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The Socioeconomic Gradient in Physical Inactivity in England

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Centre for Market and Public Organisation
University of Bristol
2 Priory Road
Bristol BS8 1TX
http://www.bristol.ac.uk/cmpo/

Tel: (0117) 33 10952
Fax: (0117) 33 10705
E-mail: cmpo-admin@bristol.ac.uk

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Lisa Farrell[1], Bruce Hollingsworth[2], Carol Propper[3] and Michael A. Shields[4]

[1]RMIT University

[2]Lancaster University

[3]Imperial College London, Bristol University and CEPR

[4]Monash University

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Abstract
Physical inactivity is recognised as an important precursor of chronic ill health. It is also recognised as a modifiable health behaviour, so knowing who is physically inactive is important for design of policy interventions to reverse the increase in physical inactivity. Studies examining the correlates of physical inactivity have identified socioeconomic position and aspects of the geographical environment as important. In this paper we contribute to this literature by exploiting detailed data on over one million individuals in England to more precisely identify and separate the associations between several measures of physical inactivity, different aspects of socioeconomic position and a wide range of local geographical factors. Our results show high levels of physical inactivity and clear separate associations with important dimensions of socioeconomic position. Education, household income and local area deprivation are all independently and strongly associated with inactivity, controlling for local availability of physical recreation and sporting facilities, the local weather and regional geography. Importantly, local area facilities and geographical factors explain very little of the variation in physical inactivity in England. Further, the income gradient increases with age and more financially costly forms of physical activity are associated with larger socioeconomic position differences, suggesting that financial as well as cultural barriers need to be overcome to reduce inactivity prevalence.

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Address for correspondence
CMPO
University of Bristol
2 Priory Road
Bristol BS8 1TX
Cmpo-admin@bristol.ac.uk
www.bristol.ac.uk/cmpo/

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Lisa Farrell
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Physical inactivity is recognised as an important precursor of chronic ill health. It is also recognised as a modifiable health behaviour, so knowing who is physically inactive is important for design of policy interventions to reverse the increase in physical inactivity. Studies examining the correlates of physical inactivity have identified socioeconomic position and aspects of the geographical environment as important. In this paper we contribute to this literature by exploiting detailed data on over one million individuals in England to more precisely identify and separate the associations between several measures of physical inactivity, different aspects of socioeconomic position and a wide range of local geographical factors. Our results show high levels of physical inactivity and clear separate associations with important dimensions of socioeconomic position. Education, household income and local area deprivation are all independently and strongly associated with inactivity, controlling for local availability of physical recreation and sporting facilities, the local weather and regional geography. Importantly, local area facilities and geographical factors explain very little of the variation in physical inactivity in England. Further, the income gradient increases with age and more financially costly forms of physical activity are associated with larger socioeconomic position differences, suggesting that financial as well as cultural barriers need to be overcome to reduce inactivity prevalence.

Key words
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1. Introduction

Physical inactivity is increasingly recognised as an important precursor of chronic ill health with large costs for individuals and society (Das and Horton, 2012). The World Health Organisation (WHO) estimates that physical inactivity causes 1.9 million deaths per year worldwide, 10 to 16 per cent of breast cancer, colon cancer and diabetes cases, and about 22 per cent of coronary heart disease cases (WHO, 2004). Physical inactivity is also recognised as potentially the most important modifiable health behaviour for chronic disease. Scarborough et al. (2011) argue that of the four modifiable causes - smoking, alcohol, diet, and lack of physical activity - low physical activity is the most prevalent chronic disease risk factor. As a result, governments are seeking ways to decrease physical inactivity (for example, WHO, 2007) and knowing who is physically inactive is important for designing cost effective policy interventions (Hamer, 2012).

Studies that have examined the correlates of physical inactivity in the developed world have repeatedly identified socio-economic position (SEP) and aspects of the local geographical environment as important (Giles-Corti and Donovan, 2002; Humpel et al., 2002; WHO, 2004, 2007; Frost et al., 2010; van Dyck et al., 2010; Pascual et al., 2013). However, most studies of physical inactivity (with a couple of notable examples which we discuss below) have been based on relatively small-scale samples so while they have drawn attention to SEP as a determinant of lack of physical activity, they have been more limited in their ability to precisely disentangle the individual association of different facets of SEP and to separately identify local area factors such as lack of area resources, poor supply of sports facilities and geographical configuration from individual or household SEP.

In this paper we seek to contribute to this knowledge base by providing evidence from a unique data set on over one million individuals in England from the Active People Surveys (APS). The large sample size and the associated geographical identifiers allow us to match in information on local area attributes including the availability of sport and exercise facilities, green space and the weather. This detailed local information enables us to obtain precise estimates of the association between physical inactivity and different aspects of individual SEP, controlling for local geographical factors that may affect the costs of physical activity. Our data also allow us to examine an extensive set of physical inactivity measures that we employ, allowing us to check that our results are not sensitive to the exact definition of inactivity and to consider the role of cost as well as income.

Our analyses show the following. First, levels of physical inactivity in England are very high. About 8 per cent of the adult population that can walk do not even walk for five minutes continuously in a four-week period. Nearly 80 per cent do not hit key national government targets. Second, whatever aspect of SEP is considered, there are significant SEP differences that increase monotonically in terms of disadvantage. There is a large socioeconomic gradient even for activities that have low direct cost (for example walking) and the more costly the activity, the larger the socioeconomic gradient. Third, different aspects of SEP disadvantage (education and household income) are independently associated with a lack of physical activity, controlling for local availability of facilities, weather and geography. Fourth, these differences are already evident in young adults, but they steadily increase with age. Finally, while local area characteristics are significant and the direction of their impact appears sensible, they explain very little of the differences in activity levels over and above individual and household characteristics.

2. Background

2.1. Health consequences of physical inactivity

The importance of walking and physical activity as determinants of good health has been well established in the medical and public health literature (see, for example, U.S. Department of Health and Human Services, 1996; WHO, 2002). The WHO has identified physical inactivity as a leading global risk factor for morbidity and premature mortality (WHO, 2004). Das and Horton (2012) argue that lack of physical activity is a major risk factor in non-communicable disease (NCD) internationally and note that landmark papers published in *The Lancet* in 1953 first showed the association between physical inactivity and heart disease (Morris et al., 1953a,b). Inactivity has been identified as a risk factor for a number of serious health issues including cardiovascular disease, type 2 diabetes, obesity, some cancers, poor skeletal health, poor mental health, and overall mortality (Hallal et al., 2012). It is estimated one third of deaths are caused by diseases which could, at least in part, be impacted upon by increased physical activity (Allender et al., 2007) and Min Lee et al. (2012) suggest that the number of deaths due to a lack of physical activity is approximately the same number of deaths as caused by tobacco. Gregory and Dhaval (2013) found that physical activity has a durable impact on health.

The first US Surgeon General's Report on Physical Activity and Health, released almost twenty years ago in 1996, recommended that adults engage in thirty minutes of moderate physical activity at least five days per week. Subsequently these limits have been raised in the US, Canada and the UK (Physical Activity Guidelines Advisory Committee, 2008; Tremblay et al., 2008; Bull et al., 2010). However, Das and Horton (2012) argue that lack of physical activity is still neglected in importance compared to other risk factors, such as tobacco, diet, and alcohol. Wen and Wu (2012) also note the lack of concern over physical activity levels and make a comparison with the campaign against smoking, where doctors emphasize the harm and there are international actions to control tobacco consumption (e.g. WHO, 2003).

2.2. Physical inactivity and socioeconomic position (SEP)

Inactivity and obesity are not just public health problems. They are also economic and cultural phenomenon and so are likely to be differentially patterned by SEP. There are many routes by which SEP may be associated with inactivity. First, physical activity has a direct cost. Philipson (2001) argues that long-term technological change in methods of production means that the cost of expending calories has increased because physical labour has been replaced by machine labour. A hundred years ago, individuals were paid to do physical work, while currently individuals have to pay to exercise. As a consequence, sedentary leisure industries are growing at a rate faster than GDP growth (Sturm, 2004). However, the costs of these changes are not born equally. Paying to exercise represents a higher proportion of the budget of a poor than a rich individual and low-income individuals may be very time constrained because their rate of pay per hour is low. As a consequence, both the direct and the indirect financial costs of activity are higher for individuals with lower incomes.

Second, from a health production perspective (Grossman, 2006), education increases the productivity of a given set of healthcare and other inputs, so greater education enables individuals to increase the amount of physical activity from a given set of resources (either their own or ones around them). From a more sociological and public health perspective the association between health knowledge and education (Cutler and Lleray-Muney, 2006) means that individuals who are better educated may be more aware of the consequences of inactivity and therefore better motivated to overcome the changes brought about by technological change.

Third, the costs of physical activity will be determined in part by the physical configuration of the localities in which individuals work and live. Housing markets mean that low-income individuals tend to live near other low-income individuals and these areas may have poor tax bases with which to finance recreation and other facilities that enable individuals to take exercise (Moore, 2008; Powell, 2006). These areas are also likely to have fewer general physical and recreational amenities and higher crime rates that also make physical activity more difficult (Gomez, 2004). Fourth, as the public health literature has emphasized, there are strong cultural dimensions to participation in physical activity (Wilbur, 2002; Arredondo, 2012).

2.3. The empirical literature

The empirical literature is large and researchers have drawn attention to the association between SEP, physical activity and local geography in many different countries and settings. We focus here on key findings and concerns from recent systematic reviews. Gidlow et al. (2006) undertook a systematic review of the relationship between physical activity and SEP. Looking at over 25 studies published from 1991 to 2004 (some using data for 20 years earlier) there was consistent evidence of higher prevalence, or higher levels, of activity among those in higher SEPs. Education was the most commonly used indicator of SEP. Later large cross-national studies have confirmed this association with education (for example, de Almeida et al. 1999). Education has also been found to be an important determinant of leisure (as distinct from work) physical activity (for example, Borodulin et al. (2008) for 4,000 men and women in Finland). Recent studies examining longitudinal data have also confirmed the importance of education (for example, Hamer et al., 2012) use the UK Whitehall II cohort study and find a relationship between objective measures of physical activity and sedentary behavior and levels of education, but not other aspects of SEP).

Gidlow et al. (2006) noted that a small number of studies also reported a gradient across social classes. However, most of the studies they review used only three categories of social class, making identification of gradients perhaps somewhat crude. The same overview also found that when income was used rather than social class, the majority of studies found a positive relationship between income and physical activity, but again most studies used only three or fewer categories of income group, making it difficult to identify income gradients.

