A Socioeconomic Profile of Physical Inactivity in England

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Abstract

Physical inactivity is increasingly recognized as an important precursor of chronic ill health with consequent costs for both individuals and society and potential impact on the future distribution of health. It is also recognized as a modifiable health behavior, so knowing who is physically inactive is important for designing policy interventions to reverse the long term increase in physical inactivity. Many studies have examined the correlates of physical inactivity in wealthy economies and identify socio-economic position and aspects of the physical environment as important. However, most studies of physical inactivity are small scale and therefore unable to disentangle different facets of socioeconomic position or separate out local area supply and demand and geographical configuration, all of which are argued to be important determinants of physical inactivity, from individual socio-economic position. In this paper we exploit rich data on over one million individuals in England to separately identify the association between physical inactivity and different aspects of socio-economic position (SEP), controlling for local geographical factors. Our analyses show extremely high levels of physical inactivity and clear separate associations with important dimensions of SEP. Gender, ethnicity, education and household income are all independently associated with inactivity, controlling for local availability of facilities, the local weather and geography. The income gradient increases with age and more financially costly forms of physical activity are associated with larger SEP differences, suggesting that financial as well as cultural barriers need to be overcome to reduce inactivity.

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I. Introduction

Physical inactivity internationally is increasingly recognized as an important precursor of chronic ill health with consequent costs for both individuals and society (Das and Horton, 2012). Estimates of these costs are large: the World Health Organisation estimated that physical inactivity causes 1.9 million deaths per year worldwide, about 10 to 16 percent of breast cancer, colon cancer and diabetes cases, and about 22 percent of coronary heart disease (WHO, 2004). Physical inactivity is also recognized as a modifiable health behaviour for chronic disease and potentially the most important, for example, Scarborough et al (2011) argue that of the four modifiable causes of smoking, alcohol, diet, and lack of physical activity, low physical activity is the most prevalent chronic disease risk factor. As a result, governments across the developed (and increasingly the developing) world are seeking ways to decrease physical inactivity (e.g. WHO 2007). Knowing who is physically inactive is important for designing cost effective policy interventions to reverse this rise in inactivity (Hamer, 2012). In addition given the long term consequences of physical inactivity, identifying those who currently are inactive informs, in the absence of successful policy intervention or behavior change, future socio-economic position (SEP) related inequalities in health.

Many studies have examined the correlates of physical inactivity in the developed world. SEP and aspects of the local physical environment are repeatedly identified as important (Frost et al, 2010; van Dyck et al, 2010; WHO, 2007; WHO, 2004; Giles-Corti and Donovan, 2002; Humpel et al, 2002). However, most studies of physical inactivity are based on relatively small scale samples (e.g. Varro et al 2003 which surveys around 1,000 people in 15 European Union Countries. Saffer et al, 2011 is one exception which uses a sample of 76,623, 29,234 of which have health data, from American Time Use Surveys – we discuss this more below). While these studies can therefore draw attention to SEP as a determinant of lack of physical activity, they are generally not able to disentangle the individual association of different facets of socio-economic position (SEP) or to separate out 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 address this lack of evidence by exploiting a unique data set on over one million individuals in England. These individuals are asked extensive questions about their physical activity in the last four weeks and provide detailed information on their socio-economic position. The large sample size and the associated geographical identifiers allow us to control for local area configuration and match in information on local area attributes that may facilitate participation independently of individual SEP, such as the availability of sport and exercise facilities and the distribution of green space. This detailed local information enables us to identify the association between physical inactivity and different aspects of individual SEP, controlling for local geographical factors which may affect the costs of physical activity.

Our analyses show the following. First, on average levels of physical inactivity in England are very high. Just over 8 percent of the adult population does not even walk for 5 minutes continuously in a four week period and nearly 80 percent 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 socio-economic gradient even for activities that have low direct cost (for example walking) and the more costly the activity, the larger the socio-economic gradient. Third, different aspects of SEP disadvantage (gender, ethnicity, education and household income) are independently associated with 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, whilst local area characteristics are significant and the direction of their impact seems sensible, they do not explain a great deal of the differences in activity levels over and above individual and household characteristics.

II. Background

A. The 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 (for example, U.S. Department of Health and Human Services 1996, World Health Organisation, 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 activity 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) and 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). Min Lee et al (2012) estimate that up to 10 per cent of all deaths from NCDs are caused by a lack of physical activity and that 9 per cent of premature mortality (5 million of 57 million deaths annually) is due to a lack of physical activity, which is approximately the same number of deaths as caused by tobacco. Das and Horton (2012) go further arguing that physical activity contributes to individual physical and mental well being overall and to improving quality of life. Hallal et al (2012) argue that both genders, all socioeconomic groups, and all ethnic groups can benefit by increasing physical activity.

The first US Surgeon General's Report on Physical Activity and Health, released almost 20 years ago in 1996, recommended that adults engage in thirty minutes of moderate physical activity at least five days per week and 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. They postulate that this is because it is only seen as a risk factor for obesity[1] but recent research suggests this is too narrow a view. 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 emphasized the harm from smoking and there is a WHO Framework Convention on Tobacco Control (WHO FCTC, 2003), ratified by 175 countries. In contrast, there are seen to be few concerted efforts to increase physical activity, even though prevalence of inactivity is higher than smoking internationally and more preventable deaths are attributable to lack of activity. Government programmes to increase exercise are often seen as useful, but not essential.

B. The association with socio-economic position

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 socio-economic position. 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, 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 financial costs and the indirect financial costs of activity are higher for individuals with lower incomes.

Second, also from a health production perspective (Grossman, 2006), education increases the productivity of a given set of healthcare and other inputs, so from this perspective 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 lower general physical amenities and higher crime rates that also make physical activity more difficult (Gomez, 2004). Fourth, there are strong cultural dimensions to participation in physical activity (Wilbur, 2002; Arredondo, 2012).

