

**Supplementary table 1** Summary of studies on the association between running participation and the risk of all-cause, cardiovascular, and cancer mortality

Cohort	Study and location	Sample	Age at baseline <i>Mean±SD</i> years	Follow-up	Person-Years	Number of runners in the sample	Number of non-runners in the sample	Number of death events	Assessment of running	Outcome assessment	Adjustment for confounding variables	Data analysis method	Summary results <i>Hazard ratios (HR) from adjusted models (if not stated otherwise)</i>	Dose-response analysis
Runners from the 50+ Runners Association with controls from the Stanford University Lipid Research Clinics Prevalence Study	Fries et al. (1994), USA (Northern Carolina)	Exposure group: members of a nationwide runners club aged ≥ 50 years (n = 451, 83% males); Controls: permanent university staff and faculty between 50 and 72 years of age recruited from the roster of the Stanford University Lipid Research Clinics Prevalence Study (n = 330, 56% males)	Exposure group: 58±5.7; Controls: 61±7.1	8 years	n/a	Exposure group: n = 451; Total number of runners (across both groups): n = 534	Controls: n = 330; Total number of non-runners: n = 247	Whole sample: 38 (all-cause), 11 (CVD); Exposure group: 8 (all-cause), 1 (CVD); Controls: 30 (all-cause), 10 (CVD)	Membership in a running club; Self-administered questionnaire ("Have you ever run for exercise for a period of greater than 1 month?")	National Death Index	Baseline age, initial disability assessed by Health Assessment Questionnaire Disability Index (HAQ-DI), educational level, smoking, body mass index, history of arthritis, and comorbid conditions	Cox proportional hazards model (only for all-cause mortality)	All-cause mortality: HR = 0.23 (95% CI: 0.10, 0.56)	n/a
	Wang et al. (2002), USA (Northern Carolina)	Exposure group: members of a nationwide runners club aged ≥ 50 years (n = 538, 82% males); Controls: permanent university staff and faculty between 50 and 72 years of age recruited from the roster of the Stanford University Lipid Research Clinics Prevalence Study (n = 423, 56% males)	Exposure group: 58±5.2; Controls: 61±6.5	13 years	12,493	Exposure group: n = 538	Controls: n = 423	Whole sample: 93 (all-cause), 28 (CVD), 35 (cancer); Exposure group: 26 (all-cause), 9 (CVD), 11 (cancer); Controls: 67 (all-cause), 19 (CVD), 24 (cancer)	Membership in a running club; Self-administered questionnaire ("Have you ever run for exercise for a period of greater than 1 month?")	National Death Index	Baseline age, sex, weekly time spent in aerobic exercise other than running, and smoking. BMI and alcohol consumption were considered but were not included in the final model based on "statistical grounds".	Cox proportional hazards model; Rate ratios expressed per 100,000 person-years (HRs only available for all-cause mortality)	All-cause mortality: HR = 0.36 (95% CI: 0.20, 0.65), rate ratio = 3.28 (no p-value reported); CVD mortality: rate ratio = 2.68 (p = 0.55); Cancer mortality: rate ratio = 2.77 (p = 0.56)	n/a
	Chakravarty et al. (2008), USA (Northern Carolina)	Exposure group: members of a nationwide runners club aged ≥ 50 years (n = 538, 84% males); Controls: permanent university staff and faculty between 50 and 70 years of age recruited from the roster of the Stanford University Lipid Research Clinics Prevalence Study (n = 423, 56% males)	Exposure group: 58±5.6; Controls: 62±7.2	19 years	17,201	Exposure group: n = 538; Total number of runners (across both groups): n = 681	Controls: n = 423; Total number of non-runners: n = 280	Whole sample: 225 (all-cause), 72 (CVD), 71 (cancer); Exposure group: 81 (all-cause), 29 (CVD), 30 (cancer); Controls: 144 (all-cause), 43 (CVD), 41 (cancer)	Membership in a running club; Self-administered questionnaire ("Have you ever run for exercise for a period of greater than 1 month?")	