Studies have also identified the importance of local area factors in a variety of settings. Parks et al. (2003), in a cross sectional study of 1,818 US adults, found those in rural settings were less likely to meet recommended levels of physical activity. The importance of environmental factors, such as places to exercise, also varied across income groups. Pascual et al. (2013) in a case study in Madrid found availability of sports facilities explained an important part of physical inactivity. This association between physical activity settings and SEP was also reported by Powell et al. (2004), who looked at associations across 209 communities in the USA. The HABITAT multilevel longitudinal study examined associations between neighborhood disadvantage and physical activity for a sample of 11,037 individuals in 200 neighborhoods in Australia (Turrell et al., 2010) and found those in advantaged neighborhoods had significantly higher levels of total and moderate physical activity, as well as walking. However, Giles-Corti and Donovan (2002) in a cross sectional study of 1,803 Australian adults, found that even when those in lower SEP areas have superior access to facilities, they are less likely to use them than those resident in higher SEP areas.

Finally, there are studies which draw attention to ethnic differences. Dogra et al. (2010) using Canadian data show that there are clear preference differences in the modes of physical activity between Whites and ethnic minorities. Ethnic groups are less active and have a much smaller and more conventional set of physical activities that they engage in. In the UK, Williams et al. (2011) conclude that low levels of physical activity among South Asians may be contributing to their much higher levels of coronary heart disease. A recent study by Saffer et al. (2011) of over 75,000 American adults in 2003-2009 showed that non-work physical activity is significantly lower for non-white racial groups and for males. Work related physical activity has a negative effect on non-work physical activity, and work related physical activity is significantly lower among Asians and higher among other groups relative to Whites.

The existing literature also has important limitations. First, education is generally better measured than income or social class and as a consequence is seen as providing the most robust results (Gidlow et al., 2006). However, it does not follow from this that income or other measures of SEP are unimportant. Second, even studies that have adopted explicitly quantitative approaches tend to suffer from either sample size or sample selection issues. In many cases studies focus only on one city, identifying variation from between different areas in the city or restrict their attention to one geographical area (a notable exception is Saffer et al., 2011) [1]. In addition, many of the studies to date have used diverse, and often crude, measures of physical activity and SEP, making it difficult to establish robust effects. Gidlow et al. (2006) called for further studies using better measures, drew attention to the use of area level socioeconomic measurement and the need to use larger samples. This was echoed in a review of the sizeable literature that examines the relationship between physical activity and its association with neighbourhood attributes, including community attributes such as crime (Loukatiou-Sideris, 2006).

2.4. Research design

In the present study we exploit a data set containing over one million individuals, representative of the adult population of England. Our approach has a number of important advantages. First, the number of observations in our data allows us to establish the patterns in the lack of physical activity by various correlated aspects of SEP (education, income and local area deprivation) to establish whether each aspect of SEP contributes independently to differences in inactivity levels. Second, the data set identifies around 300 separate physical activities so we can focus our study on the most common physical activities and can undertake separate analyses for physical activities that differ in their direct cost, allowing us to go some way in separating out a price effect from an income effect. While we do not observe the monetary price paid for an activity, if there is a price as well as an income effect, we would expect that income has a greater effect on the lack of participation in physical activities which are generally accepted as having higher direct costs. Third, the large sample size means we can examine whether the physical activity gap across SEP increases with age i.e. we can examine whether there is a significant SEP-age gradient. Fourth, the large size of our sample means we can separate out the effect of geographical variation in the physical environment

[1] For example, van Lenthe et al. (2005) examine the association between the neighbourhood socioeconomic environment and physical inactivity in 78 neighbourhoods of Eindhoven, The Netherlands, with a sample size of 8,767. Harrison et al. (2007) use data from a population-based health and lifestyle survey of adults in northwest England to analyse associations between individual and neighbourhood perceptions and physical activity. The achieved sample was 15,461 and the authors argue this is one of the most comprehensive assessments of individual and contextual associations with physical activity among adults in the UK general population.

from individual characteristics by allowing for unobserved time invariant heterogeneity at the local level. Fifth, we match the respondents to data at the local area level on the availability of sports and recreation facilities, enabling us to assess whether these supply side factors contribute to a SEP gradient over and above individual and household characteristics. Finally, England is a good case study. It is one of the least physically active nations in Europe (de Almeida and Afonso, 1999). By an objective measure (using accelerometers) only 6 per cent of men and 4 per cent of women reach the UK's Department of Health's recommended levels for activity and over one quarter of the adult English population is obese and 44 per cent of men and 33 per cent of women are overweight (Department of Health, 2011).

3. Data description and research design

3.1. Data

The Active People Survey (APS) is collected annually for a large sample of English adults. The data are cross-sectional and the sampling is clustered at local authority level. Interviews are spread evenly across the 12 months of each year. The survey is conducted by telephone using Random Digit Dialing and one person aged 16 or over is randomly selected from eligible household members. Average response rates are around 25 per cent (we therefore apply population weights in all our statistical modeling). The survey contains detailed measures of participation in physical recreation and sport undertaken in the four weeks prior to interview as well as a wide-range of individual and household level demographic and socioeconomic characteristics.

To date there have been five waves of data released for analysis. The data collection for each APS runs from October to October, with APS1 (2005-2006), APS2 (2007-2008), APS3 (2008-2009), APS4 (2009-2010) and APS5 (2010-2011). There is a gap October 2006- October 2007. The sample sizes were APS1 (n=363,724), APS2 (n=191,325), APS3 (n=193,947), APS4 (n=188,354) and APS5 (n=166,805), giving a total pooled sample of 1,104,155 individuals aged 16 and over. The APS5 differed to APS1-4 in that for certain questions only about half of the sample were asked, including the question on household income. Questions relating to general health status and life satisfaction were included in APS5 for the first time.[2]

[2] While the data used here are quite unique in their detail and size, they have been little used for research purposes. Sport England (2010) is one of the few quantitative analyses of these data. It uses the APS for one 12 month period (2008/9, n=251,022) and estimates a model of respondents' achievement of the government's key national indicator for sports participation (the National Indicator 8 (NI8), defined as "the percentage of the adult population in a local area who participate in sport and active recreation, at moderate intensity, for at least 30 minutes on at least 12 days out of the last 4 weeks"). It finds income, education, household composition, car ownership, and local authority funding to be independently correlated with achieving the NI8 target and also shows that participation in 11 specific sports tends to be associated with different socio-demographic characteristics.

There are 354 English local authorities (LAs) identified in APS1-4. The number of LAs was reduced in APS5 following merging of a number of authorities to 326. We recoded the LAs in APS1-4 to be consistent with APS5 and thus use variation across 326 LAs here. After eliminating missing values for the variables used to construct our main physical inactivity measure, as well as dropping APS5 respondents who were not asked about their household income, we are left with a working sample of 1,002,219 adults (91 per cent of the total sample). Where there are missing responses to the variables we use as covariates in our empirical models, we include dummy indicator variables to control for this non-response.

3.2. Dependent variables

A contribution of this paper is that we construct a number of alternative measures of physical inactivity. Our primary measure is constructed using information about any types of physical recreation or sports participation in the last four weeks. At the start of each APS respondents are asked about their recent walking activities, in particular whether they have done at least one continuous walk lasting five minutes, which also identifies individuals who report not to be able to walk[3], followed by the number of days in the last four weeks that the respondent has done at least one continuous walk lasting at least 30 minutes. The intensity (e.g. a 'slow' pace; a 'fast' pace) of this walking is also then asked. The same information is then collected for cycling. Both walking and cycling can include getting to and from work, but the frequency of walking and cycling for health and recreation only is also separately recorded in the survey. The questionnaire then asks respondents to think about "other types of sport and recreational physical activity they may have done, whether it be for competition, training or receiving tuition, socially, casually or for health and fitness". Using this information we define physically inactive as reporting not having walked or cycled for at least 30 continuous minutes at least once in the last four weeks, nor reported participating in any other type of sport or recreational physical activity of any duration.

We also use information on each type of activity recorded, plus information on the length and intensity of participation, to construct a number of key participation variables. These are defined with respect to the UK national indicator of physical activity NI8. We focus on episodes of at least 30 minutes and of at least moderate intensity. We create three separate variables: (1) physical activity on no days - denoted KPV=0, (2) physical activity on less than four days (i.e. less than one episode per week) - denoted KPV<4, and (3) the inverse of the NI8 measure. NI8 tracks physical activity by looking at people who engage in *at least* 12 episodes of physical activity at

[3] We do not exclude from our sample individuals who are not able to walk (except for our models of walking activity alone) as such a disability does not exclude an individual from all physical activity. Indeed, our data has a rich set of para-sports including: Boccia and wheelchair basketball. We do, however, control for 'not being able to walk' and 'having a chronic limiting condition' as separate dummy variables as appropriate in our modelling.

moderate intensity. As our focus is on inactivity we look at those not achieving the NI8 measure, i.e. those with *less than* 12 episodes of physical activity at moderate intensity (an average of less than three episodes per week) in the last four weeks - denoted KPV<12.

We also examine the constituent parts of our main inactivity measure, distinguishing between common types of activity, its duration and purpose. The variables we create are whether the respondent has: (1) not done at least one continuous walk lasting five minutes - denoted "No Walk 5", (2) has not done at least one walk of a 30 minute continuous duration for any reason - denoted "No Walk 30 All", (3) has not done at least one walk of a 30 minute continuous duration for health or leisure purposes - denoted "No Walk 30 Leisure", (4) has not done at least one cycle ride of a 30 minute continuous duration for any reason - denoted "No Cycling 30 All" and (5) has not done at least one cycle ride of a 30 minute continuous duration for health or leisure purposes - denoted "No Cycle 30 Leisure". We also focus on (absence of) two other common types of physical activity, (7) swimming - denoted "No Swimming" or (8) using a gym - denoted "No Gym".

The survey covers a wide range of recreational activities (including gardening) but does not ask explicitly about occupational physical activity or housework. An analysis of 14,018 adults in England found the contributions of occupational physical activity to meeting government physical activity targets to be socially patterned (Allender et al., 2008). When occupational physical activity was included, men in manual jobs were more likely to meet government targets than those in non-manual jobs. Similar patterns were observed for women. This omission means that our data may lead us to under-estimate the amount of physical activity and possibly also over-estimate the SEP gradient in total physical activity. However, *within* the large set of common physical activities that we examine this bias should not be present. Further, to partially circumvent this problem we include analysis of a very marginal level of the most common physical activity (whether the individual has walked for five continuous minutes in the last four weeks).

