Is active commuting associated with obesity in mid-life? Cross-sectional, observational evidence from UK Biobank

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Abstract

Background: This study examines the relationship between active commuting (AC) and obesity in mid-life using objectively measured anthropometric data from UK Biobank.

Methods: Baseline (2006-2010) cross-sectional data were used (n=502,664, of which 264,341 commuted). Participants were aged 40-69. Self-reported commuting mode was operationalised as 7-categories, ordered to reflect typical physical activity (PA). Outcomes were BMI (based on objectively measured weight and height) and percentage bodyfat (BF%). Hypothesised confounders were: income, area deprivation, urban/rural residence, education, alcohol, smoking, leisure PA, recreational walking, occupational PA, general health, limiting illness. Gender-stratified multivariate linear regression models were estimated. Final complete case sample sizes were 72,999 males, 83,667 females (BMI); 72,139 males, 82,788 females (BF%).

Findings: AC was significantly and independently associated with lower BMI and BF% for both genders, with a graded pattern apparent across the 7 categories. In fully adjusted models, compared to their car-only counterparts, mixed public and active transport commuters had significantly lower BMI (males: -1.00kg/m^2, 95%CI -1.14 to -0.87; females: -0.67kg/m^2, 95%CI -0.86 to -0.47). Cycling predicted lower BMI (males: -1.71kg/m^2, 95%CI -1.86 to -1.56; females: -1.65kg/m^2, 95%CI -1.92 to -1.38). Similar pattern and magnitude of association was observed for BF%. Compared with car users, mixed public transport and active commuters had significantly lower BF% (males: -1.32%, 95%CI -1.53 to -1.12; females: -1.10%, 95%CI -1.40 to -0.81). Cycling predicted lower BF% (males: -2.75%, 95%CI -3.03 to -2.48; females: -3.26%, 95%CI -3.80 to -2.71).

Interpretation: This study is the first to use UK Biobank to address the topic of AC and obesity; finding robust, independent associations between AC and healthier bodyweight and composition. This research supports the case for interventions to promote active travel as a population-level policy response to the prevention of obesity in mid-life.

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Research in context

Evidence before this study

Previous studies have found evidence of an association between active commuting and a range of obesity and cardiovascular disease related health outcomes in the UK context. Walking, cycling and taking public transport to work has been shown to predict self-reported and objectively measured BMI, objectively measured percentage body fat, self-reported doctor-diagnosed diabetes and self-reported hypertension. However, previous studies have been hampered by insufficiently detailed information on commute mode exposures (making it largely impossible to capture mixed-mode journeys, for example); self-reported outcome measures; limited scope to control for confounding by health behaviours especially diet; and small sample sizes for meaningful subgroup analyses.

Added value of this study

This study is the first to use UK Biobank data to investigate the relationship between commuting behaviour and BMI, based on objectively measured bodyweight and height; and body fat. UK Biobank is a large, observational study of 500,000 middle-aged individuals in the United Kingdom. This dataset offers the opportunity to conduct a definitive cross-sectional, observational investigation into the relationship between active commuting and obesity in terms of sample size, gradation of exposure, robust biological measures, and use of a wide range of covariates. The age span of the participants covers a key lifestage for the development of physical inactivity, obesity and related CVD risk. UK Biobank allows a considerably more detailed and fine-grained categorisation of commute-mode exposure by allowing the derivation of mixed-mode categories. This study also uses objectively measured height, bodyweight and percentage body fat, so is not subject to bias introduced when respondents are asked to report their own measurements. The comprehensive range of socioeconomic, demographic, behavioural, occupational and health data available in UK Biobank allows for comprehensive adjustment for confounding. Independent associations between active commuting and obesity are further isolated in sensitivity analyses controlling for dietary energy intake. To the authors' knowledge, this is the first study of active commuting and obesity to incorporate this dimension.

Implications of all the available evidence

This study and the growing body of evidence to which it contributes, suggests that the promotion and facilitation of active commuting should form part of the global policy response to population-level obesity prevention.

Background

Physical inactivity is one of the leading causes of morbidity and premature mortality.[1,2] In England, two-thirds of adults do not meet recommended levels.[3] The mass adoption of private motorised transport has contributed to declines in active travel worldwide. In England and Wales, 23.7 million individuals regularly commute to a workplace, 67% by car.[4] Individuals who commute to work actively achieve higher levels of total physical activity (PA) than car users, independently of leisure PA.[5-8] Active commuting (AC) has been identified by the UK National Institute for Clinical Excellence as a feasible way to increase population PA without requiring unacceptable financial or time expenditure.[9] Middle-age is an important life-stage for the development of obesity. In the 2012 Health Survey for England, BMI was found to increase steadily into middle-age, before declining beyond age 75.[10] In the same survey, 44% of adults aged 55-64 did not meet recommended PA levels.[11] Laverty and colleagues found that after adjustment for socioeconomic and demographic factors, adults aged 50-65 were 55% less likely to commute by public transport, 45% less likely to commute on foot, and 30% less likely to commute by bicycle; compared with 16-29 year olds.[12]

Previous research has shown that walkers and cyclists have lower BMI,[12-15] lower percentage body fat (BF%)[13] and lower waist circumference[15] than car commuters, are less likely to report diagnosed diabetes and hypertension,[13-15] and report higher levels of physical wellbeing.[16] Compared with continued car use, switching from sedentary to active commuting was found to predict a decrease in self-reported BMI.[17] However, many individuals live too far from their workplace for walking or cycling to be feasible**.** Cross-sectional studies have shown that individuals who commute by public transport have significantly lower BMI, BF% and self-reported diagnosed diabetes and hypertension, and that associations are similar in magnitude to those observed for walking and cycling.[12,13] This indicates that incidental PA involved with public transport journeys is significant. A growing body of research consistently suggests that mass transit contributes to overall PA[18,19] and is negatively associated with obesity.[20,21]

Important gaps in the literature remain. Firstly, it is unclear whether AC has a graded relationship with obesity. Operationalising the exposure using multiple mixed-mode categories provides better observational evidence of causality, but existing studies are hampered by inadequately detailed measurement. Secondly, the use of objectively measured obesity is important in order to reduce the bias associated with self-reporting. A third common limitation of using secondary datasets to investigate AC and bodyweight is the failure to rule out confounding by energy intake. The extent to which associations between AC and obesity are moderated by demographic and socioeconomic factors are also underexplored in the literature.

This study is the first to use UK Biobank[22,23] to investigate the relationship between AC and obesity. A large and comprehensive dataset, UK Biobank offers the opportunity to address key limitations in the existing literature. The aim of this study is to investigate the relationship between AC and objectively measured indicators of obesity in a middle-aged UK sample. Hypotheses are: (1) an independent relationship exists between commuting mode and two measures of obesity; (2) adjustment for socioeconomic, demographic, health, occupational and leisure factors will not fully attenuate the central association; (3) dietary energy intake will have a small but significant confounding effect; (4) among walkers and cyclists, distance of commute will be independently, inversely associated with BMI and BF%.

Methods

Data

Baseline data from UK Biobank were used (project 5935). Data were collected from 502,656 individuals aged 40-69 who visited 22 assessment centres across the UK (2006-2010). Respondents were selected through NHS patient registers based on distance from their nearest UK Biobank assessment centre. The scientific rationale, study design, ethical approval, survey methods and limitations are described elsewhere.[22,23]

Sample

Participants who did not report commuting behaviour (largely due to retirement) were excluded, yielding an initial sample size of 264,341. This was further restricted to participants who had complete data on all analytic covariates (n=156,994). Of these, 439 had missing BMI data and 2,067 had missing BF% observations. Two main analytic samples were therefore derived: (i) BMI, n=156,555 (72,888 males, 83,667 females); (ii) BF%, n=154,927 (72,139 males, 82,788 females). In addition, two sets of sensitivity analyses were undertaken. The first used a subsample with complete data on energy intake and all analytic variables: (i) BMI diet subsample, n=75,229; (ii) BF% diet subsample, n=74,430. The second complete-case sensitivity analysis was applied to just the walking commuters (BMI n=7,746, BF% n=7,660) and cycling commuters (BMI n=4,195, BF% n=4,146).

Variables

Exposure variable: Commuting mode

Participants were asked *"what types of transport do you use to get to and from work?"* and were able to select one or more of the following: car/motor vehicle; walk; public transport; cycle. In order to capitalise on this rich data a 15-category commute mode variable was derived, encapsulating all mode combinations. This was then collapsed to create a 7-category primary exposure variable, ordered to approximate typical levels of physical exertion: (1) Car only; (2) Car and public transport; (3) Public transport only; (4) Car and other mixed modes (a heterogeneous category comprising combinations of car, public transport, walking and cycling); (5) Public transport and active transport (walking and/or cycling); (6) Walking only; (7) Cycling only or cycling and walking. In sensitivity analyses of those who commuted by walking or cycling, self-reported one-way commute distance (miles) was conceptualised as an exposure variable. For the walking subsample, distance was operationalised as an ordered categorical variable (<1 mile; 1 mile; 2 miles; 3 miles; ≥ 4 miles). For the cycling subsample, it was categorised as: 0-1 miles; 2-4 miles; 5-7 miles; 8-10 miles; ≥ 11 miles.