National Death Index	Baseline age, gender, and initial disability assessed by Health Assessment Questionnaire Disability Index (HAQ-DI). Although initially considered as covariates, BMI, smoking history, and weekly aerobic exercise at baseline "did not meet statistical significance to be included in the final model".	Cox proportional hazards model; Unadjusted rate ratios expressed per 100,000 person-years (adjusted HRs only available for all-cause mortality)	All-cause mortality: HR = 0.61 (95% CI: 0.45, 0.82), rate ratio = 2.5 (p < 0.001); CVD mortality: rate ratio = 2.1 (p = 0.001); Cancer mortality: rate ratio = 1.9 (p = 0.004)	n/a

Aerobics Center Longitudinal Study	Lee et al. (2014, 2016a, 2016b), USA (Texas)	Participants were 18-100 years old adults referred for periodic preventive medical examination at a clinic in Dallas, Texas (n = 55,137 for all-cause mortality analysis, 52,941 for CVD mortality analysis, 52,917 for cancer mortality analysis, 74% males). Those reporting myocardial infarction, stroke or cancer at baseline, and those who died within less than 1 year of follow up were excluded from analyses.	Runners Q1: 40±9; Runners Q2: 41±9; Runners Q3: 42±9; Runners Q4: 42±9; Runners Q5: 43±9; Non-runners: 45± 11	14.7 years (mean for all-cause mortality sample); 14.6 (mean for CVD and cancer mortality samples)	827,055	n = 13,016 (all-cause mortality analysis); n = 12,622 (CVD mortality analysis); n ≈ 12,700 (cancer mortality analysis)	n = 42,121 (All-cause mortality analysis); n = 40,319 (CVD mortality analysis); n ≈ 40,217 (cancer mortality analysis)	Whole sample: 3,413 (all-cause), 1,217 (CVD), 1,193 (cancer); Runners: 556 (all-cause), 162 (CVD); Non-runners: 2,857 (all-cause), 1,055 (CVD)	Self-reported running or jogging activity over the past 3 months, including data about duration, distance, frequency and speed (assessed at two medical examinations; in 1974 and 2002)	National Death Index	In Model 1: baseline age, sex, examination year, smoking status, alcohol consumption, other physical activities except running (0, 1-499 MET-min/wk ≥500 MET-min/wk), and parental CVD (except in cancer mortality analysis)  In Model 2: baseline age, sex, examination year, smoking status, overweight/obesity based on body mass index, parental CVD, abnormal electrocardiogram, hypertension, diabetes, hypercholesterolemia	Cox proportional hazards model	Model 1: All-cause mortality: HR(total) = 0.70 (95% CI: 0.64, 0.77), HR(males) = 0.71 (95% CI: 0.64, 0.78), HR(females) = 0.61 (95% CI: 0.45, 0.85); CVD mortality: HR = 0.55 (95% CI: 0.46, 0.65), HR(males) = 0.56 (95% CI: 0.47, 0.67), HR(females) = 0.32 (95% CI: 0.16, 0.64); Cancer mortality: HR(total) = 0.79 (95% CI: 0.68, 0.92)  Model 2: All-cause mortality: HR = 0.81 (95% CI: 0.73, 0.88), CVD mortality: HR = 0.71 (95% CI: 0.60, 0.85)	In Lee et al. (2014), HRs and their 95% CIs for all-cause and CVD mortality available for quintiles of running time, running distance, weekly frequency, running speed, and total volume of running.  In Lee et al. (2016a), HRs and their 95% CIs for all-cause and CVD mortality available for groups by running time in minutes/wk (0, <51, 51-80, 81-119, 120-175, 176-209, 210-269, and ≥270), running distance in miles/wk (0, <6, 6-8, 9-12, 13-19, 20-23, 24-30, ≥31), weekly frequency of running (0, 1-2, 3, 4, 5, 6, ≥7), and total amount of running in MET-minutes/wk (0, <506, 506-812, 813-1199, 1200-1839, 1840-2249, 2250-2943, ≥2944). These represent non-runners (first group), the first four quintiles (second to fifth group), and three tertiles of the last quintile (sixth to eighth group), except for weekly frequency of running that includes 7 groups.  In Lee et al. (2016b), HRs and their 95% CIs for cancer mortality available for quintiles of running time, running distance, weekly frequency, and total volume of running.  The results are summarised in Supplementary table 2.