Table 1, final block, presents summary statistics at the individual level for our range of physical inactivity measures. These confirm the high levels of physical inactivity found in earlier studies of the UK population. Nearly 20 per cent of the sample did not do any sustained exercise in a four-week period. In terms of the NI8 target nearly 80 per cent did not meet the criteria of moderate exercise at least 12 times in a four-week period. Just fewer than 10 per cent (or just over 8 per cent of those who are physically able to walk) of the sample did not even walk for five minutes continuously in the previous four weeks. Mean levels of participation in even the most common recreation activities were very low. 46 per cent had not walked for leisure for 30 minutes continuously, 88 per cent had not swum and 90 per cent had not used a gym.

3.3. Covariates

One of our aims is to establish the extent of the relationship between different aspects of SEP and physical inactivity. To do this we use measures of SEP at the individual, household and LA levels. Our key individual level measures are highest educational attainment and current employment status. Our key household measure is annual household income, which is reported in bands in the APS, and also whether the household resides in council or LA housing (public housing). The other demographic variables we use are respondent's (1) age (provided in bands), (2) gender, (3) ethnicity, (4) family structure (i.e. single adult, children at various ages (0-4, 5-10, and 11-15), number of individuals in the household), (5) having a chronic health condition, (6) reporting not being able to walk, and (7) broad occupational grouping for those in work. In our models we also control for region, survey year, month of interview, and include dummy variables to capture missing information.

We are also interested in establishing the relationship between local area characteristics (at the LA level) and physical inactivity. To this end we map to each respondent a range of externally sourced measures at the LA level. As direct indicators of LA SEP we use the Index of Multiple Deprivation (IMD) score (which is a measure of deprivation on 6 domains of the LA population); the LA unemployment rate and the percentage of non-UK British individuals in the LA. We have information on the extent of the physical nature of the LA – its urbanisation and the percentage of green space - and on sports facilities. We have data on the number of various types of sports facilities in the LA per capita and the amount of money received by the LA from the National Lottery for the purpose of increasing physical activity per capita and from the APS data we construct a measure of local population satisfaction with the LA recreational facilities. Finally, the data allow us to identify day of survey interview, which enables us to match weather data on average rainfall and temperature for the four week period over which the physical activity questions applied (allowing this to affect the level of outdoor activities conditional on month of the year).[4] Descriptive statistics for each variable are shown in Table 1.

3.4. Modeling approach

Our focus is on the association of physical inactivity with key SEP variables at the individual/household level (highest education, household income) and at the local level (e.g. LA deprivation). We begin by undertaking simple graphical analysis of the patterns in inactivity. We

[4] The Active People Surveys can be accessed through the Data Archive at Essex University. The information on the percentage of green space in each LA was taken from the National Obesity Observatory, as was the information on obesity rates show in Figure 1 (http://www.sepho.nhs.uk). The data on National Lottery awards by LA was provided directly from Sport England, as was data from "Active Places" on sporting and recreation facilities in each LA. The contacts at Sport England can be obtained from the corresponding author, as can the data files subject to permission from Sports England. Weather variables are from the network of national and local weather monitoring stations.

then exploit the large scale of our data to examine whether differences we observe by SEP in the raw data persist once we control for all covariates together, controlling also for month of interview, year and LA effects. We then examine the impact of time varying variables at local authority level.

We estimate the following linear probability regression model (we drop the individual subscript):

$$\Pr(PI) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 Z + \beta_4 LA + v \qquad (1)$$

Where $Pr(PI)$ is the probability of an individual being physical inactive, X_1 is a vector of individual SEP measures (annual household income in bands and highest educational qualifications), X_2 a vector of further controls that may be correlated with individual SEP e.g housing tenure, Z is a vector of 'noise' controls (year and month of interview, dummies for missing variables, and an interaction of income band with time to remove inflation effects) and LA is a set of Local Authority fixed effects (for 326 LA's). We estimate equation (1) as a linear probability model, as we have a very large number of observations and we include LA fixed effects in most models, making the estimation of the non-linear models potentially problematic (Greene, 2000). However, we do show that our main SEP results are robust to fitting binary probit models instead. Throughout, we weight by national proportional LA weights and estimate robust standard errors clustered at the LA level to allow for within LA correlation due to sampling design.

We first estimate (1) using our overall physically inactive measure, with and without LA fixed effects. To examine the effect of non-time varying local authority characteristics, we then re-estimate (1) without LA fixed effects instead including dummies for the nine broad administrative regions of England and LA level measures of unemployment, IMD deprivation, sport and recreation resources and geographical characteristics. We then examine specific inactivity measures related to the NI8 target as the dependent variable in (1), allowing us to see whether the SEP gradient varies across the most common forms of physical activity and sports and how it changes as the direct cost of the activity increases. Finally, to examine the income-age gradient, we re-estimate equation (1) replacing the income bands with the mid-point of the band and estimate a model that is linear in income with additional interaction terms between income and the seven age groups.

4. Results

4.1. Graphical analyses

We start by showing external validation of our physical inactivity measure. We plot the relationship between our main measure of physical inactivity (not having walked or cycled for at least 30 minutes or undertaken any other kind of physical activity in the last four weeks) and the percentage of the population that are obese at LA level measured from the Health Survey for England. Figure 1 shows there is a strong positive relationship, suggesting this physical inactivity measure has informational content.

Figure 2 presents patterns of this physical inactivity measure by ethnicity, education, household income and LA deprivation, for males and females. Panel (1) shows clear differences across ethnic groups (as well as by gender). With the exception of those of Chinese ethnicity, all groups are more physically inactive than Whites. The differences are particularly marked for those of South-East Asian ethnicity (Indian, Pakistani and Bangladeshi). 20 per cent of White females and 17 per cent of White males had done no physical activity of at least 30 minutes duration in the four weeks prior to interview. The comparable figures for those of Pakistani ethnicity are nearly 30 and 25 per cent. Differences between males and females vary across ethnic groups: there are particularly large gaps between males and females of Black African or Caribbean origin, 28 per cent for men compared to a lower 18 per cent for females. Panel (2) shows the gradient by education. Degree educated males and females only have a 12 per cent chance of being physically inactive, whilst those with no qualifications are three times as likely to be physically inactive. Panel (3) shows these differences are also present by household income: those with lowest income have more than a 30 per cent chance of doing no physical activity whilst those in the highest group have a less than a 10 per cent chance. Panel (4) shows these SEP differences are also seen when a measure of local area deprivation is used. Around 15 per cent of individuals in the least deprived LA's do no physical activity; while over 20 per cent of those in the most deprived LA's do none. These figures also show that the male-female differential remains controlling for SEP, so that within SEP category females participate less in sport and recreational physical activity than males.

Figure (3) examines differences by income across age. Panel (1) shows the differences for males and Panel (2) the differences across females. Lack of physical activity rises, not unexpectedly, with age. However, for all age groups there is a large difference by income. In the youngest age group the differences in rates of inactivity between the lowest and highest income group are approximately two-fold. Nearly 9 per cent of lowest income young males do no activity; only 4 per cent of highest income young males do none. The comparable figures for females are 15 and 7.5 per cent. Between the age extremes the income gap steadily rises with age, there being particularly large gaps as individuals approach retirement for both males and females. The relative differences shrink for the oldest age group so the gap between richest and poorest amongst males aged 85 or over is only 10 per cent, though for females it is still 20 per cent. However, survivor bias is likely to narrow this gap at the oldest ages.

We conclude that the raw data shows large SEP differences in physical inactivity. Females, ethnic minorities, and lower SEP individuals are all less likely to do any activity than males, those classifying themselves as White and those with highest SEP. Income differences also increase with age.

4.2. Multivariate analysis

We now examine whether SEP, ethnicity and gender have independent effects on the probability of physical inactivity using our main measure of inactivity (i.e. no walking or cycling of 30 minutes or more, or any other type of physical activity in the last four weeks). Table 2 presents these estimates. In Column (1) we present estimates for age, gender, ethnicity and education, controlling for household composition and the individual's health status. The clear differences by age, gender, ethnicity and education remain in the multivariate analysis, all coefficients being statistically different from zero at the 1 per cent level. Column (3) adds LA fixed effects to this specification. It is clear that controlling for all the fixed characteristics of LAs does not substantively change the SEP gradient in physical inactivity; in particular the education gradient remains considerable and the overall fit of the model does not increase much when the LA controls are included (0.147 to 0.150). This suggests that it is not simply the case that the SEP gradients exist because individuals with low SEP reside in local areas with, for example, worse leisure and sporting faculties, than high SEP individuals.

Column (2) adds in a range of measures of income and wealth (current household income, housing tenure, work status and occupation), with the addition of LA fixed effects in Column (4). Again, all the coefficients are very well defined individually, although the improvement in the overall model fit is modest (0.155 to 0.157). Importantly, there are clear gradients within all these measures of SEP. Individuals with higher SEP are less likely to be physically inactive, with the exception of those in full time work who are more likely to be physically inactive (controlling for all other factors) than those who spend less time working. Even with this rich set of controls for wealth, occupation and local area effects, both education and income are separately associated with physical inactivity and a clear gradient within both education and income remains, differences between the least and most educated being in the order of ten percentage points and between the highest and lowest income categories in the order of four percentage points.

Columns (5) and (6) repeat this analysis for males and females separately. These show that, differences by education, income and housing tenure are similar within gender while associations with age, ethnicity, occupation and work status differ slightly across gender. In particular, the different ethnic patterns by gender seen in Figure 2 remain robust to the inclusion of a large set of other individual and LA controls, especially the large gap between males and females of African or Caribbean heritage. Finally, Column (7) examines the robustness of our estimates to functional form and presents probit estimates (presented as marginal effects evaluated at the mean) of the LPM specification in column (4). Comparison of the two columns shows that our estimates are very robust to functional form and most of the coefficients change very little. Importantly, clear gradients in all the separate aspects of SEP remain.

In Table 3 we replace the LA fixed effects with observed LA level characteristics that might be expected to be associated with physical inactivity, including measures of recreational facility supply and new expenditure, and the local geographical configuration. The model uses the same set of individual and family level characteristics as the extended models in Table 2, Column 2, but only the coefficients on the area-level characteristics from this model are presented in the table.

