Table of contents for the supplementary materials

Supplementary Material 1. Results from Tests of Proportional Hazard Assumption in the Complete-Case and Multiply Imputed Datasets. Supplementary Material #1 is provided as a csv file with the chi-square and p-values of every covariate in each of the 50 versions of the imputed datasets for the primary steps/day model.

Supplementary Material 2

Supplementary Procedures: Covariate Measurement

Covariates

Participants completed questionnaires during enrollment on age, race-ethnicity, and education. Family history of diabetes was assessed by asking, "Did your mother or father, or full-blooded sisters, full-blooded brothers, daughters, or sons ever have sugar diabetes or high blood sugar that first appeared as an adult?" Subsequent questionnaires around the time of accelerometry were used to assess alcohol consumption, current smoking status, general health status, and physical functioning (RAND 36-Item Health Survey). Health status prior to the OPACH study has been extensively characterized from the WHI baseline (1993 through 1998), enabling adjustment for multimorbidity. Multimorbidity was the number of chronic health conditions at the time of accelerometry (cardiovascular disease; cancer; cognitive impairment; depression; osteoarthritis; history of frequent falls; chronic obstructive pulmonary disease, hypertension; cerebrovascular disease). Diagnostic criteria for each of these chronic conditions have been previously defined [1]. At the WHI Long Life Study (2012-2013) home visit immediately before accelerometer wear, trained technicians measured height and weight, which was then used to calculate body mass index (BMI; kg/m^2). Phlebotomy was conducted on all women when not contraindicated, from which fasting blood glucose was obtained: a total of 79% of OPACH participants had successful phlebotomy (n=3831) [2].

Supplementary Procedures: Multiple Imputation

Multiple imputation (mice package) was performed using 50 rounds of imputation over 5 iterations, and all models were executed using multiple imputation to avoid inducing selection bias by otherwise restricting to those with complete data. Our multiple imputation model included all independent variables, in addition to covariates that we adjusted for. We did not investigate additional auxiliary variables, since the multiple imputation model already included confounding covariates of the steps-diabetes association among older adults. The procedure used for imputation varied depending on the data type of the variable for which we were performing imputation. For continuous variables (e.g., physical function score), we used predictive mean matching. For binary categorical variables (e.g., family history of diabetes), we imputed these values using logistic regression. For categorical variables with multiple categories (e.g., overall health category), we used polychotomous logistic regression.

Supplementary Procedures: Steps/Day-Diabetes Mediation Analysis of Body Mass Index

Accelerated failure time models were modeled using an exponential distribution with the "mediation" package in R [3] to estimate the proportion of the steps/d and diabetes risk mediated through BMI. Specifically, 5,000 quasi-Bayesian Monte Carlo simulations were run based on normal approximation [4] with control and treatment values of steps/d set at the 25th and 75th percentile of steps, respectively. Robust standard errors were computed using White's heteroskedasticity-consistent estimator for the covariance matrix from the "sandwich" package [5].

Supplementary Table 1 – Baseline (2012-2014) Characteristics in OPACH Participants of those Included and Excluded in Analytic Sample