National Health and Nutrition Examination Survey	Loprinzi (2015), USA	Participants were 18-85 years old adults who participated in NHANES 1999-2006 surveys (n = 16,049, 49% males). Those with self-reported physician-diagnosed congestive heart failure, coronary artery disease, heart attack, stroke, emphysema, or bronchitis were excluded from analyses.	43 (standard deviation not available)	8.7 years (mean follow-up)	n/a	n = 358 (≥2000 MET-min/month of jogging); n = 698 (≥2000 MET-min/month of running)	n = 15,691 (<2000 MET-min/month of jogging); n = 15,351 (<2000 MET-min/month of running)	Whole sample: 1,290; data not available for joggers and runners	Self-reported running and jogging over the past 30 days, including data about duration and frequency. Exposure variables were binary variables including the categories "≥2000 MET-min/month" and "<2000 MET-min/month for running and jogging. Data collected using face-to-face interviews.	National Death Index	Baseline age, gender, race-ethnicity, body mass index, total moderate-to-vigorous physical activity (MET-min/month), and binary variables including the categories "≥2000 MET-min/month" and "<2000 MET-min/month for the following activities: aerobics; basketball; bicycling; dance; stair climbing; swimming; walking; and weight lifting	Cox proportional hazards model	≥2000 MET-min/month of jogging and ≥2000 MET-min/month of running were not significantly associated with the risk of all-cause mortality (results not shown in the paper)	n/a

Health Survey for England and the Scottish Health Survey	Oja et al. (2017), Stamatakis et al. (2017), United Kingdom (England and Scotland)	<p>Participants were 30-98 years old adults from the population-representative Health Survey from England and Scottish Health Survey (n = 80,306 for all-cause mortality analysis and 75,014 for CVD mortality analysis, 46% males). Those reporting doctor-diagnosed CVD at baseline were excluded from the analyses on CVD mortality. In a sensitivity analysis participants who died in the first 24 months of follow-up were excluded.</p> <p>In a subsequent sensitivity analysis, Stamatakis et al. (2017), due to missing income data, 35% of the full sample was excluded (n = 52,031 for the all-cause mortality analysis and n = 48,965 for the CVD mortality analysis).</p>	51.9±14.5 years	9.2±4.3 years (mean±SD)	736,463	<p>n = 4,012 (all-cause mortality analysis); n = 3,988 (CVD mortality analysis)</p> <p>In the subsequent sensitivity analysis: n = 2857 (all-cause mortality analysis); n = 2,840 (CVD mortality analysis)</p>	<p>n = 76,294 (All-cause mortality analysis); n = 71,026 (CVD mortality analysis)</p> <p>In the subsequent sensitivity analysis: n = 49,174 (all-cause mortality analysis); n = 46,125 (CVD mortality analysis)</p>	<p>Whole sample: 8,790 (all-cause), 1909 (CVD); Runners: 68 (all-cause), 13 (CVD); Non-runners: 8,722 (all-cause), 1,896 (CVD)</p> <p>In the subsequent sensitivity analysis - Whole sample: data not shown; Runners: 36 (all-cause), 5 (CVD); Non-runners: data not shown</p>	Self-reported running over the past 4 weeks. Face-to-face interviews conducted using the Physical Activity and Sedentary Behaviour Assessment Questionnaire (PASBAQ).	British National Health Service (NHS) Central Registry	<p>Baseline age, sex, long-standing illness, alcohol drinking frequency, psychological distress, BMI, smoking status, education level, doctor-diagnosed cancer, and weekly volume of other physical activity in MET-hours/week. The all-cause mortality analysis was also additionally adjusted for doctor-diagnosed CVD.</p> <p>In the subsequent sensitivity analyses additionally adjusted for occupational social class and household income.</p>	Cox proportional hazards model	<p>All-cause mortality: HR(total) = 0.87 (95% CI: 0.68, 1.11); CVD mortality: HR = 0.81 (95% CI: 0.47, 1.39); Cancer mortality: HR = 0.65 (95% CI: 0.43, 0.97)</p> <p>In the subsequent sensitivity analysis - HR(total) = 1.06 (95% CI: 0.76, 1.48); CVD mortality: HR = 0.84 (95% CI: 0.34, 2.04).