Outcome variables: BMI and percentage body fat

Anthropometric measurements were taken by trained staff using standard procedures detailed elsewhere.[22] For the purposes of this study, measurements of interest were: height and weight (BMI calculation: kg/m^2), and BF%, measured by bio-impedance. Standing height was measured using the Seca202 stadiometer. BF% and weight were measured using the Tanita BC418MA body composition analyser.[24] Both were normally distributed and operationalised as continuous variables.

Covariates

A range of factors were hypothesised to confound the association between AC and obesity. These were self-reported, with the exception of residential area classification, Townsend deprivation score (census data), and energy intake (24-hour dietary recall questionnaires).[25,26] Demographic covariates were: age (years); sex; ethnicity (White British, other white background, South Asian, Black Caribbean, Black African, Chinese, mixed, other); residential area classification (urban, fringe, rural). Socioeconomic covariates were: gross annual household income (<£18,000; £18,000-£30,999; £31,000-£51,000; £52,000-£100,000; >100,000); residential output area Townsend deprivation index (quintiles); highest educational qualification (university/college degree; A-levels/equivalent; GCSEs/equivalent; CSEs/equivalent; NVQ/HND/HNC/equivalent; professional qualifications; none). Health behaviour covariates were: alcohol (daily; 3-4 times per week; 1-2/week; 1-3/month; special occasions; never); smoking (never, previous, current). PA covariates were: days/week ≥10minutes moderate PA (0-7); walking for pleasure in past 4 weeks (once, 2-3 times, once/week, 2-3/week, 4-5/week, daily); typical transport mode for non-commuting travel (walking and/or cycling: yes/no); job involves standing/walking (never/rarely; sometimes; usually; always); manual work (never/rarely; sometimes; usually; always); shift work (never/rarely; sometimes; usually; always). Health covariates were: poor self-rated health (yes/no); limiting illness/disability (yes/no). Total energy intake (kcals) in previous 24hours was used in sensitivity analyses. The diet recall questionnaire module was added to the assessment centre towards the end of the baseline data collection phase. Subsequently, participants were contacted via email and completed up to 5 questionnaires online.[25,26] Energy intake was operationalised as a continuous variable, truncated at 6000kcal/day. For respondents who participated in more than one 24-hour diet recall questionnaire, the median value was used.

Statistical analysis

In order to investigate the relationship between commuting mode and BMI/BF% and test the first and second study hypotheses; nested, gender-stratified, multivariate linear regression analysis was undertaken using Stata 14.[27] For each outcome, the following model series was fitted for men and women separately. M0 tested the bivariate association between commute mode and the outcome. M1 introduced demographic, socioeconomic and other factors (urban/rural residence, age, ethnicity, income, Townsend deprivation quintiles, highest educational qualification). M1 was then nested within M2 which introduced the other hypothesised confounders: alcohol intake, smoking status, leisure PA, non-work active travel, walking for pleasure, occupational PA, shift work, manual work, self-rated health and longstanding limiting illness. Models were adjusted for clustering by assessment centre. Interactions by gender, ethnicity and household income category were investigated using Wald tests. Sensitivity analysis using dietary recall data was undertaken in order to test the third hypothesis. The gender stratified multivariate linear regression modelling strategy above was replicated using the subsample of participants with valid energy intake data, adding 24-hour energy intake (kcal) as a covariate. In order to investigate the fourth hypothesis, sensitivity analyses were undertaken using separate subsamples of walking commuters and cycling commuters with compete data. For each subsample, a bivariate (M0) and multivariate linear (M2, specified as above) regression model was fitted for each outcome (BMI and BF%), using commute distance as the exposure of interest.

Role of the funding source

This secondary data analysis was funded by a UK Medical Research Council Postdoctoral Strategic Skills Fellowship awarded to EF. UK Biobank is a registered charity which receives funding from the Wellcome Trust, UK MRC, UK Department of Health, Scottish Government, Welsh Assembly, British Heart Foundation, Diabetes UK and the Northwest Regional Development Agency. SC is funded by a UK National Institute of Health Research Senior Fellowship. The funders had no role in determining the study design, analytical strategy, interpretation of findings, writing the report or the decision to submit this paper for publication. The authors had full access to all the data presented in the study and bear final responsibility for the decision to submit this paper for publication.

Results

Descriptive analysis is presented in Table 1. Car travel was the most prevalent commuting mode (64% men, 61% women). Four percent of men and 7% of women reported walking as their only commute mode, while a further 4% of men and 2% of women reported cycling only or a mix of cycling and walking. Overall, 23% of men and 24% of women used active transport either solely or as a component within a mix of modes. The BF% analytic sample was representative of the BMI analytic sample.

The results of the series of multivariate linear regression models fitted to investigate the relationship between AC and BMI are presented in Table 2 and Figure 1. The results for BF% are presented in Table 3 and Figure 2. A significant interaction was found for gender, so all analyses were gender stratified. No significant interactions were found for ethnicity or household income category.

Across all models, a significant association between commuting mode and obesity was observed, with a graded relationship apparent across the 7 ordered commuting categories. With the exception of mixed car and public transport, all categories independently predicted significantly lower BMI and BF% when compared with sole car use. In both BMI and BF% analyses, adjustment for hypothesised confounding factors attenuated the bivariate associations to some degree, but a significant, relationship remained evident in the fully adjusted models for both men and women. These findings supported the first and second study hypotheses.

For men and women, across BMI and BF% analyses, the largest and most significant results were observed for cyclists. In fully adjusted models, compared to car-only commuters, male cyclists had BMI 1.71kg/m^2 lower (95%CI -1.86, -1.56) controlling for demographic, socioeconomic, health, behavioural, and non-commute PA. In fully adjusted models, female cyclists had BMI 1.65kg/m^2 lower on average than their car-only counterparts (95%CI -1.92, -1.38), and had 3.26% lower BF% (95%CI -3.80, -2.71).

In fully adjusted models, men who used solely public transport had a BMI 0.70kg/m^2 lower than car-only commuters (95%CI -0.83, -0.57) while men who combined car use with active modes had a BMI 0.56kg/m^2 lower (95%CI -0.68, -0.45). Greater associations were observed for men who combined public transport with active modes: compared to car-only commuters, these individuals had a BMI 1.00kg/m^2 lower (95%CI -1.14, -0.87) in the fully adjusted model. The results from the BF% models corroborated these results.

For women who used various combinations of car, public and active modes, coefficients were typically smaller than those observed for men, though still highly statistically significant. Women who combined public transport with active modes had BMI on average 0.67kg/m^2 lower than car users (95%CI -0.86, -0.47) and had 1.09% lower BF% (95%CI -1.38, -0.80), in fully adjusted models.

Men who reported walking as their sole mode had a BMI 0.98kg/m^2 (95%CI -1.20, -0.76) lower than car-only commuters in fully adjusted analyses, and had 1.19% lower BF% (95%CI -1.49, -0.88). In adjusted analyses, women who used walking as their sole commute mode had BMI 0.80kg/m^2 (-0.94, -0.66) lower than car commuters, and had 1.12% lower BF% (95%CI -1.31, -0.94).

Results from subsample sensitivity analyses to investigate the effects of energy intake on the association between commuting mode and obesity (Appendices 1 and 2) found that for men, energy intake was a non-significant covariate in fully adjusted BMI models (p=0.72). However, an extremely small but significant association was seen for BF% among men (adjusted b=-0.0004 kcal/day, p<0.001). For women, an extremely small association between energy intake and BMI was observed (adjusted b=0.0002 kcal/day, p<0.001), but not for BF%. Support for the third study hypothesis was therefore equivocal.

Results from sensitivity analyses to investigate the relationship between commute distance and BMI/BF% among walkers and cyclists (Appendices 3 and 4) broadly supported the fourth hypothesis. In fully adjusted models, compared with pedestrians who walked <1mile, individuals who walked 2miles had BMI 0.43kg/m^2 lower (95%CI -0.76, -0.09), and -0.79% lower BF% (95%CI -1.28, -0.31). For both outcomes, a graded relationship was apparent across the walking distance categories (with the exception of the ≥4miles category which was not significantly different to the reference category for either outcome). Results for the cycling subgroup were corroborative. For example, in fully adjusted models, compared with cyclists who travelled 0-2miles, those who cycled 5-7miles had BMI 0.36 kg/m^2 lower (95%CI -0.67, -0.05) and 1.14% lower BF% (95%CI -1.64, -0.64). Those who cycled 8-10miles had

BMI 0.56kg/m^2 lower (95%CI -1.05, -0.08). For BF%, a significant, graded, independent relationship was observed across all cycling distance categories. However for BMI, only the 5-6mile and 8-10mile categories were significantly different from the 0-2mile reference category.