	Missing in Analytic Sample n, (%)	Included in Analytic Sample (n=4838)	Excluded from Analytic Sample (n=183)†	p-values
Age, yrs.; *mean (sd)*	0 (0)	78.92 (6.73)	78.68 (6.59)	0.63
Age Groups; % ≥80 Years	0 (0)	2487 (51.4)	87 (47.5)	0.34
Race-ethnicity; %	0 (0)			0.16
White		2568 (53.1)	84 (45.9)	
Black		1469 (30.4)	63 (34.4)	
Hispanic		801 (16.6)	36 (19.7)	
Education; %	31 (0.6)			0.68
High School/GED		951 (19.8)	31 (17.1)	
Some College		1817 (37.8)	71 (39.2)	
College Graduate+		2039 (42.4)	79 (43.6)	
Self-Rated Health; %	16 (0.3)			0.44
Excel./Very Good		2633 (54.6)	92 (51.1)	
Good		1818 (37.7)	70 (38.9)	
Poor/Very Poor		371 (7.7)	18 (10.0)	
Light Intensity Steps, steps; *mean (sd)*	0 (0)	1875.32 (790.77)	1469.69 (835.23)	<0.001
MV Steps, steps; *mean (sd)*	0 (0)	1853.57 (1762.38)	1228.99 (1514.39)	<0.001
Physical Function; *mean (sd)*	51 (1)	70.63 (25.14)	66.17 (26.79)	0.02
Smoker Status; %	0 (0)			
Smoker		133 (2.7)	3 (1.6)	0.50
Alcohol Frequency; %	0 (0)			<0.001
<1 per Week		1526 (31.5)	55 (30.1)	
≥1 per Week		1546 (32.0)	53 (29.0)	
Non-Drinker		1390 (28.7)	43 (23.5)	
Unspecified		376 (7.8)	32 (17.5)	
Incident Diabetes; %	0 (0)	395 (8.2)	17 (9.3)	0.68
Family History of Diabetes; %	22 (0.5)	1599 (33.2)	60 (32.8)	0.97
BMI, kg/m^2; *mean (sd)*	308 (6)	27.58 (5.43)	28.15 (5.67)	0.19
Glucose, mg/dL; *mean (sd)*	1007 (21)	92.53 (16.08)	95.41 (17.21)	0.32
No. Comorbidities[#], %	0 (0)			0.06
Zero		548 (11.3)	15 (8.2)	
One		1660 (34.3)	63 (34.4)	
Two		1719 (35.5)	57 (31.1)	
Three or More		911 (18.8)	48 (26.2)	

Abbreviations: BMI = body mass index. sd = standard deviation. No = number

p-value: chi-squared for categorical variables and trend test for continuous.

chronic conditions used to compute this included: cardiovascular disease; cancer; cognitive impairment; depression medication use; osteoarthritis; history of frequent falls; chronic obstructive pulmonary disease, hypertension; cerebrovascular disease.

†Note, a total of 183 participants "excluded from the analytic sample" were excluded based on the exclusion criteria described in the methods, except on the basis of prevalent diabetes (n=1,358) or excessive stepping (greater than 30,000 steps/day, n=3).

Supplementary Table 2 – Comparison of Results from the Multiply Imputed (MI) Data and the Complete-Case Analysis: Associations between Steps/day and Incident Diabetes Among Older Women who had Accelerometry during 2012-2014 and Follow-up through February 28, 2020

	Main Analysis using MI Data Steps/day, Unit=2,000 steps (n=4,838; events=395)		Complete Case Analysis Steps/day, Unit=2,000 steps (n=4,437; events=355)	
	HR (95% CI)	P-value	HR (95% CI)	P-value
Model 1	0.86 (0.77-0.96)	0.007	0.86 (0.76-0.97)	0.01
Model 2	0.88 (0.78-1.00)	0.045	0.88 (0.78-1.00)	0.06
Model 3	0.90 (0.80-1.02)	0.11	0.90 (0.79-1.03)	0.13

Abbreviations: HR=hazard ratio; CI=confidence interval. Model 1 (M1) is adjusted for age and race-ethnicity. Model 2 = M1 + education, self-rated health, family history of diabetes, number of chronic conditions, physical functioning (Rand-36), alcohol consumption, and current smoking status. Model 3 additionally adjusts for BMI, which we consider in the steps/day and diabetes pathway.

