Chen M, Yerramalla MS, van Hees VT, et al. Individual barriers to an active lifestyle at older ages among Whitehall II study participants after 20 years of follow-up. *JAMA Netw Open*. 2022;5(4):e226379. doi:10.1001/jamanetworkopen.2022.6379

**eMethods 1.** Procedure for Function-on-Scalar Regression

**eMethods 2.** Exposure Variables: Sociodemographic, Behavioral, and Health-Related Factors

**eFigure 1.** Study Flowchart

**eFigure 2.** Cross-Sectional Association of Sociodemographic Factors With Activity Intensity Distribution

**eFigure 3.** Cross-Sectional Association of Behavioral Factors With Activity Intensity Distribution

**eFigure 4.** Cross-Sectional Association of Health-Related Factors With Activity Intensity Distribution

**eTable 1.** Interactions of Sex With Factors for Association With Activity Intensity Distribution

**eTable 2.** Characteristics of Participants Included and Not Included in Analyses

**eTable 3.** Association of Exposure Variables With Sedentary Behavior and Physical Activity Among Men at 20 and 9 Years

**eTable 4.** Association of Exposure Variables With Sedentary Behavior and Physical Activity Among Women at 20 and 9 Years

**eTable 5.** Association of Exposure Factors With Outcomes Among 3552 Men Accounting for Missing Data Using Multiple Imputation

**eTable 6.** Association of Exposure Factors With Outcomes Among 1328 Women Accounting for Missing Data Using Multiple Imputation

This supplemental material has been provided by the authors to give readers additional information about their work.
eMethods 1. Procedure for Function-on-Scalar Regression

Estimation of activity intensity distribution

For each participant, the density function of acceleration during waking period was estimated by kernel density estimation on a logarithmically distributed 150-point grid, using a Gaussian kernel and a plug-in bandwidth selector. As acceleration distribution was skewed, the log transformed (1 + acceleration) was used for the kernel smoothing. The complete diurnal intake, overweight, and obesity groups, respectively.

\[ A_i(x) = T_i \times f_i(x) \]

where \( T_i \) and \( f_i \) are the daily waking time and the density function for the \( i \)th participant, respectively. \( x \) is the magnitude of acceleration variable which takes its values over the range of the recorded acceleration, and \( A_i(x) \) represents the time spent at magnitude \( x \). The integral of \( A_i \) over any range of acceleration represents the time (minutes) spent in this acceleration range per day, with integral over the total range of acceleration representing the daily waking time.

Function-on-scalar regression

Equation of the functional model adjusted for all covariates:

\[
A_i(x) = \alpha(x) + \beta_{age}(x) \times \text{age}_i + \beta_{sex}(x) \times \text{sex}_i + \beta_{ethnicity}(x) \times \text{ethnicity}_i + \beta_{position}(x) \times \text{position}_i + \beta_{smok,ex}(x) \times \text{smok,ex}_i \times D_{smok,ex}i + \beta_{smok,cur}(x) \times D_{smok,cur}i + \beta_{alc,0}(x) \times D_{alc,0}i + \beta_{alc,14}(x) \times D_{alc,14}i + \beta_{low,fruit,veg}(x) \times D_{low,fruit,veg}i + \beta_{bmi,overweight}(x) \times D_{bmi,overweight}i + \beta_{bmi,obese}(x) \times D_{bmi,obese}i \\
+ \beta_{DBmi,obese}i + \beta_{mental,score}(x) \times \text{mental,score}_i + \beta_{physical,score}(x) \times \text{physical,score}_i + \beta_{multimorbidity, index}(x) \times D_{multimorbidity, index}i
\]

In this model, \( A_i(x) \) is the activity intensity distribution function for the \( i \)th participant and corresponds to the outcome. \( \alpha(x) \) is the intercept activity distribution function. \( \beta_{age}(x) , \beta_{sex}(x) , \beta_{ethnicity}(x) , \beta_{position}(x) , \beta_{smok,ex}(x) , \beta_{smok,cur}(x) , \beta_{alc,0}(x) , \beta_{alc,14}(x) , \beta_{low,fruit,veg}(x) , \beta_{bmi,overweight}(x) , \beta_{bmi,obese}(x) , \beta_{mental,score}(x) , \beta_{physical,score}(x) , \) and \( \beta_{multimorbidity, index}(x) \) are the functional coefficients of the model; they represent the association between the covariates and the outcome. \( D_{smok,ex}i, D_{smok,cur}i, D_{alc,0}i, D_{alc,14}i, D_{bmi,overweight}i, \) and \( D_{bmi,obese}i \) are “dummy” binary variables indicating the belonging to ex-smokers, current smokers, 0 unit per week alcohol intake, >14 units per week alcohol intake, overweight, and obesity groups, respectively.

In order to facilitate interpretation of results, functional regression coefficients were integrated over 0.005 g intervals to estimate the time difference (in minutes/day) in each acceleration interval between the different subgroups.

Software and packages

All analyses were undertaken using R version 3.6.1 (version 3.6.1, http://www.r-project.org/). Kernel smoothing was implemented using the package ks (version 1.11.7, https://cran.r-project.org/web/packages/ks/ks.pdf) of R. All function-on-scalar regressions were conducted using the REFUND package in R (version 0.1-21, https://cran.r-project.org/web/packages/refund/refund.pdf). The trapezoidal integration of functional coefficients was undertaken using the pracma R package (version 2.2.9, https://cran.r-project.org/web/packages/pracma/pracma.pdf). Significance of associations was examined using p-values from function-on-scalar regression, that accounts for the entire activity intensity distribution, after Bonferroni correction leading to \( p<0.004 \) (0.05 divided by 14 tests per model).
eMethods 2. Exposure Variables: Sociodemographic, Behavioral, and Health-Related Factors

Data were drawn from questionnaires and clinical evaluations as well as from electronic health records (Hospital Episode Statistics (HES), cancer registry, and the Mental Health Services Data Set).

