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Cross-country skiing is associated with lower all-cause mortality: A population-based follow-up study

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Abstract

Objectives: The prospective relationship between leisure time cross-country skiing and any fatal events is uncertain. We aimed to assess the associations of leisure time cross-country skiing habits with the risk of all-cause mortality in a general population.

Methods: A 12-month physical activity questionnaire was used at baseline to assess the frequency, average duration, and intensity of cross-country skiing in a prospective population-based cohort of 2,087 middle-aged men from Eastern Finland. Hazard ratios (HRs) (95% confidence intervals) were calculated for all-cause mortality.

Results: During a median (interquartile range) follow-up of 26.1 (18.7-28.0) years, 1,028 all-cause mortality outcomes were recorded. In analyses adjusted for several established risk factors and other potential confounders, when compared to men who did not do any cross-country skiing, the HRs (95% CIs) of all-cause mortality were 0.84 (0.73 to 0.97) and 0.80 (0.67 to 0.96) for men who did 1-200 and > 200 MET hours per year of cross-country skiing, respectively. Similarly, compared to men who did not do any cross-country skiing, the corresponding adjusted HRs (95% CIs) for all-cause mortality were 0.84 (0.72 to 0.97) and 0.82 (0.69 to 0.97) for men who did 1-60 mins per week and > 60 mins week of cross-country skiing respectively. The associations were similar across several subgroups, except for evidence of effect modification by body mass index and history of diabetes.

Conclusions: Total volume as well as duration of leisure time cross-country skiing are each inversely and independently associated with all-cause mortality in a middle-aged Caucasian male population.

Keywords: Physical activity, cross-country skiing, all-cause mortality

INTRODUCTION

Many studies have indicated that higher-intensity exercise (with shorter duration) may yield more favorable effects on mortality and cardiovascular disease (CVD) risk than lower-intensity exercise.¹⁻³ These previous studies consistently found a greater reduction in the risk of CVD with vigorous (typically ≥ 6 metabolic equivalent, METs) than with moderate intensity physical activity and reported more favorable risk profiles for individuals engaged in vigorous, as opposed to moderate to light intensity physical activity⁴. Brisk walking as a physical activity, has many advantages as it is easy to perform. The most important advantage of walking is its high safety factor that can be sustained for months or years, although it may not be so effective in reducing CVD risk⁵. The aerobic exercise training section of recent physical activity guidelines² recommend 30 min per day of moderate-intensity exercise or 75 min per week of vigorous-intensity exercise, with emphasis on low-to-moderate intensity physical activity due to better adherence and safety issues at the population level compared to higher intensity physical activity. Although high-intensity physical activity with shorter duration could be potentially protective, data is very limited on the associations between high-intensity physical activities such as cross-country skiing and all-cause mortality outcome events.

A previous study found that running, even less than the recommended amount of time or at slower speeds, was associated with significant benefits⁶. Individuals who were inactive had an increased risk of mortality compared with individuals in the low-volume physical activity group; even 15 min a day or 90 min a week of moderate-intensity exercise might be of benefit, even for individuals at risk of CVD⁷. The benefits of running were superior to walking not only at the same volume but also at lower volumes than walking. Compared with moderate intensity activity, vigorous-intensity activity, such as running, may be a better option for time efficiency, producing similar, if not greater mortality benefits for 5 to 10 min/day in many healthy but sedentary individuals who may find 15 to 20/30 min per day of moderate-intensity activity. There is convincing observational evidence of the benefits of higher intensity physical exercise in preventing chronic diseases, including coronary heart disease (CHD), stroke, hypertension, diabetes, and hypercholesterolemia^{8,9} and reducing the levels of cardiovascular risk factors^{10,11}. Exceeding intensity levels of physical activity suggested in the guidelines may produce even more important CHD and mortality risk reductions.^{9,12} Indeed,

long-term endurance cross-country skiing has been shown to be associated with reduced risk of all-cause mortality.^{13 14}

Leisure time cross-country skiing, which is a high-intensity type conditioning physical activity and undertaken during the winter season, may have potential health benefits; however, the prospective associations of cross-country skiing habits with all-cause mortality events in general populations have not been previously investigated. We therefore aimed to assess the nature and magnitude of the associations of the total volume (MET hours) and duration of leisure cross-country skiing with the risk of all-cause mortality events using the established Kuopio Ischemic Heart Disease (KIHD) population-based cohort comprising apparently healthy middle-aged men from eastern Finland.