C. The empirical literature and its limitations

The empirical literature is large and comes from a variety of academic disciplines. Empirical studies have drawn attention to the consequent association between socio-economic status and physical activity and local geography in many different countries and settings. We highlight here the findings and concerns from systematic reviews and recent studies. Gidlow et al (2006) undertook a systematic review of the relationship between physical activity and socioeconomic position (SEP) in an attempt to identify SEP gradients. They identified twenty eight cross sectional and five longitudinal studies, published from 1991 to 2004, although data were used from up to 20 (and in one case up to 40) years earlier. Regardless of the indicator of SEP, there was consistent evidence of higher prevalence, or higher levels, of activity in those of a higher SEP, compared to those of a lower position. [2]

In terms of the relative contribution of dimensions of SEP, Gidlow et al (2006) note that education was the most commonly used indicator of SEP. Later, larger cross national studies have confirmed the association with education, for example, de Almeida et al (1999) in a study of 15,239 subjects in 15 EU countries found higher

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[1] Obesity itself has been shown to be associated with a large range of problems. Not only is it a major risk factor for heart problems, diabetes and cancer but it also gives rise to problems related to psychological health (Averett and Korenman, 1999), productivity, wages (Cawley, 2004; Baum and Ford, 2004) and absenteeism (Bungum et al, 2003).

[2] Education has also been found to be an important determinant of leisure (as distinct from work) physical activity (for example, Borodulin et al (2008) who found, in a cross sectional sample of 1,940 men and 2,497 women in Finland using self-reported data on education and leisure time physical activity, that those with lower education levels were less likely to undertake activity than those in the middle or high education groups).

levels of activity participation in those with a higher level of education. Recent studies have also examined longitudinal data. Hamer et al (2012, forthcoming) use data on 394 healthy men and women from the Whitehall II cohort study from baseline in 1997 through to follow up in 2010. They find a relationship between physical activity and levels of education, but not social position, associated with objective measures of physical activity and sedentary behavior. They conclude that the gradient in leisure time physical activity can be explained by knowledge gained through education. In another longitudinal study, Cleland et al (2009) using a two time points for a cohort of 2,185 Australian adults find the impact of childhood SEP to be important in terms of physical activity and fitness. Upward social mobility was associated with a greater likelihood of increased activity, and persistently high SEP was associated with greater likelihood of increasing activity from childhood to adulthood. The authors conclude education may be one pathway through which physical activity and fitness could be improved.

Gidlow et al (2006) noted that a small number of studies also reported a gradient across social classes. However, most studies used only three categories of social class, making identification of gradients 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 only used three or fewer categories of income group, making it difficult to identifying accurate gradients. Studies have also identified the importance of local area factors. For example, Parks et al (2003), in a cross sectional study of 1,818 US adults, found that those on a lower income are less likely to meet physical activity recommended levels, as were those in rural settings. Urban, higher income individuals were twice as likely to reach recommended physical activity levels. The importance of environmental factors, such as places to exercise, also varied across income groups. 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. They found that availability of facilities such as parks, sports areas and pools was significantly associated with ethnicity and SEP. The HABITAT multilevel longitudinal study (Turrell et al, 2010) examined associations between neighborhood disadvantage and physical activity for a sample of 11,037 individuals in 200 neighborhoods in Australia. Those in advantaged neighborhoods had significantly higher levels of total, moderate and physical activity, as well as walking. Those in advantaged neighborhoods were more likely to exceed physical activity recommendations. However, Giles-Corti and Donovan (2002) report in a cross sectional study of 1,803 Australian adults, that even when those in lower SEP areas have superior access to facilities, they are less likely to use them than those in higher SEP areas.

However, it is also clear that the existing literature has limitations. Often education is better measured than income or social class and as a consequence is seen as providing robust results that are less susceptible to confounding (Gidlow et al 2006). However, this does not mean that income or other measures of SEP are unimportant. Even studies which have adopted explicitly quantitative approaches tend to have relatively small samples. Very few use data on more than 20,000 persons, partly because the studies of physical activity often use data sets collected for the express purpose of measuring the relationship between physical activity and neighbourhood attributes and collection of the latter is time consuming and costly. This means in some cases the studies focus only on one city, identifying variation from between different areas in the city (e.g. van Lenthe et al (2005) who examine the association between the neighbourhood socioeconomic environment and physical inactivity, and the contribution of neighbourhood characteristics to this association, in 78 neighbourhoods of Eindhoven, The Netherlands, with a sample size of 8,767). An example of a large study is Harrison et al (2007) who used 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 responders 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. Saffer et al (2011), as stated earlier, do use a larger sample of 76,623 adults using the American Time Use Surveys, drawn from the monthly Current Population Surveys from 2003-2009, of which 29,234 have associated health data. Studying racial, ethnic and gender differences in physical activity, making use of all inclusive (work and non-work) measures of physical activity, they find that non work physical activity is significantly lower for non-white racial groups, and lower for males. These differences are consistent with differences in these groups in health. Between a quarter and half of these differences can be put down to differences in SEP, education, time constraints and location fixed effects. Work PA has a negative effect on non-work PA, and work PA is significantly lower among Asians and higher among other groups relative to whites. Between one third and half the differences in work and non work PA can be put down to human capital, time constraints and locational choices, but substantial differences remain. They conclude that it is important to differentiate between different forms of PA, and reducing differences may help mental and physical health inequalities, as non-work PA improves these measures.

In conclusion, Gidlow et al (2006) note that many of the studies to date have used diverse, and often crude, measures of activity and socioeconomic status, making it difficult to establish robust effects. They 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 call is 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). It is argued that there are several methodological weaknesses and inconsistencies in the literature that make drawing conclusions difficult. These included variation across studies in the definition of outcome measures and lack of use of area level data.

C. Our research approach

In the present study we seek to overcome the limitations of existing studies by using a data set containing over one million individuals, representative of the adult population of the UK. To our knowledge, the scale of our data differs from all other studies of physical activity. The data set has a number of important advantages. First, the number of observations in the data allows us to establish the patterns in lack of physical activity by various correlated aspects of SEP – gender, ethnicity, education, income - to establish whether each aspect of SEP contributes independently to differences in inactivity levels. Second, the data set examines up to 252 activities which allows us to examine the most common activities and to undertake analysis separately for physical activities which vary in their direct cost, so allowing us to go some way in separating out a price from an income effect (even though we do not observe the actual price individuals paid for the activity). If there is a price as well as an income effect, we would expect that income has a greater effect on lack of participation in physical activities which have higher direct costs. Third, the large sample size means we can examine whether the gap across SEP increases with age i.e. 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 from individual characteristics by allowing for fixed local effects in our examination of the association of activity with SEP. Finally, by matching the data at local level to data on availability of sports and recreation facilities and other factors that may affect physical inactivity (such as the local weather), we can assess whether and to what extent these factors contribute to an SEP gradient over and above individual and household characteristics.

