Daily Steps and Health:

Exercise and Sport Sciences Reviews,
Perspective for Progress

Supplement figures/tables

Table of Contents

Description of Methods for Systematic Review:

We conducted a systematic literature search to identify new studies since our previous meta-analyses on mortality and CVD (1, 2). We searched in Medline, and the Cumulated Index in Nursing and Allied Health Literature (CINAHL) for papers published during August 1, 2019 to August 28, 2024. The search strategy was based on criteria from the initial review of this topic (3) and combined terms related to daily step count measured by pedometer or accelerometer with terms related to mortality and CVD. CVD was defined as a diagnosis of fatal and nonfatal coronary heart disease, stroke, or heart failure. Details of the search strategy are provided in Section 1 of the Supplement. Inclusion criteria were prospective studies with device-measured steps and outcomes of all-cause mortality or fatal and nonfatal CVD events. Studies focused on children, populations with chronic disease, and conference abstracts were all excluded. We also excluded studies using suboptimal accelerometry data collection procedures for steps or using data from cohorts with already published results. We used Rayyan for screening and selection of papers (4). Two reviewers screened 891 articles and disagreements were resolved by a third reviewer (Supplement Figure 1). For all-cause mortality, our previous meta-analysis (2) included 15 studies. For this meta-analysis, one of the original 15 studies did not meet inclusion criteria because investigators applied the low frequency extension to their accelerometer data, which inflated step values (5). From the literature search, we identified three new studies (6–8) meeting inclusion criteria, bringing the total number of studies to 17 in the updated meta-analysis (Supplemental Figure 1; Table 1). For CVD, our previous meta-analysis6 included 8 studies. From the literature search, we identified 3 new studies (6, 9, 10) meeting inclusion criteria, bringing the total number of studies to 11 in the updated meta-analysis (Supplemental Figure 1; Table 2).

Studies not meeting inclusion criteria for this meta-analysis were excluded. In total, we identified 21 studies(6–8, 11–22) on daily steps and mortality (Table 1) and identified 12 studies (6, 9, 10, 17, 22–25) on CVD (Table 2). For the steps and mortality meta-analysis, three published studies were excluded because they reported the association between steps and mortality as continuous data only (per 1,000 daily steps) (18–20); this meta-analysis required categorical group comparisons. Another published study was excluded from the steps and mortality and steps and CVD meta-analyses because it used a composite of incident CVD and all-cause mortality (17), and did not report mortality and CVD separately.

Data were extracted for the following: descriptive information on primary outcomes; covariates included in the statistical models; sample size; characteristics of study participants, including age, sex, and other clinical characteristics; mean daily steps of the sample at baseline; exposure measurement, including duration of monitoring period, type of device, number of valid days required for inclusion in accelerometer studies only; outcome measurements, including number of events, mean or median follow-up time, and total person-years of follow-up; authors and year of publication. We also found studies examining the association with stepping intensity, and from these studies, we extracted the step intensity metrics, statistical approaches to adjust for step volume, and associations with mortality or CVD.

Summary of Literature Search and Search Terms Used

Database: Pubmed

Dates: Aug 1 2019-Aug 28 2024

Outcome: All-cause Mortality

((step w3 count*) or pedometer* or acceleromet* or actigraph*) AND mortality AND ((cohort or longitudinal or prospective or retrospective or (follow* w2 up))

233 results

Outcome: CVD

((step w3 count*) or pedometer* or acceleromet* or actigraph*) AND (cardiovascular disease* or coronary heart disease* or ischemic heart disease or coronary artery disease or stroke or heart failure or metabolic syndrome) AND ((cohort or longitudinal or prospective or retrospective or (follow* w2 up))

530 results

Database: CINAHL (Ebscohost)

Dates: Aug 1 2019-Aug 28 2024

Outcome: All-cause Mortality

((step w3 count*) or pedometer* or acceleromet* or actigraph*) AND mortality AND ((cohort or longitudinal or prospective or retrospective or (follow* w2 up))

Limiters: Exclude MEDLINE records

67 results

Outcome: CVD

((step w3 count*) or pedometer* or acceleromet* or actigraph*) AND (cardiovascular disease* or coronary heart disease* or ischemic heart disease or coronary artery disease or stroke or heart failure or metabolic syndrome) AND ((cohort or longitudinal or prospective or retrospective or (follow* w2 up))

Limiters: Exclude MEDLINE records

123 results

Supplement Figure 1. Studies included in updated meta-analysis, Steps for Health Collaborative.

Studies included in Steps for Health Collaborative meta-analysis:
Mortality (n=15)
CVD (n=8)

Studies not meeting inclusion criteria for updated meta-analysis:
Used low frequency extension, inflating step values: Mortality (n=1)

Studies from Steps for Health Collaborative meta-analysis included in this updated meta-analysis:
Mortality (n=14)
CVD (n=8)

Identification of new, published studies

Previous studies:
Mortality (n=5)
CVD (n=3)

Hall et al, 2019

New records Identified for screening (n=953)

Records excluded (n=861)
Duplicates (n=62)

New records assessed for eligibility (n=30)

Reports excluded:
Did not measure steps (n=12)
Repeat of same cohort (n=2)
Wrong study design (n=1)
Abstract/commentary (n=2)

New studies eligible to be included in update:
Mortality (n=9)
CVD (n=4)

Sum of new, eligible studies and previous studies:
Mortality (n=14)
CVD (n=7)

Studies excluded:
Mortality (n=11)
Included in previous analysis (n=7)
Insufficient data (n=4)

CVD (n=4)
Included in previous analysis (n=3)
Insufficient data (n=1)

New studies added to Steps for Health Collaborative updated meta-analysis:
Mortality (n=3)
CVD (n=3)

Updated Meta-analysis

Total studies in updated meta-analysis:
Mortality (n=17)
CVD (n=11)

Description of Methods for Meta-analysis

We used data from our previously published meta-analyses on steps and mortality (2) and CVD (1) and added additional studies where associations of steps and mortality and CVD were reported by quantiles. Using this approach, we added 3 studies on mortality (6–8) and 3 studies on CVD (6, 9, 10). We used published data for all studies (7–10) reporting results based on our pre-established analytic plan of quartile comparisons (1, 2). We did not include studies using a linear approach, which is a limitation of our categorical (non-linear) analytic approach. The UK Biobank study was originally published by quintiles (6); we requested data from study authors following the standardized quartile analytic plan developed by the Steps for Health Collaborative for both all-cause mortality and CVD results (1, 2). Investigator time and resources precluded us from using this approach with other included studies. A step algorithm previously applied in UK Biobank analyses was used for quantifying step counts (6).

Each study included in the meta-analysis examined associations with all-cause mortality or CVD events (reference: lowest quartile) using Cox proportional hazards regression (satisfying proportional hazards assumptions), producing hazard ratios (HR) and 95% confidence intervals (95% CI). Models were adjusted for age, sex, race/ethnicity, education or income, body mass index (BMI), device wear time, lifestyle factors (e.g. smoking, alcohol, diet), and study-specific variables representing diabetes, hypertension, high cholesterol, other chronic conditions, and self-rated health or functional status.

The total number of participants, events, and person-years of follow-up were summed across all studies. For the total sample, median daily steps by quartile were calculated from the medians of the individual studies. Pooled HRs and 95% CIs were computed using inverse-variance weighted random effects models. Restricted cubic spline models were used to generate log-transformed hazard ratios with knots at 25th, 50th, and 75th percentiles of daily steps for the total sample and by age group. References were set at the median of the study-level medians in the lowest quartile group. In addition, we calculated the hazard ratios along this spline curve for every 1,000 daily steps in comparison to the median step count for the lowest quartile for younger (rounded to 5,000 daily steps) and older (rounded to 3,000 daily steps) adults. We conducted a priori stratified analyses by age, given our prior meta-analyses suggesting an age difference in the associations of steps and mortality and CVD (1, 2). Age was grouped into younger (<60 years) and older (≥60 years) groups based on a definition of older people (34). The Wald test was used to evaluate non-linearity (26, 27). Heterogeneity across studies was determined by I2 statistics (28), representing the proportion of total variation attributable to systematic differences between studies rather than chance. I2 values were considered low (<25%), moderate (25%-75%), or high (>75%) (28). Funnel plots were used to assess study bias by comparing study hazard ratios against standard errors and Egger's test for funnel plot symmetry (29). Substantial health benefit is a subjective term indicating a threshold for health benefit (30, 31). For this analysis, we interpreted substantial health benefit as the range in steps where most of the leveling occurs on the dose-response curve, and beyond this range there appears to be diminishing returns on risk of mortality or CVD.

To evaluate the robustness of findings, the following series of sensitivity analyses were conducted: 1) a "leave-one-out analysis" to exclude one study at a time to determine the influence of any single study with an extreme result; 2) stratification by device type (subgroup analysis comparing pedometer vs. accelerometer); and spline curves when leaving one device out; and 3) models using fixed effects. Meta-analyses were performed using R version 4.3.3.

Supplement Table 1. Characteristics of studies included in meta-analysis –Descriptions of Data Collection and Processing

Study	Death Ascertainment	CVD Ascertainment	Device Type (wear location), Settings, Instructions	Device Wear Criteria	Summary of Covariates in Final Model for All-Cause Mortality	Summary of Covariates in Final Model for CVD
Activity and Function in the Elderly in Ulm (ActiFE)	The local registration offices in Ulm, Germany	n/a	ActivPAL (Thigh); 24 hours/day for 7 consecutive days; removed time from 12-6am	Device worn for 10h/d on ≥3 days	Age, sex, education, BMI, device wear time, smoking status, alcohol consumption, hypertension, diabetes, high cholesterol, CVD, cancer, five chair stand test	n/a
Atherosclerosis Risk in Communities (ARIC)	Community-wide hospital surveillance, records from national and local death registries, and death certificates.	Fatal and nonfatal: physician adjudicated probable myocardial infarction (MI) or definite fatal CHD based on ARIC criteria or coronary revascularization; HF and Stroke by hospitalization record	ActiGraph wGT3X-BT (waist); 60 second epochs; 7 consecutive days during waking hours	Device worn for 10 hrs/day for ≥ 3 days	Age, sex, race/ethnicity, education, BMI, device wear time, smoking status, alcohol consumption, hypertension, diabetes, high cholesterol, CVD, cancer, self-rated health	Age, sex, race/ethnicity, education, BMI, device wear time, smoking status, alcohol consumption, hypertension, diabetes, high cholesterol, cancer, self-rated health
British Regional Heart Study (BRHS)	The National Health Service central registers	Reivew of primary care notes for fatal and nonfatal events of physician adjudicated diagnosis MI, HF, or stroke(with symptoms lasting > 24 hours)	ActiGraph GT3X (waist), 60 second epochs; 7 consecutive days during waking hours	Device worn for 10h/d on ≥3 days	Age, socio-economic status based on occupation, BMI, device wear time, season of accelerometer wear, smoking status, region of residence, alcohol consumption, duration of night sleep, mobility disability, living alone vs with others	Age, socio-economic status based on occupation, BMI, device wear time, season of accelerometer wear smoking status, region of residence, alcohol consumption, duration of night sleep, mobility disability, living alone vs with others
Cancer Prevention Study-3 (CPS3)	U.S. National Death Index	n/a	Actigraph GT3x (waist); wake time only, collected at 1 sec epochs and aggregated to 60 sec epochs; 7 consecutive days during waking hours	Device worn for 10 hrs/day for ≥ 3 days	Age, sex, race/ethnicity, education, BMI, device wear time, smoking status, cancer, CVD, diabetes, respiratory disease	n/a
Coronary Artery Risk Development in Young Adults (CARDIA)	Medical records and death certificates	Fatal and nonfatal: Physician adjudicated diagnosis of HF, CHD (MI, acute coronary syndrome, coronary revascularization) or stroke	Actigraph 7164 (waist); 60 seconds epochs; 7 consecutive days during waking hours	Device worn for 10 hrs/day for ≥ 3 days	Age, sex, race/ethnicity, education, field center, BMI, device wear time, smoking status, healthy eating index, alcohol consumption, diabetes, hypertension, high cholesterol, CVD, self-rated health	Age, sex, race/ethnicity, education, field center, BMI, device wear time, smoking status, healthy eating index, alcohol consumption, diabetes, hypertension, high cholesterol, self-rated health
Framingham Heart Study (FHS)	Death certificate. Additional information obtained from records supplied by hospital, physician, pathologist, medical examiner, or family	Fatal and nonfatal: Physician adjudicated CHD (coronary insufficiency syndrome/myocardial infarction), HF, or stroke	Actical model #198-0200-00; 30 seconds epochs (waist); During Generation 3- exam 2, participants instructed to wear the device 24 hours a day (removed time from 12-6am); for Gen 2-based exam 9 instructed to wear for wake time only	Device worn for 10 hrs/day for ≥ 3 days	Age, sex, cohort group, race/ethnicity, education, BMI, device wear time, smoking status, hypertension, high cholesterol, CVD, cancer , self-rated health	Age, sex, cohort group, race/ethnicity, education, BMI, device wear time, smoking status, hypertension, high cholesterol, cancer , self-rated health
Healthy Ageing Initiative (HAI)	Swedish Cause of Death Register	Fatal and nonfatal: National Patient Register for MI, HF, or stroke	ActiGraph GT3X (waist), 60 second epochs; 7 consecutive days during waking hours	Device worn for 10 hrs/day for ≥ 3 days	sex, education, income, BMI, device wear time, smoking status, hypertension, high cholesterol, CVD, cancer, antithrombotic agents, physical function	Age, sex, education, income, BMI, device wear time, smoking status, marital status, hypertension, high cholesterol, cancer, antithrombotic agents, physical function

Additional studies on next page

BMI = Body Mass Index; ; HF = Heart Failure; CHD = Coronary Heart Disease; CVD = Cardiovascular Disease; n/a = not applicable

Supplement Table 1 cont. Characteristics of studies included in the meta-analysis –Descriptions of Data Collection and Processing