METHODS

Participants and study setting

The study population comprised a representative sample of men living in the city of Kuopio and its surrounding rural communities in Eastern Finland, who were recruited into the KIHD Risk Factor Study. The KIHD study is a population-based prospective cohort study designed to investigate risk factors for CVD and related outcomes.¹⁵ Participants age ranged from 42 to 61 years of age during study recruitment. Of 3,235 potentially randomly selected eligible men, 2,682 (82.9%) volunteered to participate in this study. The baseline examinations were performed between March 20, 1984 and December 5, 1989. The present analysis is based on 2,087 men participating in the follow-up study with no missing data on the assessment of cross-country skiing activity, total physical activity, relevant covariates, and all-cause mortality outcomes. The study was approved by the Research Ethics Committee of the University of Eastern Finland, and each participant gave written informed consent. This study was performed following the STROBE (STrengthening the Reporting of OBservational studies in Epidemiology) guidelines for reporting observational studies in epidemiology (**Appendix 1**).¹⁶

Assessment of cross-country skiing activity

The assessment of cross-country skiing activity as well as total physical activity (kcal/day) was based on a 12-month physical activity questionnaire modified from the Minnesota Leisure-Time Physical Activity

Questionnaire.¹⁷ Cross-country skiing, which is a high-intensity conditioning physical activity and the main exposure of the current study, was assigned an intensity of 9.6 MET, which is the mean intensity of various cross-country skiing activities. The total volume of cross-country skiing (MET hours per year) was estimated using the intensity in METs multiplied by the duration. As skiing is only performed during the winter months, assessment of the frequency, average duration, and intensity of cross-country skiing was based on the winter season. Total physical activity was classified as a conditioning physical activity or non-conditioning physical activity. This detailed quantitative questionnaire deals with the most common leisure-time physical activities of middle-aged Finnish men (conditioning physical activity, e.g. walking, skiing, bicycling, swimming, rowing, ball games, etc and non-conditioning physical activity, e.g. crafts, repairs, building, gardening, hunting, fishing, etc) and enables the assessment of all components of physical activity.^{18 19} For each type of physical activity performed, participants were asked to record the frequency (number of sessions per month), average duration (hours and minutes per session), and intensity (scored as 0 for recreational activity, 1 for conditioning activity, 2 for brisk conditioning activity, and 3 for competitive, strenuous exercise). A trained interviewer collected missing data. The intensity of physical activity was expressed in metabolic units (MET, or metabolic equivalents of oxygen consumption). The four categories of intensity of activity (range of possible scores, 0 to 3) were assigned their own metabolic-unit values, revised on the basis of a synthesis of available empirical data.¹⁹

Ascertainment of outcomes

All deaths that occurred from study entry through to 2014 were included. No losses to follow-up were recorded as participants are under continuous annual surveillance for the development of new fatal events. Deaths were ascertained from hospital records, wards of health centers, questionnaires administered to health workers, death certificates, autopsy reports, and medico-legal reports.^{15 20 21} The Independent Events Committee of the KIID study, blinded to clinical data, performed classification of all deaths.

Assessment of baseline risk factors and confounders

Risk markers and all other characteristics were assessed during the same visit at study entry. A subject was defined a smoker if he had ever smoked cigarettes, cigars, or a pipe on a regular basis within the past 30

days. Resting blood pressure was measured between 8:00 and 10:00 AM with a random-zero sphygmomanometer. Alcohol consumption was assessed using the Nordic Alcohol Consumption Inventory.¹⁸ Body mass index (BMI) was computed as the ratio of weight in kilograms to the square of height in meters, using measured body weight and height. Diabetes was defined as a fasting blood glucose level ≥ 7.0 mmol/L or clinical diagnosis of diabetes with dietary, oral, or insulin treatment. The collection of blood specimens and the measurement of serum lipids, lipoproteins, creatinine and glucose have been described previously.²² ²³ The use of medications, baseline diseases, and the level of physical activity were assessed by self-administered questionnaires. Prevalent CHD was defined as either a previous myocardial infarction, angina pectoris or the use of nitroglycerin for chest pain once a week or more frequently.