Socio-demographic factors included age, sex, self-reported ethnicity (categorized as white and non-white (Black; South Asian; other), due to small numbers of non-white groups), marital status (married/cohabitating, divorced/widowed/single), and last occupational position (low, intermediate, high; coded 1, 0.5, and 0, respectively, and entered as an ordinal variable; this is a comprehensive marker of socioeconomic position in the British Civil Service that reflects salary, social status, and level of responsibility at work).

Behavioral factors were smoking status (never, past, current smoker), alcohol intake (none, moderate (1-14 units/week), high (>14 units/week)), and fruit and vegetable intake (<twice daily, ≥twice daily).

Health-related factors included body mass index (BMI; categorized as <25 (normal), 25-29.9 (overweight), and ≥30 (obese) kg/m²), Short Form 36 Health Survey1 physical and mental component summary scores, and number of chronic conditions including hypertension (systolic/diastolic blood pressure ≥140/90 mmHg, or use of antihypertensive drugs), diabetes (fasting glucose ≥7.0 mmol/L, self-reported doctor-diagnosed diabetes, use of anti-diabetic medications, or record in HES), coronary heart disease, stroke, heart failure, arthritis, cancer, depression, dementia, Parkinson’s disease, and chronic obstructive pulmonary disease (assessed using HES records and data collected at Whitehall clinical exams as well as mental health records for depression and dementia).

Reference:

1. Ware JE, Jr., Kosinski M, Bayliss MS, et al. Comparison of methods for the scoring and statistical analysis of SF-36 health profile and summary measures: summary of results from the Medical Outcomes Study. Medical care 1995;33(4 Suppl):As264-79. [published Online First: 1995/04/01]
In total, 3809 (98%) participants had 7 days of valid data, 47 (1%) had 6 days, 22 (<1%) had 5 days, and 18 (<1%), had 4 days of valid data.
eFigure 2. Cross-Sectional Association of Sociodemographic Factors With Activity Intensity Distribution

Time difference (minutes/day) spent over 0.005 g acceleration intervals between different subgroups, computed after integration of activity intensity distribution estimated by function-on-scalar regression model adjusted for all covariates (sociodemographic, behavioral, and health-related factors) and waking time. p for association between each covariate and the full activity intensity distribution from function-on-scalar regression mutually adjusted for all covariates and waking time.
eFigure 3. Cross-Sectional Association of Behavioral Factors With Activity Intensity Distribution

Time difference (minutes/day) spent over 0.005 g acceleration intervals between different subgroups, computed after integration of activity intensity distribution estimated by function-on-scalar regression model adjusted for all covariates (sociodemographic, behavioral, and health-related factors) and waking time. p for association between each covariate and the full activity intensity distribution from function-on-scalar regression mutually adjusted for all covariates and waking time.
**eFigure 4. Cross-Sectional Association of Health-Related Factors With Activity Intensity Distribution**

Time difference (minutes/day) spent over 0.005 g acceleration intervals between different subgroups, computed after integration of activity intensity distribution estimated by function-on-scalar regression model adjusted for all covariates (sociodemographic, behavioral, and health-related factors) and waking time. *p* for association between each covariate and the full activity intensity distribution from function-on-scalar regression mutually adjusted for all covariates and waking time.

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**eTable 1. Interactions of Sex With Factors for Association With Activity Intensity Distribution**

|                                | 1991-1993 (N=3808) a | 2002-2004 (N=3782) a | 2012-2013 (N=3896) a |
|--------------------------------|----------------------|---------------------|---------------------|
| **Socio-demographic factors**  |                      |                     |                     |
| Age                            | 0.057                | 0.91                | 0.69                |
| Non-white ethnicity            | <.001                | <.001               | <.001               |
| Lower occupational position    | <.001                | <.001               | <.001               |
| Not married/cohabitating       | 0.00012              | 0.79                | 0.03                |
| **Behavioral factors**         |                      |                     |                     |
| Smoking status                 |                      |                     |                     |
| Never smoker                   | Ref                  | Ref                 | Ref                 |
| Past smoker                    | <.001                | <.001               | <.001               |
| Current smoker                 | <.001                | <.001               | <.001               |
| Alcohol intake                 |                      |                     |                     |
| None                           | 0.0025               | <.001               | 0.27                |
| Moderate                       | Ref                  | Ref                 | Ref                 |
| High                           | 0.99                 | 0.61                | 0.97                |
| Fruits & vegetables intake < twice daily | 0.99 | 0.93 | 0.58 |
| **Health-related factors**     |                      |                     |                     |
| Body mass index                |                      |                     |                     |
| Normal                         | Ref                  | Ref                 | Ref                 |
| Overweight                     | <.001                | <.001               | 0.85                |
| Obese                          | 0.67                 | 0.64                | <.001               |
| SF36-mental component summary score | 0.22 | 0.0012 | <.001 |
| SF36-physical component summary score | 0.78 | 0.28 | 0.33 |
| Number of chronic conditions b | <.001                | <.001               | 0.66                |

Abbreviations: SF36: Short Form 36 Health Survey.

a p from function-on-scalar regression assessing interactions of sex with covariates.
b Chronic conditions include hypertension, diabetes, coronary heart disease, stroke, heart failure, arthritis, cancer, depression, dementia, Parkinson’s disease, and chronic obstructive pulmonary disease.
### eTable 2. Characteristics of Participants Included and Not Included in Analyses