The UK is a good case study. It is one of the least physically active nations in Europe (de Almeida and Afonso, 1999). Over 60 percent of men and 70 percent of women do not meet the UK government's standards for daily activity levels. By some objective measures (using accelerometers), a shocking low level - only 6 percent of men and 4 percent of women - reach the Department of Health's recommended levels for activity (Department of Health, 2011). Partly as a result of this inactivity just over one quarter of the adult English population is obese and 44 percent of men and 33 percent of women are overweight (Department of Health 2011). The health implications of these increases in obesity alone are large. As a simple example, the number of admission episodes in NHS hospitals with a primary diagnosis of obesity among people of all ages was 10,571 in 2009/10. This is over ten times as high as the number in 1999/00 (979) and more than 30 percent higher than in 2008/09 (7,988) (Department of Health 2011). Estimates for England suggest that the direct costs to the public purse of obesity alone are around 1.3 percent of *all* Government public spending and estimates of the additional indirect costs of physical inactivity (excluding obesity) are upto £8 billion (Allender, 2007).

There have been several recent studies of the relationship between physical activity (or lack thereof) and SEP for England or the UK. Sport England (2010) is one of the few quantitative analyses of the data we use in the paper. It uses the Active People Survey (APS) for one year (n=251,022) to estimate a model of individual's achievement of the government's key national target indicator for sport participation (NI8, see below). It examines this as a function of individual and household level variables, local authority sports and funding variables and the weather. It also examines participation in 11 sports including cycling and swimming. The paper finds income, education, household composition, car ownership, and local authority funding to be independently correlated with achieving the NI8 national target. It also shows that participation in specific sports tends to be associated with different socio-demographic characteristics. However, as the report exploits only one year of data, despite including a large range of variables the models fit quite poorly and few local authority (LA) level variables are significantly correlated with the NI8 outcome. Further, it does not focus on the role of SEP or examine the income-age gradients, control for area level income when examining the role of household income, nor control for unobserved LA heterogeneity, year or month effects. Thus the analysis is essentially quite preliminary, descriptive and not focused on the SEP gradient. This analysis does support the work of an earlier study looking at SEP factors determining participation in sport in England, using a sample of 6,467 individuals in 3,811 households from the 1997 Health Survey of England (Farrell and Shields, 2002). Using random effects probit models they found sporting participation positively related to household income, that the educated participate more, and there is no evidence of regional differences, all things we are able to examine in further detail below, given our much larger sample and range of available variables. In terms of absolute sedentary time (i.e. not just a lack of physical activity, but behaviour with low energy expenditure such as watching television), adult men and women report similar levels (around 33 percent are sedentary for six or more hours a day during the week, with rates nearer 40 percent at weekends). There appears to be a more clear gender difference among children, with patterns varying across age groups (Department of Health, 2011). Broderson et al (2007) find that there are ethnic and SEP differences (for girls) in levels of physical activity for a sample of 5,863 UK adolescents, with physical activity declining over time with these ethnic and SEP differences being established by the age of 12. Williams et al (2011) find that low levels of physical activity in UK South Asians may be contributing to their much higher levels of coronary heart disease. There are also geographical differences in physical activity, but no clear pattern (Department of Health, 2011).

III. Data and research design

A. Data

Our data comes from the Active People Survey (APS), which is collected annually for a large sample of English adults aged 16 and over, commissioned by Sport England. The data are cross-sectional in nature; interviews are spread evenly across the 12 months of each survey period; the survey is conducted by telephone using Random Digit Dialing; various piloting stages were undertaken to make sure of the quality of the data; one person age 16 or over is randomly selected from eligible household members; and the average response rate is around 25 percent. Local authorities (the primary level of local government in the UK) are identified in the data and local authority proportion weights are provided. Most importantly for this study, the survey contains detailed measures of participation in physical recreation and sport undertaken in the last four weeks prior to interview, as well as collecting a wide-range of individual and household level demographic and socioeconomic characteristics. On the official APS website, the survey is described as providing "by far the largest sample size ever established for a sport and recreation survey and allows levels of detailed analysis previously unavailable. It identifies how participation varies from place to place and between different groups in the population". One principal use of the data is to provide progress information on a number of the government's Key Performance Indicators (KPIs), and local area estimates for adult participation in sport and active recreation.

Sample

To date there have been five waves of data released for analysis. The data collection for each APS runs from October to October each year, with APS1 (October 2005 to October 2006), APS2 (2007 to 2008), APS3 (2008 to 2009), APS4 (2009 to 2010) and APS5 (2010 to 2010). No APS ran from October 2006 to October 2007. The largest sample was collected in APS1 (n=363,724), with 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 asking individuals to report their household income. However, questions relating to general health status and life satisfaction were included in APS5 for the first time. Adults living in 354 English Local Authorities (LAs) are identified in APS1-4, with the number being reduced following Government merging of a number of authorities to 326 in APS5. In this paper we have recoded the LA's in APS1-4 to be consistent with APS5, thus we use variation across 326 LAs in this study. 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 (or 91 percent 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.

Dependent variables

We use a number of alternative measures of physical inactivity. Our main measure is constructed using information about respondents' walking, cycling and any other types of physical recreation or sport 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 5 minutes, which also identifies individuals who report not to be able to walk, 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 that 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 to have 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 examine the constituent parts of the our main inactivity measures, namely, whether the respondent (1) has not done at least one continuous walk lasting 5 minutes, (2) has not done at least one walk of a 30 minute continuous duration for health or leisure purposes, and (3) has not done at least one cycle ride of a 30 minute continuous duration for health or leisure purposes. We also focus on two other common types of physical activity in England, which are swimming or using a gym. Finally, using information on each type of activity recorded, plus information on the length and intensity of participation, the key participation KPI is constructed in the data files, and used to measure progress on National Indictor 8 (NI8). This is 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 separate between (1) no days, (2) less than 4 days (an average of less than one episode per week), and (3) the NI8 measure of less than 12 episodes (an average of less than 3 episodes per week) in the last four weeks. The survey covers a wide range of recreational activities (including gardening) but does not ask explicitly about occupational physical activity. 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 targets than those in non-manual jobs. Similar patterns were observed for women. There were also age effects with a large reduction in occupational activity after retirement. This omission means that our data may lead us to underestimate 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 overcome this we deliberately include analysis of a very minimal level of the most common physical activity (whether the individual has walked for five continuous minutes).