Discussion

Summary and interpretation of findings

This study demonstrates a significant, independent association between commuting mode and both BMI and BF%, for men and women. Comprehensive adjustment for confounders only modestly attenuated the observed central associations. The largest coefficients were observed for cyclists. For example, male cyclists had a BMI on average 1.71kg/m^2 lower than their car-using counterparts after adjustment for socioeconomic, demographic, health, behavioural factors and other PA. For the average man in the sample (53 years old, 176.7cm tall, weighing 85.9kg) this equates to a substantial weight difference of 5kg. Female cyclists had a BMI on average 1.65kg/m^2 lower than car commuters after full adjustment, which translates to a weight difference of 4.4kg for the average woman in the sample (52 years old, 163.6cm tall, 70.6kg). Previous studies reliant on smaller samples typically include cycling and walking in one 'active' category.[13] The present study suggests that this may mask larger associations between cycling and obesity. The second-largest associations were seen for walking, for both genders. For both active categories, travelling greater distances was independently associated with lower BMI and BF%. However, even individuals who reported a mix of public and active modes were also found to have significantly lower BF% and BMI than those who exclusively commuted by car, with similar magnitude of association observed for the 'walking only' and the 'mixed public and active transport' categories. This corroborates and adds detail to previous studies reporting similar magnitudes of association between active and public transport, and obesity.[13] No interactions by income were found, suggesting that associations between commute mode and obesity are equally distributed across socioeconomic groups. However socioeconomic status is a predictor of commute mode, generating inequalities in access to and utilisation of active modes.[12] Across most mode categories, the magnitude of associations with BMI and BF% were larger for men than women. This was especially true for public transport users, possibly because bus travel may be more prevalent among women, whereas men may be more likely to use rail transit and hence walk or cycle further to reach stations which are typically more spatially dispersed. The only instance in which greater coefficients were seen for women than men was for the association between cycling and BF%, indicating that the 1,643 (2%) middle-aged women in this sample who cycled to work were substantially fitter than the norm, perhaps reflecting residual confounding by unobserved domains of

PA or health. Adjustment for energy intake in sensitivity analyses found that lower energy intake significantly predicted lower BMI (for women only) and %BF (for men only) but that point estimates were negligible and did not attenuate the central relationship.

Strengths and limitations

The strengths of this study lie in the quality of the data. UK Biobank is a large study with good geographical coverage. The age range is particularly useful for studying determinants of obesity, as mid-life is a key period for risk development and as such a critical juncture for interventions to promote positive behaviour change. The data presented captures multi-mode commutes, allowing differentiation between mixed modes and a more nuanced quantification of exposure than has been possible in previous work.[12,13,17] The use of two objectively measured obesity outcomes removes the possibility of misreporting of height and weight and addresses concerns around the use of BMI as an appropriate measure of adiposity among particularly lean groups. The wide range of socioeconomic, demographic, health, behavioural and occupational data also allows comprehensive adjustment for confounding. To the authors' knowledge, sensitivity analysis using UK Biobank's dietary data represents the first attempt to adjust for energy intake in this research area. However, the risk of residual confounding cannot be entirely eliminated using an observational, cross-sectional study design. For example, menopausal status is a key determinant of body composition among women in mid-life. The study is subject to a range of additional limitations. First and foremost is the risk of reverse causality, as direction of effect cannot be inferred from cross-sectional data, although sensitivity analyses establishing an independent, significant, graded relationship between distance and BMI/BF% among walkers and cyclists adds weight to a causal interpretation for these categories. Further research using the repeat-assessment subsample of UK Biobank will be undertaken by the authors in order to isolate causal processes. Secondly UK Biobank is subject to item non-response and missingness. The analytic sample were representative of the total commuting sample on key variables (though not representative of the entire baseline sample, many of whom were retired). The 75,229 individuals in the energy intake analytic subsample represented only 48% of the full analytic sample. They had a significantly higher mean BMI and were more likely to be female. However, when compared with the full analytic sample, very similar size and significance of central associations were observed when models were run on the subsample without adjustment energy intake. Thirdly, while a 7-category commute mode exposure variable incorporating mixed-mode journeys adds greater resolution than previous studies, it remains impossible to know precisely how much PA is typically involved for each category, and the relative contributions the different modes within mixed categories make to overall journey distance. Further research using UK Biobank's accelerometry subsample would allow this to be more precisely quantified. The use of self-reported mode introduces further limitations including the possibility of bias and unknown validity or reliability. Relatedly, the extent to which multivariate modelling minimises residual confounding is dependent on the quality of the covariates, which were largely self-reported and non-validated. The sensitivity analysis adjusting for energy intake also has limitations. While useful for estimating population-level energy intake, 24-hour dietary recall questionnaires are less reliable assessments of typical individual intakes, owing to high intra-person variation in daily diet. Much of the dietary data collection was via online questionnaires and not coterminous with the assessment centre. Self-reported food consumption is also subject to recall and courtesy bias, typically resulting in underestimation of energy intake.[26] Finally, while uniquely large and comprehensive, UK Biobank is not representative of the UK population and may therefore be subject to selection bias. However the sample is sufficiently large and heterogeneous for the results to be considered generalisable.[28]

Conclusions and implications

There is a clear consensus that obesity leads to poor health outcomes and increased risk of premature mortality. Strategies to address obesity must target both sides of the energy balance equation and create environments which support a healthy lifestyle. Populations are increasingly sedentary and there are fewer opportunities for routine physical activity. These findings suggest that in mid-life, a key life-stage for the development of obesity, policies which enable and encourage active commuting could have a beneficial effect on the population prevalence of obesity. The findings support NHS guidelines which recommend breaking up sedentary time with light PA, in addition to undertaking frequent moderate PA.[29] Further research using longitudinal data and quasi-experimental study designs are a priority, in order to understand causal pathways and processes.

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Author contributions: EF and SC conceived of the study. EF undertook the analysis. EF and SC interpreted the findings. EF drafted the manuscript and SC commented on the draft and contributed

to redrafting. EF produced the final draft and acted as the corresponding author. **Ethical approval:** UK Biobank has approval from the North West Multi-centre Research Ethics Committee (MREC), the Patient Information Advisory Group (PIAG) and the Community Health Index Advisory Group (CHIAG). **Competing interests:** There are no competing interests.

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Variable	Men (n= 72,888)	Women (n=83,667)
	Mean (SD)	
Body Mass Index	27.5 (3.9)	26.4 (4.8)
Percentage Body Fat*	24.3 (5.5)	35.4 (6.8)
Age in years	52.9 (7.2)	52.0 (6.6)
Days per week of moderate leisure physical activity	3.5 (2.3)	3.5 (2.3)
	Frequency (%)	
Commuting mode: Car only	46,590 (64.0)	51,127 (61.1)
Car & public transport	4,602 (6.3)	5,212 (6.2)
Public transport only	5,136 (7.0)	7,303 (8.7)
Car & PT/AT	7,995 (11.0)	9,276 (11.1)
PT & AT	3,403 (4.7)	3,558 (4.3)
Walking only	2,581 (3.5)	5,548 (6.6)
Cycle only or cycle & walk	2,581 (3.6)	1,643 (2.0)
Urban residential area	62,143 (85.3)	71,731 (85.7)
Urban/rural fringe	5,220 (7.2)	5,931 (7.1)
Rural residential area	5,525 (7.6)	6,005 (7.2)
Ethnicity: White British	65,607 (90.1)	74,523 (89.1)
Irish/Other white ethnicity	4,292 (5.9)	5,752 (6.9)
South Asian	990 (1.4)	721 (0.9)
Black Caribbean	297 (0.4)	714 (0.9)
Black African	448 (0.6)	386 (0.5)
Chinese	141 (0.2)	226 (0.3)
Mixed ethnicity	363 (0.5)	563 (0.7)
Other ethnicity	750 (1.0)	782 (0.9)
Gross annual household income <£18,000	4,599 (6.3)	9,187 (11.0)
£18,000-£30,999	13,233 (18.2)	18,613 (22.3)
£31,000-£51,999	23,119 (31.7)	26,867 (32.1)
£52,000-£100,000	24,580 (33.7)	23,491 (28.1)
>£100,000	7,357 (10.1)	5,509 (6.6)
Townsend quintile 1	16,062 (22.0)	17,149 (20.5)
Townsend quintile 2	15,341 (21.1)	17,150 (20.5)
Townsend quintile 3	14,870 (20.4)	17,371 (20.8)
Townsend quintile 4	14,595 (20.0)	17,562 (21.0)
Townsend quintile 5	12,020 (16.5)	14,435 (17.3)
Highest educational qualification: University degree	31,236 (42.9)	35,547 (42.5)
A levels/AS levels	8,569 (11.8)	11,638 (13.9)
O levels/GCSEs	13,811 (19.0)	18,893 (22.6)
CSEs or equivalent	4,642 (6.4)	5,020 (6.0)
NVQ or HND or HNC	6,081 (8.4)	3,535 (4.2)

