
116 300 metres to those who had access within 301-600, 601-900 or 900-1200 metres.

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118 **Associations between social and cognitive characteristics and sitting time**

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

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

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3 121 **References**
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5 122

- 6 123 Boarnet, M. G., Day, K., Alfonzo, M., Forsyth, A., & Oakes, M. (2006). The Irvine–
7
8 124 Minnesota inventory to measure built environments: reliability tests. *American*
9
10 125 *journal of preventive medicine*, 30(2), 153-159. e143.
11 126 NHS Information Centre. (2008). Health Survey for England 2008: Statistics on
12 127 obesity, physical activity and diet: England, 2008.
13 128 Clark, C., Haines, M. M., Head, J., Klineberg, E., Arephin, M., Viner, R., . . .
14
15 129 Stansfeld, S. A. (2007). Psychological symptoms and physical health and
16
17 130 health behaviours in adolescents: a prospective 2 - year study in East
18
19 131 London. *Addiction*, 102(1), 126-135.
20
21 132 Clarke, P., Ailshire, J., Melendez, R., Bader, M., & Morenoff, J. (2010). Using Google
22
23 133 Earth to conduct a neighborhood audit: Reliability of a virtual audit instrument.
24
25 134 *Health & place*, 16(6), 1224-1229.
26
27 135 Clifton, K. J., Livi Smith, A. D., & Rodriguez, D. (2007). The development and testing
28
29 136 of an audit for the pedestrian environment. *Landscape and Urban Planning*,
30
31 137 80(1-2), 95-110.
32
33 138 Coombes, E., Jones, A. P., & Hillsdon, M. (2010). The relationship of physical
34
35 139 activity and overweight to objectively measured green space accessibility and
36
37 140 use. *Social science & medicine*, 70(6), 816-822.
38
39 141 Craig, C. L., Marshall, A. L., Sjöström, M., Bauman, A. E., Booth, M. L., Ainsworth, B.
40
41 142 E., . . . Sallis, J. F. (2003). International physical activity questionnaire: 12-
42
43 143 country reliability and validity. *Medicine & Science in Sports & Exercise*, 35(8),
44
45 144 1381.
46
47 145 Natural England. (2012). Natural England - Accessible Natural Greenspace Standard
48
49 146 (ANGSt). Retrieved from
50
51 147 http://www.naturalengland.org.uk/regions/east_of_england/ourwork/gi/accessi
52
53 148 [blenaturalgreenspacestandardangst.aspx](http://www.naturalengland.org.uk/regions/east_of_england/ourwork/gi/accessi)
54
55 149 Green, H., & Fletcher, L. (2003). *Social Capital Harmonised Question Set: A guide to*
56
57 150 *questions for use in the measurement of social capital*. Retrieved from
58
59 151 London:
60
152 Neighbourhood Renewal Unit. (2008). The English Indices of Deprivation 2007.
153 Retrieved from:

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56
57
58
59
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154 <http://www.communities.gov.uk/publications/communities/indicesdeprivation0>
155 7

156 Rabin, R., & de Charro, F. (2001). EQ-5D: a measure of health status from the
157 EuroQol Group. *Ann Med*, 33(5), 337-343.

158 Smith, G. R., & Davey, R. C. (2009). *Socio-Ecological Mapping of Physical Activity*
159 *Behaviours and Health Outcomes in Deprived Inner-City Communities*.
160 Retrieved from

161 Snyder, C. R., Harris, C., Anderson, J. R., Holleran, S. A., Irving, L. M., Sigmon, S.
162 T., . . . Harney, P. (1991). The will and the ways: development and validation
163 of an individual-differences measure of hope. *Journal of personality and social*
164 *psychology*, 60(4), 570.

165 Taylor, B. T., Fernando, P., Bauman, A. E., Williamson, A., Craig, J. C., & Redman,
166 S. (2011). Measuring the Quality of Public Open Space Using Google Earth.
167 *American journal of preventive medicine*, 40(2), 105-112.

168