Covariates

We are primarily concerned with establishing the extent of the relationship between socioeconomic status and physical inactivity. To do this we use measures of SEP at the individual, household and local authority levels. Our key individual-level measures are highest educational attainment and current employment status. The 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. To identify SEP at local area level (local authority) we have mapped in the index of multiple deprivation (IMD) to each Local Authority in the data set. The IMD is a measure of deprivation of the population across 6 domains including income, education and health and calculated by the Office for National Statistics at various local levels. We use the LA deprivation index scores calculated in 2007, which is about in the middle of our sample window. The other key 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 household), (5) having a chronic health condition, and (6) reporting not being able to walk. We are also interested in establishing the relationship between local area characteristics (at LA level) and inactivity. To this end we map a range of measures at LA level. These are LA crime and unemployment rates, a measure of how urban the LA is, the percentage of green space in the LA (from SEPHO, see http://www.sepho.org.uk/), the number of various types of sports facilities in the LA, the amount of money received by the LA from the National Lottery for the purpose of increasing physical activity and a measure of local population satisfaction with the LA recreational facilities. Finally, the data allow us to identify year and month of the interview, which allows us to match weather data (as this may affect the level of outdoor activities even conditional on the month of the year) for the date (month) in which the respondent took part in the survey.

Sample Characteristics

Table 1 presents summary statistics at the individual level. The first two blocks of Table 1 present our range of inactivity measures. This confirms the high levels of physical activity found in earlier studies of the UK population. Nearly 20% of the sample did not do any sustained exercise in a 4-week period. In terms of national government targets for physical activity, 50% of the sample did not meet the least demanding of the national targets, while nearly 80% did not meet the key national target of moderate exercise 12 times in a 4-week period. Just under 10% did not even walk for 5 minutes continuously in the previous 4 weeks. Mean levels of participation in even the most common recreation activities were very low; 47% had not walked for leisure for 30 minutes continuously, 88% had not swum and 905 had not used a gym.

Research design

We focus on key SEP variables at the individual level - gender, household income, highest qualification and ethnicity. We begin by undertaking simple graphical analysis of the patterns in inactivity to examine whether there are differences in inactivity across these, separately for men and for women. We then repeat this focusing on differences by geographical area, where we examine regional differences, and differences by deprivation of the LA. We 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 local authority effects. This allows us to examine whether different aspects of SEP have an independent effect on the risk of lack of physical inactivity after controlling for the correlation between measures of SEP and other possible confounders. To do this we undertake the following regression at the individual level (subscripts for the individual dropped for ease of presentation):

(1) $Pr\ (PI) = b_o + b_1X_1 + b_2X_2 + b_3Z + b_4LA + v$

where pr(PI) is the probability of being physically inactive (variously defined), X_1 is a vector of individual SEP measures (age, gender, ethnicity, household income in bands, highest educational qualifications), X_2 a vector of further controls that may be correlated with individual SEP, 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 take out inflation) and

LA is a set of LA fixed effects.

We estimate (1) as a linear probability model, as we have a large number of observations and wish to include local authority fixed effects, making estimation of a probit model potentially problematic. 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. To examine the effect of non-time varying local authority characteristics, we re-estimate (2) without LA fixed effects but including dummies for the 9 broad administrative regions of England and LA level measures of SEP, crime, sport and recreation resources and physical characteristics. To test robustness to functional form we estimate this model with no LA fixed effects as both a linear probability model and a probit model. We then estimate separate empirical models for the constituent parts of the our main inactivity measures to show that the SEP gradient in our inactivity measure is closely related to that for important government targets, to examine whether the gradient varies across the most common forms of physical activity and how it changes as the direct cost of the activity increases. Finally, to examine the income-age gradient we re-estimate (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.

IV. Results

Patterns in the data

We begin by plotting the relationship between our measure of inactivity and the percentage of the population that are obese at local authority level. Figure 1 shows there is a strong positive relationship, suggesting our physical inactivity measure has informational content. Figure 2 presents patterns of physical inactivity by ethnicity, education, household income and LA deprivation, for males and females. The top panel shows clear differences across ethnic groups (as well as by gender). With the exception of those of Chinese ethnicity, all groups are more inactive than whites. The differences are particularly marked for those of South-East Asian ethnicity (Indian, Pakistani and Bangladeshi). Twenty percent of white women and 17 percent of white men do no physical activity. The comparable figures for those of Pakistani ethnicity are nearly 30 and 25 percent. Differences between men and women vary across ethnic groups: there are particularly large gaps between men and women of Black African or Caribbean origin.

The next panel shows the gradient by education. Degree educated men and women only have a 12 percent chance of being physically inactive, whilst those with no qualifications are 3 times as likely to be inactive. The next panel shows these differences are also present by household income: those with lowest income have more than a 30 percent chance of doing no physical activity whilst those in the highest group have a less than 10 percent chance. The final panel shows these SEP differences are also seen when a measure of local area SEP is used. Around 15 percent of individuals in the least deprived local authorities do no physical activity; while over 20 percent of those in the most deprived LAs do none. These three panels also show that the male-female differential remains controlling for SEP such that within SEP category women do less activity than men. The final figure examines differences by income across age, focusing just on differences between those in the lowest income band and those in the top. The top panel shows the differences for men, the bottom the differences across women. 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 percent of lowest income young men do no activity; only 4 percent of highest income young men do none. The comparable figures for women are 15 and 7.5 percent. Between the age extremes the income gap steadily rises with age, there being particularly large gaps as individuals approach retirement for both men and women. The relative differences shrink for the oldest age group so the gap between richest and poorest amongst men aged 85 or over is only 10%, though for women it is still 20%.[3] We conclude that the raw data shows clear and large SEP differences in physical inactivity. Women, ethnic minorities, and lower SEP individuals are all less likely to do any activity than men, those classifying themselves as white and those with highest SEP. Income differences also increase with age.

Multivariate Analysis

We now examine whether SEP and ethnicity and gender have independent effects on the probability of physical inactivity. Table 2 presents these estimates. In columns (1 and 3) we present estimates for age, gender, ethnicity and education, controlling for household composition, the individual's health status, without and then with local authority fixed effects. The clear differences by age, gender, ethnicity and education remain in this multivariate analysis, all coefficients being statistically different from zero at the 1 percent level. Columns (2 and 4) add in a range of measures of non-human income and wealth, these being current household income, tenure, work status and occupation. Again, all the coefficients are very well defined. There are clear gradients within all these measures of SEP. Individuals with higher SEP are less likely to be inactive, with the exception of those in full time

[3] Survivor bias is likely to narrow this gap at oldest ages.

work, who are more likely to be 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 income, 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 5 percentage points and between the highest and lowest income categories in the order of 4 percentage points.