Professional qualifications	2,509 (3.4)	4,027 (4.8)
No formal qualifications	6,040 (8.3)	5,007 (6.0)
Alcohol daily/almost daily	18,092 (24.8)	13,482 (16.1)
Alcohol 3-4 times a week	21,453 (29.4)	20,606 (24.6)
Alcohol 1-2 times a week	19,911 (27.3)	23,667 (28.3)
Alcohol 1-3 times a month	6,447 (8.9)	11,386 (13.6)
Alcohol on special occasions only	3,871 (5.3)	9,685 (11.6)
Never consumed alcohol	3,114 (4.3)	4,841 (5.8)
Never **smoked**	40,601 (55.7)	51,809 (62.0)
Previous smoker	24,720 (33.9)	25,237 (30.1)
Current smoker	7,567 (10.4)	6,621 (7.90)
No **non-work active travel**	34,574 (47.4)	38,374 (45.9)
Does non-work active travel	38,314 (52.6)	45,293 (54.1)
Walked for pleasure once a month	7,038 (9.7)	8,123 (9.7)
Walked for pleasure 2-3 times a month	23,631 (32.5)	28,141 (33.7)
Walked for pleasure once a week	14,485 (20.0)	15,468 (18.5)
Walked for pleasure 2-3 times a week	14,691 (20.1)	16,494 (19.7)
Walked for pleasure 4-5 times a week	6,425 (8.8)	7,306 (8.7)
Walked for pleasure every day	6,618 (9.0)	8,135 (9.7)
Job never/rarely **involves standing/walking**	25,474 (35.0)	31,605 (37.8)
Job sometimes involves standing/walking	24,124 (33.1)	25,549 (30.5)
Job usually involves standing/walking	10,828 (14.9)	12,104 (14.5)
Job always involves standing/walking	12,462 (17.1)	14,409 (17.2)
Job never/rarely **manual**	46,659 (64.0)	60,381 (72.2)
Job sometimes manual	15,471 (21.2)	16,154 (19.3)
Job usually manual	5,608 (7.7)	3,751 (4.5)
Job always manual	5,150 (7.1)	3,381 (4.0)
Never/rarely works **shifts**	59,741 (82.0)	71,887 (86.0)
Sometimes works shifts	5,664 (7.8)	5,172 (6.2)
Usually works shifts	1,551 (2.1)	1,512 (1.8)
Always works shifts	5,932 (8.1)	5,096 (6.1)
Excellent/good/fair **self-rated health**	71,627 (98.3)	82,597 (98.7)
Poor self-rated health	1,261 (1.7)	1,070 (1.3)
No **limiting longstanding illness/disability**	54,111 (74.2)	65,753 (78.6)
Has limiting longstanding illness/disability	18,777 (25.8)	17,914 (21.4)

Table 1: Distribution of outcome variables, commuting exposure variable and hypothesised confounding covariates in the BMI analytic sample. * % body fat observations in the BMI analytic sample: 72,108 for men; 82,774 for women.

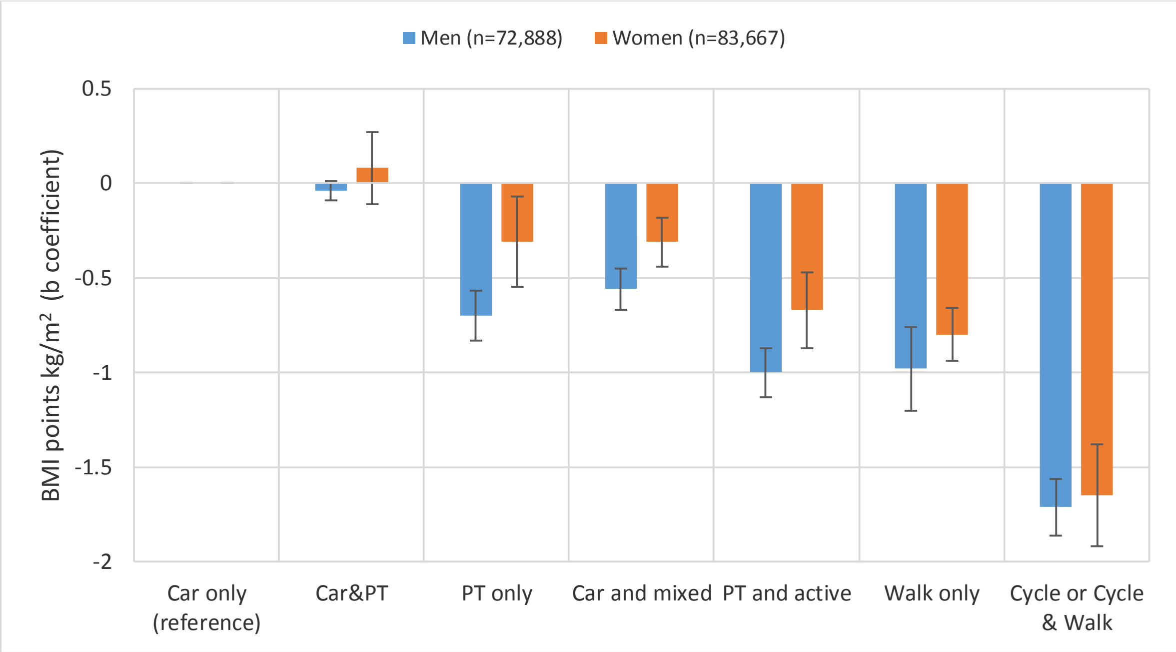

Figure 1: Graph showing association between commuting mode and BMI, adjusted for age, days per week of moderate leisure PA, urban/rural area, ethnicity, household income quintiles, Townsend area deprivation quintiles, highest educational qualification, alcohol intake, smoking status, non-work active travel, walking for pleasure, job involves standing/walking, manual job, shift work, self-rated health, limiting longstanding illness.

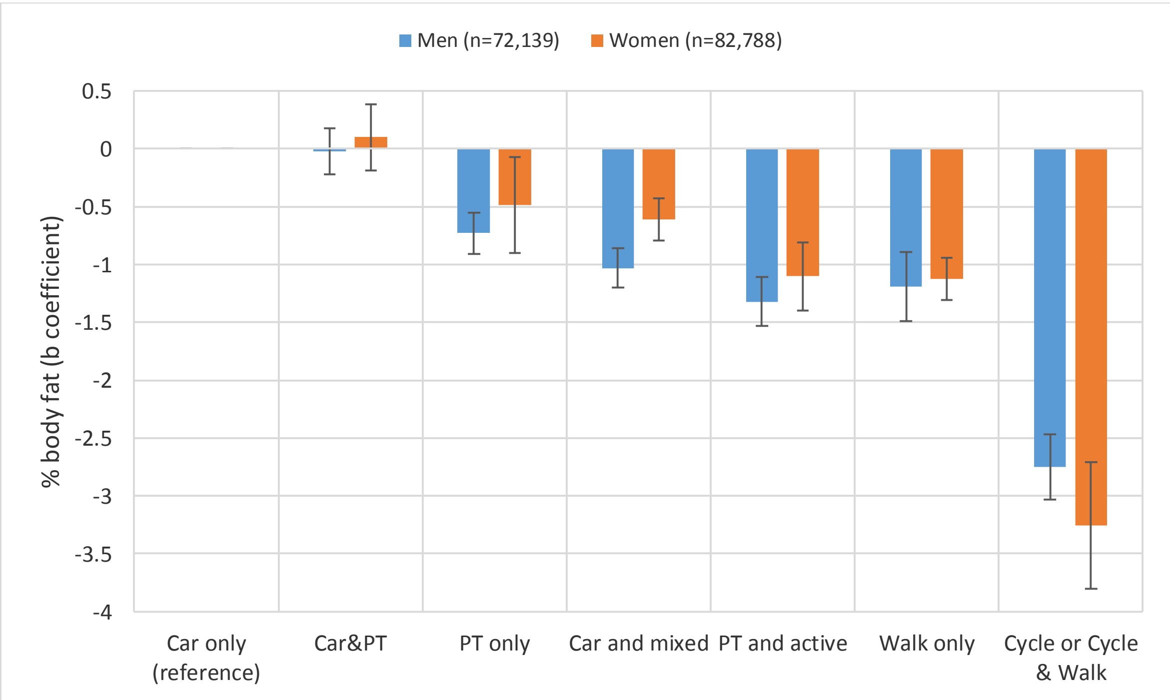

Figure 2: Graph showing association between commute mode and percentage body fat, adjusted for age, days per week of moderate leisure PA, urban/rural area, ethnicity, household income quintiles, Townsend area deprivation quintiles, highest educational qualification, alcohol intake, smoking status, non-work active travel, walking for pleasure, job involves standing/walking, manual job, shift work, self-rated health, limiting longstanding illness.