Supplementary Table 3 – Complete-Case Analysis: Associations between Light and MV Steps/Day and Incident Diabetes Among Older Women who had Accelerometry during 2012-2014 and Follow-up through February 28, 2020 (n=4,437; events=355)

Light Intensity Steps/day, Unit=2,000 steps		Steps/day, Unit=2,000 steps	
HR (95% CI)	P-value	HR (95% CI)	P-value
0.98 (0.72-1.33)	0.89	0.87 (0.74-1.01)	0.07

Abbreviations: HR=hazard ratio; CI=confidence interval; MV=moderate-to-vigorous. Estimates adjusted for age, race-ethnicity, education, self-rated health; family history of diabetes number of chronic conditions; physical functioning (Rand-36); alcohol consumption; and current smoking status.

Supplementary Table 4 – Associations between Step Cadence Measures and Incident Diabetes Among Older Women who had Accelerometry during 2012-2014 and Follow-up through February 28, 2020; (n=4,838, events=395)

	HR (95% CI)	P-value
Peak 30-minute cadence, per 20 steps/min increment	0.91 (0.81-1.02)	0.09
Percentile of Time at greater than 40 steps per minute, per one percentile increment	0.95 (0.89-1.02)	0.13
Total Steps Accumulated in Bouts, per 200 steps increment	0.99 (0.97-1.01)	0.22

Estimates adjusted for age, race-ethnicity, education, self-rated health; family history of diabetes number of chronic conditions; physical functioning (Rand-36); alcohol consumption; and current smoking status.

Supplementary Table 5 – Sensitivity Analysis: Hazard Ratios for Incident Diabetes from Adjusted Cox Regression Models after Removal of Women with High Fasting Glucose, or Diabetes Onset within 2 Years of Baseline Among Older Women who had Accelerometry during 2012-2014 and Follow-up through February 28, 2020

	Removal of Individuals with Diabetes Onset with High Fasting Glucose Levels Steps/day (n=4,668; events=358)		Removal of Individuals with Diabetes Onset within 2 Years of Baseline Steps/day (n=4,717; events=274)	
	HR (95% CI)	P-value	HR (95% CI)	P-value
Model 1	0.87 (0.78-0.98)	0.02	0.89 (0.78-1.01)	0.07
Model 2	0.88 (0.78-1.00)	0.05	0.91 (0.79-1.05)	0.22
Model 3	0.90 (0.79-1.03)	0.12	0.93 (0.81-1.08)	0.35

Model 1 (M1) is adjusted for age and ethnicity. Model 2 = M1 + education, self-reported health; family history of diabetes number of chronic conditions; physical functioning (Rand-36); alcohol consumption; and current smoking status. Model 3 additionally adjusts for BMI, which we considered to be in the steps and diabetes pathway.

Supplementary Table 6 – Association between Steps/day and Incident Diabetes Among Older Women who had Accelerometry during 2012-2014 and Follow-up through February 28, 2020; (n=4,838; diabetes cases=395)

	Steps per day‡ Quartiles				P-trend†
	Q1	Q2	Q3	Q4	
Diabetes Cases [Rate per 1000 Person-years]	89 [16.2]	120 [19.9]	103 [16.5]	83 [12.7]	
Model 1	1.00	1.16 (0.88-1.54)	0.94 (0.70-1.27)	0.71 (0.51-0.98)	0.007
Model 2	1.00	1.21 (0.91-1.61)	1.02 (0.75-1.39)	0.78 (0.54-1.11)	0.045
Model 3	1.00	1.21 (0.91-1.61)	1.04 (0.76-1.42)	0.82 (0.57-1.17)	0.11

†P-values from Cox multivariable linear regression models including steps/day in models in a continuous form.

‡ Steps per day is defined as quartiles, which were determined using the awake wear-time adjusted steps values. Q1= Min to 2,337, Q2= 2,337-3,396, Q3=3,396-4,914, Q4=4,914 to Max.

Model 1 (M1) is adjusted for age and ethnicity. Model 2 = M1 + education, self-reported health; family history of diabetes number of chronic conditions; physical functioning (Rand-36); alcohol consumption; and current smoking status. Model 3 additionally adjusts for BMI, which we considered to be in the steps and diabetes pathway.

Supplement References

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