Unabridged Methods

Study Sample

The Health Survey for England (HSE) is a repeated nationally representative study of individuals living in private households in England. We drew our sample from the 2008 HSE which had a special focus on physical activity and sedentary behaviour. The sample is drawn using multi-stage stratified probability sampling with postcode sectors as the primary sampling unit. More details of the sample design are available elsewhere (2). The household response rate was 64% for the main sample, and 73% for the accelerometer sub-sample (3). Ethical approval for the 2008 HSE was obtained from the Oxford A Research Ethics Committee (reference number 07/H0604/102). We included adults aged 16 and over who had both valid accelerometry and self-reported SB data. Participants provided written informed consent. In total, 2289 adults (1030 males) provided valid accelerometry data, with 2279 (1020 males) and 2253 (1014 males) also providing self-reported TV and non-TV time respectively. 1170 (576 males) provided occupational sitting/standing time.

Demographics and contextual variables

Trained fieldworkers assessed participants’ demographics, self-rated health, long standing illness, alcohol consumption and smoking using Computer Assisted Personal Interviewing. Height and weight were measured by the same fieldworkers using standard protocols that have been described in detail elsewhere (5). Body mass index (BMI) was computed as weight (kilograms) divided by squared height (metres).

Socioeconomic position measures

Social class was determined using the Registrar General’s classification and was grouped as I&II (professional and managerial/technical), III Non-manual, III manual, IV&V (semi-skilled manual and
unskilled manual). Household income was converted to equivalised annual household income that is adjusted for the number of persons in the household using the McClements scoring system (15). The income data presented here are based on quartiles. Highest education qualification was coded as no qualification and three levels: Level 1 represents secondary school or below (NVQ1/CSE and NVQ2/GCE O Level equivalent); Level 2 represents post-compulsory secondary school (NVQ3/GCE A Level equivalent) and Level 3 represents higher education (higher education below Degree and NVQ4/NVQ5/Degree or higher). Area deprivation was assessed using the 2004 Index of Multiple Deprivation (IMD) which provides a measure of area deprivation with deprivation based on measures in seven domains: income, employment, health deprivation and disability, education, skills and training, barriers to housing and services, crime and living environment. IMD was initially a continuous score that we grouped into quintiles (1 representing the most deprived quintile, and 5 representing the least deprived).

**Sedentary time and physical activity measures**

**Objective measures**

A random sub-sample of HSE 2008 participants were selected to wear a uniaxial accelerometer (Actigraph model GT1M, Pensacola, Florida) during waking hours for seven consecutive days. At the core addresses that were eligible for accelerometry, up to two adults in total were selected to wear the accelerometer (up to one adult in those households with eligible children). Full details of the accelerometry sample selection procedure can be found elsewhere (6). At the end of the initial HSE 2008 interview, interviewers obtained agreement for participation in the accelerometry study, provided the accelerometers and explained procedures. The accelerometry data were processed using specialist software (KineSoft, New Brunswick). In consistency with previous epidemiological SB studies (8), the sampling epoch was one minute and non-wear time was defined as periods of at least 60 consecutive minutes of zero counts, with allowance for up to 2 consecutive minutes of 1–99 counts/minute. For a day to be ‘valid’ for inclusion in the analyses, participants had to have worn the accelerometer for a minimum of 600 minutes. Like previously (7), participants with at least one day
of valid wear were included in these analyses, although the majority (76%, N=1742) had between six and seven days and 95% (N=2165) had at least three valid days. All physical activity and sedentary time variables were converted to time (in minutes) per valid day.

**Self-reported measures**

Sedentary time was assessed using a set of questions on the usual weekday time spent on: a) TV (including DVDs and videos) viewing (“In the last four weeks, how much time did you spend watching TV/videos) on an average week day?”); and b) any other sitting during non-work times, including reading and computer use (“In the last 4 weeks, how much time did you spend sitting down doing any other activity on an average weekday? Please do not include time spent doing these activities while at work”). An equivalent set of questions assessed TV and non-TV sedentary time in the weekend days. For those participants who were economically active (i.e. those who answered “yes” to the question “In the last 4 weeks, did you do any paid or unpaid work either as an employee or as self-employed (including voluntary or part time work)?”) another set of questions assessed the average daily times spent sitting/standing while at work (“On an average work day in the last four weeks, how much time did you usually spend sitting down or standing up?”). While it is not ideal to include standing as a measure of sedentary time, it is often necessitated by the unavailability of sitting-specific data, and standing is routinely included in objectively measured sedentary data as most accelerometers are unable to differentiate between time spent sitting or standing. For the purposes of this study, standing will be considered a measure of sedentary behaviour.

Physical activity was assessed using the long version of the Health Survey for England questionnaire that was used in the 1997 Survey for the first time and was repeated in the 1998, 2006, and 2008 Surveys. Questions included frequency (number of days in the last 4 weeks) and duration (minutes per day) of participation in walking for any purpose, domestic physical activity (12) (11) and any recreational exercise, (e.g. cycling, swimming, aerobics, gym exercises, dancing, team sports, racket sports) (9). Occupational activity was measured as average daily (per day at work) times spent on
walking, climbing stairs or ladders, and lifting, carrying or moving loads (5). We calculated MVPA using established metabolic equivalent tables (1). The criterion validity of the physical activity questionnaire has been demonstrated in a study of 106 English adults from the general population (45 men) where the output of accelerometers (worn for two non-consecutive weeks over a month period) was compared against the above questions (4, 13).