Columns (5) and (6) repeat this analysis for men and women separately controlling for LA fixed effects. These show that, differences by education, income and 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 inclusion of a large set of other individual and LA controls, particularly the large gap between women and men of African or Caribbean heritage. We then replace the local authority fixed effects with measures of recreational facility supply and expenditure and local geographical configuration (results not currently shown in Table 2). The results indicate that the overall explanatory power of the model in column (4) is very similar, showing that these measures are associated with local authority differences in mean activity levels. 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 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 are individuals within it to be physically inactive. Higher LA unemployment and crime is associated with higher inactivity, while the greater the number of sports facilities and the higher expenditure and satisfaction, the less likely individuals are to be inactive (with the exception of sport 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 go to 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. We also find that in England, physical activity is affected by rain and temperature, over-and-above controlling for month of interview.

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 estimates change very little. Importantly, clear gradients in all the separate aspects of SEP remain. In Table 3 we test that our results are robust to exactly how physical inactivity is defined. We replace the overall measure of inactivity used in Table 2 with three specific measures of physical inactivity that are government targets. 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 estimate models for (a) no days (column (1) of Table 3), (b) less than 4 days (column (2) of Table 3 and (c) the NI8 measure of less than 12 episodes (column (3) of Table 3) in the last four weeks. We present only the estimates for the individual measures of SEP that are our focus, but each model controls for the same extended set of controls as Table 2, column (5), and includes LA fixed effects.

Age, ethnicity, gender, education and income differences are evident for all three measures and are also very similar to those seen for our global physical inactivity measure in Table 2, indicating that our measure picks up the public health issues embodied in the national measures. Presentation of the three measures also allows comparison of the SEP gradients as the definition of physical inactivity becomes more absolute. Comparison across the columns of Table 3 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 meet the key national target than whites. Differences by income group across the three measures also exist. As we do not have measures of price, the income associations we observe will be picking up a mixture of an income effect (that individual 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 get some handle on this. We cannot control directly for a price effect. However, our detailed data means we can examine cheaper and more expensive 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. For the lowest priced activities we essentially recover the income effect uncontaminated by a direct price effect. In addition, by looking at cheap 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 measure of overall physical inactivity, walking and the three most common activities (cycling, swimming and using the gym). Walking is least costly and the other activities are more expensive (though in some cases still relatively low cost).

Within walking we examine three definitions of lack of walking activity. In Table 4, in column (1) we present estimates of whether the respondent (1) has not walked continuously for 5 minutes in the last month. This is an extremely minimal measure of activity. In column (2) we examine whether the respondent has not walked for 30 minutes continuously and 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 the associations with our key SEP measures of age, gender, ethnicity, education and income, but our estimates include all other controls.

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 inactivity examined in Table 2. Further, there is no income effect. This suggests that while there is a SEP gradient in doing no walking at all it is also correlated with factors we do not observe in our data. This is confirmed by the lower explanatory power of the model. 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 walking more than no walking at all is socially graded. But not walking for 30 minutes is still not strongly associated with income: the income gradient in column (2) is very small. However, 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.[4] 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, swimming or 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 5 presents these estimates. We present the education and income estimates only. 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 activities. This suggests that price does deter 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 6 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 (2). Column (1) pools men and women. The first entry in column (1) shows the effect of income. The coefficient estimate shows that a 10 percent increase in income reduces the change of being inactive by 13 percentage points. The remaining columns show that differences by income widen across each age group. The differences are highest amongst those of just post retirement age and fall a little thereafter. This 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 (unobservedly) better health. Columns (2) and (3) present the estimates for men and women respectively to allow examination of whether the income gradient differs by gender. While the same gradient is evident for both men and women, it is less steep for women, whilst the overall effect of income is higher for women. Thus income differences across men when young are small, but increase with age, whilst income differences in women exist but remain more constant across cohorts.

V. Discussion

We exploit a very large data set to examine the patterns in physical inactivity in the English population. Our large data allow us to separate out the various aspects of SEP that have been conflated in smaller scale studies and to control for differences at local level in geography, 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 percent of the population over age 16 do minimal levels of physical activity and 8 percent do not even walk continuously for 5 minutes per month. The second is that this physical inactivity in England has a large SEP gradient however SEP is defined. We show clear evidence of independent disparities by gender, ethic 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 by income widening across age with the largest differences occurring in those who are upto 10 years post statutory retirement age. Finally, we find statistically significant and sensible signs on local area characteristics, but these explain little in terms of increased fit of models with no controls for area.

Our data, while rich, do have the limitation that they do not ask individuals explicitly about work related physical activity. Studies have shown this to be socially graded, such that poorer and lower income individuals do more work related physical activity. However, one study that explored work and leisure physical activity in some detail

[4] 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.

concluded that the major contributor to SEP differences in total physical activity is non-work related activity (Saffer et al 2011). And while we do not examine on the job physical activity, we are able to look at definitions of (lack of) walking and cycling that include walking or cycling to work as well as for leisure. We find SEP gradients in these activities too. 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 (as we have controlled for these with our LA controls). 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