Study	Death Ascertainment	CVD Ascertainment	Device Type (wear location), Settings, Instructions	Device Wear Criteria	Summary of Covariates in Final Model for All-Cause Mortality	Summary of Covariates in Final Model for CVD
Nateglinide and Valsartan in Impaired Glucose Tolerance Outcomes Research trial (NAVIGATOR)	Death certificates	Fatal and nonfatal: Physician adjudicated CHD (MI, angina, revascularization), or stroke or transient ischemic attack	Accusplit AE120 pedometer (waist) ; instructed to wear it during waking hours for 7 consecutive days. Participants were given a log book to write down their daily step count at the end of each day.	Device worn for ≥ 1 day. Excluded days with zero steps and > 40 000 steps.	Age, sex, race/ethnicity, BMI, smoking status, CVD, diabetes, high cholesterol, cancer, emphysema,	Age, sex, race/ethnicity, socio-economic status BMI, smoking status, diabetes, high cholesterol, cancer, emphysema
National Health and Nutrition Examination Survey (NHANES)	U.S. National Death Index	n/a	Actigraph 7164 (waist); 60 seconds epochs, uniaxial; & 7 consecutive days during waking hours	Device worn for 10 hrs/day for ≥ 3 days	Age, sex, race/ethnicity, education, BMI, device wear time, diet quality smoking status, alcohol consumption, self-rated health; mobility limitation; diabetes, CVD, cancer, chronic bronchitis, and emphysema	n/a
Niigata Elderly Study (NES)	Participants completed a health once a year. Contacted family member in case of missing health survey and confirmed date with death record.	n/a	Yamax EC-100S pedometer (waist); wear consecutively for 1 week during waking hours	Device worn for ≥ 3 days	Sex, education, BMI, smoking status, alcohol consumption, medication use	n/a
Norwegian National Physical Activity Surveillance 1 (NNPAS1)	The Norwegian Cause of Death Registry	n/a	ActiGraph GT1M (waist), non-LFE; collected at 10 sec, aggregated to 60 sec epochs; 7 consecutive days during waking hours	Device worn for 10 hrs/day for ≥ 4 days	Age, sex, education, BMI, device wear time, alcohol, smoking, diabetes, CVD, cancer, stroke; daily minutes of vigorous physical activity	n/a
Jackson Heart Study (JHS)	U.S. National Death Index	Fatal and nonfatal: Physician adjudicated HF, CHD, or stroke	Yamax SW-200 pedometer (waist). 3-day monitoring sessions that was repeated for a maximum of three separate occasions within a 6 month period (i.e. max 9 days total)	Device worn for ≥ 3 consecutive days for at least one of the assessment periods	education, BMI, hypertension, high cholesterol, smoking status, alcohol consumption, hypertension, diabetes, CVD	Age, sex, race, education, BMI, hypertension, high cholesterol, smoking status, alcohol consumption, hypertension, Type 2 diabetes
Kyoto–Kameoka Study	Basic Resident Register managed by the Kameoka City Hall	n/a	EW-NK52 triaxial accelerometer (waist); 10 consecutive days during waking hours	Device worn for ≥ 4 days; excluded any days with steps lower than the 1st percentile according to the step counts in older adults 60–69 years old as reported in the National Health and Nutrition Surveys Japan (499 steps for males and 653 for females)	Age, sex, population density, step count assessment season, BMI, smoking, alcohol, living alone, education, socioeconomic status, denture use, medication use, number of chronic diseases, frailty status	n/a

Additional studies on next page

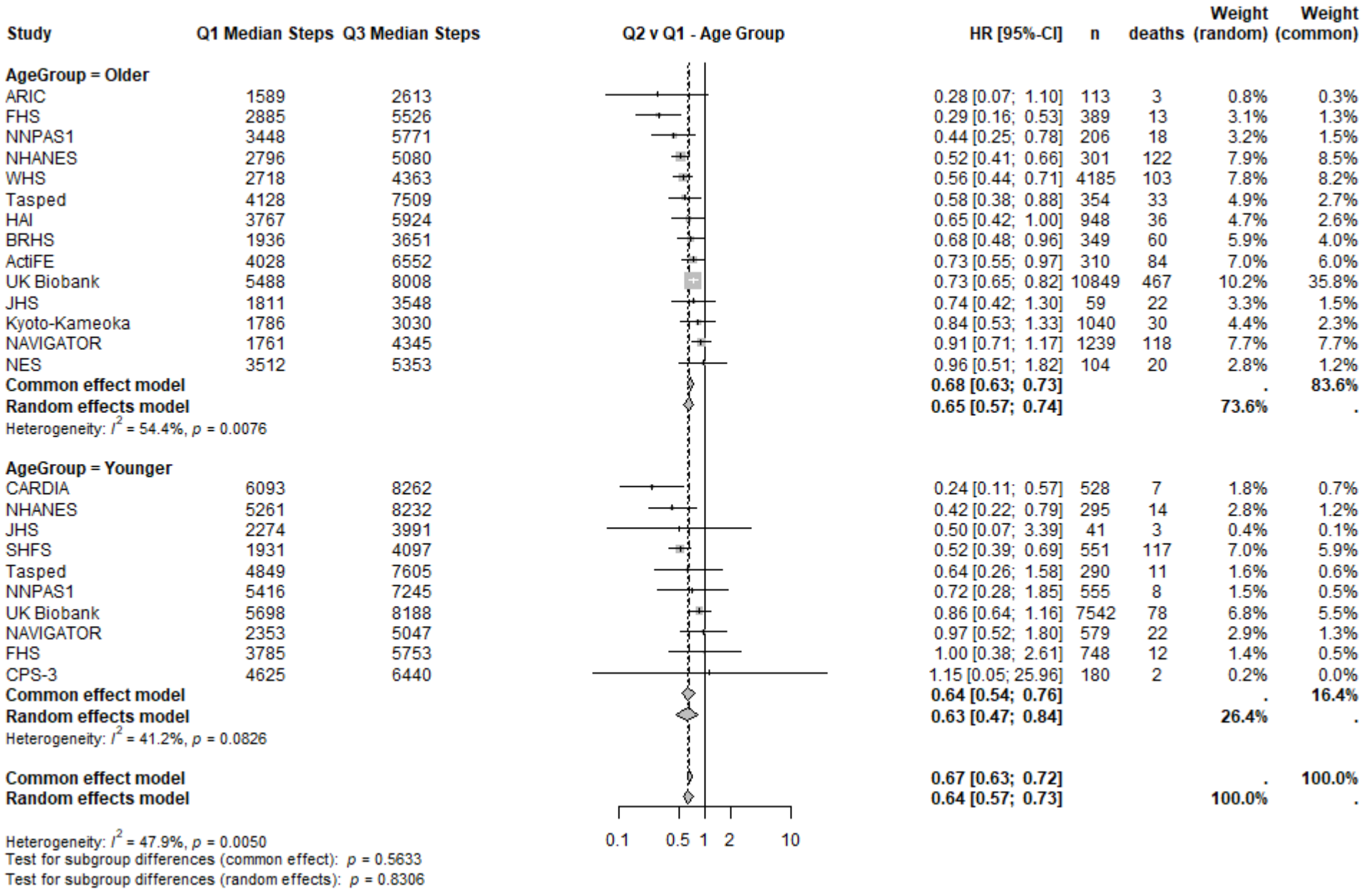
BMI = Body Mass Index; ; HF = Heart Failure; CHD = Coronary Heart Disease; CVD = Cardiovascular Disease; n/a = not applicable

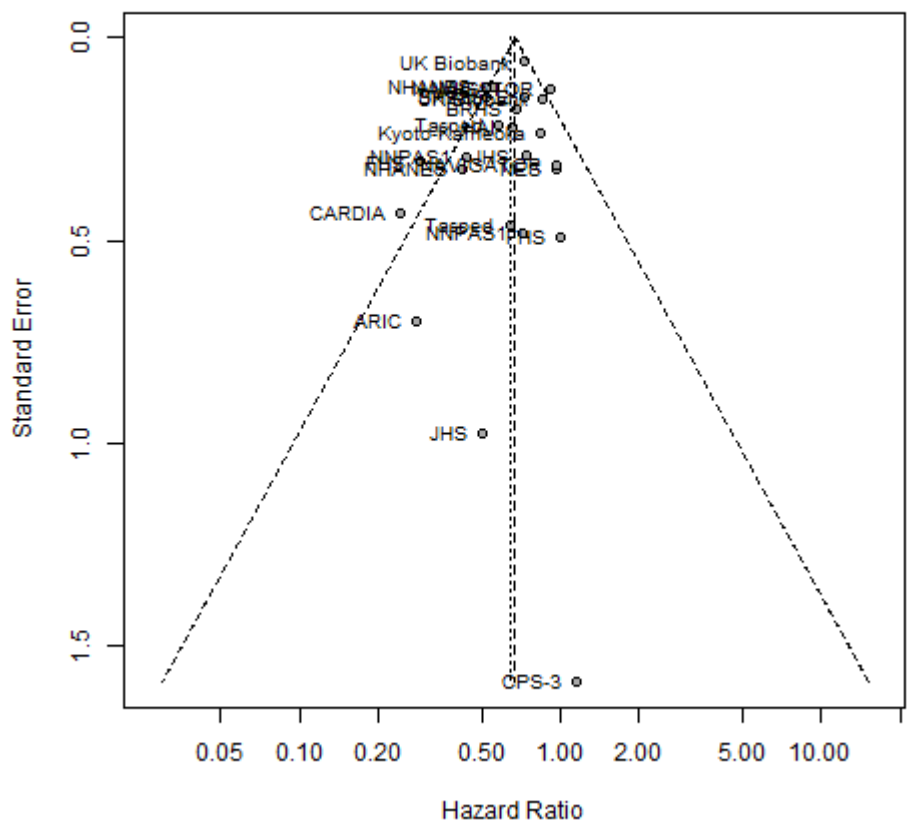
Supplement Table 1 cont. Characteristics of studies included in the meta-analysis –Descriptions of Data Collection and Processing

Study	Death Ascertainment	CVD Ascertainment	Device Type (wear location), Settings, Instructions	Device Wear Time Criteria	Summary of Covariates in Final Model for All-Cause Mortality	Summary of Covariates in Final Model for CVD
Lifestyle Interventions and Independence for elders (LIFE)	n/a	Fatal and nonfatal: Physician adjudicated HF, CHD (MI, angina, revascularization), or stroke or transient ischemic attack	ActiGraph GT3X (waist), 7 consecutive days during waking hours	Device worn for 10h/day on ≥3 days	n/a	Age, sex, race, education, BMI, hypertension, high cholesterol, smoking status, hypertension, Type 2 diabetes, high cholesterol, blood pressure
Objective Physical Activity and Cardiovascular Health (OPACH)	n/a	physician adjudicated HF using medical records requiring a diagnosis of HF, symptoms of HF, initiation of HF treatment, and appropriate response to therapy.	ActiGraph GT3X+ (waist), 7 consecutive days, 24 hrs/day	Device worn for 10h/day on ≥4 days	n/a	Age, race, ethnicity, education, alcohol, smoking, self-rated health, walking device use, physical function score, hypertension, atrial fibrillation, multi-morbidity score, BMI, systolic and diastolic blood pressure, total:HDL cholesterol ratio, triglycerides, c-reactive protein, glucose
Strong Heart Family Study (SHFS)	medical records, death certificates from state health departments, review of the National Death Index, autopsy and coroner reports, local review of obituaries, and/or interviews with next of kin	Physician adjudicated fatal and non-fatal MI and CHD.	AE120 Accusplit Pedometer (waist), 7 consecutive days during waking hours	Device worn for ≥ 3 days	Age, sex, study site, education, smoking, alcohol, diet quality, BMI, systolic blood pressure, diabetes, CVD, fibrinogen, LDL cholesterol, triglycerides, medication use, self reported health status	Age, sex, study site, education, smoking, alcohol, diet quality, BMI, hypertension, diabetes, LDL cholesterol
Tasped Pooled Cohort (Tasped)	The Australian National Death Index	n/a	Omron HJ-003 (waist), Omron HJ-102 (waist), and Yamax Digi-Walker (waist); 7 days at wake time	Device worn for ≥ 2 days, with at least one weekday	Age, sex, BMI, smoking status, alcohol consumption, stroke, myocardial infarction, hypertension, diabetes	n/a
Women's Health Study (WHS)	U.S. National Death Index, follow up with family members or postal authorities, with medical records, and death certificates.	n/a	Actigraph GT3X+ (waist); 30 Hz and aggregated into 60 seconds epochs; 7 consecutive days during wake time	Device worn for 10h/day on ≥4 days	Age, BMI, device wear time, smoking status, alcohol consumption, hypertension, high cholesterol, CVD, diabetes, cancer, use of post-menopausal hormones, saturated fat intake	n/a
UK Biobank	national death registry	fatal and non-fatal coronary heart disease (ICD-10 codes: I20-25), stroke (ICD-10 codes: I60-61, I63-64) and heart failure (ICD-10 codes: I50), as recorded in the Hospital Episode Statistics and the national death registry.	Axivity AX3 (dominant wrist); 100 Hz; 7 consecutive days, 24 hrs/day	Device worn ≥ 72 hours. Excluded participants with device calibration or data reading errors (>1% of values outside +/-8g range), inadequate wear time (<72 hours), unreasonably high average acceleration (>100 mg)	age as the timescale, sex, ethnicity, education, Townsend deprivation index, alcohol intake, smoking status, processed meat intake, fresh fruit intake, oily fish intake, and added salt intake	age as the timescale, sex, ethnicity, education, Townsend deprivation index, alcohol intake, smoking status, processed meat intake, fresh fruit intake, oily fish intake, and added salt intake

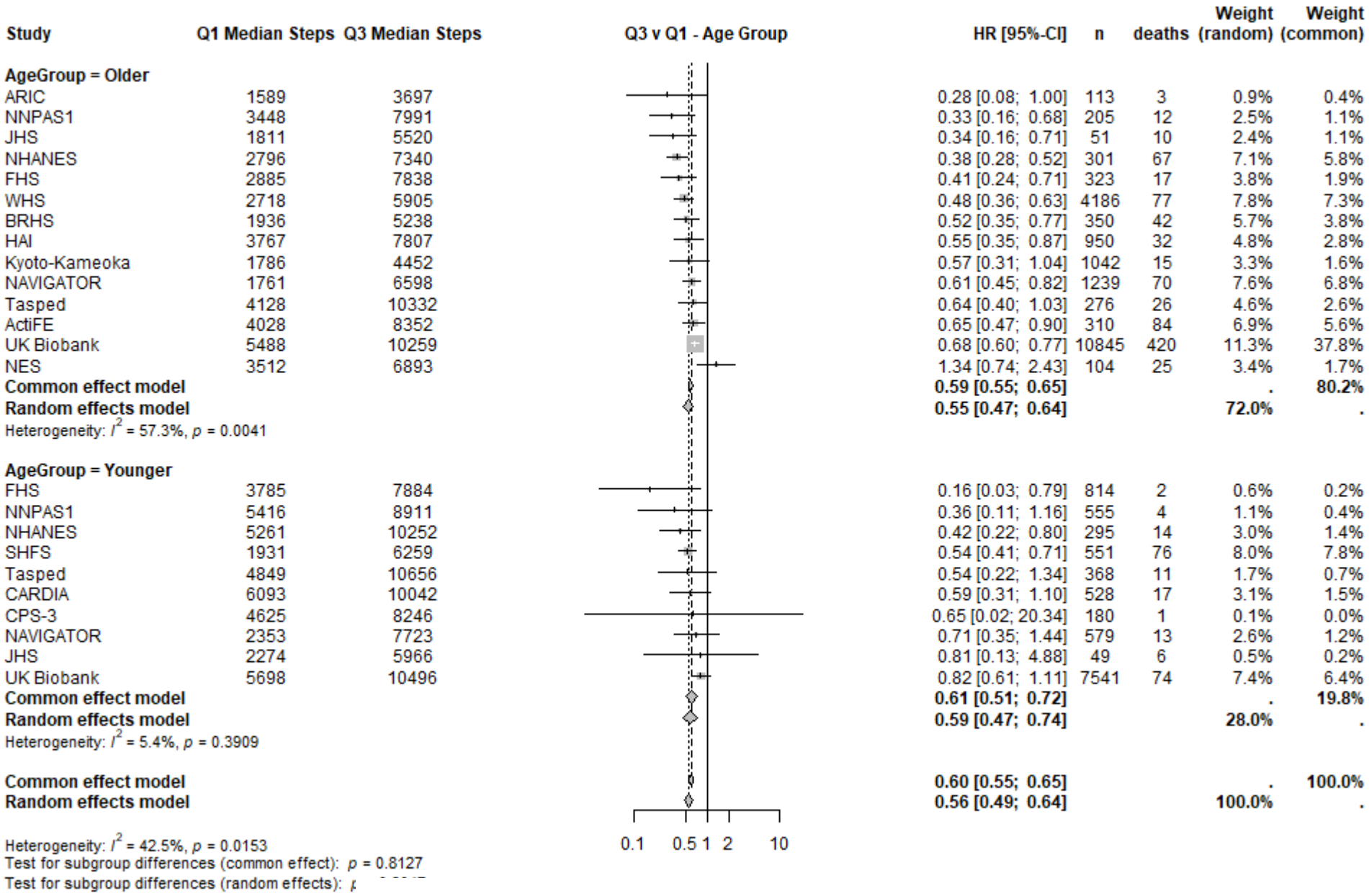
BMI = Body Mass Index; ; HF = Heart Failure; CHD = Coronary Heart Disease; CVD = Cardiovascular Disease; MI = myocardial infarction; n/a = not applicable