|                | 1991-1993 | 2002-2004 | 2012-2013 |
|----------------|-----------|-----------|-----------|
|                | Included  | Not included | Included  | Not included | Included  | Not included |
|                | N=3808    | N=1072    | N=3782    | N=1098    | N=3896    | N=984    |
| **Socio-demographic factors** |           |           |           |           |           |           |
| Age, mean (SD) | 49.1 (5.7) | 48.6 (5.7) | 60.4 (5.7) | 59.5 (5.6) | 69.4 (5.7) | 68.9 (5.6) | 0.009 |
| Sex            |           |           |           |           |           |           |
| Men            | 2823 (74.1%) | 729 (68.0%) | 2828 (74.8%) | 724 (65.9%) | 2910 (74.7%) | 642 (65.2%) | <.001 |
| Women          | 985 (25.9%) | 343 (32.0%) | 954 (25.2%) | 374 (34.1%) | 986 (25.3%) | 342 (34.8%) | <.001 |
| **Ethnicity**  |           |           |           |           |           |           |
| White          | 3532 (92.8%) | 960 (89.6%) | 3523 (93.2%) | 969 (88.3%) | 3622 (93.0%) | 870 (88.4%) | <.001 |
| Non-white      | 276 (7.2%) | 112 (10.4%) | 259 (6.8%) | 129 (11.7%) | 274 (7.0%) | 114 (11.6%) |           |
| **Occupational position** |           |           |           |           |           |           |
| High/intermediate | 3396 (89.2%) | 933 (87.0%) | 3458 (91.4%) | 869 (88.1%) | 3563 (91.5%) | 870 (88.4%) | 0.003 |
| Low            | 412 (10.8%) | 139 (13.0%) | 324 (8.6%) | 117 (11.9%) | 333 (8.5%) | 114 (11.6%) |           |
| Missing        | 0 | 0 | 0 | 122 | 0 | 0 |           |
| **Marital status** |           |           |           |           |           |           |
| Married/cohabitating | 2978 (78.2%) | 825 (77.0%) | 2903 (76.8%) | 726 (76.4%) | 2916 (74.8%) | 719 (73.5%) | 0.39 |
| Not married/cohabitating | 830 (21.8%) | 246 (23.0%) | 879 (23.2%) | 224 (23.6%) | 980 (25.2%) | 259 (26.5%) |           |
| Missing        | 0 | 1 | 0 | 148 | 0 | 6 |           |
| **Behavioral factors** |           |           |           |           |           |           |
| Smoking status |           |           |           |           |           |           |
| Never smoker   | 2026 (53.2%) | 549 (51.5%) | 1903 (50.3%) | 476 (50.7%) | 1875 (48.1%) | 420 (47.6%) | 0.33 |
| Past smoker    | 1406 (36.9%) | 381 (35.8%) | 1624 (42.9%) | 392 (41.7%) | 1897 (48.7%) | 426 (48.2%) |           |
| Current smoker | 376 (9.9%) | 135 (12.7%) | 255 (6.7%) | 71 (7.6%) | 124 (3.2%) | 37 (4.2%) |           |
| Missing        | 0 | 7 | 0 | 159 | 0 | 101 |           |
| Alcohol intake |           |           |           |           |           |           |
| None           | 612 (16.1%) | 164 (15.3%) | 548 (14.5%) | 160 (17.1%) | 777 (19.9%) | 216 (22.1%) | 0.31 |
| Moderate       | 2238 (58.8%) | 612 (57.2%) | 2043 (54.0%) | 466 (49.8%) | 2207 (56.6%) | 534 (54.6%) |           |
| High           | 958 (25.2%) | 293 (27.4%) | 1191 (31.5%) | 310 (33.1%) | 912 (23.4%) | 228 (23.3%) |           |
|                           | 1991-1993 |               | 2002-2004 |               | 2012-2013 |               |
|---------------------------|-----------|--------------|-----------|--------------|-----------|--------------|
|                           | Included N=3808 | Not included N=1072 | Included N=3782 | Not included N=1098 | Included N=3896 | Not included N=984 |
| Missing                   | 0         | 3            | 0         | 162          | 0         | 6            |
| Fruits & vegetables intake|           |              |           |              |           |              |
| < twice daily             | 861 (22.6%) | 191 (23.0%)  | 1565 (41.4%) | 384 (40.6%)  | 2268 (58.2%) | 579 (59.4%)  | 0.79         |
| ≥ twice daily             | 2947 (77.4%) | 638 (77.0%)  | 2217 (58.6%) | 561 (59.4%)  | 1628 (41.8%) | 396 (40.6%)  | 0.68         |
| Missing                   | 0         | 243          | 0         | 153          | 0         | 9            |
| Health-related factors    |           |              |           |              |           |              |
| Body mass index           |           |              |           |              |           |              |
| Normal                    | 2124 (55.8%) | 619 (57.7%)  | 1449 (38.3%) | 337 (37.9%)  | 1511 (38.8%) | 380 (38.9%)  | 0.37         |
| Overweight                | 1404 (36.9%) | 370 (34.5%)  | 1712 (45.3%) | 395 (44.4%)  | 1677 (43.0%) | 396 (40.5%)  | 0.67         |
| Obese                     | 280 (7.4%)  | 83 (7.7%)    | 621 (16.4%)  | 157 (17.7%)  | 708 (18.2%)  | 201 (20.6%)  | 0.17         |
| Missing                   | 0         | 0            | 0         | 209          | 0         | 7            |
| SF36-mental component summary score |           |              |           |              |           |              |
| Mean (SD)                 | 51.0 (8.5)  | 50.9 (8.3)   | 52.2 (8.9)  | 51.4 (9.1)   | 53.8 (8.3)  | 53.4 (7.9)   | 0.83         |
| Missing                   | 0         | 247          | 0         | 183          | 0         | 33           |
| SF36-physical component summary score |           |              |           |              |           |              |
| Mean (SD)                 | 52.9 (6.5)  | 52.4 (7.2)   | 49.8 (8.2)  | 49.5 (8.4)   | 48.3 (8.9)  | 48.0 (9.1)   | 0.06         |
| Missing                   | 0         | 247          | 0         | 183          | 0         | 33           |
| Number of chronic conditions, mean (SD) | 0.2 (0.5) | 0.2 (0.5) | 0.7 (0.8) | 0.6 (0.8) | 1.2 (1.1) | 1.2 (1.0) | 0.63 |
| Accelerometer variables, time (min/day) in: |           |              |           |              |           |              |
| Sedentary behavior, mean (SD) |         |              |           |              |           | 718.2 (100.0) | 688.1 (152.2) | <.001       |
| Light-intensity physical activity, mean (SD) |         |              |           |              |           | 210.1 (69.1) | 214.0 (81.9) | 0.044       |
| Moderate-to-vigorous physical activity, mean (SD) |         |              |           |              |           | 56.1 (38.5) | 74.1 (119.4) | <.001       |
| Missing                   | 0         | 787          | 0         | 787          | 0         | 787          |

Data are No. (%) unless otherwise indicated. Abbreviations: SD, standard deviation; SF36: Short Form 36 Health Survey.