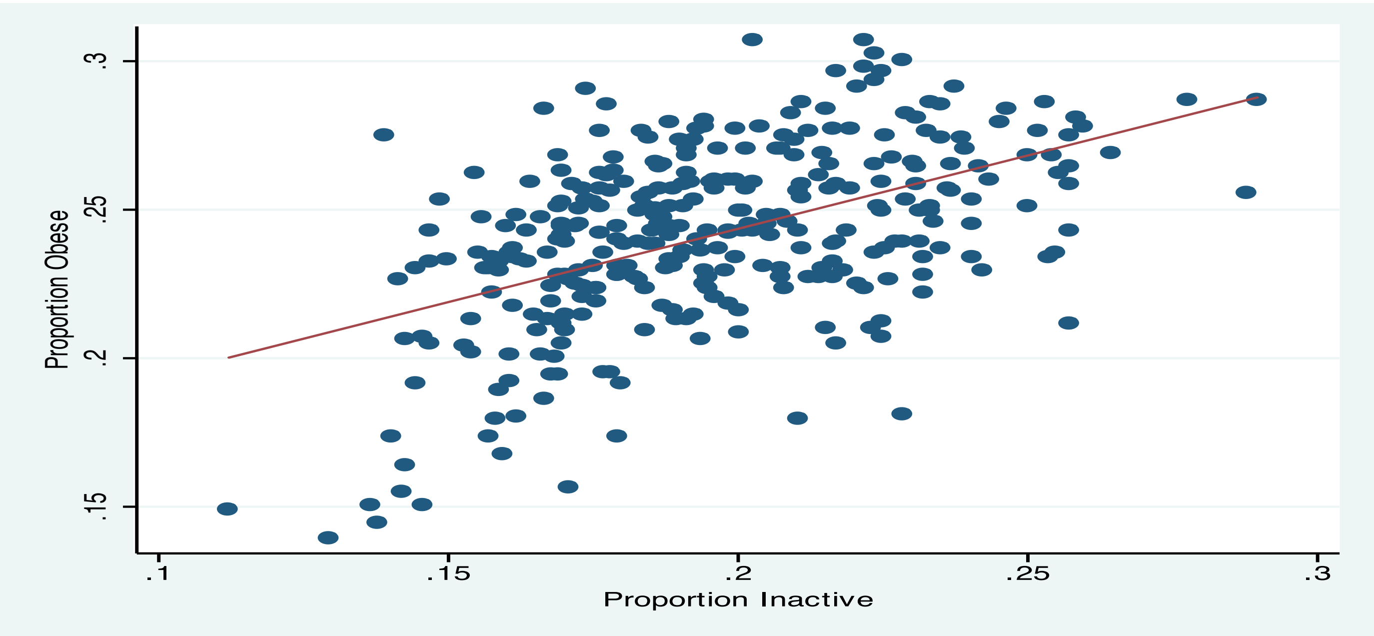
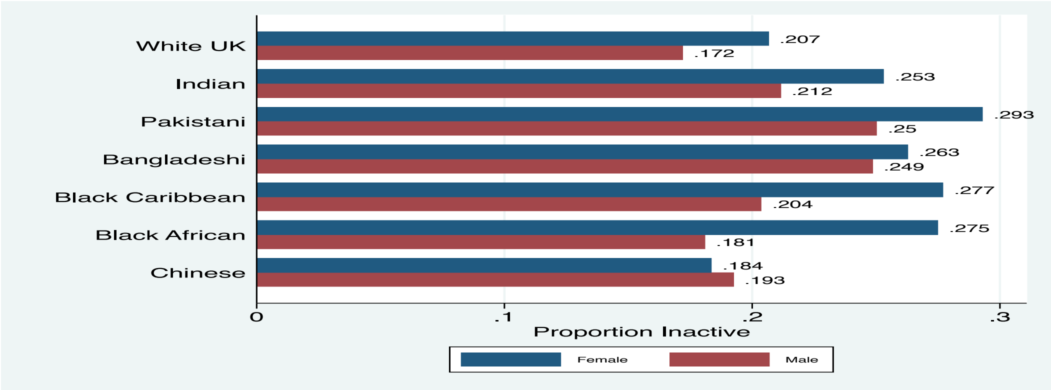
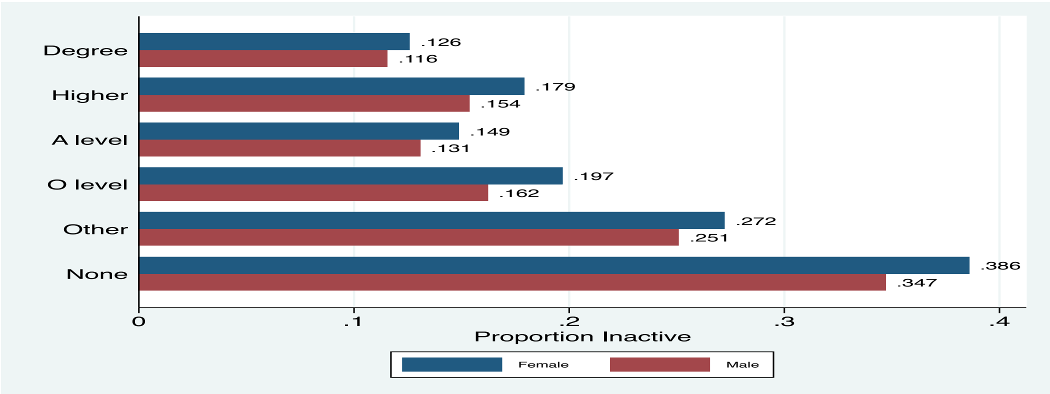


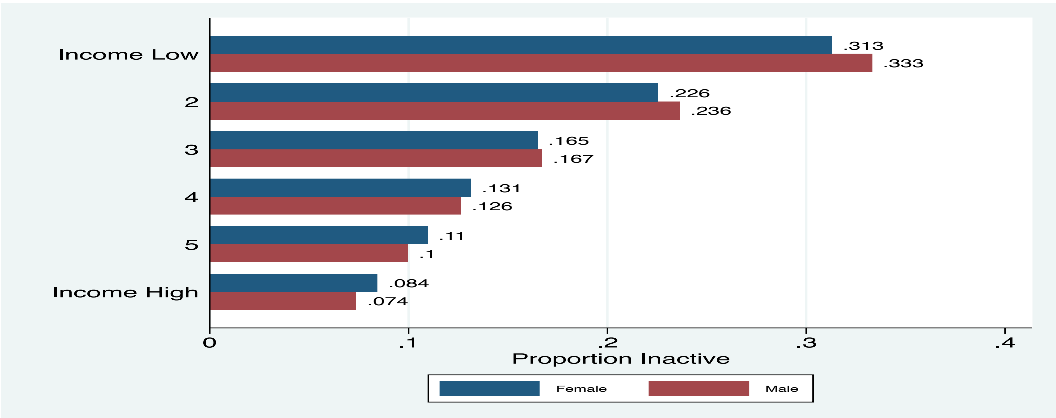
Figure 2: Proportion Physically Inactive by Ethnicity, Highest Qualification, Household Income and Local Authority Deprivation Decile
Panel 1