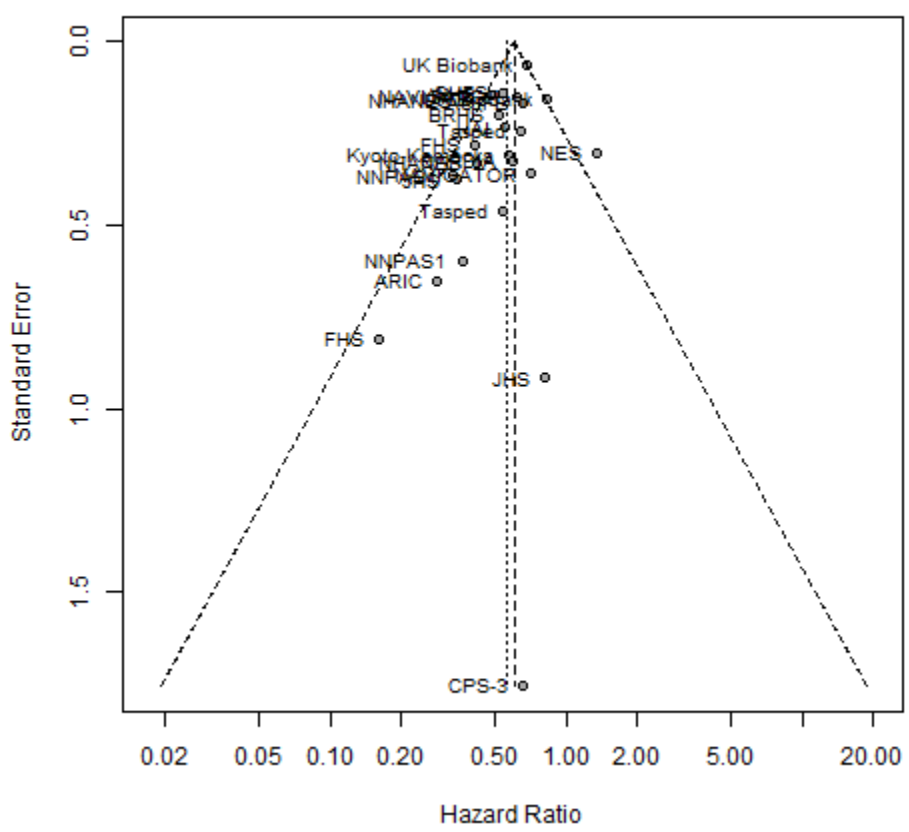
Supplement Figure 2a Forest Plot and Funnel Plot of Association of Daily Steps with All-Cause Mortality, Quartile 1 (Reference) vs Quartile 2
Including Both Fixed (Common) and Random Effect Estimates



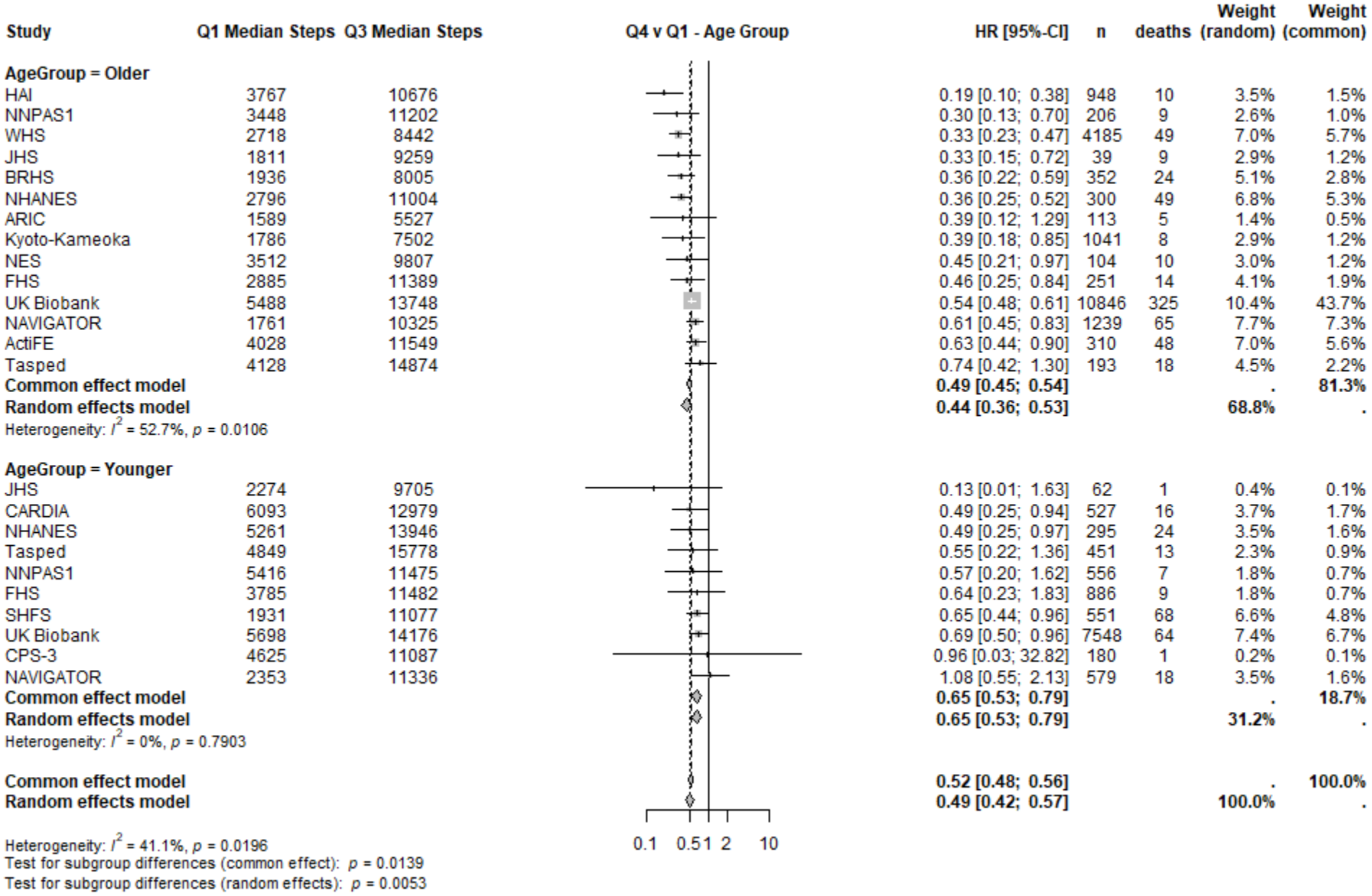


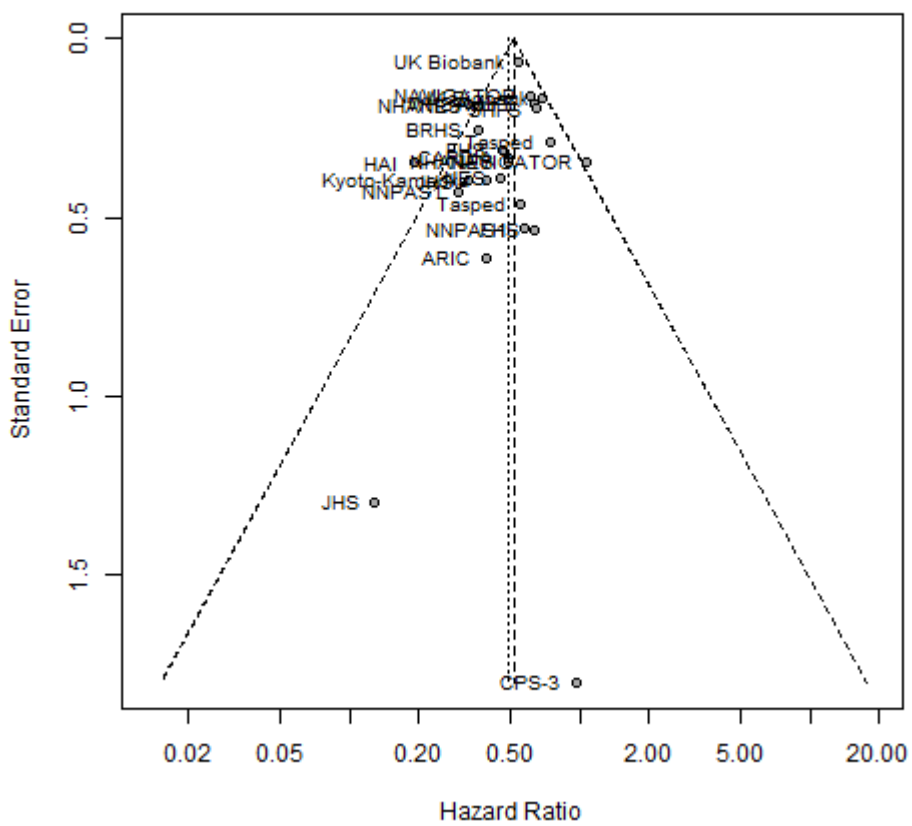
Supplement Figure 2b Forest Plot and Funnel Plot of Association of Daily Steps with All-Cause Mortality, Quartile 1 (Reference) vs Quartile 3
Including Both Fixed (Common) and Random Effect Estimates



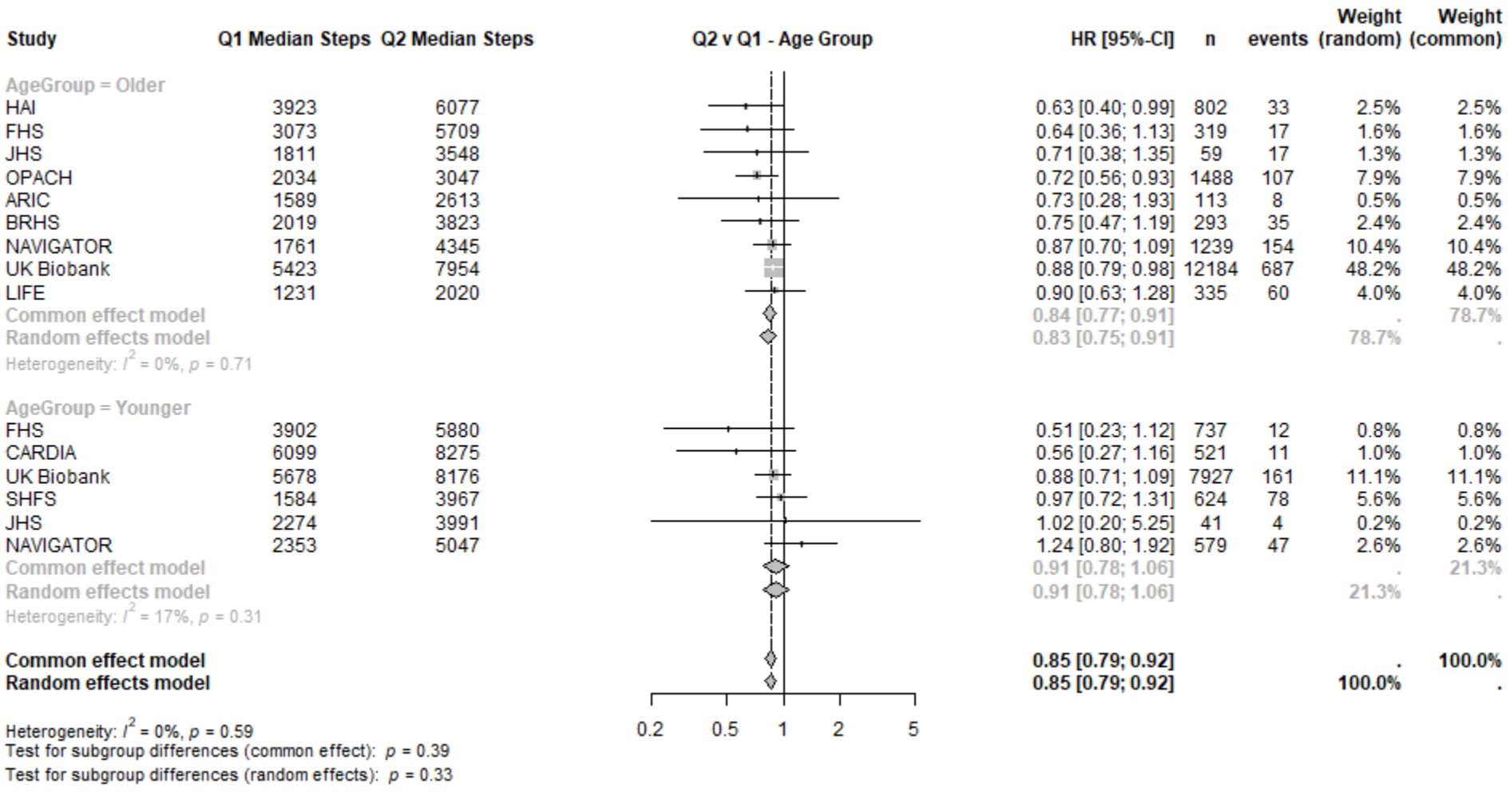


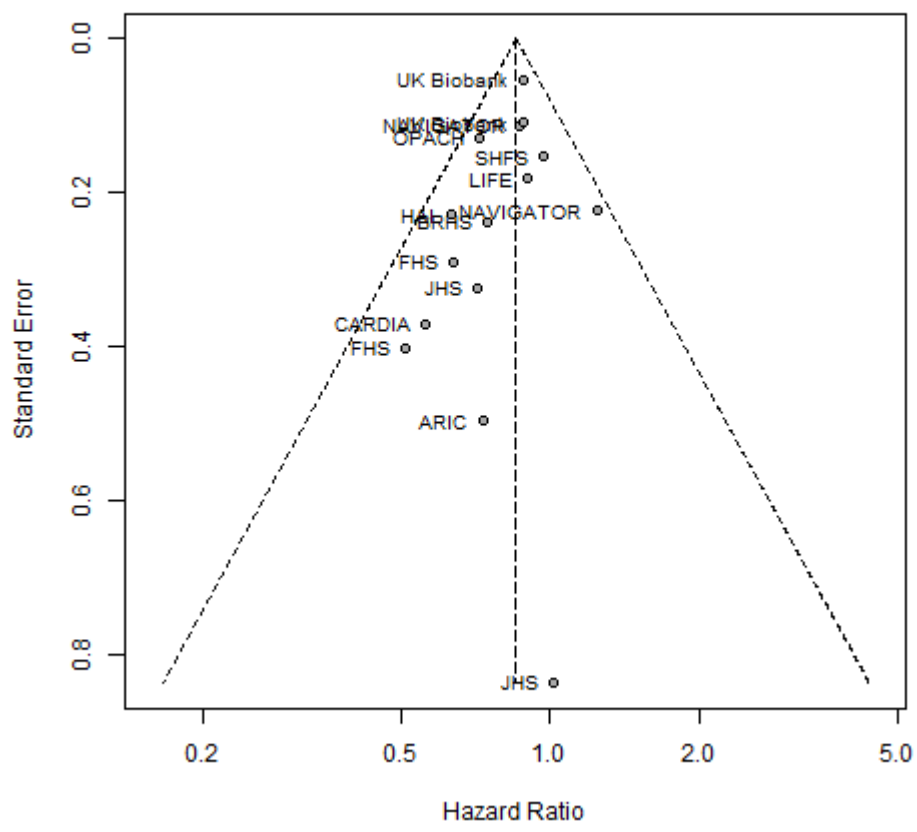
Supplement Figure 2c Forest Plot and Funnel Plot of Association of Daily Steps with All-Cause Mortality, Quartile 1 (Reference) vs Quartile 4
Including Both Fixed (Common) and Random Effect Estimates