Column (1) Table 3 shows that physical inactivity is significantly related to local-area deprivation. We extend this analysis in the remaining columns to control for a broader set of local-area factors that may or may not be correlated with local deprivation. In Column (2) we include broader regional controls and the degree of urbanization of the LA and in Column (3) we additionally control for quite detailed characteristics of the LA's sporting facilities, investment in new facilities and general satisfaction levels with these facilities and for the weather in the four week window prior to the respondent's interview date. Examination of these area level factors shows that, after controlling for a rich set of both individual and local factors, high-level regional differences are relatively unimportant, with only the North West and the West Midlands having higher levels of physical inactivity than the South East. However, there are clear differences at the LA level and by LA type. The more rural the LA, the less likely the individuals living within it are to be physically inactive. The greater the number of sports facilities, the higher new expenditure, and the better the LA facilities satisfaction the less likely individuals are to be physically inactive (with the exception of sports pitches, which may reflect the presence of professional sports facilities where individuals watch rather than play). In a cross sectional analysis we cannot separate out causality (more facilities leads to less inactivity) from selection (individuals who are interested in physical activity choose to live in places with better facilities) or reverse causation (individuals who are physically active lobby for better local facilities). Nevertheless it is clear that there is a statistically significant and sensible association between facilities and lack of inactivity. Finally, the last block of estimates in column (3) shows that, in England, warm weather promotes overall physical activity, while rain reduces activity, even after controlling for month of interview.

In Table 4 we test that our results are robust to exactly how physical inactivity is defined. We replace the measure of inactivity used in Tables 2 and 3 (i.e. no walking or cycling of 30 minutes or more, or any other type of physical activity in the last four weeks) with three specific measures of physical inactivity that are related to the UK Government targets. As discussed above, these are based on the number of days in the last four weeks that an individual has participated in sport or physical recreation for at least 30 minutes with at least moderate intensity. We present estimates for (a) no days (Table 4, Column 1), (b) less than four days (Column 2) and (c) the inverse of the NI8 measure i.e. less than 12 episodes in the last four weeks (Column 3). We present only the estimates of the individual measures of SEP that are our focus, but each model controls for the same extended set of controls and LA fixed effects as Table 2, Column (4).

Age, ethnicity, gender, education and income differences are evident for all three measures. The differences are similar to those seen for our main physical inactivity measure in Table 2, indicating that our main measure picks up the public health issues embodied in the national indicators. Presentation of the national indicator measures also allows comparison of the SEP gradients as the definition of physical inactivity becomes more absolute. Comparison across the columns of Table 4 shows that the gradients become steeper as the definition becomes more absolute. So, for example, the most educated individuals are 15 percentage points less likely to do no activity but 6 percentage points less likely to not meet the government's key national indicator target of 12 episodes of moderate exercise per month than the least educated, while those of Indian ethnicity are 14 percentage points more likely to do no activity but 7 percentage points less likely to not meet the key national target than Whites. Differences by income group across the three measures are also clear.

As we do not have measures of price, the income associations we observe will be picking up a mixture of an income effect (that individuals who become richer want to do more activity) and a price effect (that any price will represent a larger share of income for individuals in poorer households, so will deter activity more in these households). Since price is an important policy variable we would like to investigate this further. While we cannot control directly for a price effect, our detailed data means we can examine less costly and more costly activities and so control indirectly for price. If our income effect is also picking up the price effect then as the activities become more expensive, the effect of income should become larger. And for the lowest priced activities we essentially recover the income effect uncontaminated by a direct price effect. In addition, by looking at less costly and more expensive activities we can separate out the effect of human capital and knowledge (education) from purchasing power (income). To do this we unpack, from our main measure of physical inactivity, walking and the three most common activities of cycling, swimming and using a gym. Walking is least costly and the other activities are more expensive (though relatively low cost).

Within walking we examine three definitions of lack of walking activity. In Table 5, Column (1), we present estimates of whether the respondent (1) has not walked continuously for five minutes in the last month. This is obviously a very marginal measure of physical activity. In Column (2) we examine whether the respondent has not walked for 30 minutes continuously. In Column (3) we separate out walking 30 minutes for leisure, which may be more expensive, both in terms of time (as it will take time above any time individuals are paid for) and direct cost, if individuals travel to do leisure walking. We present only the associations with our key SEP measures of age, gender, ethnicity, education and income, but our estimates include all other controls and LA fixed effects.

Column (1) shows that while there are differences by age, gender, ethnicity, and education in doing no walking at all, these are relatively compressed compared to the differences for the broader measures of physical inactivity examined in Table 2. Further, there is no income effect. When we compare doing no walking at all with not undertaking longer amounts of walking (Column 2), differences by gender, ethnicity and education all widen, suggesting increases in walking are socially graded. However, not walking for 30 minutes is not strongly associated with income. But when we examine not walking for leisure we see the association with both education and income is much stronger for lack of leisure walking than lack of any walking.[5] The education effect therefore seems to be picking up factors such as health knowledge and tastes, while the income effect probably reflects the effect of the higher price associated with walking for leisure.

To further examine the role of price, we present models of not cycling, not swimming, and not going to the gym. We separate out not cycling for 30 minutes for any purpose from not cycling for 30 minutes for leisure alone as the latter may be more expensive than cycling for transport purposes. Table 6 presents the estimates. Comparison across the columns clearly shows that as the activity gets more expensive, the association with income rises. Individuals in poorer households are less likely to do more costly sporting activities. This suggests that price does deter physical activity. The gradients in education are not patterned by price but are activity specific: there is less of an education gradient for not cycling than for not undertaking other activities, a little more for not using the gym, and most for not swimming.

In our final exploration of the role of income we present estimates of the income-age gradient (more strictly, the income gradient across cohorts). We show in Table 7 estimates of the linear effect of income and cohort-income interactions but all models also control for the full set of covariates in Table 2, Column (4). Table 7, Column (1) pools males and females. The first entry in Column (1) shows the significant effect of income. The coefficient estimate shows that a one-log point increase in household income is associated with a 1.3 percent points lower probability of being physically inactive, but that this significantly increases with up to just post-retirement age (65-74) and falls a little thereafter (75-84). This fall (particularly for 85+ individuals) probably reflects survivor bias: mortality is patterned by income in the UK, so the lowest income groups in the oldest cohorts will include more individuals who are in (unobserved) better health. Columns (2)

[5] The effect of ethnicity is similar whether we look at any walking in column (2) or leisure walking in column (3), suggesting that lack of walking has a cultural component on top of any other SEP associations. Comparing the effect of age across columns (2) and (3) indicates that individuals in their teens and early 20s do not walk for leisure.

and (3) present the estimates for males and females respectively to allow examination of whether the income gradient differs by gender. While the same increasing income gradient is evident for both males and females, it is less steep for females. Thus income differences across the physical inactivity levels of males when young are small, but increase with age substantively, while income differences in the physical inactivity levels for females exist when young but increase less sharply across cohorts.

5. Conclusion

In this paper we have exploited an extensive data set to examine physical inactivity in the English population. Our large sample size allows us to more precisely separate out the various aspects of SEP that have been conflated in smaller scale studies, to examine different measures of inactivity and to control for differences at the local level in geography, availability of sporting facilities, funding for sport and weather.

Our results show several stark facts. The first is the sheer lack of activity: there are very high levels of physically inactivity in the English population. Around 20 per cent of the population over the age 16 do minimal levels of physical activity, and about 10 per cent do not even walk continuously for five minutes over four weeks. The second is that this physical inactivity in England has a large and robust SEP gradient, however SEP is defined. We show clear evidence of independent disparities by gender, ethnic group, age, SEP and geographic area in the probability of being physically inactive. Third, we are able to show that the effect of income is larger for activities that are more costly while the education gradient is less patterned by cost. Fourth, there is clear evidence of an income-age gradient. The differences in physical activity by income widen by cohort with the largest differences occurring in those who are up to 10 years post statutory retirement age. Finally, we find statistically significant and sensible signs on local area characteristics, but these explain little of the variance in lack of physical activity.

Our results, coupled with the effect of physical inactivity on later health outcomes, have the following implications. First, England is building up a large future health problem and one that is heavily socially graded on a large range of dimensions of SEP. So unless patterns in behaviours are altered there are likely to be growing SEP disparities in health. Second, our estimates suggest that all aspects of SEP need to be targeted to influence behavior. The independent effect of income and its larger effect for more costly activities suggest that price is important, independent of other aspects of access. This suggests that efforts to lower price barriers might help reduce disparities. However, it is also clear that education and ethnicity are independent associates of physical inactivity, so that lowering price barriers will not be enough to tackle these disparities: other more targeted policies are likely to be needed. Finally, the large SEP gaps suggest that the many current campaigns may not be reaching those who need them most.

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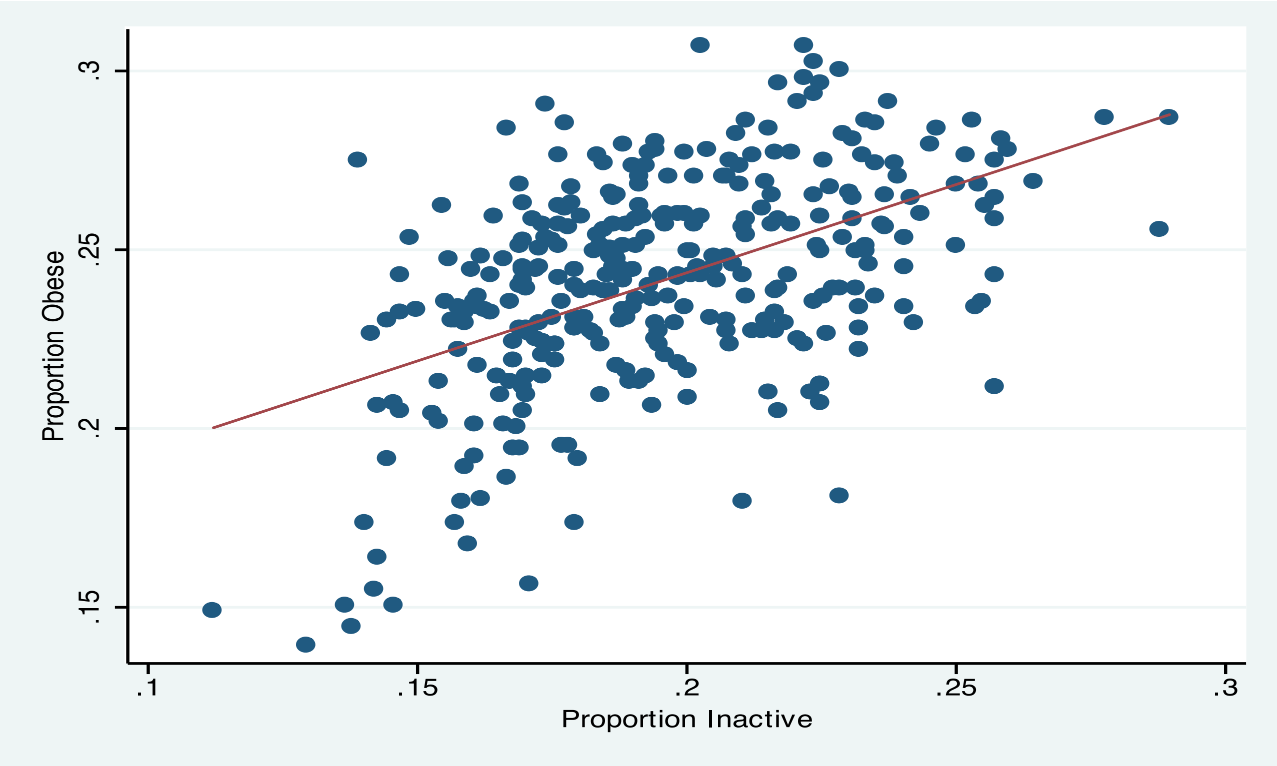
Figure 1: Relationship between Proportions Inactive (APS) and Obese (HSE) by Local Authority