</p>	<p>HRs and their 95% CIs for all-cause and CVD mortality are available for intensity ('Lower', 'Higher'), weekly duration ('Low', 'High'), and weekly volume ('Low', 'High') categories. Low and high intensity, respectively, were defined as answering "no" or "yes" to the question: "Was the effort of [(name of activity)] usually enough to make you out of breath or sweaty?". Low/high weekly duration and volume were defined using median split. Additional results for more detailed categorisations of running doses were obtained upon request from the authors.</p> <p>The results are summarised in Supplementary table 2.</p>
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Copenhagen City Heart Study	Schnohr et al. (2000), Denmark (Copenhagen)	Participants were 20-79 years old adults randomly selected from the Copenhagen Population Register (n = 4,658), who attended two examinations (1976-1978 and 1981-1983). Those with a history of myocardial infarction were excluded from the original sample.	n/a	17-22 years (range)	n/a	Runners in at least one survey year n = 323; Runners in both survey years ("persistent runners") n = 96	Non-runners in at least one survey year n = 4,562; Non-runners in both survey years n = 4,335	n/a	Self-reported participation in jogging or competitive running (general question "Are you a jogger or competition runner?")	National Central Person Register and National Register of Causes of Death	Baseline age, diabetes, smoking household income, education, alcohol consumption, systolic blood pressure, concentration of plasma total cholesterol, concentration of plasma high density lipoprotein cholesterol, and body mass index	Cox proportional hazards model	Significant association with the risk of all-cause mortality only found for "persistent runners": HR = 0.39 (95% CI: 0.19, 0.73)	n/a
	Schnohr et al. (2013), Denmark (Copenhagen)	Participants were 20-98 years old adults randomly selected from the Copenhagen Population Register (n = 18,219; 47% males). Those with a history of coronary heart disease, stroke, and/or cancer were excluded from the original sample.	Male runners: 36.4±12.1 years; Male non-runners: 51.0±13.0 years; Female runners: 33.3±10.4 years; Female non-runners: 50.4±13.0 years	8-35 years (range)	n/a	Males n = 1,089; Females n = 741 (all-cause mortality analysis) Males n = 1,098; Females n = 745 (coronary heart disease mortality, stroke mortality and cancer mortality analyses)	Males n = 7,398 and females n = 4,878 (whole sample in all-cause mortality analysis); Males n = 91 and females n = 26 (sample of runners in all-cause mortality analysis); Males n = 4,843 and females n = 4,852 (sample of non-runners in all-cause mortality analysis)	Males n = 4,934 and females n = 4,878	Self-reported participation in jogging or competitive running (general question "Are you a jogger or competition runner?")	National Central Person Register and National Register of Causes of Death	Baseline age, education, income, smoking, alcohol drinking habits, diabetes mellitus (coronary heart disease mortality, stroke mortality, cancer mortality, dose-response analyses) + leisure-time physical activity, resting heart rate, cholesterol, body mass index, systolic blood pressure, and the use of antihypertensive drugs (all-cause mortality analysis)	Cox proportional hazards model	All-cause mortality: HR(males) = 0.78 (95% CI: 0.64, 0.94), HR(females) = 0.71 (95% CI: 0.50, 1.01); Coronary heart disease mortality: HR(males) = 0.32 (95% CI: 0.15, 0.67), HR(females) = 0.48 (95% CI: 0.12, 1.96); Stroke mortality: HR(males) = 0.95 (95% CI: 0.42, 2.18), HR(females) = 0.85 (95% CI: 0.21, 3.42); Cancer mortality: HR(males) = 0.82 (95% CI: 0.58, 1.16), HR(females) = 0.68 (95% CI: 0.38, 1.23)	HRs and their 95% CIs for all-cause mortality are available for groups by weekly duration, weekly frequency, and pace of running. The analysis included participants who participated in the second, third, and fourth surveys.