Outcome: **BMI**						
Men (n= 72,888)	**Model 0**		**Model 1**		**Model 2**	
	b (95% CI)	**p-value**	**b (95% CI)**	**p-value**	**b (95% CI)**	**p-value**
Car only	0		0		0	
Car & public transport	-0.21 (-0.34, -0.07)	0.0050	-0.06 (-0.19, 0.08)	0.39	-0.04 (-0.19, 0.01)	0.54
Public transport only	-0.82 (-0.97, -0.67)	<0.0001	-0.77 (-0.90, -0.63)	<0.0001	-0.70 (-0.83, -0.57)	<0.0001
Car & PT/AT	-0.86 (-0.98, -0.73)	<0.0001	-0.72 (-0.83, -0.60)	<0.0001	-0.56 (-0.68, -0.45)	<0.0001
PT & AT	-1.42 (-1.54, -1.30)	<0.0001	-1.24 (-1.37, -1.12)	<0.0001	-1.00(-1.14, -0.87)	<0.0001
Walking only	-1.17 (-1.40, -0.95)	<0.0001	-1.15 (-1.38, -0.93)	<0.0001	-0.98 (-1.20, -0.76)	<0.0001
Cycle only or cycle & walk	-2.35 (-2.50, -2.20)	<0.0001	-2.22 (-2.37, -2.08)	<0.0001	-1.71 (-1.86, -1.56)	<0.0001
Urban residential area			0		0	
Urban-rural fringe			-0.05 (-0.20, 0.11)	0.54	-0.04 (-0.18, 0.10)	0.59
Rural residential area			-0.23 (-0.38, -0.09)	0.0031	-0.18 (-0.33, -0.03)	0.020
Age in years			0.01 (0.00, 0.01)	0.0026	0.00 (-0.00, 0.01)	0.27
Ethnicity: White British			0		0	
Irish/Other white ethnicity			0.07 (-0.07, 0.21)	0.31	-0.01 (-0.15, 0.12)	0.84
South Asian			-0.62 (-0.80, -0.44)	<0.0001	-0.73 (-0.91, -0.54)	<0.0001
Black Caribbean			0.95 (0.10, 1.81)	0.031	0.89 (0.07, 1.72)	0.036
Black African			0.95 (0.54, 1.37)	0.00010	0.77 (0.33, 1.20)	0.0017
Chinese			-1.90 (-2.56, -1.24)	<0.0001	-2.02 (-2.60, -1.44)	<0.0001
Mixed ethnicity			-0.13 (-0.46, 0.20)	0.42	-0.18 (-0.52, 0.16)	0.28
Other ethnicity			0.22 (-0.08, 0.52)	0.14	0.01 (-0.26, 0.28)	0.93
<£18,000 gross annual household income			0		0	
£18,000-£30,999			0.31 (0.16, 0.46)	0.00040	0.31 (0.16, 0.46)	0.00040
£31,000-£51,999			0.43 (0.28, 0.59)	<0.0001	0.44 (0.29, 0.59)	<0.0001
£52,000-£100,000			0.56 (0.42, 0.70)	<0.0001	0.62 (0.49, 0.75)	<0.0001
>£100,000			0.58 (0.35, 0.82)	<0.0001	0.74 (0.53, 0.95)	<0.0001

Townsend quintile 1		0		0	
Townsend quintile 2		0.05 (-0.02, 0.12)	0.19	0.05 (-0.03, 0.13)	0.22
Townsend quintile 3		0.23 (0.15, 0.32)	<0.0001	0.22 (0.13, 0.30)	0.00010
Townsend quintile 4		0.29 (0.15, 0.42)	0.00030	0.26 (0.12, 0.39)	0.00090
Townsend quintile 5		0.49 (0.25, 0.73)	0.00050	0.41 (0.17, 0.65)	0.0017
University degree		0		0	
A levels/AS levels		0.59 (0.48, 0.70)	<0.0001	0.49 (0.37, 0.60)	<0.0001
O levels/GCSEs		0.97 (0.86, 1.09)	<0.0001	0.83 (0.72, 0.93)	<0.0001
CSEs or equivalent		1.18 (1.04, 1.33)	<0.0001	1.05 (0.91, 1.19)	<0.0001
NVQ or HND or HNC		1.04 (0.89, 1.18)	<0.0001	0.89 (0.74, 1.05)	<0.0001
Professional qualifications		0.85 (0.69, 1.02)	<0.0001	0.73 (0.57, 0.89)	<0.0001
No formal qualifications		1.23 (1.02, 1.43)	<0.0001	1.08 (0.88, 1.28)	<0.0001
Alcohol daily/almost daily				0	
Alcohol 3-4 times a week				0.21 (0.13, 0.30)	<0.0001
Alcohol 1-2 times a week				0.48 (0.38, 0.58)	<0.0001
Alcohol 1-3 times a month				0.72 (0.62, 0.82)	<0.0001
Alcohol on special occasions only				0.59 (0.43, 0.75)	<0.0001
Never consumed alcohol				0.30 (0.15, 0.46)	0.00060
Never smoked				0	
Previous smoker				0.68 (0.61, 0.75)	<0.0001
Current smoker				-0.15 (-0.33, 0.02)	0.077
Days per week of moderate leisure PA				-0.13 (-0.14, -0.12)	<0.0001
No non-work active travel				0	
Does non-work active travel				-0.31 (-0.37, -0.26)	<0.0001
Walked for pleasure once a month				0	
Walked for pleasure 2-3 times a month				0.27 (0.17, 0.37)	<0.0001
Walked for pleasure once a week				0.17 (0.07, 0.27)	0.0017

Walked for pleasure 2-3 times a week			0.27 (0.14, 0.39)	0.00020
Walked for pleasure 4-5 times a week			0.17 (0.00, 0.34)	0.056
Walked for pleasure every day			0.33 (0.21, 0.45)	<0.0001
Job never/rarely involves standing/walking			0	
Job sometimes involves standing/walking			0.23 (0.14, 0.32)	<0.0001
Job usually involves standing/walking			0.10 (-0.06, 0.27)	0.20
Job always involves standing/walking			-0.09 (-0.22, 0.05)	0.20
Job never/rarely manual			0	
Job sometimes manual			0.23 (0.13, 0.33)	0.00010
Job usually manual			0.10 (-0.05, 0.24)	0.19
Job always manual			0.20 (-0.02, 0.42)	0.067
Never/rarely works shifts			0	
Sometimes works shifts			0.56 (0.4, 0.73)	<0.0001
Usually works shifts			0.41 (0.13, 0.68)	0.0055
Always works shifts			0.56 (0.42, 0.70)	<0.0001
Excellent/good/fair self-rated health			0	
Poor self-rated health			2.38 (2.13, 2.64)	<0.0001
No longstanding limiting illness			0	
Has longstanding limiting illness			0.78 (0.72, 0.84)	<0.0001

Table 2a: Results of gender stratified series of nested multivariate linear regression models investigating the association between commuting mode (7 categories) and body mass index(kg/m^2) (males only). M0: bivariate association between commuting mode and BMI; M1: adjusting for demographic and socioeconomic covariates listed; M2: additionally adjusting for health, occupational and physical activity covariates listed.