*p for difference between included and non-included participants at each time point.

Chronic conditions include hypertension, diabetes, coronary heart disease, stroke, heart failure, arthritis, cancer, depression, dementia, Parkinson’s disease, and chronic obstructive pulmonary disease.
### eTable 3. Association of Exposure Variables With Sedentary Behavior and Physical Activity Among Men at 20 and 9 Years

| Socio-demographic factors       | SB (95% CI) | LIPA (95% CI) | MVPA (95% CI) | p<sup>b</sup> for activity distribution | SB (95% CI) | LIPA (95% CI) | MVPA (95% CI) | p<sup>b</sup> for activity distribution |
|---------------------------------|-------------|---------------|---------------|----------------------------------------|-------------|---------------|---------------|----------------------------------------|
| **20-year follow-up (N=2823)**  |             |               |               |                                        |             |               |               |                                        |
| Age (per 5 years)               | 17.0 (14.1, 19.9) | -6.1 (-8.2, -3.9) | -11.0 (-12.1, -9.8) | <.001<sup>*</sup> | 18.5 (15.6, 21.5) | -7.0 (-9.2, -4.8) | -11.5 (-12.7, -10.3) | <.001<sup>*</sup> |
| Non-white ethnicity             | 25.8 (11.2, 40.4) | -19.0 (-29.9, -8.1) | -6.8 (-12.8, -0.9) | <.001<sup>*</sup> | 22.3 (7.9, 36.6) | -16.4 (-27.2, -5.7) | -5.8 (-11.7, 0.0) | <.001<sup>*</sup> |
| Lower occupational position     | -13.1 (-25.1, -1.1) | 12.6 (3.7, 21.6) | 0.4 (-4.4, 5.3) | <.001<sup>*</sup> | -20.8 (-32.7, -8.9) | 17.4 (8.4, 26.3) | 3.4 (-1.5, 8.2) | <.001<sup>*</sup> |
| Not married/cohabitating        | 10.1 (1.2, 19.0) | -12.3 (-19.0, -5.6) | 2.2 (-1.4, 5.8) | <.001<sup>*</sup> | 8.9 (0.2, 17.5) | -12.1 (-18.6, -5.6) | 3.2 (-0.3, 6.8) | <.001<sup>*</sup> |
| **Behavioral factors**          |             |               |               |                                        |             |               |               |                                        |
| Smoking status                  |             |               |               |                                        |             |               |               |                                        |
| Never smoker                    | Ref         | Ref           | Ref           |                                        | Ref         | Ref           | Ref           |                                        |
| Past smoker                     | -7.7 (-14.6, -0.9) | 5.6 (0.5, 10.7) | 2.1 (-0.6, 4.9) | <.001<sup>*</sup> | -8.6 (-15.0, -1.9) | 5.8 (0.9, 10.7) | 2.7 (-0.0, 5.3) | <.001<sup>*</sup> |
| Current smoker                  | 19.2 (7.7, 30.6) | -11.2 (-19.7, -2.6) | -8.0 (-12.7, -3.3) | <.001<sup>*</sup> | 22.7 (9.4, 35.9) | -14.6 (-24.6, -4.6) | -8.1 (-13.5, -2.7) | <.001<sup>*</sup> |
| Alcohol intake                  |             |               |               |                                        |             |               |               |                                        |
| None                            | 4.2 (-5.7, 14.2) | -1.5 (-9.0, 5.9) | -2.7 (-6.8, 1.4) | <.001<sup>*</sup> | 8.2 (-2.4, 18.8) | -5.5 (-13.4, 2.5) | -2.7 (-7.0, 1.6) | <.001<sup>*</sup> |
| Moderate                        | Ref         | Ref           | Ref           |                                        | Ref         | Ref           | Ref           |                                        |
| High                            | 2.1 (-5.2, 9.3) | -1.5 (-7.0, 3.9) | -0.5 (-3.5, 2.4) | <.001<sup>*</sup> | -3.2 (-10.0, 3.6) | 3.2 (-1.9, 8.3) | -0.0 (-2.8, 2.8) | <.001<sup>*</sup> |
| Fruits & vegetables intake <twice daily | 12.5 (4.6, 20.5) | -7.4 (-13.4, -1.5) | -5.1 (-8.3, -1.8) | <.001<sup>*</sup> | 6.8 (0.4, 13.3) | -3.2 (-8.1, 1.6) | -3.6 (-6.2, -0.9) | <.001<sup>*</sup> |
| **Self-reported MVPA**           |             |               |               |                                        |             |               |               |                                        |
| None                            | 26.8 (14.8, 38.8) | -17.9 (-26.8, -8.9) | -9.0 (-13.8, -4.1) | <.001<sup>*</sup> | 45.4 (31.4, 59.4) | -35.5 (-46.0, -25.0) | -9.9 (-15.6, -4.1) | <.001<sup>*</sup> |
| 0.1-2.4 h/week                  | 15.9 (9.0, 22.7) | -8.7 (-13.8, -3.6) | -7.1 (-9.9, -4.3) | <.001<sup>*</sup> | 17.2 (10.3, 24.1) | -11.1 (-16.2, -5.9) | -6.1 (-8.9, -3.3) | <.001<sup>*</sup> |
| ≥2.5 h/week                     | Ref         | Ref           | Ref           |                                        | Ref         | Ref           | Ref           |                                        |
| **Health-related factors**      |             |               |               |                                        |             |               |               |                                        |
| Body mass index                 |             |               |               |                                        |             |               |               |                                        |
| Normal                          | 16.8 (10.1, 23.5) | -8.3 (-13.4, -3.3) | -8.5 (-11.2, -5.7) | <.001<sup>*</sup> | 13.1 (6.3, 19.9) | -5.6 (-10.8, -0.5) | -7.5 (-10.3, -4.7) | <.001<sup>*</sup> |
| Obese                           | 50.0 (35.8, 64.2) | -27.0 (-37.6, -16.4) | -23.0 (-28.7, -17.2) | <.001<sup>*</sup> | 44.7 (34.6, 54.7) | -24.6 (-32.2, -17.1) | -20.1 (-24.2, -16.0) | <.001<sup>*</sup> |
| MCS (per 10-point decrease)     | 0.9 (-3.1, 5.0) | 0.3 (-2.8, 3.3) | -1.2 (-2.9, 0.4) | <.001<sup>*</sup> | 1.1 (-2.7, 5.0) | 0.2 (-2.6, 3.1) | -1.4 (-2.9, 0.2) | 0.94 |
| PCS (per 10-point decrease)     | 8.1 (2.3, 13.9) | -3.1 (-7.4, 1.2) | -5.0 (-7.3, -2.6) | <.001<sup>*</sup> | 7.0 (2.6, 11.4) | -2.9 (-6.2, 0.4) | -4.1 (-5.9, -2.3) | <.001<sup>*</sup> |
| Number of chronic conditions    | 12.7 (5.6, 19.8) | -7.6 (-12.9, -2.3) | -5.1 (-8.0, -2.2) | <.001<sup>*</sup> | 13.5 (9.2, 17.8) | -8.0 (-11.3, -4.8) | -5.5 (-7.2, -3.7) | <.001<sup>*</sup> |