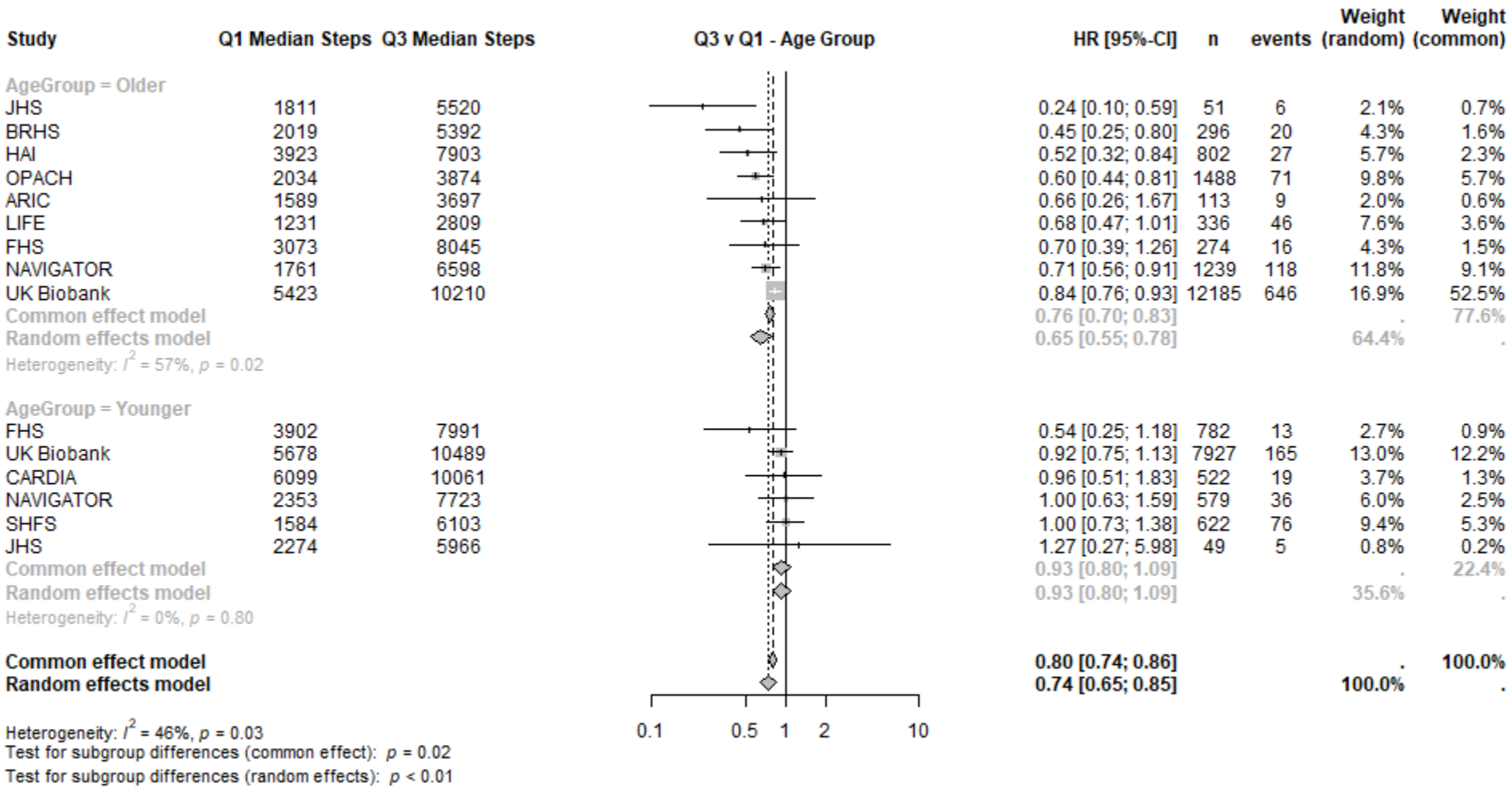


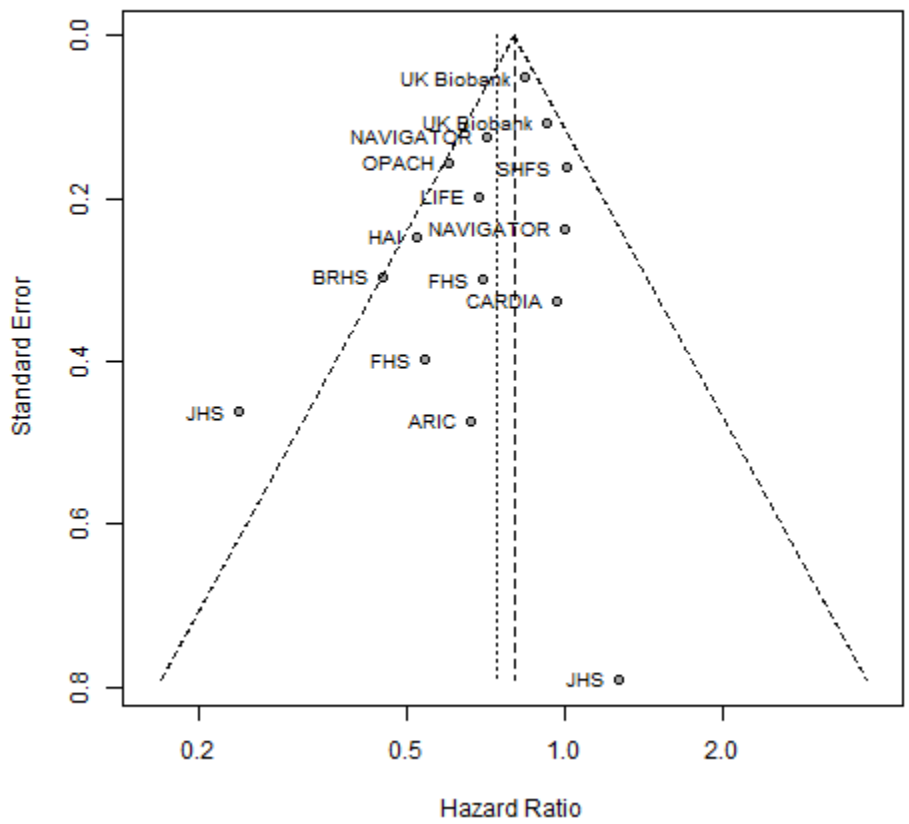
Supplement Figure 3a Forest Plot and Funnel Plot of Association of Daily Steps with Cardiovascular Disease Events, Quartile 1 (Reference) vs Quartile 2
Including Both Fixed (Common) and Random Effect Estimates



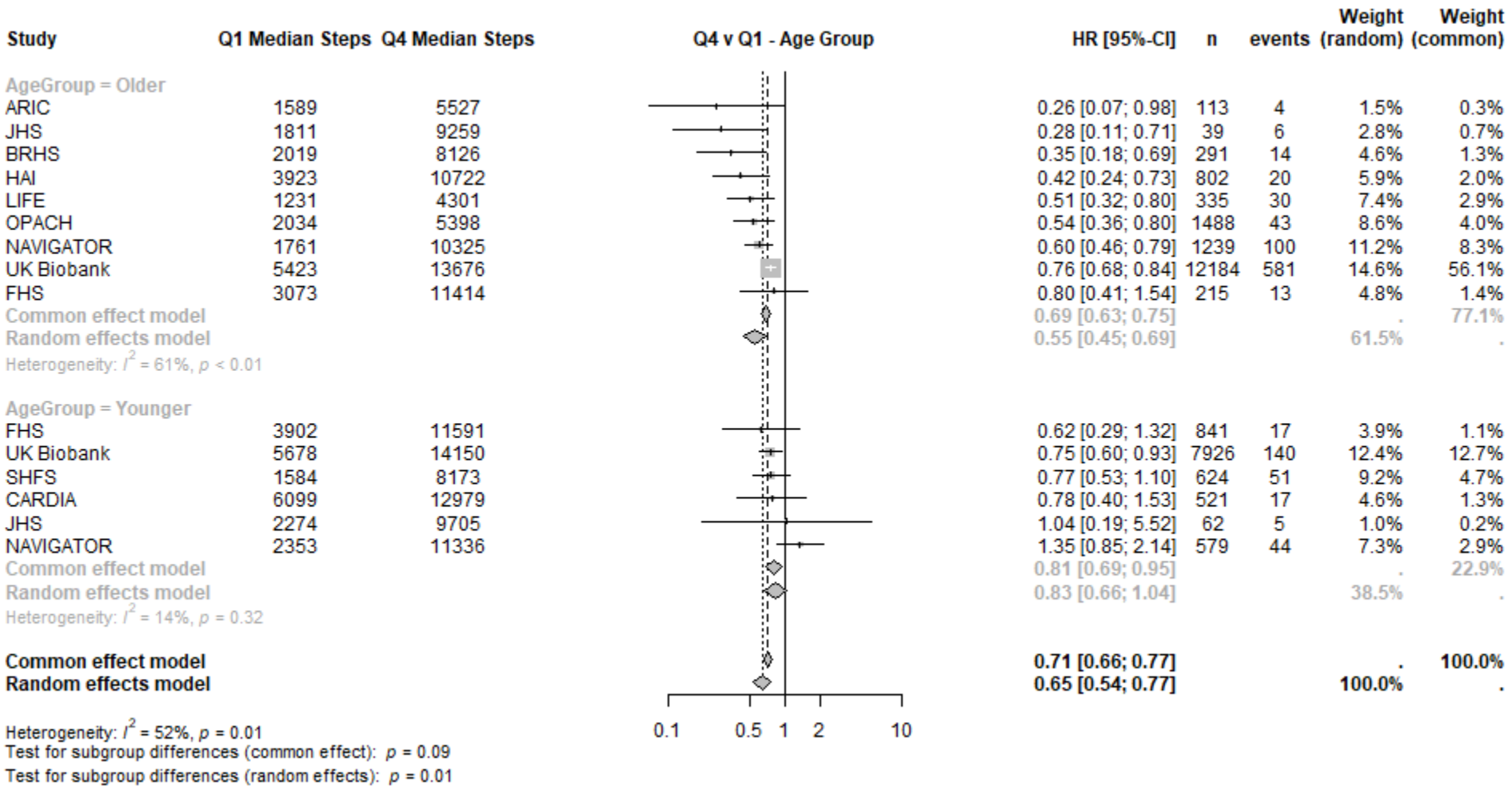


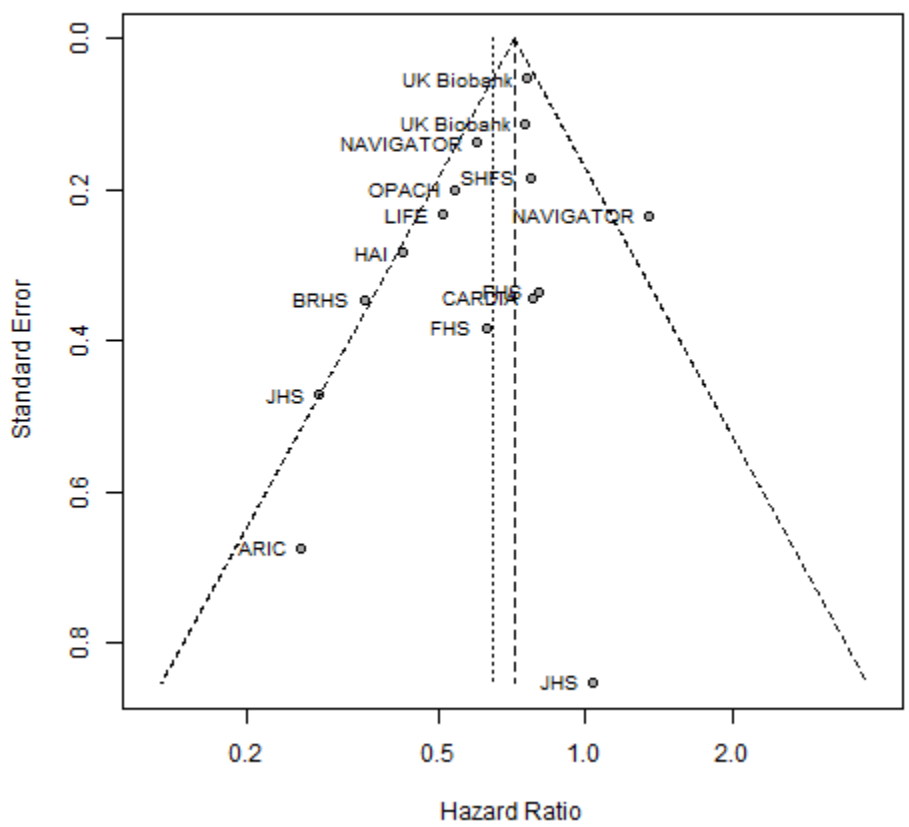
Supplement Figure 3b Forest Plot and Funnel Plot of Association of Daily Steps with Cardiovascular Disease Events, Quartile 1 (Reference) vs Quartile 3
Including Both Fixed (Common) and Random Effect Estimates