Outcome**: BMI**

(**Women**, n=83,667)	Model 0		Model 1		Model 2	
	b (95% CI)	**p-value**	**b (95% CI)**	**p-value**	**b (95% CI)**	**p-value**
Car only	0		0		0	
Car & public transport	0.07 (-0.13, 0.27)	0.49	0.00 (-0.20, 0.20)	0.96	0.08 (-0.11, 0.27)	0.40
Public transport only	0.13 (-0.21, 0.48)	0.44	-0.41 (-0.67, -0.14)	0.0049	-0.31 (-0.56, -0.07)	0.016
Car & PT/AT	-0.53 (-0.72, -0.35)	<0.0001	-0.56 (-0.71, -0.40)	<0.0001	-0.31 (-0.45, -0.18)	0.00010
PT & AT	-0.75 (-1.05, -0.45)	<0.0001	-0.95 (-1.17, -0.73)	<0.0001	-0.67 (-0.86, -0.47)	<0.0001
Walking only	-0.61 (-0.79, -0.42)	<0.0001	-1.08 (-1.24, -0.93)	<0.0001	-0.80 (-0.94, -0.66)	<0.0001
Cycle only or cycle & walk	-2.41 (-2.66, -2.15)	<0.0001	-2.40 (-2.68, -2.13)	<0.0001	-1.65 (-1.92, -1.38)	<0.0001
Urban residential area			0		0	
Urban/rural fringe			-0.15 (-0.32, 0.02)	0.076	-0.12 (-0.27, 0.03)	0.12
Rural residential area			-0.42 (-0.53, -0.31)	<0.0001	-0.30 (-0.40, -0.19)	<0.0001
Age in years			0.03 (0.02, 0.03)	<0.0001	0.03 (0.03, 0.04)	<0.0001
Ethnicity: White British			0		0	
Irish/Other white ethnicity			-0.10 (-0.26, 0.05)	0.19	-0.15 (-0.30, 0.00)	0.055
South Asian			0.03 (-0.33, 0.39)	0.87	-0.40 (-0.74, -0.06)	0.025
Black Caribbean			2.35 (2.03, 2.68)	<0.0001	1.85 (1.53, 2.17)	<0.0001
Black African			3.80 (3.14, 4.46)	<0.0001	3.09 (2.45, 3.73)	<0.0001
Chinese			-2.95 (-3.47, -2.44)	<0.0001	-3.45 (-3.98, -2.91)	<0.0001
Mixed ethnicity			0.54 (0.15, 0.93)	0.0096	0.36 (-0.04, 0.75)	0.077
Other ethnicity			0.37 (-0.03, 0.77)	0.071	-0.07 (-0.48, 0.34)	0.73
<£18,000 gross annual household income			0		0	
£18,000-£30,999			0.08 (-0.09, 0.25)	0.35	0.17 (-0.01, 0.35)	0.069
£31,000-£51,999			-0.03 (-0.16, 0.09)	0.59	0.15 (0.02, 0.27)	0.022
£52,000-£100,000			-0.30 (-0.45, -0.16)	0.00040	0.01 (-0.14, 0.17)	0.84
>£100,000			-0.95 (-1.16, -0.74)	<0.0001	-0.45 (-0.66, -0.24)	0.00020

Townsend quintile 1		0		0	
Townsend quintile 2		0.22 (0.14, 0.31)	<0.0001	0.19 (0.11, 0.27)	0.00010
Townsend quintile 3		0.37 (0.27, 0.48)	<0.0001	0.33 (0.24, 0.43)	<0.0001
Townsend quintile 4		0.60 (0.42, 0.79)	<0.0001	0.56 (0.40, 0.71)	<0.0001
Townsend quintile 5		1.13 (0.83, 1.44)	<0.0001	1.01 (0.77, 1.26)	<0.0001
University degree		0		0	
A levels/AS levels		0.48 (0.33, 0.63)	<0.0001	0.38 (0.24, 0.52)	<0.0001
O levels/GCSEs		0.81 (0.67, 0.95)	<0.0001	0.68 (0.56, 0.80)	<0.0001
CSEs or equivalent		1.21 (1.02, 1.41)	<0.0001	1.07 (0.90, 1.24)	<0.0001
NVQ or HND or HNC		1.41 (1.19, 1.64)	<0.0001	1.18 (0.97, 1.38)	<0.0001
Professional qualifications		0.77 (0.63, 0.91)	<0.0001	0.51 (0.35, 0.67)	<0.0001
No formal qualifications		1.10 (0.85, 1.35)	<0.0001	0.96 (0.73, 1.18)	<0.0001
Alcohol daily/almost daily				0	
Alcohol 3-4 times a week				0.35 (0.27, 0.42)	<0.0001
Alcohol 1-2 times a week				0.89 (0.77, 1.01)	<0.0001
Alcohol 1-3 times a month				1.55 (1.40, 1.70)	<0.0001
Alcohol on special occasions only				1.98 ((1.81, 2.14)	<0.0001
Never consumed alcohol				1.27 (1.14, 1.39)	<0.0001
Never smoked				0	
Previous smoker				0.32 (0.20, 0.43)	<0.0001
Current smoker				-0.43 (-0.63, -0.24)	0.00010
Days per week of leisure PA				-0.19 (-0.21, -0.18)	<0.0001
No non-work active travel				0	
Does non-work active travel				-0.41 (-0.47, -0.35)	<0.0001
Walked for pleasure once a month				0	
Walked for pleasure 2-3 times a month				0.17 (0.02, 0.32)	0.028
Walked for pleasure once a week				-0.01 (-0.14, 0.13)	0.93

Walked for pleasure 2-3 times a week			0.09 (-0.07, 0.24)	0.25
Walked for pleasure 4-5 times a week			-0.10 (-0.27, 0.07)	0.24
Walked for pleasure every day			-0.02 (-0.16, 0.11)	0.71
Job never/rarely involves standing/walking			0	
Job sometimes involves standing/walking			0.11 (0.03, 0.18)	0.0086
Job usually involves standing/walking			-0.10 (-0.18, -0.02)	0.018
Job always involves standing/walking			-0.15 (-0.25, -0.05)	0.0047
Job never/rarely manual			0	
Job sometimes manual			0.24 (0.16, 0.32)	<0.0001
Job usually manual			0.14 (-0.06, 0.33)	0.16
Job always manual			0.29 (0.10, 0.49)	0.0049
Never/rarely works shifts			0	
Sometimes works shifts			0.48 (0.33, 0.64)	<0.0001
Usually works shifts			0.17 (-0.09, 0.43)	0.18
Always works shifts			0.80 (0.65, 0.95)	<0.0001
Excellent/good/fair self-rated health			0	
Poor self-rated health			2.56 (2.28, 2.83)	<0.0001
No longstanding limiting illness			0	
No longstanding limiting illness			1.23 (1.13, 1.33)	<0.0001

Table 2b: Results of gender stratified series of nested multivariate linear regression models investigating the association between commuting mode (7 categories) and body mass index(kg/m^2) (females only). M0: bivariate association between commuting mode and BMI; M1: adjusting for demographic and socioeconomic covariates listed; M2: additionally adjusting for health, occupational and physical activity covariates listed.

Outcome: Percentage body fat						
Men, n=72,139	**Model 0**		**Model 1**		**Model 2**	
	b (95% CI)	**p-value**	**b (95% CI)**	**p-value**	**b (95% CI)**	**p-value**
Car only	0		0		0	
Car & public transport	-0.10 (-0.28, 0.08)	0.25	0.06 (-0.13, 0.26)	0.52	-0.02 (-0.22, 0.19)	0.88
Public transport only	-0.66 (-0.85, -0.47)	<0.0001	-0.72 (-0.90, -0.53)	<0.0001	-0.73 (-0.91, -0.54)	<0.0001
Car & PT/AT	-1.61 (-1.80, -1.42)	<0.0001	-1.27 (-1.44, -1.10)	<0.0001	-1.03 (-1.20, -0.85)	<0.0001
PT & AT	-1.91 (-2.08, -1.75)	<0.0001	-1.58 (-1.76, -1.39)	<0.0001	-1.32 (-1.53, -1.12)	<0.0001
Walking only	-1.39 (-1.70, 1.07)	<0.0001	-1.39 (-1.70, -1.08)	<0.0001	-1.19 (-1.49, -0.88)	<0.0001
Cycle only or cycle & walk	-4.04 (-4.34, -3.74)	<0.0001	-3.70 (-3.97, -3.44)	<0.0001	-2.75 (-3.03, -2.48)	<0.0001
Urban residential area			0		0	
Urban/rural fringe			-0.21 (-0.42, -0.00)	0.047	-0.20 (-0.39, -0.00)	0.045
Rural residential area			-0.56 (-0.88, -0.41)	<0.0001	-0.56 (-0.80, -0.32)	0.00010
Age in years			0.12 (0.11, 0.12)	<0.0001	0.10 (-0.10, 0.11)	<0.0001
Ethnicity: White British			0		0	
Irish/Other white ethnicity			-0.02 (-0.24, 0.20)	0.83	-0.11 (-0.32, 0.11)	0.31
South Asian			1.71 (1.33, 2.9)	<0.0001	1.67 (1.26, 2.07)	<0.0001
Black Caribbean			0.41 (-0.53, 1.35)	0.38	0.35 (-0.54, 1.24)	0.42
Black African			2.06 (1.63, 2.49)	<0.0001	1.87 (1.46, 2.27)	<0.0001
Chinese			-2.53 (-3.36, -1.69)	<0.0001	-2.63 (-3.43, -1.88)	<0.0001
Mixed ethnicity			-0.15 (-0.62, 0.32)	0.52	-0.19 (-0.66, 0.28)	0.41
Other ethnicity			1.17 (0.83, 1.51)	<0.0001	1.00 (0.68, 1.32)	<0.0001
<£18,000 gross annual household income			0		0	
£18,000-£30,999			0.49 (0.33, 0.66)	<0.0001	0.40 (0.24, 0.56)	0.00010
£31,000-£51,999			0.67 (0.52, 0.83)	<0.001	0.41 (0.26, 0.57)	<0.0001
£52,000-£100,000			0.92 (0.76, 1.09)	<0.0001	0.59 (0.43, 0.75)	<0.0001
>£100,000			0.86 (0.57, 1.16)	<0.0001	0.58 (0.30, 0.85)	0.00030