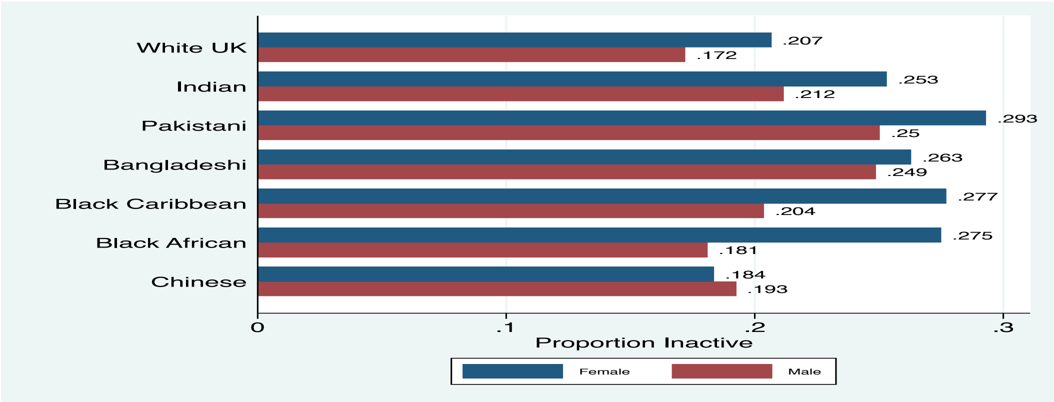
(Data source: National Obesity Observatory e-atlas; derived from Health Survey for England, 2006-2008)



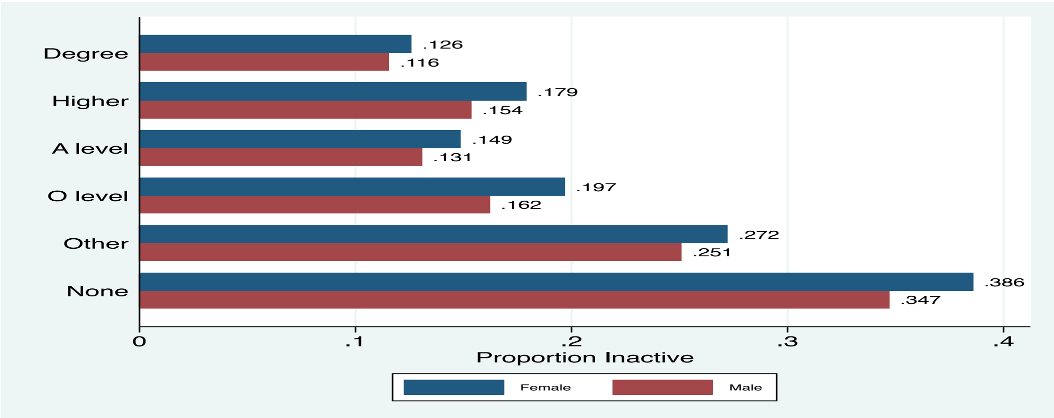
Proportion Obese
.15
.2
.25
.3
.1
.15
.2
.25
.3
Proportion Inactive

Figure 2: Proportion Physically Inactive by Ethnicity, Highest Qualification, Household Income and Local Authority Deprivation Decile

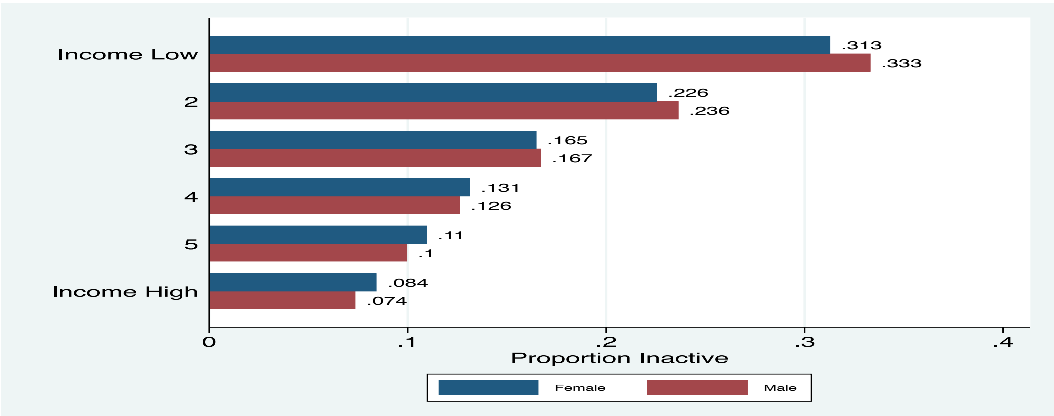
Panel 1



Panel 2



Panel 3



Panel 4

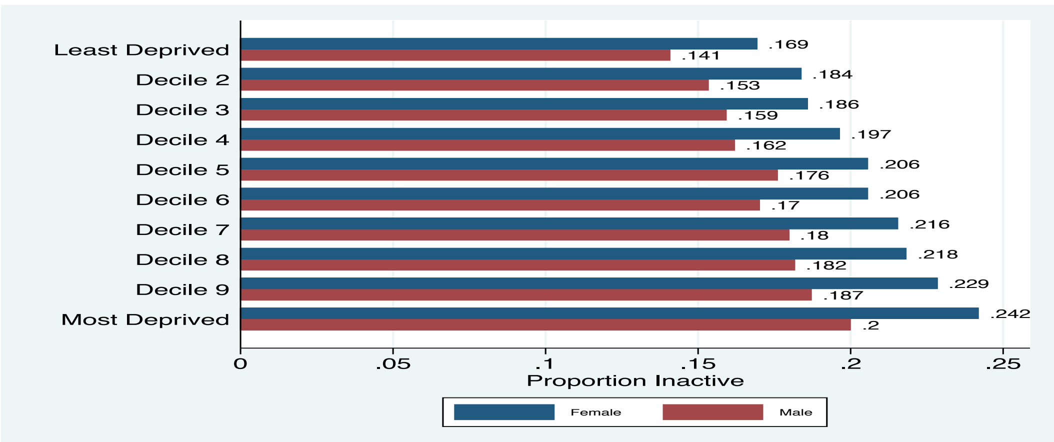
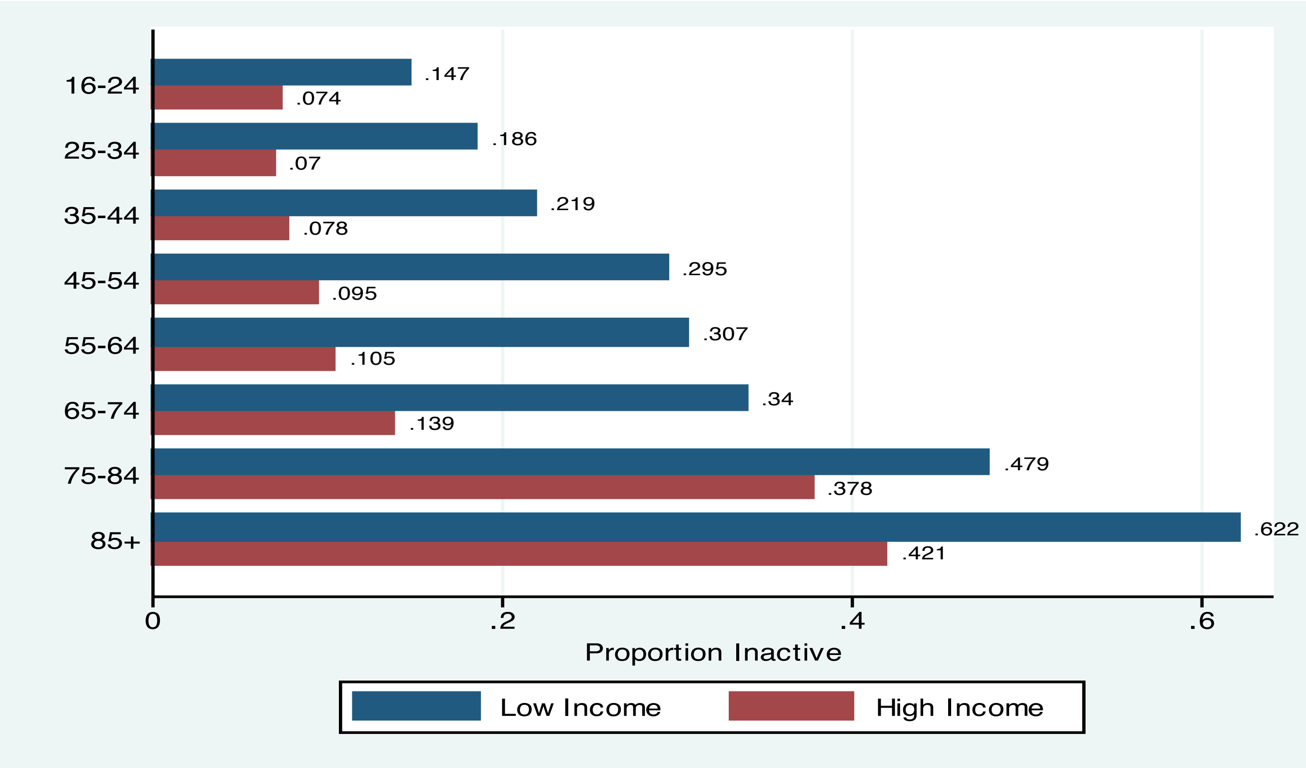


Figure 3: Proportion Physically Inactive by Age and High/Low Household Income
(Top Panel = Males; Bottom Panel = Females)