Abbreviations: CI: confidence interval; SB: sedentary behavior; LIPA: light-intensity physical activity; MVPA: moderate-to-vigorous physical activity; MCS: Mental component summary score from the Short Form 36 Health Survey; PCS: SF 36 Physical component summary score from the Short Form 36 Health Survey.

*estimated from linear regression adjusted for all covariates (including self-reported MVPA) and waking time.

<sup>b</sup>p for association between covariates and activity intensity distribution from function-on-scalar regression mutually adjusted for all covariates and waking time; *p-values <0.004 were considered significant according to the Bonferroni correction for multiple testing.

<sup>c</sup>Lower MCS and PCS correspond to poorer mental and physical summary score, respectively.

<sup>d</sup>Chronic conditions include hypertension, diabetes, coronary heart disease, stroke, heart failure, arthritis, cancer, depression, dementia, Parkinson’s disease, and chronic obstructive pulmonary disease.

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# eTable 4. Association of Exposure Variables With Sedentary Behavior and Physical Activity Among Women at 20 and 9 Years

| Socio-demographic factors               | 20-year follow-up (N=985) | 9-year follow-up (N=954) | p for activity distribution |
|-----------------------------------------|----------------------------|--------------------------|-----------------------------|
| Time difference (95% CI) in:            | SB | LIPA | MVPA | SB | LIPA | MVPA |
| Age (per 5 years)                       | -16.1 (-10.8, 21.5) | -5.7 (-9.9, -1.6) | -10.4 (-12.4, -8.5) | <.001* | 19.9 (14.5, 25.3) | -8.2 (-12.5, -4.0) | <.001* |
| Non-white ethnicity                     | 8.4 (-11.2, 28.0) | -4.4 (-19.7, 10.9) | -4.0 (-11.2, 3.2) | <.001* | 6.3 (-14.0, 26.5) | -2.0 (-17.9, 14.0) | <.001* |
| Lower occupational position             | -7.2 (-25.6, 11.3) | 10.0 (4.5, 24.5) | -2.9 (-9.7, 3.9) | 0.557 | -16.0 (-34.6, 2.6) | 13.1 (-1.6, 27.7) | 2.9 (4.0, 9.9) | <.001* |
| Not married/ cohabitating               | 15.5 (3.4, 27.5) | -14.1 (-23.5, -4.6) | -1.4 (-5.9, 3.1) | <.001* | 9.1 (-27.2, 21.0) | -8.5 (-17.8, 0.8) | 0.6 (-5.1, 3.8) | <.001* |

## Behavioral factors

### Smoking status

| SB | LIPA | MVPA |
|----|------|------|
| Never smoker | Ref | Ref | Ref |
| Past smoker | -5.0 (-18.3, 8.2) | 1.9 (-8.5, 12.3) | 3.1 (-1.8, 8.0) | 0.797 | 1.0 (-11.5, 13.5) | -1.8 (-11.6, 8.0) | 0.9 (-3.8, 5.5) | 0.054 |
| Current smoker | 11.6 (-7.4, 30.6) | -4.5 (-19.4, 10.4) | -7.1 (-14.1, -0.1) | 0.001* | 10.3 (-11.9, 32.5) | -0.4 (-17.9, 17.0) | -9.9 (-18.2, -1.5) |

### Alcohol intake

| SB | LIPA | MVPA |
|----|------|------|
| None | 13.6 (-0.6, 27.8) | -10.9 (-22.0, 0.3) | -2.7 (-7.9, 2.5) | <.001* | 14.3 (-0.3, 28.8) | -10.8 (-22.3, 0.6) | -3.4 (-8.9, 2.0) | <.001* |
| Moderate | Ref | Ref | Ref |
| High | 2.0 (-17.6, 21.6) | -3.0 (-18.4, 12.3) | 1.0 (-6.2, 8.2) | 0.294 | 0.6 (-16.5, 17.7) | -5.1 (-18.5, 8.4) | 4.5 (-1.9, 10.9) | <.001* |