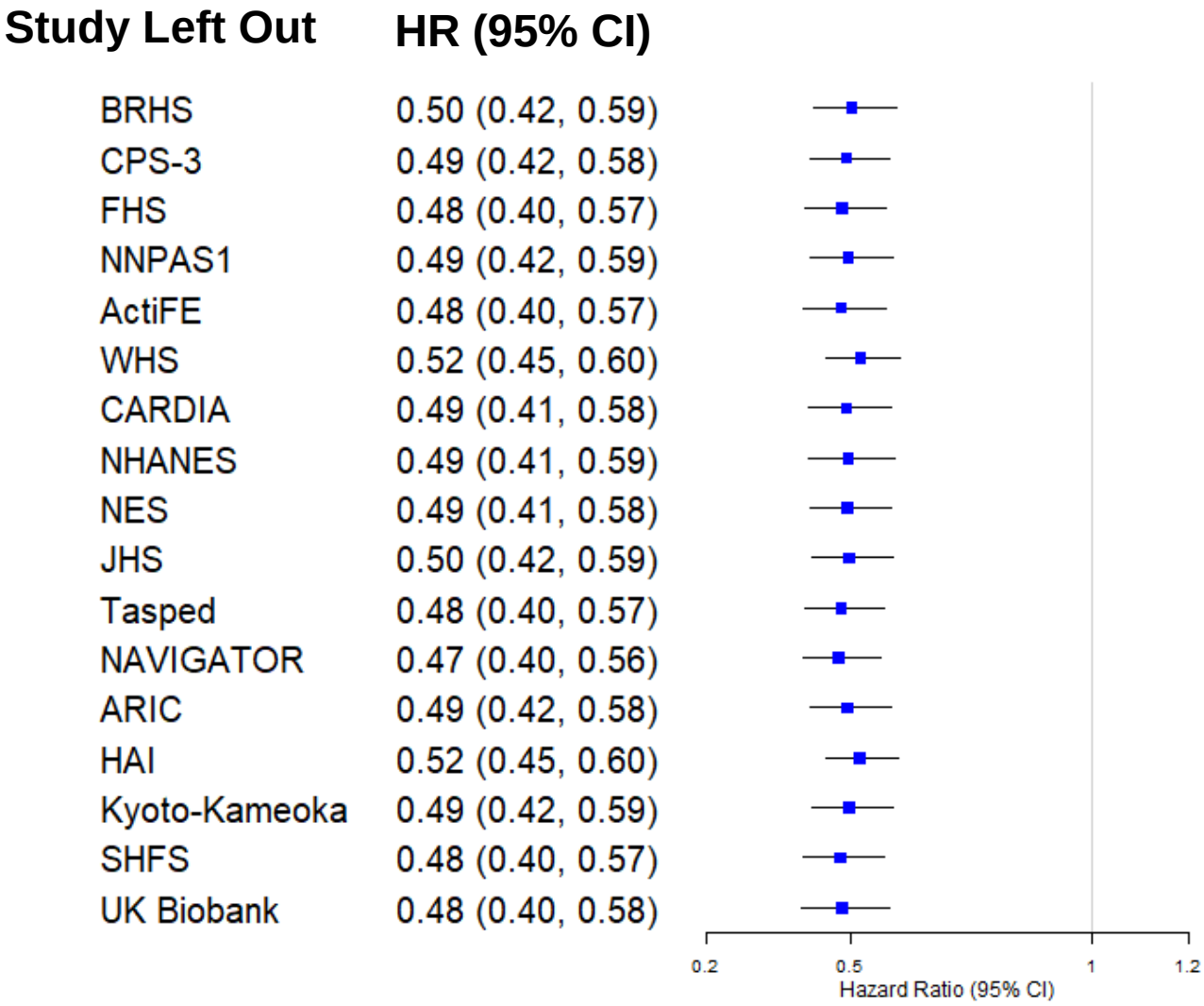


Supplement Figure 3c. Forest Plot and Funnel Plot of Association of Daily Steps with Cardiovascular Disease Events, Quartile 1 (Reference) vs Quartile 4
Including Both Fixed (Common) and Random Effect Estimates

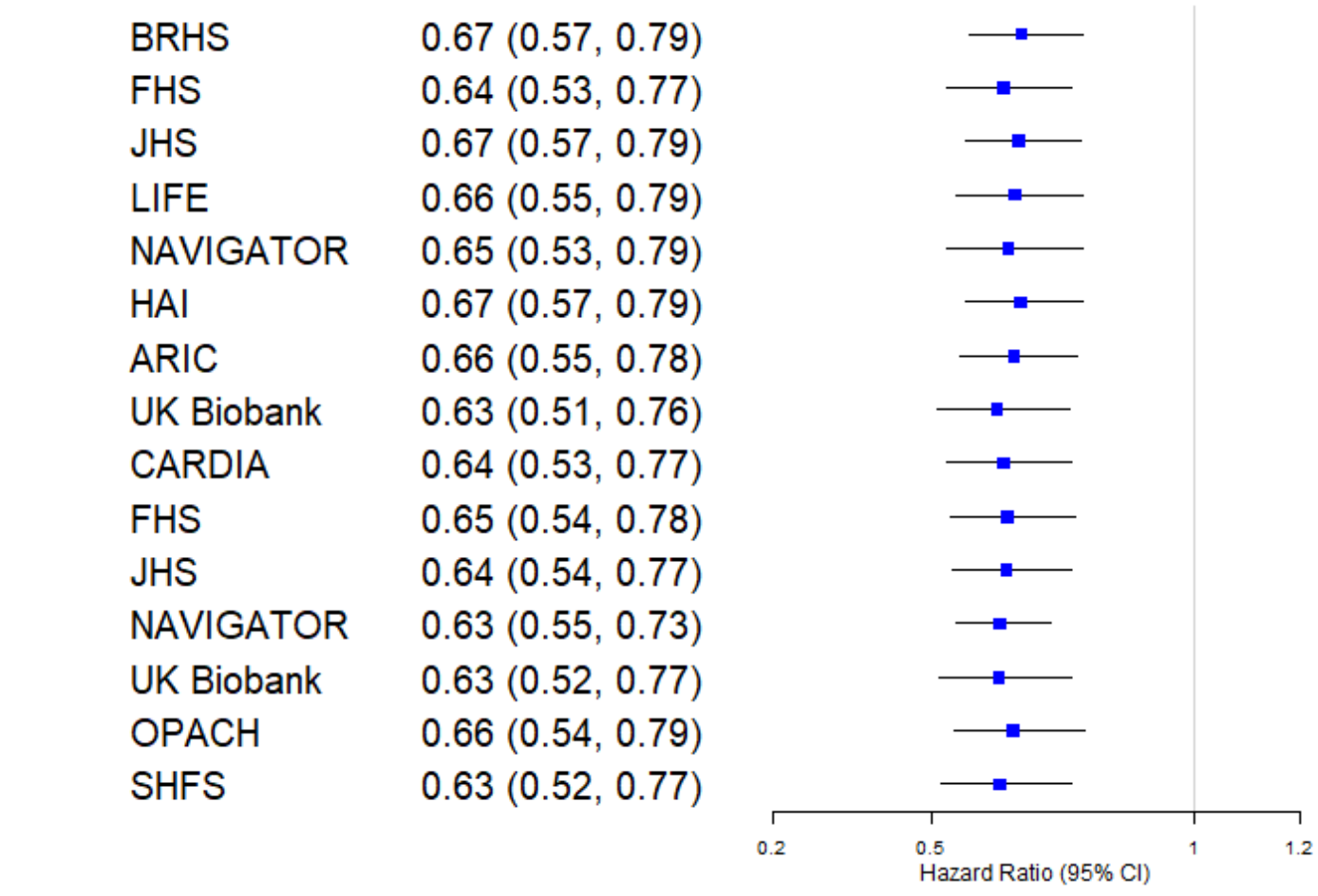




Supplement Figure 4a. Leave-One-Study Out Analysis of Association of Daily Steps with All-Cause Mortality, Quartile 1 (Reference) vs Quartile 4

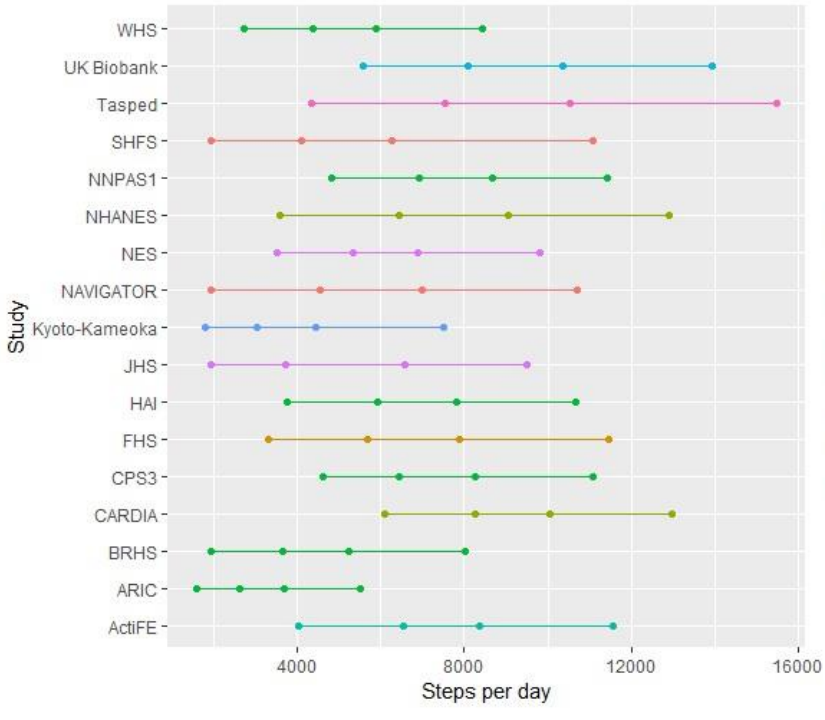


Supplement Figure 4b. Leave-One-Study Out Analysis of Association of Daily Steps with CVD, Quartile 1 (Reference) vs Quartile 4

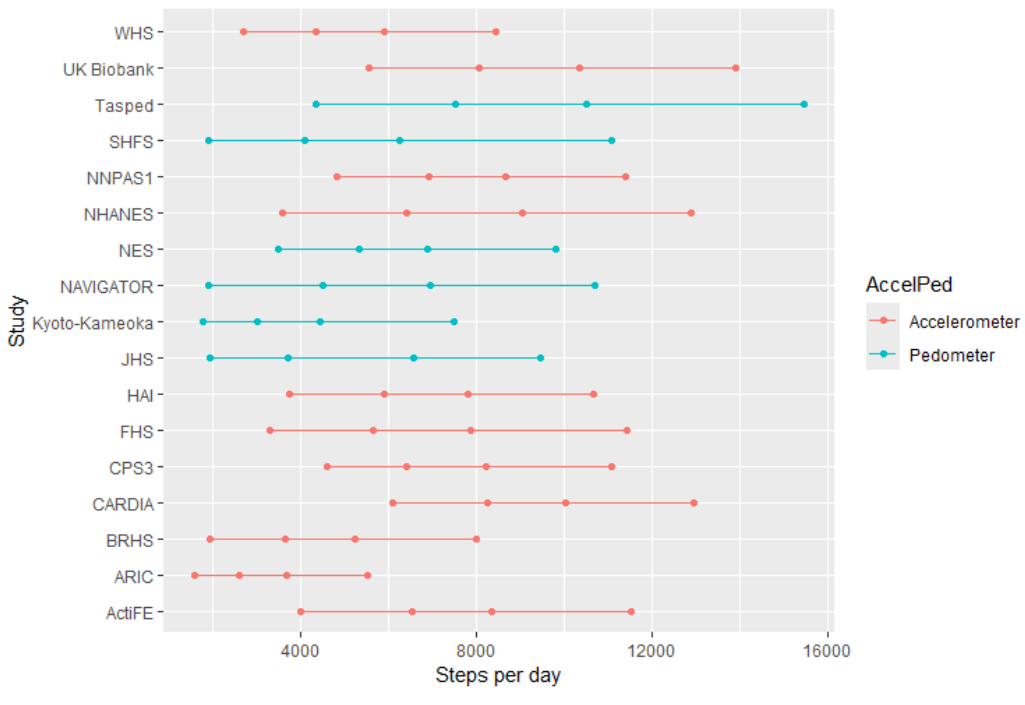


Supplement Figure 5a. Study Level Median Daily Steps by Quartile Labeled by :