Panel 2



Panel 3



Panel 4

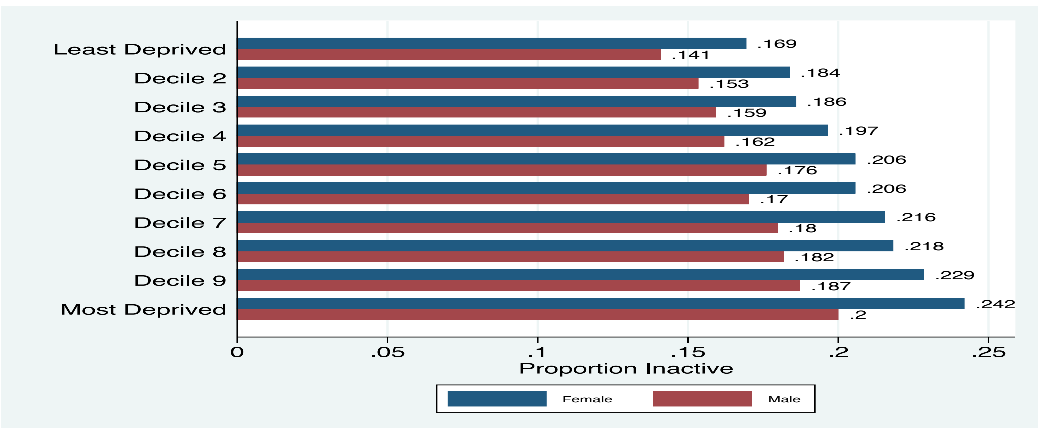
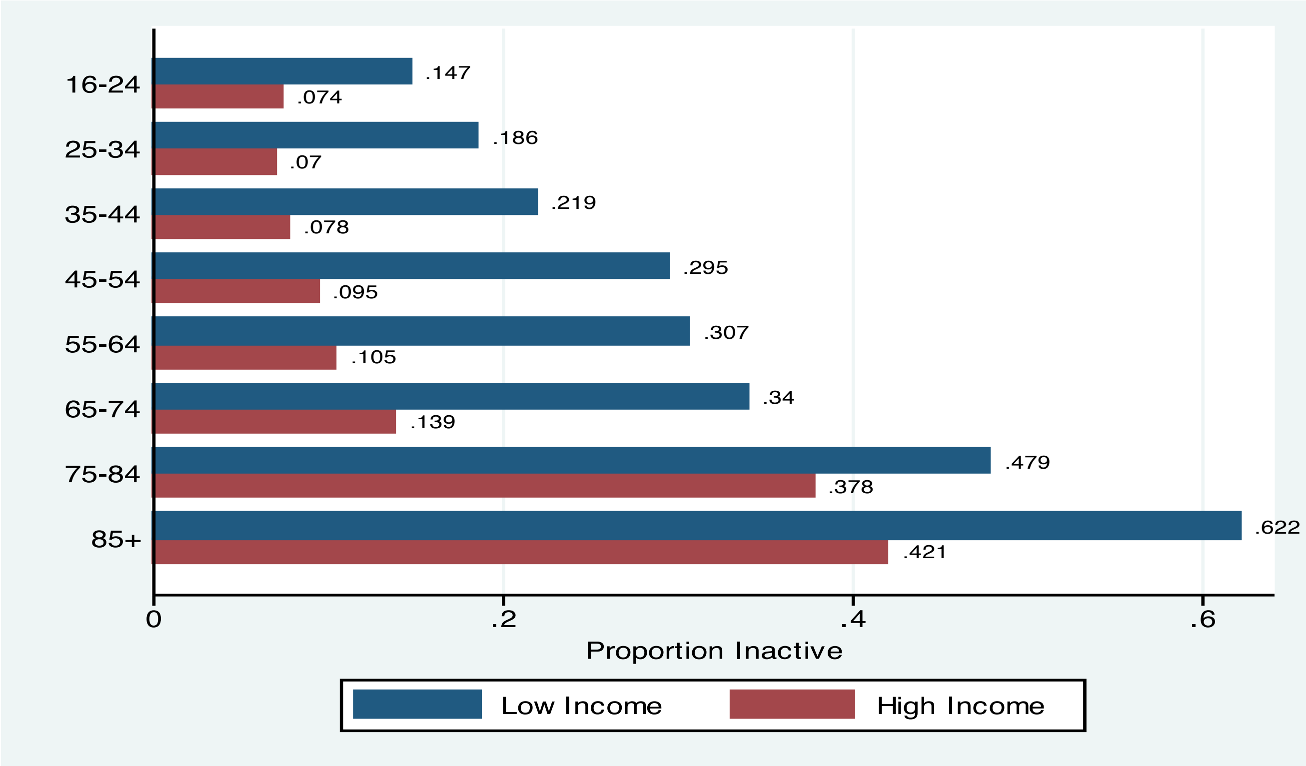


Figure 3: Proportion Physically Inactive by Age and High/Low Household Income
(Top Panel = Males; Bottom Panel = Females)