	Schnohr et al. (2015), Denmark (Copenhagen)	Participants were 20-92 years old adults randomly selected from the Copenhagen Population Register who participated in the fourth examination, 2001-2003 (n = 1,511; 51% males). Those with a history of coronary heart disease, stroke, and/or cancer were excluded from the original sample.	Runners: 42.5 (standard deviation not available); "Sedentary" non-runners: 61.3±16.2	12 years	n/a	n = 1,098	n = 413 (defined as "sedentary" non-runners)	Whole sample: n = 128; Sample of runners n = 28; Sample of "sedentary" non-runners n = 100	Self-reported weekly quantity, frequency, and pace (slow, average, fast) of running	National Central Person Register	Baseline age, sex, smoking, alcohol intake, education, and diabetes mellitus	Cox proportional hazards model	No results are available for the association between overall running participation and mortality. The results from dose-response analyses are summarised in Supplementary table 2.	HRs and their 95% CIs for all-cause mortality are available for groups by weekly duration of running (<1 hour, 1-2.4 hours, 2.5-4 hours, >4 hours), weekly frequency of running (≤1 time, 2-3 times, >3 times), running pace (slow, average, fast) and overall "dose" of running (light jogger, moderate jogger, strenuous jogger). "Sedentary" non-runners (not all non-runners) were used as the reference group.  The results are summarised in Supplementary table 2.
	Schnohr et al. (2018), Denmark (Copenhagen)	Participants were 20+ years old adults randomly selected from the Copenhagen Population Register who participated in the third examination, 1991-1994 (n = 1,325; 51% males). Those with a history of coronary heart disease, stroke, cancer, and/or missing information about leisure-time physical activity were excluded from the original sample.	Runners: 40±12; "Sedentary" non-runners: 61±15	25 years	n/a	n = 309	n = 926 (defined as "sedentary" non-runners)	Whole sample: n = 693; Sample of runners n = 64; Sample of "sedentary" non-runners n = 629	Self-reported participation in jogging	National Central Person Register	Baseline age, sex, weekly volume of overall leisure-time physical activity, smoking, education, income, alcohol intake, and diabetes mellitus	Cox proportional hazards model	All-cause mortality: HR = 0.72 (95% CI: 0.55, 0.94);	n/a

Shanghai Men's Health Study	Wang et al. (2013), China (Shanghai)	Participants were 40-74 years old men recruited from 2002-2006 from urban communities in Shanghai, China (n = 61,477). Those with previously diagnosed cancer were excluded from the analyses. A sensitivity analysis was performed on participants without a history of CVD at baseline and who did not die within the first year of follow-up (n = 50,505).	55.4 years (standard deviation not available)	5.5 years (mean)	336,894	3,214	58,263	Whole sample: 2,421 (all-cause), 800 (CVD), 1053 (cancer); Runners: 99 (all-cause), 33 (CVD), 44 (cancer); Non-runners: 2,322 (all-cause), 767 (CVD), 1,009 (cancer) In the sensitivity analysis - Whole sample: 1,784 (all-cause), 473 (CVD), 892 (cancer); Runners: 85 (all-cause), 26 (CVD), 42 (cancer); Non-runners: 1,699 (all-cause), 447 (CVD), 850 (cancer)	Self-reported participation in jogging or running for exercise in the past 5 years. Face-to-face interviews conducted using the Shanghai Men's Health Study Physical Activity Questionnaire	Through biennial in-home surveys and data linkage to the Shanghai Cancer Registry and the Shanghai Vital Statistics Registry	Baseline age, educational level, income, occupation (professional, clerical, manual workers), cigarette smoking, alcohol intake, daily physical activity other than exercise, participation in exercise other than jogging, body mass index, history of CVD, chronic liver disease, diabetes, hypertension, and pulmonary disease, total energy intake, intake of red meat, intake of vegetables and fruit intake.	Cox proportional hazards model	All-cause mortality: HR = 0.73 (95% CI: 0.59, 0.90); CVD mortality: HR = 0.74 (95% CI: 0.52, 1.06); Cancer mortality: HR = 0.69 (95% CI: 0.51, 0.94). In the sensitivity analysis - All-cause mortality: HR = 0.79 (95% CI: 0.63, 0.99); CVD mortality: HR = 0.90 (95% CI: 0.60, 1.36); Cancer mortality: HR = 0.74 (95% CI: 0.54, 1.02)	n/a
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Lee et al (2016a) = reference number 30; Lee et al (2016b) = reference number 50