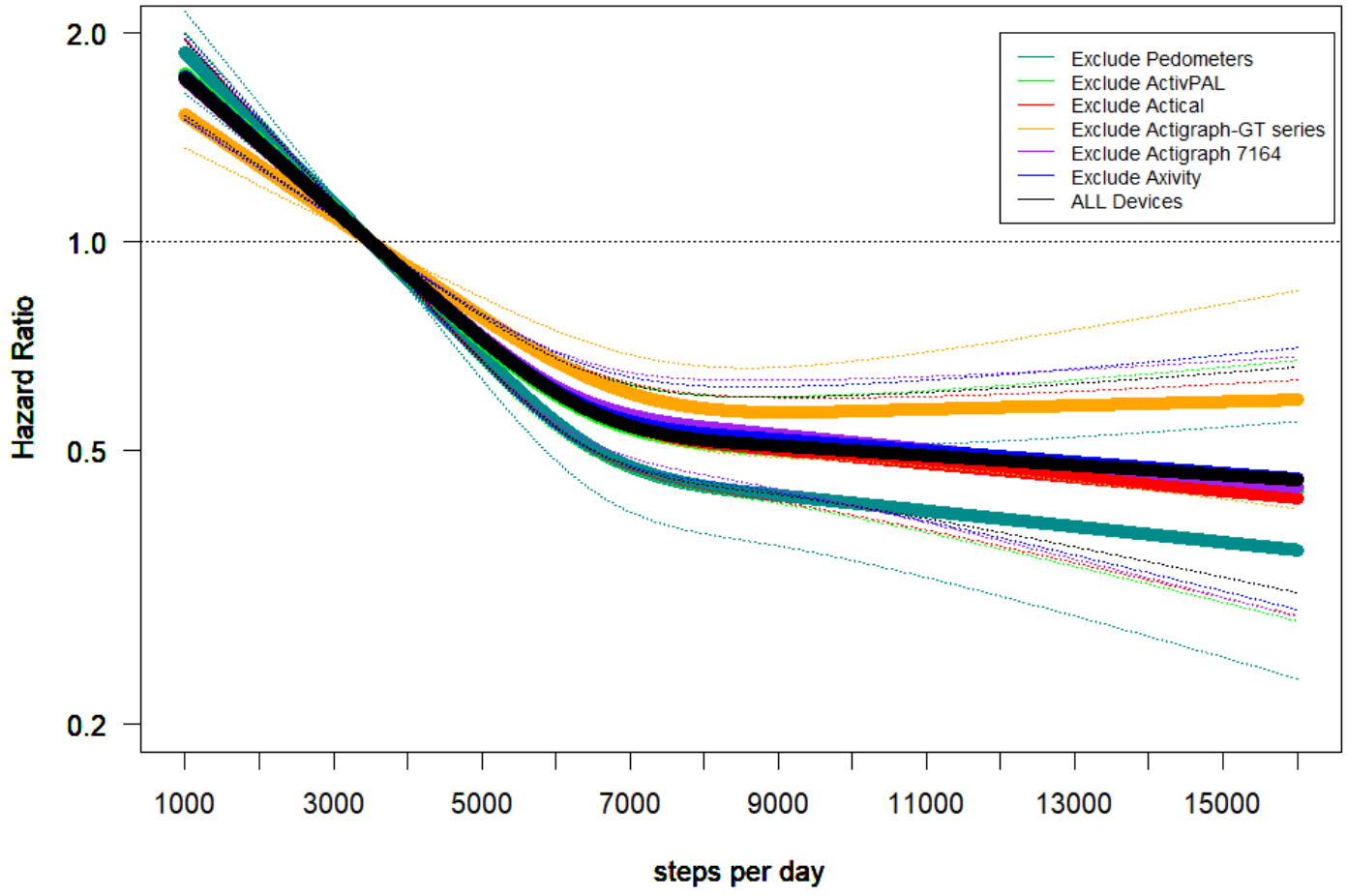
Device Manufacturer



Accelerometer or Pedometer

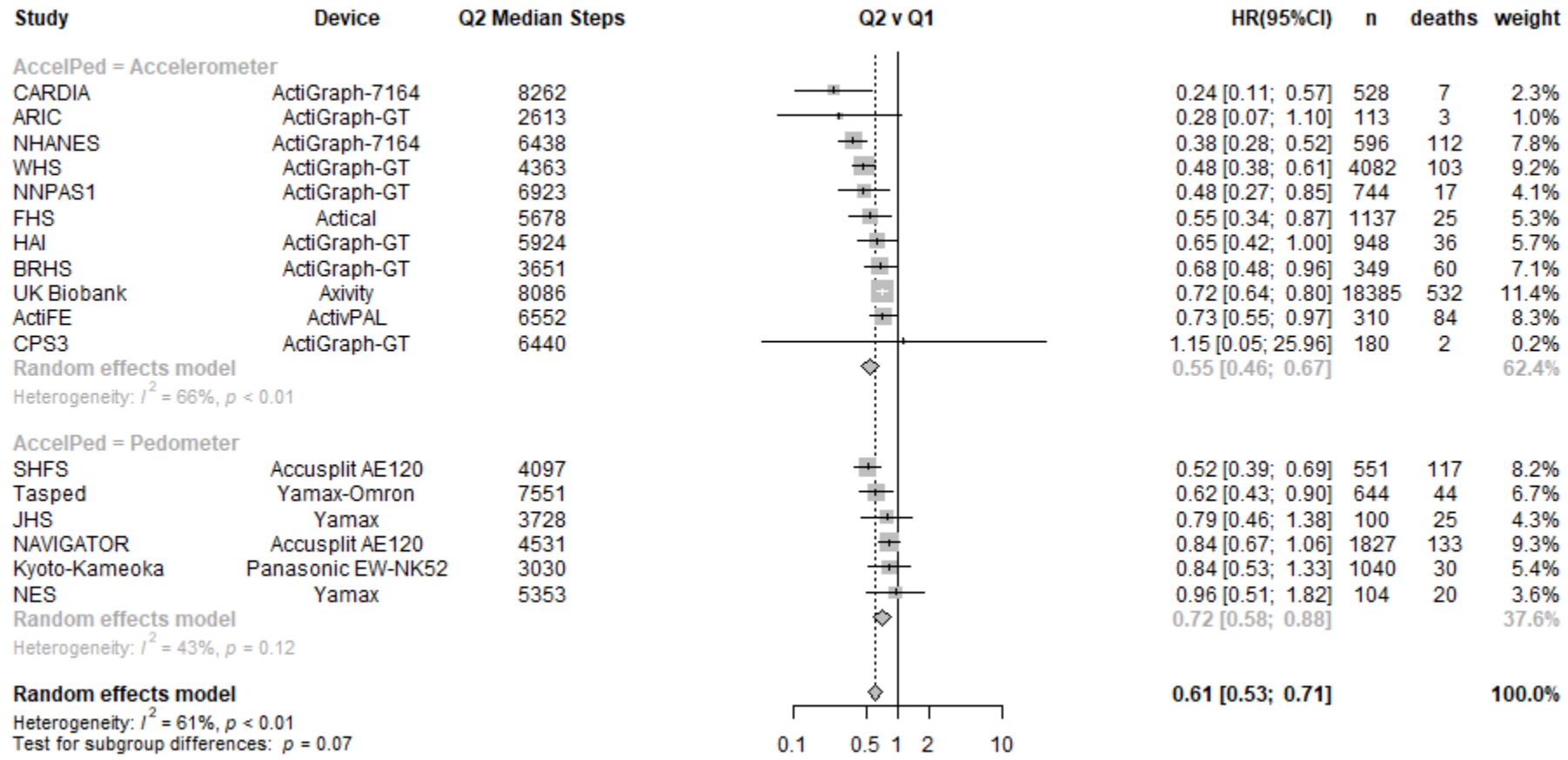


Supplement Figure 5b. Dose Response Association of Daily Steps with All-Cause Mortality – Leave-One-Device Type out

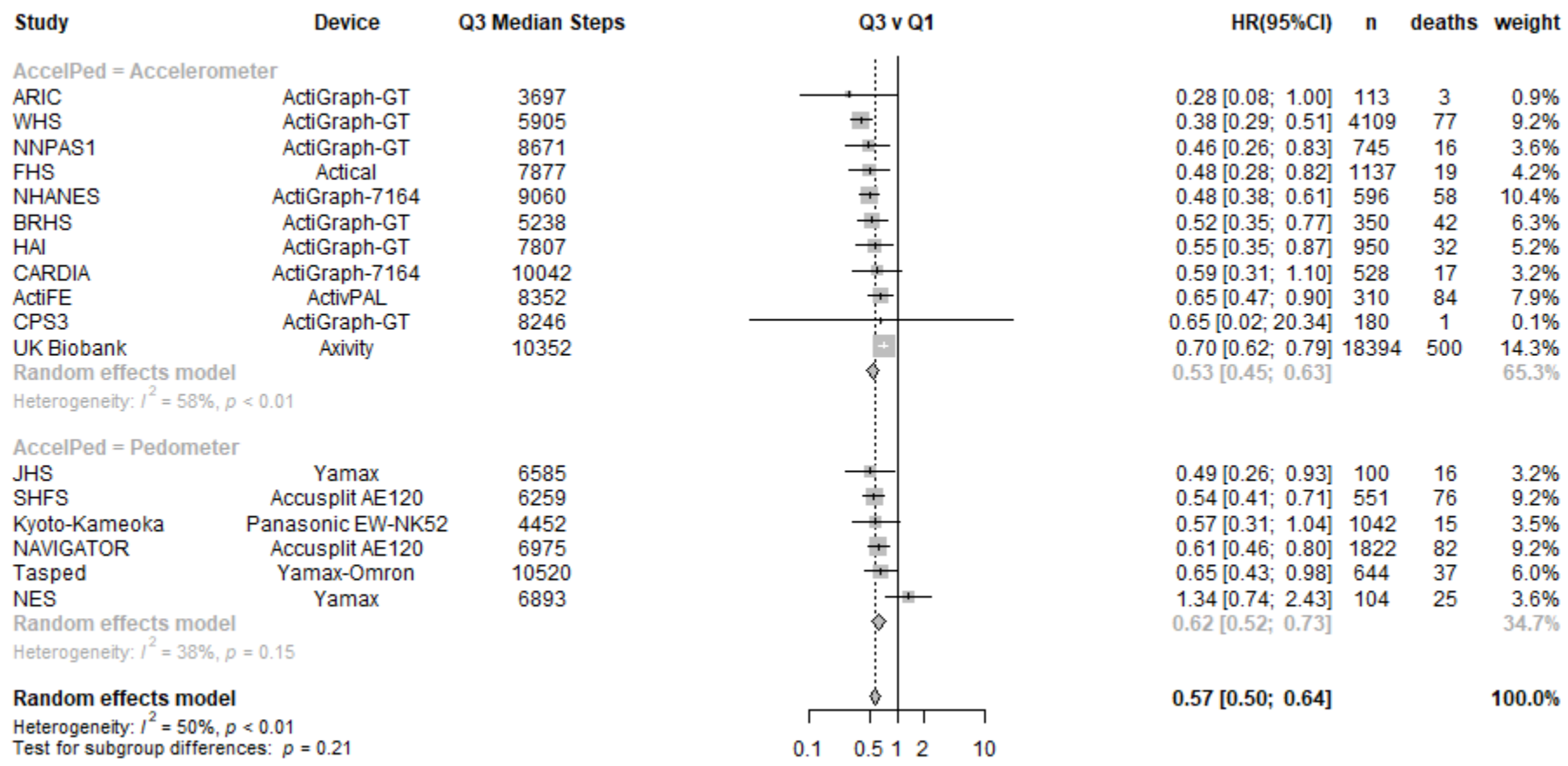


All devices worn on the hip, except for Axivity worn on the wrist and ActivPAL worn on the thigh. Models adjusted for age, sex, race/ethnicity, socioeconomic status, BMI, lifestyle factors and chronic conditions

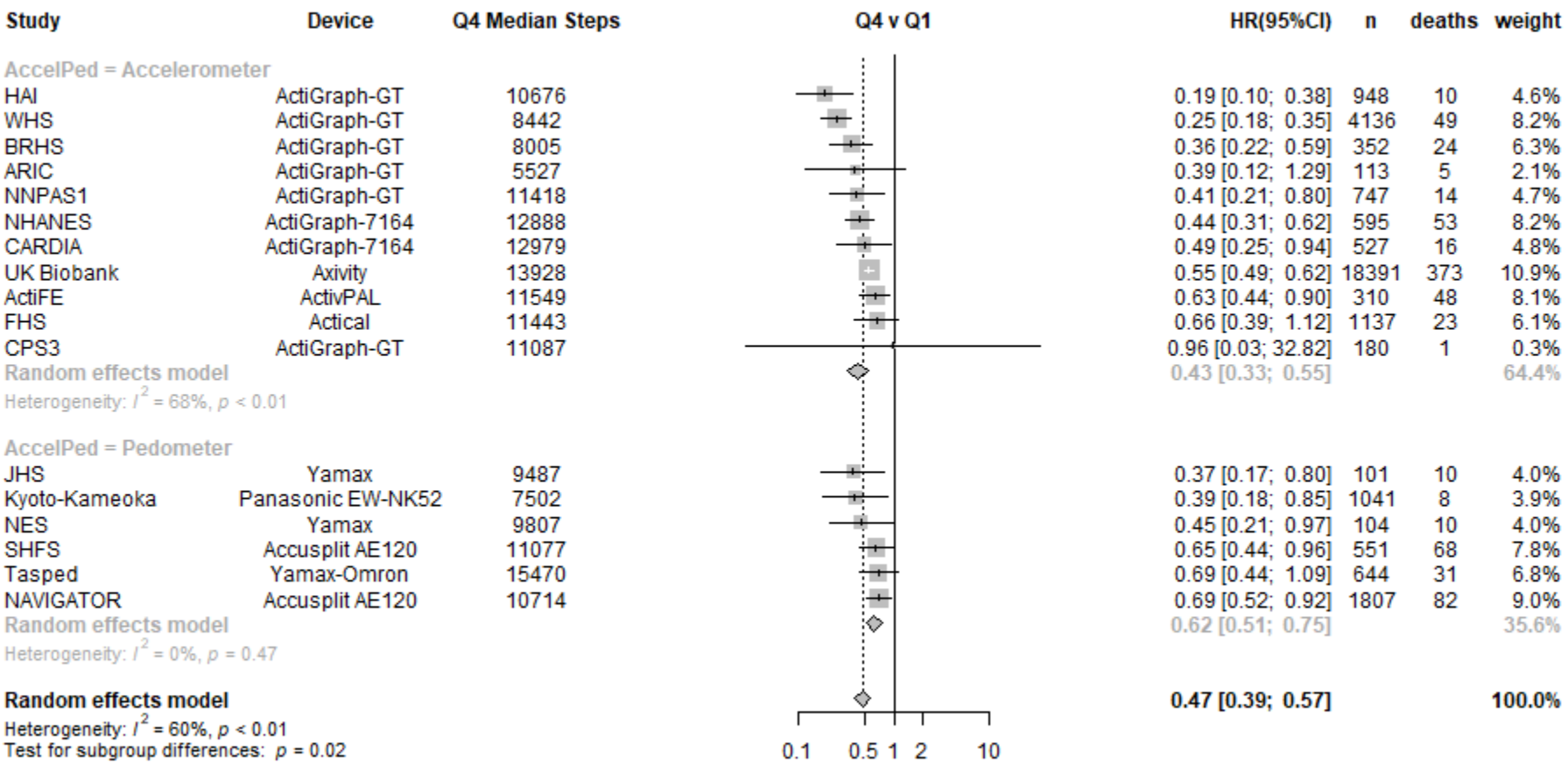
Supplement Figure 6a. Subgroup Analysis by Accelerometer vs Pedometer
Association of Daily Steps with All-Cause Mortality, Quartile 1 (Reference) vs Quartile 2



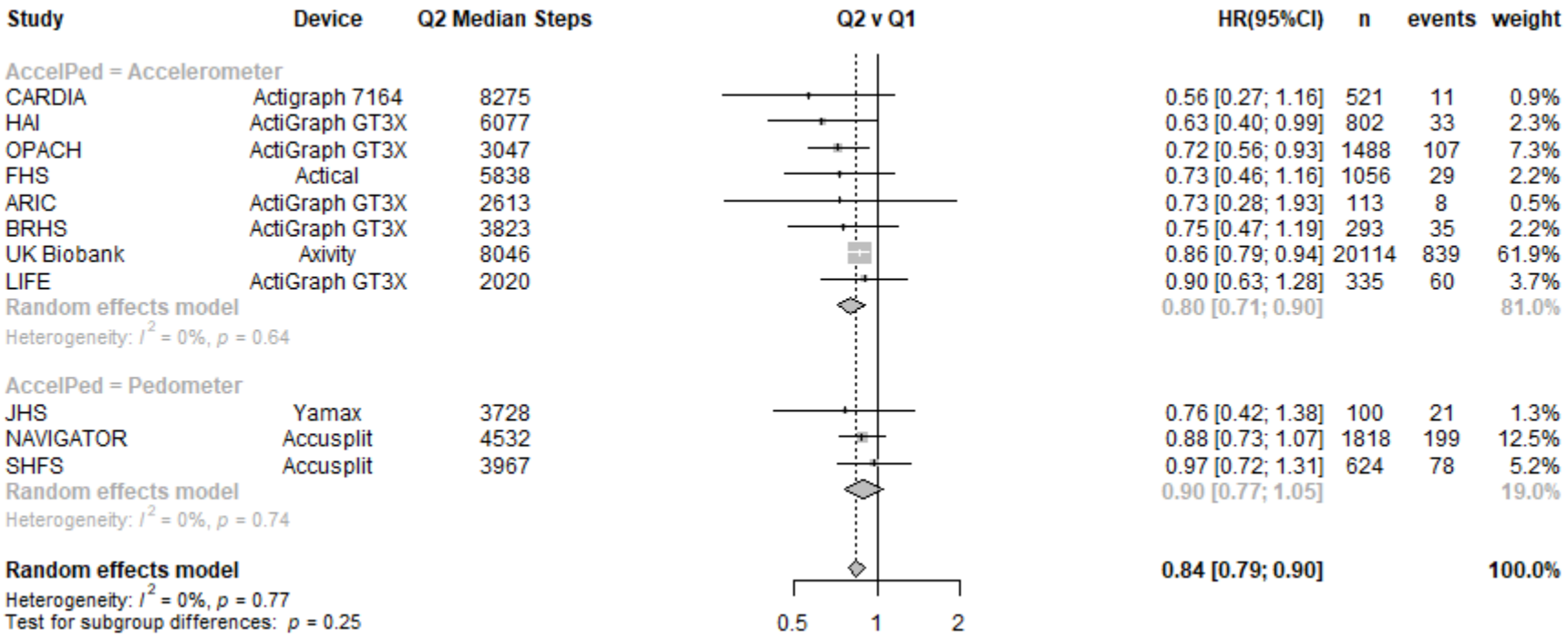
Supplement Figure 6b. Subgroup Analysis by Accelerometer vs Pedometer
Association of Daily Steps with All-Cause Mortality, Quartile 1 (Reference) vs Quartile 3