Panel 1



Panel 2

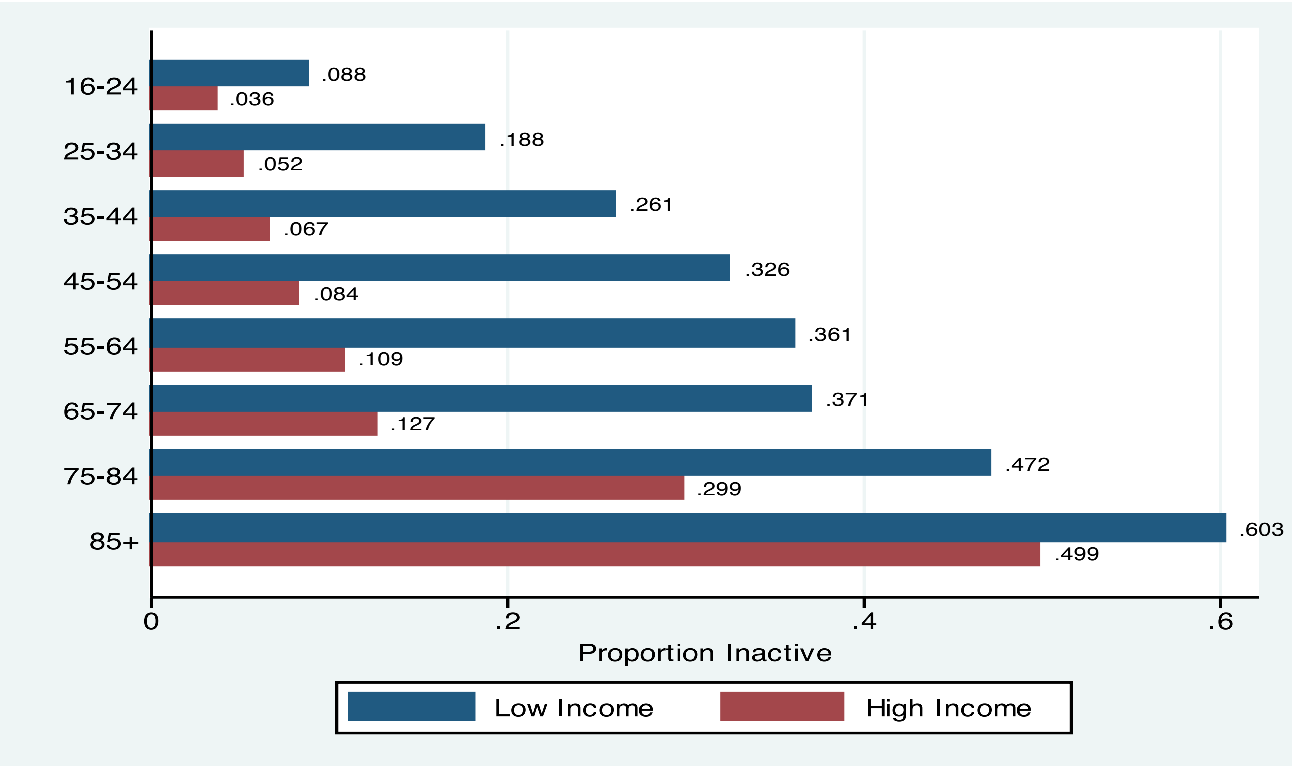


Table 1: Sample Characteristics: Covariates and Physical Inactivity Measures

Covariates	**Mean**	**SD**	**Covariates**	**Mean**	**SD**
Age 16-24	0.079	0.269	Working full-time	0.406	0.491
Age 25-34	0.128	0.334	Working part-time	0.153	0.360
Age 35-44	0.193	0.394	Unemployed<12 months	0.020	0.140
Age 45-54	0.177	0.381	Unemployed>12 months	0.025	0.155
Age 55-64	0.189	0.391	Retired	0.282	0.450
Age 65-74	0.141	0.348	Non-participant (home/child)	0.047	0.212
Age 75-84	0.079	0.270	Non-participant (disabled)	0.024	0.154
Age 85 or above	0.017	0.128	Student	0.038	0.190
Male	0.411	0.492	Other	0.005	0.076
UK White	0.896	0.305	North East	0.063	0.242
Indian	0.014	0.117	North West	0.129	0.336
Pakistani	0.007	0.085	Yorkshire	0.058	0.234
Bangladeshi	0.002	0.044	West Midlands	0.106	0.308
Caribbean	0.010	0.097	East Midlands	0.112	0.316
African	0.009	0.097	East	0.133	0.339
Chinese	0.002	0.046	South West	0.121	0.326
Other ethnic groups	0.060	0.046	South East	0.183	0.387
Single adult	0.366	0.482	London	0.095	0.293
Child aged 0-4	0.102	0.303	Urban 1 (Most urban)	0.236	0.425
Child aged 5-10	0.141	0.348	Urban 2	0.126	0.332
Child aged 11-15	0.128	0.334	Urban 3	0.149	0.357
Log household Size	0.689	0.554	Urban 4	0.142	0.349
Chronic limiting condition	0.179	0.383	Urban 5	0.157	0.364
Cannot walk	0.015	0.123	Urban 6 (Most Rural)	0.189	0.392
Degree of higher education	0.307	0.461	Log (% Green Space)	4.183	0.441
Higher education (less than degree)	0.100	0.301	IMD Deprivation Index	19.689	9.302
'A' levels	0.158	0.364	Log (Unemployment Rate)	1.664	0.325
'O' level	0.237	0.430	Log (Percentage Non-UK British)	1.952	0.801
Other	0.035	0.184	Log (Main Pools per 10,000 pop)	-0.772	0.590
No qualifications	0.164	0.370	Log (Health Suites per 10,000)	0.092	0.490
Income: £52,000 or more	0.158	0.364	Log (Sports Halls per 10,000)	0.500	0.481
£41,600 to £51,999	0.101	0.301	Log (Sports Pitches per 10,000)	1.795	0.702
£31,200 to £41,599	0.140	0.347	Log (Lottery Amount per 10,000)	11.659	1.420
£20,800 to £31,199	0.201	0.401	Log (LA Facilities Satisfaction)	1.306	0.038
£10,400 to £20,700	0.250	0.433	Mean Precipitation	2.079	1.299
<£10,400 per annum	0.150	0.357	Maximum Temperature	14.137	5.816
Council or LA housing	0.124	0.330	Minimum Temperature Squared/10	233.662	167.795
Occ class: Higher managerial	0.058	0.235			
Higher professional	0.084	0.277	**Physical Inactivity Measures**	**Mean**	**SD**
Lower professional	0.195	0.396	Physically Inactive (Main measure)	0.197	0.398
Lower managerial	0.079	0.270	KPV=0	0.506	0.500
Higher supervisor	0.053	0.224	KPV<4	0.592	0.491
Intermediate	0.114	0.317	KPV<12	0.792	0.406
Employer	0.025	0.156	No Walk 5 Minutes	0.096	0.295
Own account worker	0.083	0.276	No Walk 30 Minutes (All)	0.295	0.456
Lower supervisor	0.079	0.269	No Walk 30 Minutes (Leisure)	0.464	0.499
Lower technical	0.022	0.147	No Cycling 30 Minutes (All)	0.894	0.308
Semi-routine	0.124	0.329	No Cycling 30 Minutes (Leisure)	0.913	0.281
Routine	0.068	0.251	No Swimming	0.875	0.330
Unknown	0.017	0.129	No Gym	0.903	0.296

Notes: Raw sample means and standard deviations shown. Mean values calculated conditional on no missing observations. Mean value for occupational classifications are conditional on respondent reporting to work either full-time or part-time.

Table 2: Linear Probability and Binary Probit Models of Physical Inactivity
(1= Physically Inactive in last 4 weeks; 0 = otherwise)

	Linear Probability Models												**Probit**	
	Without LA Fixed Effects				**With LA Fixed Effects**									
	(1) All		**(2) All**		**(3) All**		**(4) All**		**(5) Males**		**(6) Females**		**(7) All**	
	β	***t*-stat**	***β***	***t*-stat**	***β***	***t*-stat**	***β***	***t*-stat**	***β***	***t*-stat**	***β***	***t*-stat**	**ME**	***z-stat***
Age 25-34	0.038	19.12	0.029	13.12	0.038	19.53	0.029	13.09	0.043	13.00	0.014	4.42	0.039	12.72
Age 35-44	0.053	28.75	0.046	20.56	0.053	29.10	0.046	20.52	0.063	18.08	0.026	8.45	0.064	20.48
Age 45-54	0.073	34.26	0.065	29.91	0.074	33.13	0.065	29.35	0.086	26.28	0.041	14.31	0.092	31.45
Age 55-64	0.090	38.45	0.090	33.05	0.092	37.45	0.091	32.57	0.120	32.30	0.058	15.92	0.126	33.85
Age 65-74	0.119	47.75	0.139	42.70	0.121	47.96	0.141	42.59	0.157	36.15	0.117	24.58	0.189	43.05
Age 75-84	0.238	78.89	0.263	69.73	0.241	78.58	0.265	69.31	0.269	49.79	0.253	50.94	0.326	61.74
Age 85 or above	0.392	70.48	0.419	68.52	0.397	73.61	0.424	70.16	0.431	50.50	0.408	51.26	0.507	67.38
Male	-0.014	-12.18	-0.019	-16.14	-0.014	-12.56	-0.020	-16.49	-	-	-	-	-0.021	-17.15
Indian	0.119	25.67	0.114	24.15	0.106	22.39	0.103	21.38	0.097	17.49	0.110	14.39	0.132	23.51
Pakistani	0.155	22.75	0.147	21.98	0.143	17.59	0.136	17.11	0.126	9.55	0.145	19.87	0.170	20.14
Bangladeshi	0.153	11.63	0.136	9.39	0.151	12.55	0.137	11.46	0.142	8.10	0.130	8.43	0.181	14.71
Caribbean	0.089	12.14	0.076	10.59	0.081	11.14	0.070	10.16	0.038	3.70	0.097	11.37	0.085	12.20
African	0.126	18.55	0.109	15.59	0.119	18.76	0.105	16.63	0.071	9.39	0.138	13.58	0.139	21.25
Chinese	0.100	7.79	0.100	7.96	0.101	8.17	0.101	8.40	0.115	6.18	0.089	6.53	0.143	10.05
Other ethnic groups	0.033	11.52	0.029	10.60	0.034	14.88	0.031	13.81	0.028	9.03	0.034	11.30	0.041	15.58
Single adult	0.024	11.49	0.012	5.30	0.022	10.94	0.010	4.81	0.016	4.70	0.006	1.97	0.010	4.65
Child aged 0-4	0.014	6.71	0.015	7.38	0.014	6.68	0.015	7.24	0.011	3.85	0.015	5.09	0.018	7.14
Child aged 5-10	-0.014	-8.63	-0.012	-7.57	-0.014	-8.70	-0.012	-7.73	-0.012	-4.45	-0.012	-5.93	-0.014	-7.29
Child aged 11-15	-0.013	-7.05	-0.011	-5.75	-0.013	-7.05	-0.011	-5.86	-0.012	-4.92	-0.010	-3.87	-0.013	-5.69
Log household Size	0.008	3.65	0.010	4.62	0.007	3.16	0.009	3.91	0.006	2.10	0.013	3.88	0.011	4.26
Chronic limiting condition	0.175	76.61	0.155	72.83	0.173	79.36	0.154	73.89	0.153	48.00	0.155	63.88	0.144	83.90
Cannot walk	0.450	113.21	0.429	103.77	0.449	112.02	0.428	103.24	0.432	57.85	0.424	89.35	0.482	75.24
Degree of higher education	-0.140	-70.49	-0.110	-55.76	-0.133	-69.50	-0.104	-54.25	-0.098	-35.13	-0.109	-41.39	-0.084	-50.09
Higher education (less than degree)	-0.109	-49.71	-0.089	-40.52	-0.104	-49.21	-0.085	-39.82	-0.077	-24.72	-0.092	-32.79	-0.060	-33.37
'A' levels	-0.099	-46.06	-0.082	-39.27	-0.095	-45.35	-0.080	-38.43	-0.073	-24.38	-0.087	-30.04	-0.058	-32.76
'O' level	-0.072	-39.93	-0.063	-34.64	-0.070	-39.37	-0.061	-34.02	-0.058	-22.01	-0.063	-24.52	-0.041	-27.79
Other	-0.069	-21.60	-0.059	-18.62	-0.066	-20.44	-0.057	-17.72	-0.052	-11.40	-0.065	-13.67	-0.038	-14.84
Income: £52,000 or more	-	-	-0.042	-8.30	-	-	-0.039	-7.66	-0.045	-5.50	-0.033	-5.72	-0.042	-7.64
£41,600 to £51,999	-	-	-0.030	-5.67	-	-	-0.028	-5.30	-0.032	-3.66	-0.027	-4.02	-0.027	-4.83
£31,200 to £41,599	-	-	-0.018	-3.89	-	-	-0.017	-3.67	-0.023	-2.85	-0.015	-2.63	-0.013	-2.91
£20,800 to £31,199	-	-	-0.014	-2.97	-	-	-0.013	-2.74	-0.018	-2.36	-0.012	-2.16	-0.008	-1.78
£10,400 to £20,700	-	-	-0.008	-1.80	-	-	-0.007	-1.56	-0.010	-1.29	-0.006	-1.15	-0.002	-0.39