Townsend quintile 1			0		0	
Townsend quintile 2			-0.01 (-0.13, 0.12)	0.90	0.01 (-0.12, 0.15)	0.83
Townsend quintile 3			0.22 (0.09, 0.36)	0.0020	0.24 (0.10, 0.37)	0.0020
Townsend quintile 4			0.26 (0.09, 0.43)	0.0047	0.26 (0.09, 0.44)	0.0046
Townsend quintile 5			0.61 (0.27, 0.95)	0.0012	0.58 (0.25, 0.91)	0.0015
University degree			0		0	
A levels/AS levels			0.82 (0.68, 0.97)	<0.0001	0.73 (0.58, 0.88)	<0.0001
O levels/GCSEs			1.28 (1.13, 1.43)	<0.0001	1.27 (1.13, 1.40)	<0.0001
CSEs or equivalent			1.32 (1.11, 1.53)	<0.0001	1.52 (1.32, 1.73)	<0.0001
NVQ or HND or HNC			1.29 (1.11, 1.48)	<0.0001	1.36 (1.15, 1.57)	<0.0001
Professional qualifications			1.11 (0.85, 1.37)	<0.0001	1.14 (0.88, 1.39)	<0.0001
No formal qualifications			1.54 (1.30, 1.79)	<0.0001	1.77 (1.54, 2.00)	<0.0001
Alcohol daily/almost daily					0	
Alcohol 3-4 times a week					0.06 (-0.05, 0.17)	0.25
Alcohol 1-2 times a week					0.26 (0.11, 0.42)	0.0018
Alcohol 1-3 times a month					0.44 (0.27, 0.61)	<0.0001
Alcohol on special occasions only					0.16 (-0.06, 0.37)	0.14
Never consumed alcohol					0.04 (-0.18, 0.26)	0.71
Never smoked					0	
Previous smoker					0.85 (0.75, 0.96)	<0.0001
Current smoker					-0.29 (-0.49, -0.08)	0.0089
Days per week of leisure PA					-0.30 (-0.32, -0.29)	<0.0001
No non-work active travel					0	
Does non-work active travel					-0.40 (-0.48, -0.32)	<0.0001
Walked for pleasure once a month					0	
Walked for pleasure 2-3 times a month					0.30 (0.14, 0.45)	0.00060
Walked for pleasure once a week					0.21 (0.05, 0.36)	0.014

Walked for pleasure 2-3 times a week			0.36 (0.21, 0.51)	<0.0001
Walked for pleasure 4-5 times a week			0.19 (-0.04, 0.41)	0.096
Walked for pleasure every day			0.24 (0.06, 0.41)	0.0099
Job never/rarely involves standing/walking			0	
Job sometimes involves standing/walking			0.27 (0.12, 0.42)	0.0012
Job usually involves standing/walking			0.13 (-0.06, 0.32)	0.18
Job always involves standing/walking			-0.08 (-0.29, 0.12)	0.41
Job never/rarely manual			0	
Job sometimes manual			-0.03 (-0.16, 0.10)	0.60
Job usually manual			-0.55 (-0.73, -0.37)	<0.0001
Job always manual			-0.59 (-0.88, -0.31)	0.00030
Never/rarely works shifts			0	
Sometimes works shifts			0.63 (0.41, 0.85)	<0.0001
Usually works shifts			0.55 (0.29, 0.80)	0.00030
Always works shifts			0.88 (0.70, 1.07)	<0.0001
Excellent/good/fair self-rated health			0	
Poor self-rated health			2.67 (2.37, 2.96)	<0.0001
No longstanding limiting illness			0	
No longstanding limiting illness			1.00 (0.90, 1.11)	<0.0001

Table 3a: Results of gender stratified series of nested multivariate linear regression models investigating the association between commuting mode (7 categories) and percentage body fat (males only). M0: bivariate association between commuting mode and BMI; M1: adjusting for demographic and socioeconomic covariates listed; M2: additionally adjusting for health, occupational and physical activity covariates listed.

Outcome: Percentage body fat						
Women, n=82,788	**M0**		**M1**		**M2**	
	b (95% CI)	**p-value**	**b (95% CI)**	**p-value**	**b (95% CI)**	**p-value**
Car only	0		0		0	
Car & public transport	0.12 (-0.17, 0.42)	0.39	0.02 (-0.27, 0.31)	0.90	0.10 (-0.19, 0.38)	0.48
Public transport only	0.06 (-0.52, 0.63)	0.84	-0.59 (-1.03, -0.16)	0.011	-0.49 (-0.90, -0.07)	0.025
Car & PT/AT	-0.98 (-1.23, -0.74)	<0.0001	-0.96 (-1.16, -0.76)	<0.0001	-0.61 (-0.79, -0.43)	<0.0001
PT & AT	-1.33 (-1.79, -0.88)	<0.0001	-1.47 (-1.79, -1.16)	<0.0001	-1.10 (-1.40, -0.81)	<0.0001
Walking only	-0.91 (-1.16, -0.67)	<0.0001	-1.55 (-1.74, -1.37)	<0.0001	-1.12 (-1.31, -0.94)	<0.0001
Cycle only or cycle & walk	-4.66 (-5.20, -4.11)	<0.0001	-4.46 (-4.98, -3.93)	<0.0001	-3.26 (-3.80, -2.71)	<0.0001
Urban residential area			0		0	
Urban/rural fringe			-0.28 (-0.52, -0.03)	0.031	-0.22 (-0.45, 0.00)	0.055
Rural residential area			-0.87 (-1.11, -0.62)	<0.0001	-0.68 (-0.91, -0.45)	<0.0001
Age in years			0.12 (0.10, 0.13)	<0.0001	0.12 (0.11, 0.13)	<0.0001
Ethnicity: White British			0		0	
Irish/Other white ethnicity			-0.25 (-0.49, -0.02)	0.037	-0.28 (-0.51, -0.05)	0.020
South Asian			1.63 (1.10, 2.17)	<0.0001	1.26 (0.75, 1.77)	<0.0001
Black Caribbean			2.54 (1.89, 3.19)	<0.0001	1.98 (1.34, 2.61)	<0.0001
Black African			4.89 (4.33, 5.45)	<0.0001	4.21 (3.58, 4.84)	<0.0001
Chinese			-4.97 (-5.92, -4.03)	<0.0001	-5.40 (-6.38, -4.43)	<0.0001
Mixed ethnicity			0.81 (0.33, 1.29)	0.0021	0.65 (0.13, 1.16)	0.016
Other ethnicity			0.42 (-0.18, 1.02)	0.16	0.02 (-0.58, 0.62)	0.94
<£18,000 gross annual household income			0		0	
£18,000-£30,999			0.29 (0.07, 0.50)	0.012	0.30 (0.07, 0.53)	0.013
£31,000-£51,999			0.31 (0.12, 0.51)	0.0032	0.39 (0.18, 0.59)	0.00070
£52,000-£100,000			-0.02 (-0.25, 0.21)	0.86	0.18 (-0.6, 0.42)	0.13
>£100,000			-1.03 (-1.31, -0.75)	<0.0001	-0.64 (-0.94, -0.34)	0.00020

Townsend quintile 1			0		0	
Townsend quintile 2			0.24 (0.10, 0.38)	0.0025	0.20 (0.07, 0.33)	0.0036
Townsend quintile 3			0.44 (0.27, 0.61)	<0.0001	0.40 (0.25, 0.55)	<0.0001
Townsend quintile 4			0.63 (0.37, 0.89)	0.00010	0.60 (0.38, 0.82)	<0.0001
Townsend quintile 5			1.23 (0.78, 1.67)	<0.0001	1.13 (0.75, 1.51)	<0.0001
University degree			0		0	
A levels/AS levels			0.74 (0.56, 0.92)	<0.0001	0.62 (0.45, 0.79)	<0.0001
O levels/GCSEs			1.32 (1.15, 1.49)	<0.0001	1.18 (1.03, 1.34)	<0.0001
CSEs or equivalent			1.93 (1.67, 2.20)	<0.0001	1.84 (1.60, 2.08)	<0.0001
NVQ or HND or HNC			2.04 (1.73, 2.36)	<0.0001	1.88 (1.57, 2.19)	<0.0001
Professional qualifications			1.13 (0.98, 1.28)	<0.0001	0.90 (0.71, 1.08)	<0.0001
No formal qualifications			1.82 (1.52, 2.13)	<0.0001	1.79 (1.51, 2.06)	<0.0001
Alcohol daily/almost daily					0	
Alcohol 3-4 times a week					0.49 (0.32, 0.65)	<0.0001
Alcohol 1-2 times a week					1.08 (0.87, 1.28)	<0.0001
Alcohol 1-3 times a month					1.82 (1.55, 2.08)	<0.0001
Alcohol on special occasions only					2.07 (1.84, 2.30)	<0.0001
Never consumed alcohol					1.32 (1.12, 1.52)	<0.0001
Never smoked					0	
Previous smoker					0.40 (0.24, 0.57)	<0.0001
Current smoker					-0.64 (-0.89, -0.39)	<0.0001
Days per week of leisure PA					-0.34 (-0.36, -0.32)	<0.0001
No non-work active travel					0	
Does non-work active travel					-0.56 (-0.63, -0.49)	<0.0001
Walked for pleasure once a month					0	
Walked for pleasure 2-3 times a month					0.26 (0.06, 0.46)	0.014
Walked for pleasure once a week					0.02 (-0.20, 0.23)	0.87