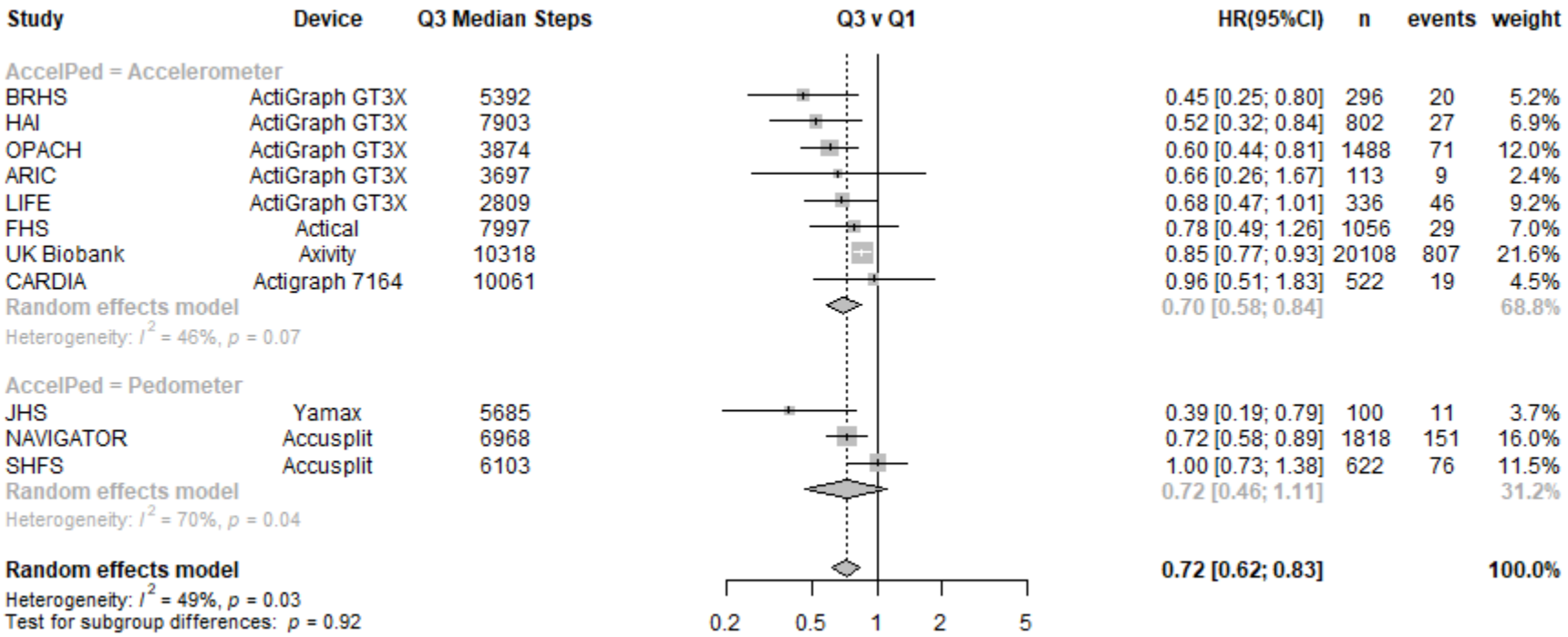
Supplement Figure 6c. Subgroup Analysis by Accelerometer vs Pedometer
Association of Daily Steps with All-Cause Mortality, Quartile 1 (Reference) vs Quartile 4



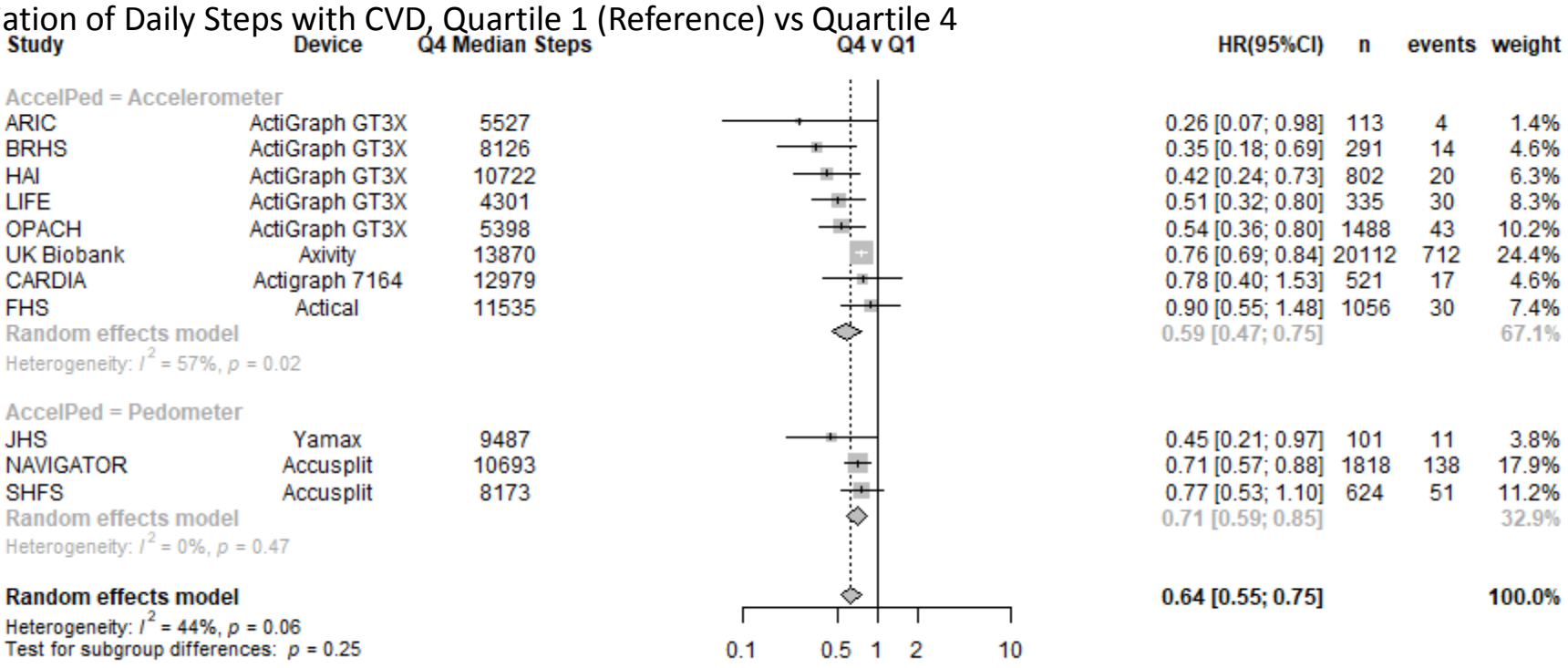
Supplement Figure 7a. Subgroup Analysis by Accelerometer vs Pedometer
Association of Daily Steps with CVD, Quartile 1 (Reference) vs Quartile 2



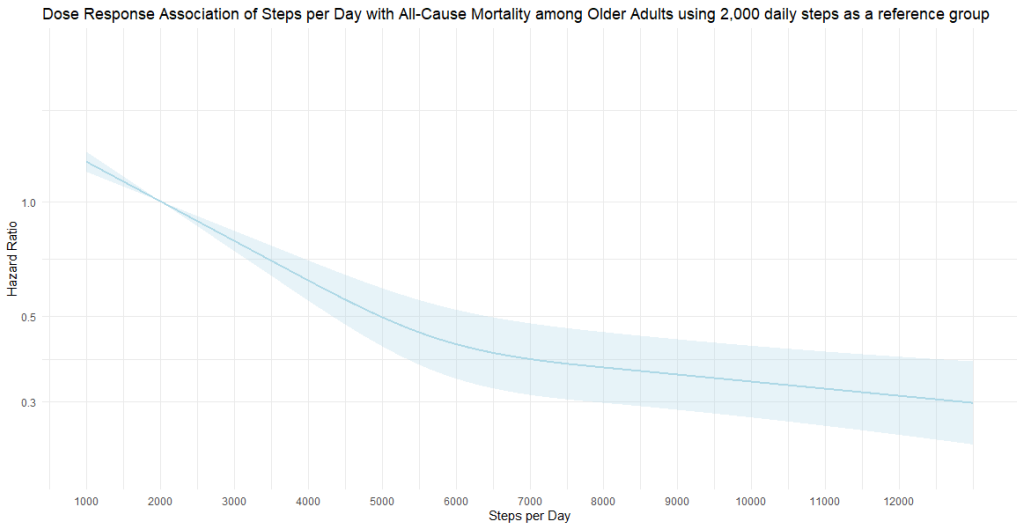
Supplement Figure 7b. Subgroup Analysis by Accelerometer vs Pedometer
Association of Daily Steps with CVD, Quartile 1 (Reference) vs Quartile 3

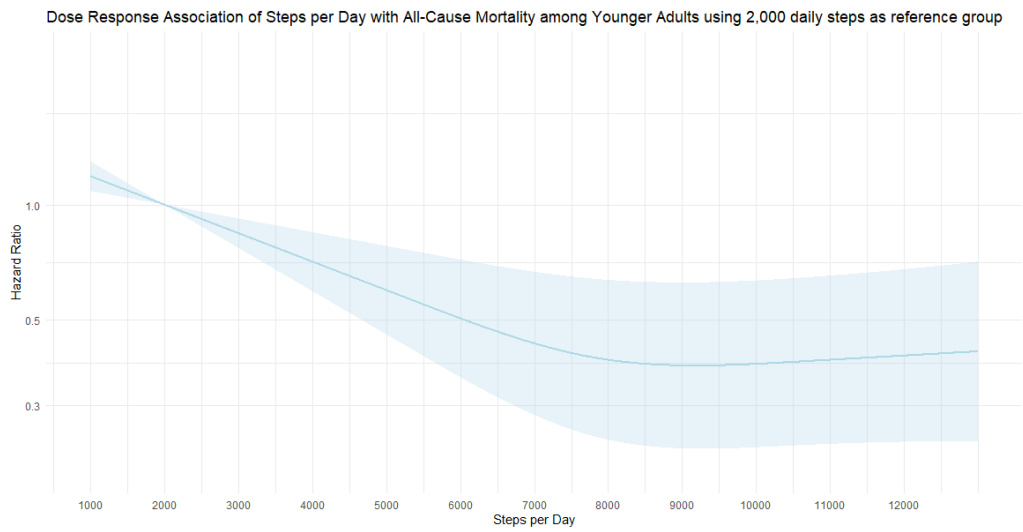


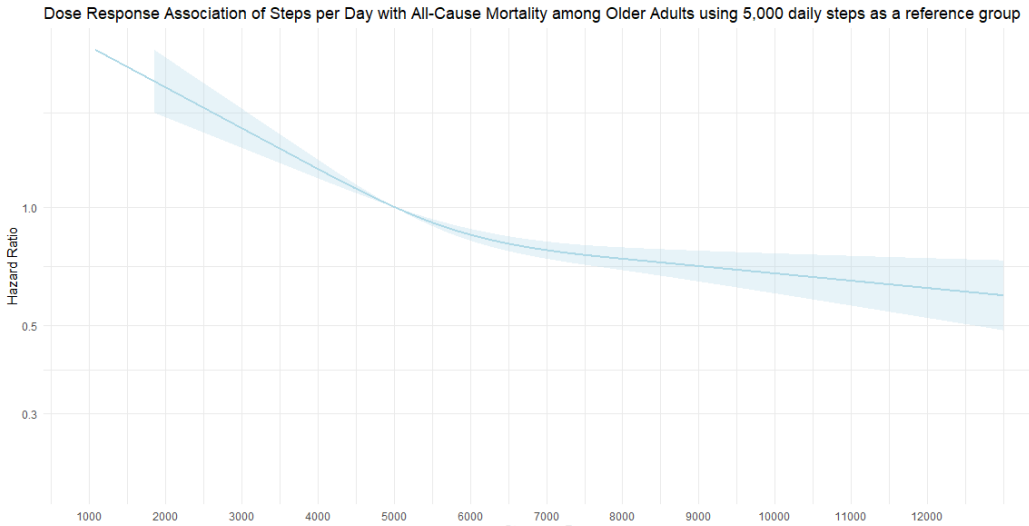
Supplement Figure 7c. Subgroup Analysis by Accelerometer vs Pedometer
Association of Daily Steps with CVD, Quartile 1 (Reference) vs Quartile 4

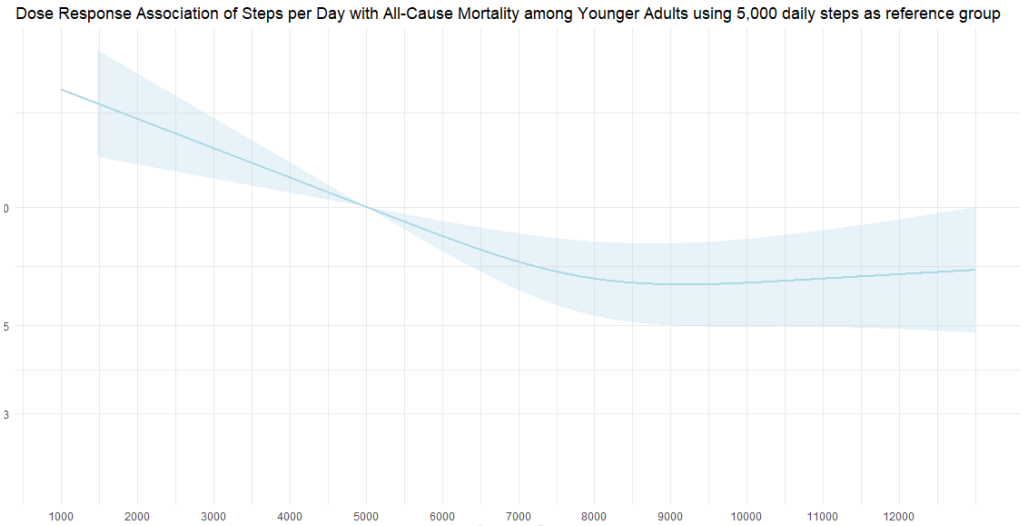


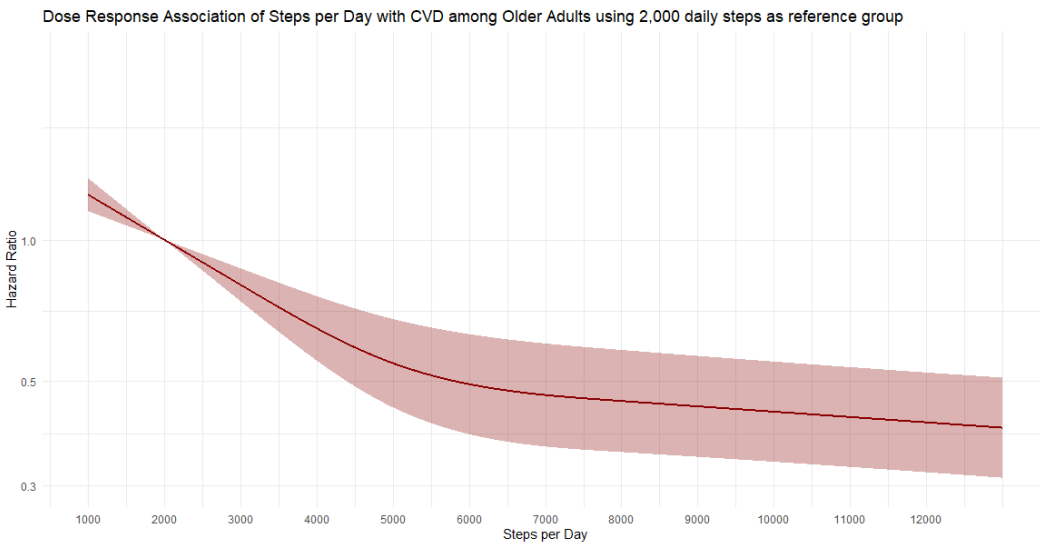
Supplement Figure 8. Dose Response Curves for Older and Younger Adults using 2,000 and 5,000 daily steps as referent