### Fruits & vegetables intake <twice daily

| SB | LIPA | MVPA |
|----|------|------|
| None | 17.1 (2.1, 32.2) | -9.6 (-21.4, 2.3) | -7.6 (-13.1, -2.0) | <.001* | 38.7 (18.5, 58.8) | -33.1 (-48.9, -17.2) | -5.6 (-13.1, 2.0) | <.001* |
| 0.1-2.4 h/week | 19.6 (5.9, 33.2) | -11.6 (-22.3, -0.9) | -8.0 (-13.0, -3.0) | <.001* | 21.8 (9.3, 34.2) | -15.9 (-25.7, -6.1) | -5.9 (-10.5, -1.2) | <.001* |
| ≥2.5 h/week | Ref | Ref | Ref |

### Self-reported MVPA

| SB | LIPA | MVPA |
|----|------|------|
| Overweight | 33.8 (20.6, 47.1) | -19.9 (-30.2, -9.5) | -14.0 (-18.8, -9.1) | <.001* | 22.0 (8.5, 35.4) | -10.4 (-21.0, 0.2) | -11.6 (-16.6, -6.5) | <.001* |
| Obese | 43.2 (24.5, 61.9) | -26.9 (-41.5, -12.2) | -16.3 (-23.2, -9.5) | <.001* | 43.6 (28.4, 58.9) | -26.1 (-38.1, -14.1) | -17.5 (-23.2, -11.8) | <.001* |
| MCS (per 10 points decrease) | 7.4 (1.0, 13.8) | -4.3 (-9.3, 0.7) | -3.1 (-5.4, -0.7) | <.001* | 6.0 (0.1, 12.0) | -4.0 (-8.7, 0.7) | -2.0 (-4.3, 0.2) | <.001* |
| PCS (per 10 points decrease) | 5.5 (-2.0, 13.0) | -1.1 (-7.0, 4.8) | -4.4 (-7.2, -1.6) | <.001* | 5.9 (-0.4, 12.2) | -1.8 (-6.7, 3.2) | -4.1 (-6.4, -1.7) | <.001* |
| Number of chronic conditions (per new condition) | 8.8 (-5.2, 22.7) | -6.5 (-17.4, 4.5) | -2.3 (-7.4, 2.8) | 0.065 | 10.8 (3.2, 18.4) | -8.3 (-14.2, -2.3) | -2.5 (-5.4, 0.3) | <.001* |

## Abbreviations
- CI: confidence interval; SB: sedentary behavior; LIPA: light-intensity physical activity; MVPA: moderate-to-vigorous physical activity; MCS: Mental component summary score from the Short Form 36 Health Survey; PCS: SF 36 Physical component summary score from the Short Form 36 Health Survey.

*Estimated from linear regression adjusted for all covariates (including self-reported MVPA) and waking time.

*For association between covariates and activity intensity distribution from function-on-scalar regression mutually adjusted for all covariates and waking time; *p-values <0.004 were considered significant according to the Bonferroni correction for multiple testing.

*Lower MCS and PCS correspond to poorer mental and physical summary score, respectively.

*Chronic conditions include hypertension, diabetes, coronary heart disease, stroke, heart failure, arthritis, cancer, depression, dementia, Parkinson’s disease, and chronic obstructive pulmonary disease.
### eTable 5. Association of Exposure Factors With Outcomes Among 3552 Men Accounting for Missing Data Using Multiple Imputation