Walked for pleasure 2-3 times a week			0.16 (-0.08, 0.39)	0.18
Walked for pleasure 4-5 times a week			-0.13 (-0.37, 0.10)	0.26
Walked for pleasure every day			-0.31 (-0.50, -0.11)	0.0034
Job never/rarely involves standing/walking			0	
Job sometimes involves standing/walking			0.05 (-0.05, 0.15)	0.33
Job usually involves standing/walking			-0.13 (-0.25, -0.02)	0.022
Job always involves standing/walking			-0.24 (-0.41, -0.07)	0.0076
Job never/rarely manual			0	
Job sometimes manual			0.14 (0.03, 0.25)	0.012
Job usually manual			-0.08 (-0.32, 0.17)	0.53
Job always manual			-0.06 (-0.30, 0.19)	0.63
Never/rarely works shifts			0	
Sometimes works shifts			0.52 (0.30, 0.74)	0.00010
Usually works shifts			0.25 (-0.11, 0.60)	0.16
Always works shifts			1.04 (0.79, 1.28)	<0.0001
Excellent/good/fair self-rated health			0	
Poor self-rated health			2.75 (2.41, 3.09)	<0.0001
No longstanding limiting illness			0	
No longstanding limiting illness			1.65 (1.52, 1.78)	<0.0001

Table 3b: Results of gender stratified series of nested multivariate linear regression models investigating the association between commuting mode (7 categories) and percentage body fat (females only). M0: bivariate association between commuting mode and BMI; M1: adjusting for demographic and socioeconomic covariates listed; M2: additionally adjusting for health, occupational and physical activity covariates listed.

APPENDIX 1: SENSITIVITY ANALYSIS TO INVESTIGATE THE CONFOUNDING EFFECT OF DIETARY ENERGY INTAKE ON THE ASSOCIATION BETWEEN COMMUTING MODE AND BMI

Outcome: BMI (kg/m2)	Men (n=33,463)		Women (n=41,766)	
	β coefficient (95% CI)	p-value	β coefficient (95% CI)	p-value
Commuting method:				
Car only (reference)	0		0	
Car and public transport	0.01 (-0.13, 0.15)	0.90	0.03 (-0.20, 0.26)	0.80
Public transport only	-0.67 (-0.83, -0.51)	<0.0001	-0.50 (-0.75, -0.25)	0.00050
Car and public or active transport	-0.63 (-0.79, -0.47)	<0.0001	-0.30 (-0.47, -0.15)	0.00060
Public and active transport	-1.01 (-1.25, -0.78)	<0.0001	-0.67 (-0.87, -0.46)	<0.0001
Walking only	-1.01 (-1.28, -0.74)	<0.0001	-0.96 (-1.06, -0.86)	<0.0001
Cycling only or cycling and walking	-1.80 (-1.96, -1.64)	<0.0001	-1.62 (-1.89, -1.36)	<0.0001
Total energy intake in past 24hours (kcals)	-0.00002 (-0.0001, 0.00008)	0.72	0.0002 (0.00008, 0.0003)	0.00090

Table A1: Results of gender stratified multivariate linear regression models for the association between method of commuting and BMI, showing results for commute mode and hypothesised confounder, total energy intake in past 24 hours.
Data are adjusted for age, days per week of moderate leisure physical activity, urban or rural area, ethnic origin, household income quintiles, Townsend area deprivation quintiles, highest educational qualification, alcohol intake, smoking status, non-work active travel, walking for pleasure, job involving standing or walking, manual work, shift work, self-rated health, and limiting longstanding illness or disability.

APPENDIX 2: SENSITIVITY ANALYSIS TO INVESTIGATE THE CONFOUNDING EFFECT OF DIETARY ENERGY INTAKE ON THE ASSOCIATION BETWEEN COMMUTING MODE AND PERCENTAGE BODY FAT

Outcome: percentage body fat	Men (n=33,129)		Women (n=)	
	β coefficient (95% CI)	p-value	β coefficient (95% CI)	p-value
Commuting method:				
Car only (reference)	0		0	
Car and public transport	0.08 (-0.16, 0.31)	0.50	0.13 (-0.26, 0.52)	0.49
Public transport only	-0.65 (-0.84, -0.47)	<0.0001	-0.76 (-1.10, -0.42)	0.00020
Car and public or active transport	-1.10 (-1.36, -0.83)	<0.0001	-0.61 (-0.80, -0.42)	<0.0001
Public and active transport	-1.27 (-1.54, -1.00)	<0.0001	-1.02 (-1.36, -0.68)	<0.0001
Walking only	-1.05 (-1.49, -0.61)	0.00010	-1.42 (-1.65, -1.20)	<0.0001
Cycling only or cycling and walking	-2.81 (-3.14, -2.47)	<0.0001	-3.14 (-3.73, -2.54)	<0.0001
Total energy intake in past 24hours (kcals)	-0.0004 (-0.0005, -0.0003)	<0.0001	-0.0005 (-0.0002, 0.0002)	0.95

Table A2: Results of gender stratified multivariate linear regression models for the association between method of commuting and percentage body fat, showing results for commute mode and hypothesised confounder, total energy intake in past 24 hours.
Data are adjusted for age, days per week of moderate leisure physical activity, urban or rural area, ethnic origin, household income quintiles, Townsend area deprivation quintiles, highest educational qualification, alcohol intake, smoking status, non-work active travel, walking for pleasure, job involving standing or walking, manual work, shift work, self-rated health, and limiting longstanding illness or disability.

APPENDIX 3: SENSITIVITY ANALYSIS TO INVESTIGATE THE ASSOCIATION BETWEEN COMMUTE DISTANCE AND BMI AND PERCENTAGE BODY FAT, AMONG WALKING COMMUTERS.

	Outcome: BMI (kg/m2) n=7,746		Outcome: Percentage body fat n= 7,660	
	β coefficient (95% CI)	p-value	β coefficient (95% CI)	p-value
Walking commute distance category:				
Less than 1 mile (reference)	0		0	
1 mile	-0.31 (-0.49, -0.12)	0.0020	-0.38 (-0.72, -0.04)	0.032
2 miles	-0.43 (-0.76, -0.09)	0.010	-0.79 (-1.28, -0.31)	0.0027
3 miles	-0.50 (-0.95, -0.05)	0.030	-0.95 (-1.63, -0.26)	0.0091
More than 4 miles	-0.18 (-0.88, 0.52)	0.60	-0.05 (-1.11, 1.01)	0.92

TABLE A3: Results of multivariate linear regression models for the association between distance of walking commute and (i) BMI; (ii) percentage body fat.

Data are adjusted for sex, age, days per week of moderate leisure physical activity, urban or rural area, ethnic origin, household income quintiles, Townsend area deprivation quintiles, highest educational qualification, alcohol intake, smoking status, non-work active travel, walking for pleasure, job involving standing or walking, manual work, shift work, self-rated health, and limiting longstanding illness or disability.

APPENDIX 4: SENSITIVITY ANALYSIS TO INVESTIGATE THE ASSOCIATION BETWEEN COMMUTE DISTANCE AND BMI AND PERCENTAGE BODY FAT, AMONG CYCLING COMMUTERS.

	Outcome: BMI (kg/m2) n= 4,195		Outcome: Percentage body fat n= 4,146	
	β coefficient (95% CI)	p-value	β coefficient (95% CI)	p-value
Cycling commute distance category:				
Less than 2 miles (reference)	0		0	
2-4 miles	-0.10 (-0.35, 0.15)	0.43	-0.59 (-0.10, -0.18)	0.0068
5-7 miles	-0.36 (-0.67, -0.05)	0.025	-1.14 (-1.64, -0.64)	0.00010
8-10 miles	-0.56 (-1.05, -0.08)	0.026	-1.08 (-1.92, -0.25)	0.014
More than 11 miles	-0.03 (-0.63, 0.58)	0.93	-1.18 (-2.34, -0.02)	0.047

TABLE A4: Results of multivariate linear regression models for the association between distance of cycling commute and (i) BMI; (ii) percentage body fat.

Data are adjusted for sex, age, days per week of moderate leisure physical activity, urban or rural area, ethnic origin, household income quintiles, Townsend area deprivation quintiles, highest educational qualification, alcohol intake, smoking status, non-work active travel, walking for pleasure, job involving standing or walking, manual work, shift work, self-rated health, and limiting longstanding illness or disability.