Panel 1



Panel 2

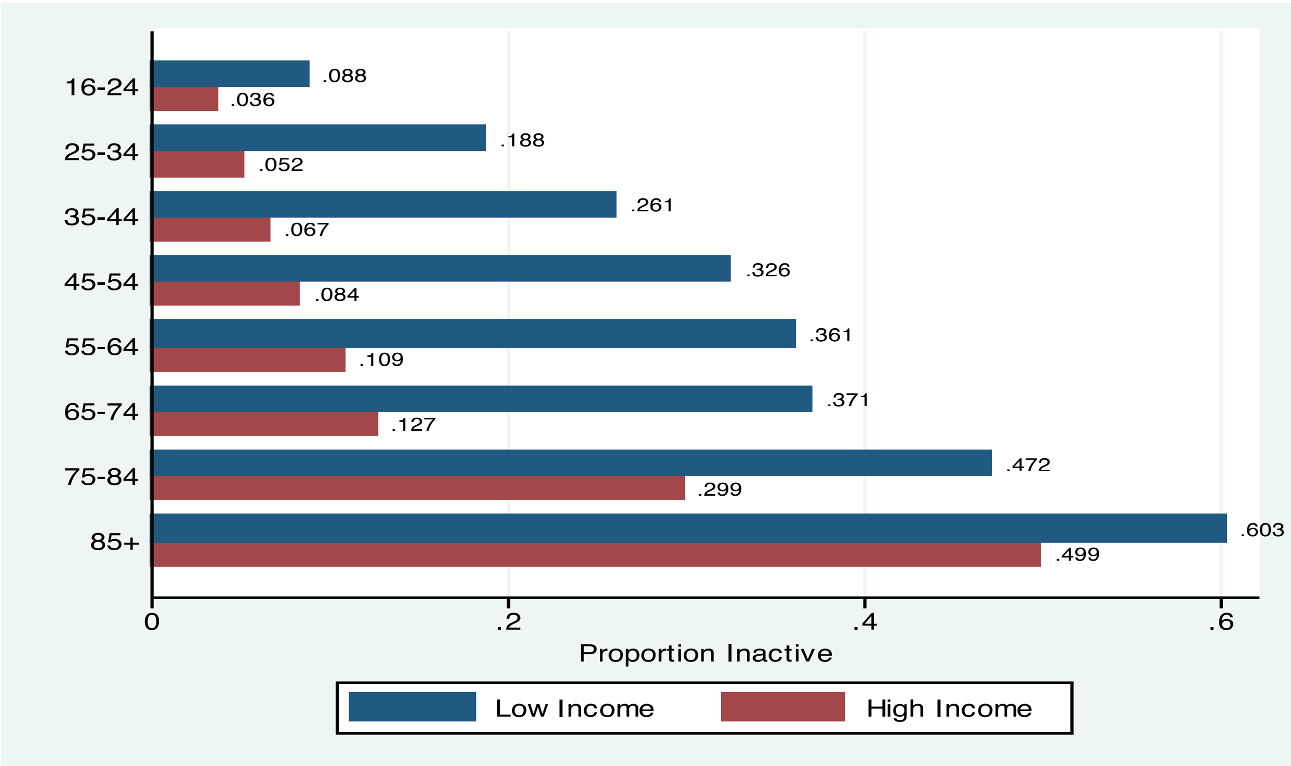


Table 1: Sample Characteristics: Covariates and Physical Inactivity Measures

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	Northeast	0.063	0.242
Indian	0.014	0.117	Northwest	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	Southwest	0.121	0.326
Other ethnic groups	0.060	0.046	Southeast	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)	0.239	0.426
Child aged 5-10	0.141	0.348	Urban 2 (More Urban)	0.129	0.335
Child aged 11-15	0.128	0.334	Urban 3	0.152	0.359
Log household Size	0.689	0.554	Urban 4	0.145	0.352
Chronic limiting condition	0.179	0.383	Urban 5	0.141	0.348
Cannot walk	0.015	0.123	Urban 6 (Most Rural)	0.194	0.396
Degree of higher	0.307	0.461	Log (% Green Space)	4.183	0.441
Higher (less than degree)	0.100	0.301	Log (Unemployment Rate)	1.664	0.325
‘A’ levels	0.158	0.364	Log (Total Crime Rate)	2.940	0.352
‘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)	-0.772	0.590
No qualifications	0.164	0.370	Log (Health Suites per 10,000)	0.092	0.490
£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	Log (Mean Precipitation)	0.532	0.676
<£10,400 per annum	0.150	0.357	Log (Maximum Temperature)	2.546	0.481
Council or LA housing	0.124	0.330	Log (Minimum Temperature)	1.598	1.036
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	KPI=0	0.506	0.500
Higher supervisor	0.053	0.224	KPI<4	0.592	0.491
Intermediate	0.114	0.317	KPI<12 (NI8)	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-

Table 2: Linear Probability and Binary Probit Models of Physical Inactivity (without and with LA Fixed Effects)
(1= Physically Inactive in last 4 weeks; 0 = otherwise)

	Linear Probability Models												**Probit**	
	Without LA Fixed Effects				**With LA Fixed Effects**									
	ALL (1)		**ALL (2)**		**ALL (3)**		**ALL (4)**		**Males (5)**		**Females (6)**		**ALL (7)**	
	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	-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 (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
£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)

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 provided.

Table 3: Linear Probability Models of KPI Based (NI8) Measures of Physical Inactivity

	KPI=0		KPI<4		KPI<12	
	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
Single adult	-0.008	-2.59	-0.012	-4.26	-0.015	-6.81
Child aged 0-4	0.055	20.86	0.064	27.20	0.068	26.29
Child aged 5-10	-0.033	-12.69	-0.017	-6.65	0.005	2.17
Child aged 11-15	-0.023	-8.27	-0.018	-6.43	-0.012	-4.96
Log household Size	0.009	2.69	0.007	2.05	0.004	1.63
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	-0.154	-66.27	-0.131	-59.95	-0.064	-35.58
Higher (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
£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 in the extended LA fixed effects models shown in Table 2.

Table 4: 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
Single adult	0.007	4.21	0.021	7.80	0.051	18.93
Child aged 0-4	-0.002	-1.27	0.002	0.64	0.011	4.08
Child aged 5-10	-0.006	-5.26	-0.006	-2.78	0.000	0.15
Child aged 11-15	0.000	-0.22	-0.008	-3.21	-0.015	-4.70
Log household Size	0.004	2.38	0.015	5.00	0.034	10.87
Chronic limiting condition	0.087	54.99	0.159	79.32	0.127	50.13
Cannot walk	-	-	-	-	-	-
Degree of higher	-0.051	-30.41	-0.106	-46.62	-0.150	-63.00
Higher (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
£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 in the extended LA fixed effects models in Table 2. Individuals reporting that they cannot walk are dropped from the estimating sample.

Table 5: 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
Degree of higher	-0.021	-14.75	-0.020	-17.24	-0.059	-38.04	-0.037	-25.51
Higher (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
£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 in the extended LA fixed effects models shown in Table 2.

Table 6: 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 (y)	-0.013	-5.02	-0.005	-1.38	-0.017	-4.06
(Age 25-34) * (Log (y))	-0.009	-2.67	-0.020	-4.21	-0.002	-0.49
(Age 35-44) * (Log (y))	-0.016	-4.63	-0.028	-5.53	-0.010	-2.04
(Age 45-54) * (Log (y))	-0.026	-6.83	-0.042	-8.27	-0.017	-3.58
(Age 55-64) * (Log (y))	-0.027	-8.18	-0.044	-10.04	-0.023	-4.39
(Age 65-74) * (Log (y))	-0.046	-11.80	-0.068	-11.62	-0.034	-6.00
(Age 75-84) * (Log (y))	-0.036	-7.25	-0.050	-6.68	-0.025	-3.37
(Age 85+) * (Log (y))	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 in the extended LA fixed effects models shown in Table 2. Cases with missing household income are dropped from the estimating sample.