|                         | 20-year follow-up |                   | 9-year follow-up |                   | Cross-sectional analyses |                   |
|-------------------------|-------------------|------------------|------------------|------------------|--------------------------|------------------|
|                         | Time difference (95% CI) in: |                   | Time difference (95% CI) in: |                   | Time difference (95% CI) in: |                   |
|                         | SB                | LIPA             | MVPA             | SB                | LIPA                     | MVPA             |
| Socio-demographic factors |                   |                   |                  |                   |                           |                  |
| Age (per 5 years)       | 19.1 (15.9, 22.3) | -7.3 (-9.6, -4.9) | -11.9 (-13.4, -10.3) | 19.9 (16.6, 23.3) | -7.4 (-9.8, -4.9) | -12.5 (-14.1, -10.9) | 17.4 (14.2, 20.7) | -6.0 (-8.4, -3.6) | -11.4 (-13.0, -9.9) |
| Non-white ethnicity     | 25.4 (11.9, 38.8) | -15.7 (-25.7, -5.6) | -9.7 (-16.1, -3.3) | 21.2 (7.9, 34.5) | -12.5 (-22.5, -2.6) | -8.7 (-15.1, -2.3) | 19.1 (6.1, 32.2) | -11.9 (-21.7, -2.1) | -7.3 (-13.5, -1.0) |
| Lower occupational position | -10.0 (-26.9, 6.8) | 7.3 (-5.1, 19.6) | 2.8 (-5.3, 10.8) | -11.5 (-29.3, 6.4) | 7.1 (-6.3, 20.6) | 4.3 (-3.9, 12.5) | -7.4 (-24.3, 9.5) | 4.2 (-8.7, 17.1) | 3.2 (-4.6, 10.9) |
| Not married/ cohabitating | 12.3 (3.6, 21.1) | -14.0 (-20.3, -7.7) | 1.6 (-2.6, 5.9) | 10.0 (1.3, 18.6) | -13.2 (-19.5, -7.0) | 3.3 (-0.9, 7.4) | 9.6 (1.2, 17.8) | -13.0 (-18.9, -7.0) | 3.4 (-0.6, 7.4) |
| Behavioral factors      |                   |                   |                  |                   |                           |                  |
| Smoking status          |                   |                   |                  |                   |                           |                  |
| Never smoker            | -7.8 (-14.5, -1.0) | 6.1 (1.1, 11.0) | 1.7 (-1.6, 5.0) | -7.9 (-14.4, -1.4) | 5.2 (0.4, 9.9) | 2.7 (-0.5, 5.9) | -7.6 (-13.9, -1.3) | 4.6 (0.0, 9.3) | 2.9 (-0.3, 6.1) |
| Past smoker             | 18.3 (6.9, 29.6) | -9.8 (-18.0, -1.6) | -8.5 (-13.8, -3.1) | 19.2 (6.1, 32.4) | -11.4 (-20.9, -1.8) | -7.9 (-14.1, -1.6) | 30.0 (12.4, 47.7) | -17.0 (-30.0, -4.1) | -13.0 (-21.5, -4.5) |
| Current smoker          |                   |                   |                  |                   |                           |                  |
| Alcohol intake          |                   |                   |                  |                   |                           |                  |
| None                    | 4.5 (-5.3, 14.3) | -2.2 (-9.4, 4.9) | -2.3 (-7.0, 2.5) | 6.6 (-4.1, 17.4) | -4.8 (-12.7, 3.1) | -1.8 (-7.1, 3.4) | 8.1 (-0.9, 17.1) | -2.9 (-9.6, 3.8) | -5.2 (-9.5, -0.9) |
| Moderate                |                   |                   |                  |                   |                           |                  |
| High                    | 0.7 (-6.3, 7.6) | -0.4 (-5.6, 4.8) | -0.3 (-3.6, 3.0) | -6.8 (-13.7, 0.1) | 4.8 (-0.3, 9.9) | 2.0 (-1.3, 5.3) | -12.8 (-19.9, -5.7) | 8.7 (3.6, 13.8) | 4.1 (0.7, 7.5) |
| Fruits & vegetables intake < twice daily | 10.9 (2.7, 19.1) | -6.6 (-12.7, -0.5) | -4.3 (-8.3, -0.4) | 7.5 (0.9, 14.1) | -3.9 (-8.7, 1.0) | -3.6 (-8.8, -0.4) | 5.4 (-1.1, 11.8) | -4.0 (-8.8, 0.8) | -1.4 (-4.5, 1.7) |
| Health-related factors  |                   |                   |                  |                   |                           |                  |
| Body mass index         |                   |                   |                  |                   |                           |                  |
| Normal                  | 16.2 (9.3, 23.1) | -7.5 (-12.8, -2.2) | -8.8 (-11.9, -5.6) | 14.8 (7.6, 21.9) | -5.7 (-11.1, -0.3) | -9.1 (-12.4, -5.8) | 19.1 (12.2, 25.9) | -8.0 (-13.2, -2.8) | -11.1 (-14.4, -7.8) |
| Obese                   | 50.8 (37.1, 64.5) | -27.1 (-37.3, -17.0) | -23.6 (-30.2, -17.1) | 46.9 (36.5, 57.2) | -24.0 (-31.7, -16.4) | -22.8 (-27.6, -18.1) | 49.6 (40.1, 59.1) | -25.9 (-32.8, -18.9) | -23.7 (-28.2, -19.2) |
| MCS (per 10-point decrease) | 2.8 (-1.2, 6.7) | -0.9 (-3.8, 2.0) | -1.9 (-3.9, 0.2) | 3.6 (-0.3, 7.4) | -1.3 (-4.2, 1.6) | -2.3 (-4.0, -0.5) | 4.7 (0.5, 8.8) | -1.3 (-4.5, 2.0) | -3.4 (-5.3, -1.5) |
| PCS (per 10-point decrease) | 10.4 (4.7, 16.1) | -4.8 (-8.9, -0.6) | -5.7 (-8.7, -2.7) | 8.1 (3.6, 12.7) | -4.3 (-7.6, -0.9) | -3.9 (-6.0, -1.7) | 11.4 (7.2, 15.5) | -5.0 (-8.0, -2.0) | -6.3 (-8.4, -4.3) |
| Number of chronic conditions (per new condition) | 11.0 (3.9, 18.1) | -7.4 (-12.6, -2.3) | -3.6 (-6.9, -0.2) | 11.0 (6.6, 15.5) | -7.5 (-10.8, -4.2) | -3.6 (-5.7, -1.5) | 6.2 (3.0, 9.4) | -4.2 (-6.5, -1.8) | -2.0 (-3.5, -0.4) |

Abbreviations: CI: confidence interval; MCS: Mental component summary score from the Short Form 36 Health Survey; PCS: SF 36 Physical component summary score from the Short Form 36 Health Survey.

*estimated from linear regression adjusted for covariates and waking time accounting for missing data using multiple imputation.

**Lower MCS and PCS correspond to poorer mental and physical summary score, respectively.

* Chronic conditions include hypertension, diabetes, coronary heart disease, stroke, heart failure, arthritis, cancer, depression, dementia, Parkinson’s disease, and chronic obstructive pulmonary disease.