Council or LA housing	-	-	0.036	17.81	-	-	0.037	18.94	0.036	11.67	0.038	16.39	0.035	19.00

Table 2: (Continued)

Occ class: Higher managerial	-	-	-0.040	-12.85	-	-	-0.038	-12.16	-0.049	-11.59	-0.017	-3.43	-0.043	-13.09
Higher professional	-	-	-0.041	-12.18	-	-	-0.038	-11.42	-0.044	-10.30	-0.030	-6.16	-0.044	-12.45
Lower professional	-	-	-0.041	-12.65	-	-	-0.040	-12.37	-0.054	-12.70	-0.017	-4.07	-0.046	-14.34
Lower managerial	-	-	-0.025	-7.36	-	-	-0.023	-6.90	-0.038	-8.66	0.005	1.07	-0.023	-7.01
Higher supervisor	-	-	-0.039	-11.45	-	-	-0.038	-11.42	-0.061	-13.88	-0.005	-0.98	-0.040	-11.62
Intermediate	-	-	-0.012	-3.59	-	-	-0.013	-3.77	-0.032	-6.98	0.010	2.45	-0.013	-3.94
Employer	-	-	-0.019	-4.31	-	-	-0.015	-3.53	-0.024	-4.37	0.003	0.34	-0.013	-2.97
Own account worker	-	-	-0.024	-6.24	-	-	-0.021	-5.39	-0.021	-4.16	-0.028	-5.77	-0.021	-5.53
Lower supervisor	-	-	-0.032	-8.68	-	-	-0.031	-8.42	-0.041	-9.29	-0.009	-1.83	-0.031	-8.62
Lower technical	-	-	-0.009	-1.98	-	-	-0.008	-1.80	-0.013	-2.64	-0.008	-0.62	-0.008	-1.71
Semi-routine	-	-	-0.017	-4.61	-	-	-0.016	-4.51	-0.020	-3.69	-0.001	-0.27	-0.016	-4.64
Unknown	-	-	-0.029	-5.10	-	-	-0.028	-4.85	-0.038	-5.25	-0.008	-1.01	-0.030	-4.92
Working part-time	-	-	-0.042	-28.51	-	-	-0.040	-26.98	-0.042	-13.67	-0.035	-19.58	-0.042	-24.93
Unemployed<12 months	-	-	-0.051	-10.73	-	-	-0.050	-10.56	-0.058	-9.05	-0.031	-5.62	-0.049	-10.53
Unemployed>12 months	-	-	-0.024	-5.01	-	-	-0.023	-5.00	-0.028	-4.44	-0.008	-1.26	-0.025	-6.00
Retired	-	-	-0.067	-21.06	-	-	-0.066	-20.79	-0.074	-15.50	-0.041	-9.47	-0.065	-22.80
Non-participant (home/child)	-	-	-0.055	-15.31	-	-	-0.052	-14.45	-0.045	-3.53	-0.035	-7.47	-0.050	-15.49
Non-participant (disabled)	-	-	0.091	16.31	-	-	0.091	16.36	0.083	11.08	0.110	15.64	0.048	10.32
Student	-	-	-0.070	-17.13	-	-	-0.068	-16.41	-0.076	-15.00	-0.053	-10.14	-0.073	-15.64
Other	-	-	-0.046	-6.81	-	-	-0.044	-6.53	-0.051	-3.88	-0.025	-2.67	-0.045	-7.61
LA Fixed Effects (326)	NO	NO	NO	NO	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
(Pseudo) R-squared	0.147		0.155		0.150		0.157		0.153		0.161		0.145	
Sample	1,002,216		1,002,216		1,002,216		1,002,216		411,828		590,388		1,002,216	

Notes: Coefficients from linear probability models, and marginal effects (evaluated at X-bar) from binary probit model, and associated *t*-statistics *(z),* shown. Omitted categories are aged 16-24, female, White British, more than one adult in household, no children under 16, no chronic limiting health condition, can walk, no qualifications, annual household income less than £10,400, working full-time, does not reside (rent) in a council or housing association house, works in a 'routine' occupation, works full-time, lives in a major urban area, and lives in the South East. Each model additionally controls for month of interview, survey year, as well dummy variables for missing information. LA national proportion weights applied. Household income bands * linear time trends included in each model that controls for household income. Robust standard errors clustered by (326) local authority.

Table 3: Linear Probability Models of Physical Inactivity with Observable LA Characteristics

	Controlling for LA Observables					
	(1)		(2)		(3)	
	β	***t*-stat**	***β***	***t*-stat**	***β***	***t*-stat**
LA Deprivation Index (Decile 2)	0.002	0.57	0.002	0.50	0.001	0.20
LA Deprivation Index (Decile 3)	0.003	1.08	0.002	0.69	0.001	0.35
LA Deprivation Index (Decile 4)	0.005	1.48	0.005	1.31	0.002	0.45
LA Deprivation Index (Decile 5)	0.012	2.64	0.009	1.99	0.005	1.24
LA Deprivation Index (Decile 6)	0.011	2.37	0.009	1.74	0.004	0.89
LA Deprivation Index (Decile 7)	0.014	3.30	0.013	3.17	0.008	2.00
LA Deprivation Index (Decile 8)	0.018	4.46	0.015	2.75	0.010	1.81
LA Deprivation Index (Decile 9)	0.020	5.58	0.014	3.00	0.011	2.15
LA Deprivation Index (Decile 10; most deprived)	0.027	6.07	0.022	3.89	0.018	3.28
North East	-	-	0.009	1.62	0.013	2.46
North West	-	-	0.006	1.40	0.008	2.04
Yorkshire	-	-	0.001	0.17	0.001	0.28
West Midlands	-	-	0.016	4.11	0.014	3.99
East Midlands	-	-	0.007	1.89	0.005	1.41
East	-	-	0.011	2.79	0.009	2.44
London	-	-	0.001	0.14	0.003	0.49
South West	-	-	-0.008	-2.02	-0.007	-1.85
Urban 2 (More Urban)	-	-	-0.008	-2.56	-0.008	-2.55
Urban 3	-	-	-0.010	-2.60	-0.006	-1.68
Urban 4	-	-	-0.015	-3.49	-0.011	-2.40
Urban 5	-	-	-0.016	-3.67	-0.014	-3.29
Urban 6 (More Rural)	-	-	-0.022	-4.84	-0.021	-4.40
Log (% Green Space)	-	-	0.013	2.70	-0.002	-0.50
Log (Percentage Non-UK British)	-	-	0.001	0.56	0.002	1.03
Log (Main Pools per 10,000 pop)	-	-	-	-	-0.006	-1.75
Log (Health Suites per 10,000)	-	-	-	-	-0.010	-2.21
Log (Sports Halls per 10,000)	-	-	-	-	-0.002	-0.41
Log (Sports Pitches per 10,000)	-	-	-	-	0.014	4.83
Log (Lottery Amount per 10,000)	-	-	-	-	-0.001	-1.13
Log (LA Facilities Satisfaction)	-	-	-	-	-0.059	-1.92
Mean Precipitation	-	-	-	-	0.001	1.56
Maximum Temperature	-	-	-	-	-0.005	-6.87
Maximum Temperature Squared / 10	-	-	-	-	0.001	4.78
LA Fixed Effects (326)	NO	NO	NO	NO	NO	NO
(Pseudo) R-squared	0.155		0.155		0.156	
Sample	1,002,216		1,002,216		1,001,203	

Notes: Selected coefficients on LA observable characteristics from linear probability models, and associated *t*-statistics *(z),* shown. Omitted categories are LA Deprivation Index Decile 1 (least deprived), South East and Major Urban. Each model has the same controls as Table 2, Column 2. Respondents from two local authorities: City of London, and Isles of Scilly, are dropped from the last model due to missing data (these are the two smallest LAs by population in England).