**Data handling/Statistical analysis**

*Regrouping the Socioeconomic position variables*

Due to small numbers of observations, the top and bottom two categories of social class were collapsed, resulting in four categories: unskilled/semi-skilled manual; skilled manual; skilled non-manual; and managerial/technical/professional. Using existing methods (10), we derived a composite Socioeconomic Position (SEP) score using household income, individual education, and occupational social class of the head of household. The lowest category of each component variable was assigned a SEP score of 0, the second lowest category was given a SEP score of 1, and so on, with the highest category given a SEP score of 4. The scores for each individual SEP indicator were then aggregated, resulting in a SEP score ranging from 0 to 12. Due to small numbers of observations in the high and low end of the score, the SEP score was collapsed into five categories of comparable size (0-3=SEP1; 4-5=SEP2; 6-7=SEP3; 8=SEP4; 9-12=SEP5), with 1 representing the lowest SEP, and 5 the highest.

*Deriving sedentary time and physical activity variables*

Week- and weekend day-specific TV and non-TV leisure time sitting were converted to all-week time (minutes) using the following formula: \((\text{weekday time} \times 5) + (\text{weekend day time} \times 2) / 7.\)

Occupational sitting/standing time (minutes) per day was calculated by multiplying the number of days worked per week by the average time spent sitting/standing at work on a work day, and dividing by 7.
Weekly self-reported MVPA hours/week were calculated as number of days of participation multiplied by time per day in each activity type (walking, cycling, and each other sport and exercise the questionnaire enquired about) (5, 6) Due to the large number of participants and the very skewed distribution, self-reported MVPA was categorised in to none, less than 30 minutes, 30 minutes to 1 hour, 1 to 2 hours, and more than 2 hours of MVPA per day.

For the accelerometry data we used 0-99 counts/minute to denote sedentary (<1.5 MET) (7); 200-2,019 counts/minute to denote light physical activity; and ≥2,020 counts/minute to denote MVPA (>3 MET) (16). Accelerometer-measured sedentary time and physical activity variables were converted to time (in minutes) per valid day.

**Missing data and multiple imputation**

To improve the normality of the residuals that are required for linear regression, outliers outside 3 standard deviations of the mean for all continuous variables apart from age were removed from the analyses. This excluded 1.3% to 2.2% of cases from each continuous variable. Due to a substantial proportion of cases with at least one missing value in at least one covariable or exposure variable (22% to 28% depending on the exposure variable) we performed multiple imputation. IBM SPSS v20 was used to conduct the multiple imputation, missing values were imputed for all covariables and exposures, with observed maximum and minimum values used as constraints. Outcome variables did not have missing values imputed, but were included in the imputation models to predict missing values in other variables. Linear regression was used as the type of imputation, and 5 cycles of imputation were conducted resulting in 5 imputed datasets. Results from these 5 datasets were combined using the multiple imputation module in SPSS to provide pooled results. The imputed sample size is limited to the number of valid observations for each outcome variable (2279 for accelerometry-measured ST, 2269 for TV time, 2253 for non-TV sitting time, and 1170 for occupational sitting time). Non-imputed results are presented in the appendix.
Dealing with non-response

Analyses were weighted for non-response (5) to give a sample that was representative of adults living in England. In brief, the non-response weights were calculated by fitting a logistic regression model (weighted by a previously developed weighting factor)(5) for all adults with interview completion as the outcome and age group by sex, household type, geographical area, and household social class as covariates. The non-response weights, which were trimmed at the 1% tails to remove extreme values, were calculated as the inverse of the predicted probabilities of response.(5) The complex samples module in SPSS was used to account for clusters in the survey design.

Statistical analysis

The associations between each of the socioeconomic indicators (household income, social class, education, SEP score, and area deprivation,) and each individual ST indicator (TV time, non-TV sitting time, occupational sitting/standing, and accelerometer-measured ST) was examined using generalised linear models, and by multiple linear regression to determine linear trend p values. Results are presented for the whole week, the weekday/weekend day-specific results can be found in the online appendix. SPSS version 21 was used for all analyses. For all multivariate analyses we used the complex samples generalised linear models (GLM) procedure to take into account the complex survey design.

All statistical models were run for each combination of dependent variable and main exposure. Different models were adjusted for: 1) age and sex; 2) additionally for BMI, limiting long standing illness, difficulty with usual activities, car ownership, drinking frequency, smoking status, and other socioeconomic indicators (household income, social class, area deprivation); 3) additionally for time spent in self-reported MVPA and accelerometer-measured MVPA, and average accelerometer wear
time on valid days. Models with accelerometer-measured ST as the outcome were also adjusted for average accelerometer wear time on each valid day. There was no evidence of colinearity in the multivariate model as no variance inflation factor value was higher than approximately 1.5, with most values just over 1. Residual statistics and plots for each model were checked for normality, independence of observations, homoscedasticity, and influential outliers.

GLM coefficients indicate mean differences in sedentary time (in minutes) between the reference category and each of the other SEP categories. The lowest SEP category (<£10671 for household income, unskilled/semi-skilled manual for social class, most deprived quintile for area deprivation, SEP1 (lowest socioeconomic position) for SEP score) is the reference category for the mean difference in the outcome (and associated confidence interval for the difference) in all CSGLMs.

References