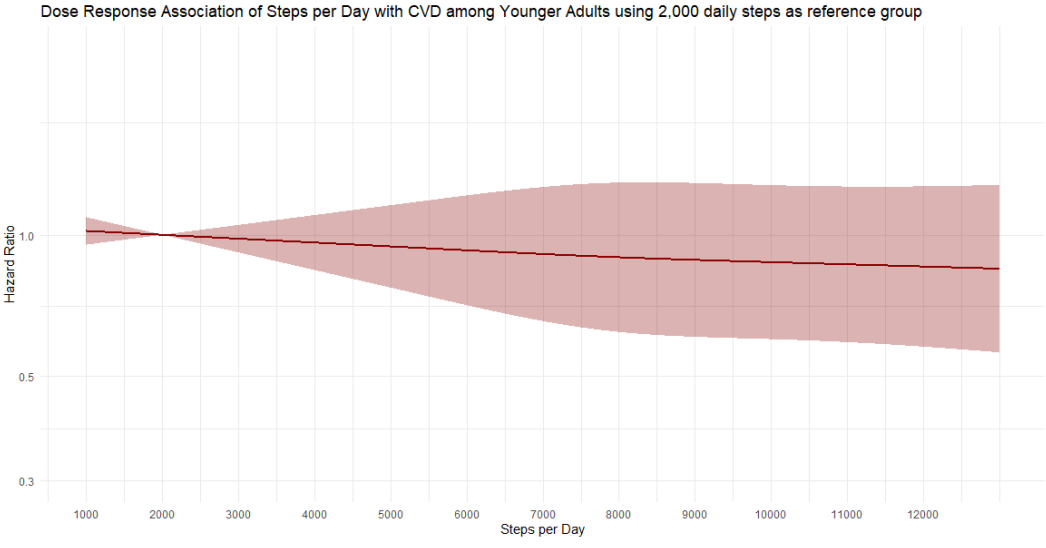


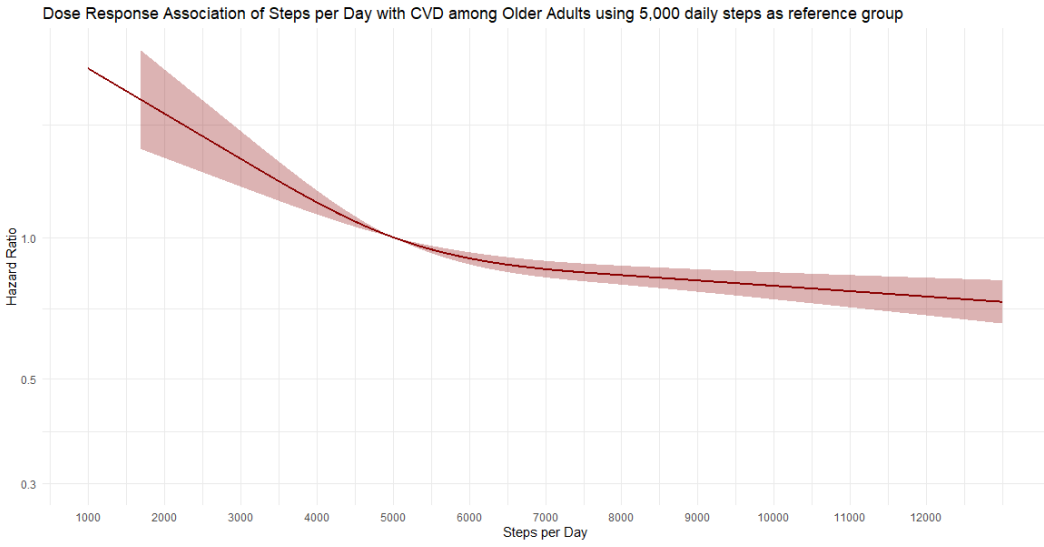


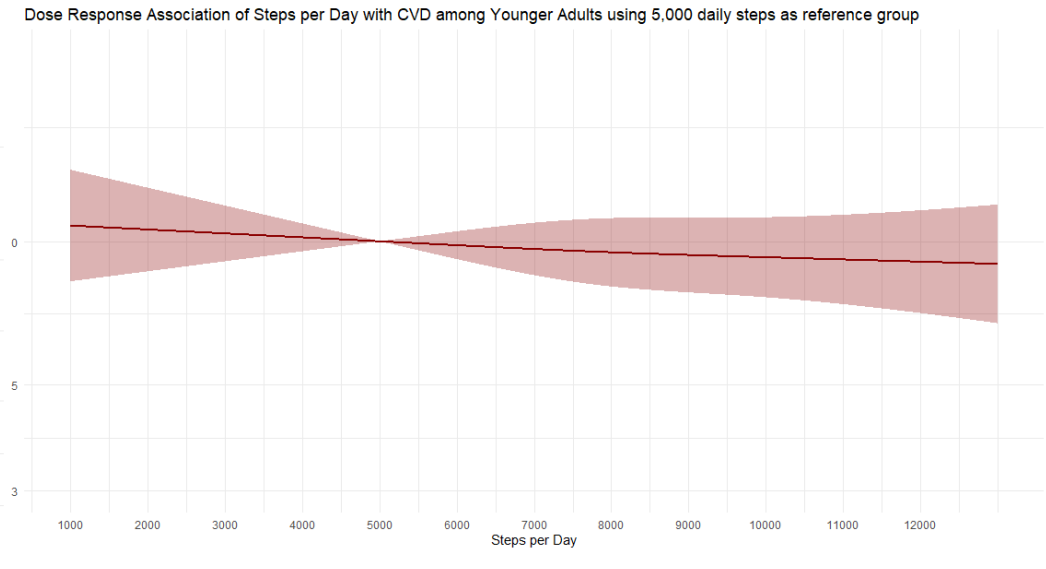












Summary of Sensitivity Analyses:

In sensitivity analyses, results were similar when using fixed effect models for mortality and CVD (Supplement Figures 2 and 3). Funnel plots were symmetrical upon visual inspection and Egger's test for symmetry suggested no evidence of study selection bias (Supplement Figure 3). Heterogeneity (I^2) was low to moderate, ranging from 0% to 61% across quartiles (Supplement Figure 3). In a leave-one-study-out analysis, removing any single study did not substantially alter the results (Supplement Figure 4). The dose-response curve of steps with mortality was similar when removing any device type or brand (Supplement Figure 5). In the subgroup analysis by device type, studies using accelerometers had significantly larger effect estimates than studies using pedometers, when comparing the least active (Q1) to the most active (Q4) quartile with mortality risk (p-value = 0.02 for subgroup difference; Supplement Figure 6). There was no subgroup difference by device type in associations with CVD (Supplement Figure 7). Because there was one study using a wrist-worn device (UK Biobank) and one study using a thigh-worn device (ActiFE-Ulm) in this meta-analysis, we were unable to conduct a subgroup analysis comparing results based on wear location. However, the results do not substantially change when removing either of these studies in the leave-one-study-out analysis (Supplement Figure 4). Supplement Figure 8 shows the dose-response curve remains consistent for both older and younger adults, even when different step counts are used as the reference. Since this is a relative comparison, hazard ratios and confidence intervals vary depending on the chosen reference step count.

REFERENCES

1. Paluch AE, Bajpai S, Ballin M, et al. Prospective Association of Daily Steps With Cardiovascular Disease: A Harmonized Meta-Analysis. *Circulation*. 2023;147(2):122–31.
2. Paluch AE, Bajpai S, Bassett DR, et al. Daily steps and all-cause mortality: a meta-analysis of 15 international cohorts. *The Lancet Public Health*. 2022;7(3):e219–28.
3. Hall KS, Hyde ET, Bassett DR, et al. Systematic review of the prospective association of daily step counts with risk of mortality, cardiovascular disease, and dysglycemia. *Int J Behav Nutr Phys Act*. 2020;17(1)
4. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan—a web and mobile app for systematic reviews. *Syst Rev*. 2016;5(1)
5. Toth L, Paluch AE, Bassett DR, et al. Comparative Analysis of ActiGraph Step Counting Methods in Adults: A Systematic Literature Review and Meta-Analysis. *Medicine & Science in Sports & Exercise*. 2024;56(1):53–62.
6. Small SR, Chan S, Walmsley R, et al. Self-Supervised Machine Learning to Characterize Step Counts from Wrist-Worn Accelerometers in the UK Biobank. *Medicine & Science in Sports & Exercise*. 2024;56(10):1945–53.
7. Fretts AM, Siscovick DS, Malloy K, et al. Ambulatory Activity and Risk of Premature Mortality Among Young and Middle-aged American Indian Individuals. *JAMA Netw Open*. 2023;6(5):e2311476.
8. Watanabe D, Yoshida T, Watanabe Y, Yamada Y, Miyachi M, Kimura M. Dose–Response Relationships between Objectively Measured Daily Steps and Mortality among Frail and Nonfrail Older Adults. *Medicine & Science in Sports & Exercise*. 2023;55(6):1044–53.
9. LaMonte MJ, LaCroix AZ, Nguyen S, et al. Accelerometer-Measured Physical Activity, Sedentary Time, and Heart Failure Risk in Women Aged 63 to 99 Years. *JAMA Cardiol*. 2024;9(4):336.
10. Pan S, Chen S, Fretts AM, Ali T. Associations of pedometer-measured ambulatory activity with incidence of atherosclerotic cardiovascular diseases: Strong heart family study. *Preventive Medicine*. 2023;177:107781.
11. Paluch AE, Gabriel KP, Fulton JE, et al. Steps per Day and All-Cause Mortality in Middle-aged Adults in the Coronary Artery Risk Development in Young Adults Study. *JAMA Netw Open*. 2021;4(9):e2124516.
12. Jefferis BJ, Parsons TJ, Sartini C, et al. Objectively measured physical activity, sedentary behaviour and all-cause mortality in older men: does volume of activity matter more than pattern of accumulation? *Br J Sports Med*. 2019;53(16):1013.
13. Yamamoto N, Miyazaki H, Shimada M, et al. Daily step count and all-cause mortality in a sample of Japanese elderly people: a cohort study. *BMC Public Health* . 2018;18(1)
14. Hansen BH, Dalene KE, Ekelund U, et al. Step by step: Association of device-measured daily steps with all-cause mortality—A prospective cohort Study. *Scandinavian Med Sci Sports*. 2020;30(9):1705–11.
15. Dwyer T, Pezic A, Sun C, et al. Objectively Measured Daily Steps and Subsequent Long Term All-Cause Mortality: The Tasped Prospective Cohort Study. *PLOS ONE*. 2015;10(11):e0141274.
16. Lee I-M, Shiroma EJ, Kamada M, Bassett DR, Matthews CE, Buring JE. Association of Step Volume and Intensity With All-Cause Mortality in Older Women. *JAMA Intern Med*. 2019;179(8):1105.
17. Alver SK, Pan S, Mossavar-Rahmani Y, et al. Physical Activity, Cardiovascular Status, Mortality, and Prediabetes in Hispanic and Non-Hispanic Adults. *JAMA Netw Open*. 2024;7(6):e2415094.
18. Oftedal S, Holliday EG, Attia J, et al. Daily steps and diet, but not sleep, are related to mortality in older Australians. *Journal of Science and Medicine in Sport*. 2020;23(3):276–82.
19. Mañas A, del Pozo Cruz B, Ekelund U, et al. Association of accelerometer-derived step volume and intensity with hospitalizations and mortality in older adults: A prospective cohort study. *Journal of Sport and Health Science*. 2022;11(5):578–85.
20. Fox KR, Ku P-W, Hillsdon M, et al. Objectively assessed physical activity and lower limb function and prospective associations with mortality and newly diagnosed disease in UK older adults: an OPAL four-year follow-up study. *Age and Ageing*. 2015;44(2):261–8.
21. Saint-Maurice PF, Troiano RP, Bassett DR, et al. Association of Daily Step Count and Step Intensity With Mortality Among US Adults. *JAMA*. 2020;323(12):1151.
22. Del Pozo Cruz B, Ahmadi MN, Lee I-M, Stamatakis E. Prospective Associations of Daily Step Counts and Intensity With Cancer and Cardiovascular Disease Incidence and Mortality and All-Cause Mortality. *JAMA Intern Med*. 2022;182(11):1139.
23. Yates T, Haffner SM, Schulte PJ, et al. Association between change in daily ambulatory activity and cardiovascular events in people with impaired glucose tolerance (NAVIGATOR trial): a cohort analysis. *The Lancet*. 2014;383(9922):1059–66.
24. Jefferis BJ, Parsons TJ, Sartini C, et al. Does total volume of physical activity matter more than pattern for onset of CVD? A prospective cohort study of older British men. *International Journal of Cardiology*. 2019;278:267–72.
24. Cochrane SK, Chen S, Fitzgerald JD, et al. Association of Accelerometry-Measured Physical Activity and Cardiovascular Events in Mobility-Limited Older Adults: The LIFE (Lifestyle Interventions and Independence for Elders) Study. *JAHA*. 2017;6(12)
25. Crippa A, Discacciati A, Bottai M, Spiegelman D, Orsini N. One-stage dose–response meta-analysis for aggregated data. *Stat Methods Med Res*. 2019;28(5):1579–96.
27. Orsini N, Li R, Wolk A, Khudyakov P, Spiegelman D. Meta-Analysis for Linear and Nonlinear Dose-Response Relations: Examples, an Evaluation of Approximations, and Software. *American Journal of Epidemiology*. 2012;175(1):66–73.
28. Higgins JPT. Measuring inconsistency in meta-analyses. *BMJ*. 2003;327(7414):557–60.
29. Egger M, Smith GD, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. *BMJ*. 1997;315(7109):629–34.
30. Piercy KL, Troiano RP, Ballard RM, et al. The Physical Activity Guidelines for Americans. *JAMA*. 2018;320(19):2020.
31. 2018 Physical Activity Guidelines Advisory Committee. 2018 Physical Activity Guidelines Advisory Committee Scientific Report. U.S. Department of Health and Human Services; 2018.