Table 4: Linear Probability Models of National Indicator Based Measures of Physical Inactivity

	KPV=0 (1)		KPV<4 (2)		KPV<12 (3)	
	β	***t*-stat**	***β***	***t*-stat**	***β***	***t*-stat**
Age 25-34	0.072	21.90	0.068	19.61	0.047	14.19
Age 35-44	0.122	39.96	0.119	35.88	0.083	28.74
Age 45-54	0.189	59.89	0.179	53.40	0.125	44.26
Age 55-64	0.255	79.16	0.234	68.99	0.168	53.41
Age 65-74	0.328	84.15	0.297	76.00	0.208	60.14
Age 75-84	0.455	98.31	0.404	89.77	0.269	70.19
Age 85 or above	0.539	98.80	0.475	90.87	0.301	73.01
Male	-0.070	-40.54	-0.062	-33.50	-0.043	-27.79
Indian	0.144	21.74	0.120	18.08	0.066	13.41
Pakistani	0.165	15.64	0.145	16.08	0.080	11.32
Bangladeshi	0.185	9.96	0.152	9.14	0.101	11.92
Caribbean	0.062	8.45	0.065	10.51	0.027	4.84
African	0.163	23.66	0.140	21.74	0.089	16.12
Chinese	0.125	7.70	0.133	7.63	0.103	7.84
Other ethnic groups	0.046	16.11	0.038	13.35	0.021	8.97
Chronic limiting condition	0.134	63.48	0.124	63.74	0.068	46.81
Cannot walk	0.101	29.71	0.078	24.05	0.039	20.79
Degree of higher education	-0.154	-66.27	-0.131	-59.95	-0.064	-35.58
Higher education (less than degree)	-0.120	-40.40	-0.099	-33.70	-0.051	-21.66
'A' levels	-0.114	-48.49	-0.097	-42.66	-0.049	-24.71
'O' level	-0.075	-35.70	-0.062	-28.91	-0.024	-13.64
Other	-0.067	-19.94	-0.050	-14.90	-0.018	-7.35
Income: £52,000 or more	-0.156	-26.51	-0.169	-27.14	-0.126	-21.81
£41,600 to £51,999	-0.117	-19.54	-0.120	-19.43	-0.074	-12.16
£31,200 to £41,599	-0.093	-14.27	-0.095	-14.14	-0.056	-11.31
£20,800 to £31,199	-0.068	-12.84	-0.066	-12.37	-0.032	-7.95
£10,400 to £20,700	-0.017	-3.62	-0.021	-4.73	-0.008	-2.03
Council or LA housing	0.067	29.21	0.059	25.63	0.032	19.68
LA Fixed Effects (326)	YES	YES	YES	YES	YES	YES
R-squared	0.196		0.152		0.078	
Sample	993,096		993,096		993,096	

Notes: Selected coefficients from linear probability models with LA fixed effects, and associated *t*-statistics, shown. Each model has the same controls as Table 2, Column 4.

Table 5: Linear Probability Models of Walking-Related Inactivity

	No Walk 5		**No Walk 30 All**		**No Walk 30 Leisure**	
	β	***t*-stat**	***β***	***t*-stat**	***β***	***t*-stat**
Age 25-34	0.009	5.45	0.003	0.88	-0.087	-21.81
Age 35-44	0.008	4.68	0.005	1.35	-0.128	-30.35
Age 45-54	0.010	5.72	0.006	2.11	-0.148	-35.42
Age 55-64	0.014	7.06	0.020	6.05	-0.145	-32.97
Age 65-74	0.035	13.86	0.079	19.06	-0.088	-21.21
Age 75-84	0.090	29.09	0.207	46.06	0.045	8.47
Age 85 or above	0.191	37.86	0.357	55.20	0.175	25.60
Male	0.009	10.43	0.019	14.31	0.029	17.76
Indian	0.044	12.66	0.162	29.00	0.151	25.28
Pakistani	0.045	11.32	0.180	19.40	0.162	13.70
Bangladeshi	0.045	8.50	0.161	13.08	0.160	11.12
Caribbean	0.027	8.37	0.142	20.10	0.146	18.39
African	0.068	17.86	0.170	24.43	0.174	28.34
Chinese	0.084	9.74	0.169	11.71	0.191	12.32
Other ethnic groups	0.026	16.30	0.042	14.14	0.046	14.38
Chronic limiting condition	0.087	54.99	0.159	79.32	0.127	50.13
Cannot walk	-	-	-	-	-	-
Degree of higher education	-0.051	-30.41	-0.106	-46.62	-0.150	-63.00
Higher education (less than degree)	-0.043	-21.73	-0.077	-28.10	-0.116	-36.21
‘A’ levels	-0.041	-23.80	-0.073	-31.12	-0.106	-41.59
‘O’ level	-0.035	-20.67	-0.052	-23.07	-0.068	-28.33
Other	-0.027	-9.74	-0.043	-11.25	-0.072	-19.18
Income: £52,000 or more	0.001	0.21	0.001	0.13	-0.041	-6.02
£41,600 to £51,999	0.000	-0.08	0.008	1.19	-0.025	-3.49
£31,200 to £41,599	0.000	0.11	0.014	2.52	-0.014	-2.24
£20,800 to £31,199	-0.002	-0.51	0.007	1.20	-0.011	-1.67
£10,400 to £20,700	-0.004	-1.24	0.001	0.28	-0.003	-0.53
Council or LA housing	0.012	8.25	0.025	9.22	0.062	23.32
LA Fixed Effects (326)	YES	YES	YES	YES	YES	YES
R-squared	0.055		0.080		0.090	
Sample	986,863		986,863		983,286	

Notes: Selected coefficients from linear probability models with LA fixed effects, and associated *t*-statistics, shown. Each model has the same controls as Table 2, Column 4. Individuals reporting that they cannot walk are dropped from the estimation sample.

Table 6: Linear Probability Models of Cycling, Swimming and Gym Inactivity

	No Cycling 30 All		**No Cycling 30 Leisure**		**No Swimming**		**No Gym**	
	β	***t*-stat**	***β***	***t*-stat**	***β***	***t*-stat**	***β***	***t*-stat**
Age 25-34	0.029	13.04	0.016	7.68	0.015	6.25	0.023	7.88
Age 35-44	0.024	10.65	0.008	4.29	0.012	5.24	0.060	19.68
Age 45-54	0.053	22.88	0.033	16.66	0.030	12.18	0.094	34.86
Age 55-64	0.085	36.71	0.060	29.73	0.047	19.17	0.118	43.44
Age 65-74	0.112	44.98	0.083	38.06	0.067	26.59	0.135	43.59
Age 75-84	0.136	49.81	0.104	42.95	0.103	38.15	0.158	49.83
Age 85 or above	0.145	47.11	0.110	43.13	0.122	40.30	0.166	48.57
Male	-0.076	-68.61	-0.057	-52.66	0.061	45.65	0.003	2.78
Indian	0.089	23.74	0.067	21.45	0.069	20.95	-0.004	-0.81
Pakistani	0.088	18.48	0.069	16.77	0.094	25.73	-0.003	-0.36
Bangladeshi	0.094	11.77	0.066	8.31	0.086	14.49	0.005	0.61
Caribbean	0.034	5.59	0.024	6.25	0.073	24.00	-0.026	-4.88
African	0.081	16.13	0.062	23.32	0.100	33.05	0.009	1.72
Chinese	0.051	3.67	0.042	3.24	0.024	2.23	0.031	3.06
Other ethnic groups	0.015	5.87	0.015	7.28	0.028	14.61	-0.005	-2.64
Chronic limiting condition	0.027	24.37	0.021	21.41	0.014	10.69	0.023	21.15
Cannot walk	0.017	12.31	0.013	11.81	0.014	7.06	0.007	4.62
Degree of higher education	-0.021	-14.75	-0.020	-17.24	-0.059	-38.04	-0.037	-25.51
Higher education (less than degree)	-0.013	-7.93	-0.017	-10.50	-0.041	-21.82	-0.023	-12.79
‘A’ levels	-0.001	-0.40	-0.007	-4.86	-0.040	-26.24	-0.028	-17.83
‘O’ level	0.000	-0.17	-0.002	-1.74	-0.017	-13.98	-0.010	-7.48
Other	0.003	1.35	-0.001	-0.71	-0.024	-11.67	-0.012	-6.13
Income: £52,000 or more	-0.020	-4.44	-0.031	-7.96	-0.037	-7.11	-0.094	-19.00
£41,600 to £51,999	0.003	0.48	-0.009	-1.81	-0.033	-7.83	-0.056	-10.98
£31,200 to £41,599	-0.007	-1.51	-0.011	-2.68	-0.031	-7.46	-0.041	-9.81
£20,800 to £31,199	-0.005	-1.43	-0.010	-3.27	-0.018	-4.61	-0.019	-5.74
£10,400 to £20,700	0.004	1.28	0.002	0.85	-0.011	-3.39	-0.004	-1.40
Council or LA housing	0.014	8.17	0.014	9.71	0.017	13.79	0.020	15.60
LA Fixed Effects (326)	YES		YES		YES		YES	
R-squared	0.071		0.057		0.043		0.056	
Sample	1,002,216		1,002,015		1,002,039		1,002,113	

Notes: Selected coefficients from linear probability models with LA fixed effects, and associated *t*-statistics, shown. Each model has the same controls as Table 2, Column 4.

Table 7: Interactions of Age and Household Income in Linear Models of Physical Inactivity

	All		**Males**		**Females**	
	β	***t*-stat**	***β***	***t*-stat**	***β***	***t*-stat**
Log (HH Income)	-0.013	-5.02	-0.005	-1.38	-0.017	-4.06
(Age 25-34) * (Log (HH Income))	-0.009	-2.67	-0.020	-4.21	-0.002	-0.49
(Age 35-44) * (Log (HH Income))	-0.016	-4.63	-0.028	-5.53	-0.010	-2.04
(Age 45-54) * (Log (HH Income))	-0.026	-6.83	-0.042	-8.27	-0.017	-3.58
(Age 55-64) * (Log (HH Income))	-0.027	-8.18	-0.044	-10.04	-0.023	-4.39
(Age 65-74) * (Log (HH Income))	-0.046	-11.80	-0.068	-11.62	-0.034	-6.00
(Age 75-84) * (Log (HH Income))	-0.036	-7.25	-0.050	-6.68	-0.025	-3.37
(Age 85+) * (Log (HH Income))	0.004	0.42	-0.006	-0.41	0.008	0.48
LA Fixed Effects (326)	YES	YES	YES	YES	YES	YES
Sample	745,997		327,811		418,186	

Notes: Selected coefficients from linear probability for log household income, and interactions between age dummies and log household income shown. Each model has the same controls as Table 2, Column 4. Cases with missing household income are dropped from the estimation sample.