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| eTable 6. Association of Exposure Factors With Outcomes Among 1328 Women Accounting for Missing Data Using Multiple Imputation |
|---------------------------------------------------------------|
| **20-year follow-up** | **9-year follow-up** | **Cross-sectional analyses** |
| Time difference (95% CI) in: | Time difference (95% CI) in: | Time difference (95% CI) in: |
| SB | LIPA | MVPA | SB | LIPA | MVPA | SB | LIPA | MVPA |
| **Socio-demographic factors** | | | | | | | | |
| Age (per 5 years) | 18.6 (12.9, 24.4) | -7.5 (-11.8, -3.1) | -11.2 (-14.0, -8.4) | 19.0 (13.1, 24.8) | -7.3 (-11.7, -2.9) | -11.6 (-14.5, -8.8) | 16.7 (10.9, 22.6) | -6.1 (-10.5, -1.6) | -10.7 (-13.5, -7.8) |
| Non-white ethnicity | 9.1 (-10.7, 28.9) | -5.6 (-19.7, 8.6) | -3.5 (-13.2, 6.1) | 5.1 (-13.9, 24.1) | -0.6 (-14.1, 13.0) | -4.6 (-14.1, 5.0) | 7.6 (-11.1, 26.2) | -3.5 (-16.8, 9.9) | -4.1 (-13.5, 5.2) |
| Lower occupational position | -8.1 (-21.6, 5.4) | 8.2 (-2.1, 18.4) | -0.0 (-6.4, 6.3) | -15.6 (-30.1, -1.0) | 10.8 (-0.1, 21.7) | 4.8 (-2.1, 11.7) | -15.22 (-29.1, -1.3) | 11.6 (1.1, 22.0) | 3.7 (-3.2, 10.6) |
| Not married/ cohabitating | 15.0 (2.8, 27.3) | -13.8 (-22.9, -4.6) | -1.3 (-7.0, 4.4) | 11.0 (-0.7, 22.8) | -9.7 (-18.9, -0.5) | -1.3 (-6.7, 4.0) | 9.0 (-2.6, 20.5) | -11.9 (-20.8, -2.9) | 2.9 (-2.5, 8.4) |
| **Behavioral factors** | | | | | | | | |
| Smoking status | | | | | | | | |
| Never smoker | Ref | Ref | Ref | Ref | Ref | Ref | Ref | Ref | Ref |
| Past smoker | -5.5 (-18.5, 7.6) | 0.5 (-9.1, 10.1) | 5.0 (-1.4, 11.4) | -2.3 (-14.3, 9.7) | -0.2 (-9.2, 8.8) | 2.5 (-3.3, 8.4) | -4.0 (-15.7, 7.8) | 1.8 (-7.0, 10.6) | 2.2 (-3.6, 7.9) |
| Current smoker | 10.9 (-7.2, 29.0) | -5.6 (-18.9, 7.7) | -5.3 (-14.1, 3.5) | 4.3 (-17.0, 25.7) | 2.7 (-13.3, 18.7) | -7.0 (-17.5, 3.5) | 13.5 (-15.2, 42.3) | -4.8 (-26.1, 16.5) | -8.7 (-22.8, 5.5) |
| Alcohol intake | | | | | | | | |
| None | 10.2 (-4.0, 24.4) | -7.2 (-17.5, 3.1) | -3.0 (-10.0, 4.0) | 13.4 (-0.9, 27.7) | -10.2 (-21.2, 0.8) | -3.2 (-9.8, 3.4) | 6.2 (-7.0, 19.4) | -4.1 (-13.8, 5.6) | -2.1 (-8.6, 4.3) |
| Moderate | Ref | Ref | Ref | Ref | Ref | Ref | Ref | Ref | Ref |
| High | 0.7 (-16.2, 17.7) | -0.4 (-13.1, 12.3) | -0.4 (-8.4, 7.6) | -4.0 (-18.9, 10.9) | -3.8 (-14.8, 7.2) | 7.8 (0.4, 15.2) | -1.6 (-19.0, 15.7) | -6.6 (-19.6, 6.4) | 8.3 (0.0, 16.5) |
| Fruits & vegetables intake <twice daily | 10.1 (-2.9, 23.2) | -5.5 (-15.5, 4.4) | -4.6 (-10.7, 1.5) | 7.7 (-5.0, 20.4) | -7.1 (-16.4, 2.1) | -0.6 (-6.8, 5.6) | 4.5 (-7.9, 16.8) | -4.7 (-14.1, 4.8) | 0.2 (-5.7, 6.1) |
| **Health-related factors** | | | | | | | | |
| Body mass index | | | | | | | | |
| Normal | Ref | Ref | Ref | Ref | Ref | Ref | Ref | Ref | Ref |
| Overweight | 33.0 (20.1, 46.0) | -18.5 (-28.3, -8.6) | -14.6 (-20.7, -8.4) | 24.5 (11.2, 37.8) | -10.8 (-20.6, -1.0) | -13.7 (-20.0, -7.3) | 17.2 (3.8, 30.7) | -8.6 (-18.6, 1.5) | -8.7 (-15.0, -2.3) |
| Obese | 45.2 (27.7, 62.8) | -26.8 (-40.4, -13.1) | -18.5 (-26.9, -10.0) | 46.5 (31.3, 61.6) | -25.7 (-37.2, -14.2) | -20.7 (-27.7, -13.8) | 52.1 (37.4, 66.8) | -31.2 (-42.4, -20.0) | -20.9 (-27.9, -14.0) |
| MCS (per 10-point decrease) | 5.6 (-0.5, 11.6) | -3.4 (-8.1, 1.2) | -2.1 (-5.1, 0.9) | 4.6 (-1.0, 10.1) | -3.1 (-7.3, 1.0) | -1.4 (-4.2, 1.4) | 4.7 (-0.9, 10.2) | -2.6 (-6.9, 1.7) | -2.1 (-4.9, 0.8) |
| PCS (per 10-point decrease) | 5.0 (-2.6, 12.6) | -0.1 (-5.7, 5.5) | -4.9 (-8.5, -1.2) | 5.3 (-0.7, 11.3) | -2.0 (-6.5, 2.6) | -3.3 (-6.3, -0.3) | 9.0 (2.9, 15.2) | -4.2 (-8.7, 0.4) | -4.9 (-7.9, -1.9) |
| Number of chronic conditions (per new condition) | 14.5 (0.8, 28.2) | -9.4 (-19.7, 1.0) | -5.2 (-11.4, 1.0) | 13.2 (5.9, 20.4) | -9.8 (-15.5, -4.1) | -3.4 (-6.7, 0.0) | 9.7 (4.3, 15.0) | -6.1 (-10.3, -2.0) | -3.6 (-6.2, -0.9) |

Abbreviations: CI: confidence interval; MCS: Mental component summary score from the Short Form 36 Health Survey; PCS: SF 36 Physical component summary score from the Short Form 36 Health Survey.

*estimated from linear regression adjusted for all covariates and waking time accounting for missing data using multiple imputation.

a Lower MCS and PCS correspond to poorer mental and physical summary score, respectively.

b Chronic conditions include hypertension, diabetes, coronary heart disease, stroke, heart failure, arthritis, cancer, depression, dementia, Parkinson’s disease, and chronic obstructive pulmonary disease.

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