Statistical analyses

Baseline characteristics of the participants were summarised using descriptive analyses. To assess the cross-sectional associations of total volume of cross-country skiing with duration of cross-country skiing and several risk markers, we calculated partial correlation coefficients. Hazard ratios (HRs) with 95% confidence intervals (CIs) for all-cause mortality were estimated using Cox proportional hazard models, after confirmation of the assumptions of the proportionality of hazards using Schoenfeld residuals.²⁴ Subjects were classified into groups on the basis of the participants' total volume of cross-country skiing (0, 1-200 and > 200 MET hours per one year) and the weekly average duration of cross-country skiing (0, 1-60, > 60 minutes per week). Hazard ratios were adjusted for (i) age and (ii) established risk factors [age, BMI, systolic blood pressure (SBP), high-density lipoprotein cholesterol (HDL-C), smoking status, alcohol consumption, prevalent CHD, history of diabetes mellitus, resting heart rate, and total physical activity]. We evaluated effect modification by age, BMI, SBP, HDL-C, total physical activity, history of diabetes, smoking status, and prevalent CHD, using tests of interaction. We conducted sensitivity analysis which involved excluding the first five years of follow-up. All statistical analyses were conducted using Stata version 14 (Stata Corp, College Station, Texas).

RESULTS

Baseline characteristics and correlates of total volume of cross-country skiing

The mean age of participants at study entry was 53 [standard deviation (SD), 5] years. The baseline median [interquartile, (IQR)] total volume of cross-country skiing was 42.5 (0-195.5) MET hours per year and the corresponding value for duration of cross-country skiing was 60 (60-90) min per week (**Table 1**). There were weak inverse correlations of total intensity of cross-country skiing with alcohol consumption, physical measures (BMI, diastolic blood pressure, and resting heart rate), triglycerides, and eGFR. Strong positive correlations were observed for total volume of cross-country skiing with average duration of cross-skiing ($r=0.43$) and total physical activity ($r = 0.40$).

Cross-country skiing and all-cause mortality

During a median (IQR) follow-up of 26.1 (18.7-28.0) years, a total of 1,028 all-cause mortality events occurred. All-cause mortality rates per 1000 person-years of follow-up across the three groups of total volume of cross-country skiing (0, 1-200 and > 200 MET hours per year) were 28.1 (95% CI: 25.7 to 30.7), 18.9 (95% CI: 16.9 to 21.0), and 17.4 (95% CI: 15.2 to 20.0) respectively. Cumulative hazard curves demonstrated a greater risk of all-cause mortality among participants who did not do any cross-country skiing compared to the other groups ($p < 0.0001$ for log-rank test; **Figure 1a**). In analyses adjusted for age at baseline, when compared to participants who did not do cross-country skiing, the HRs (95% CIs) of all-cause mortality were 0.67 (0.58 to 0.77) and 0.60 (0.51 to 0.70) for participants who did 1-200 and > 200 MET hours per year of cross-country skiing respectively (**Table 2**). After adjustment for several established risk factors and potential confounders (age, BMI, SBP, HDL-C, smoking status, alcohol consumption, prevalent CHD, history of diabetes mellitus, resting heart rate, and total physical activity), the respective HRs (95% CIs) of all-cause mortality were attenuated to 0.84 (0.73 to 0.97) for 1-200 MET hours per year of cross-country skiing and 0.80 (0.67 to 0.96) for > 200 MET hours per year of cross-country skiing.

All-cause mortality rates per 1000 person-years of follow-up across the three groups of average duration of cross-country skiing (0, 1-60, > 60 minutes per week) were 28.1 (95% CI: 25.7 to 30.7), 18.4 (95% CI: 16.5 to 20.5), and 18.1 (95% CI: 15.9 to 20.7) respectively. Similarly, cumulative hazard curves demonstrated a greater risk of all-cause mortality among participants who did not do any cross-country

skiing compared with the other groups ($p < 0.0001$ for log-rank test; **Figure 1b**). Compared with participants who did not do any cross-skiing, there was a 35% lower risk of all-cause mortality among participants who did cross-country skiing for 1-60 mins per week and a 38% lower risk of all-cause mortality among participants who did cross-country skiing for > 60 mins per week, in analysis adjusted for age (**Table 3**). The risk was 16% and 18% lower respectively after adjustment for several established risk factors and potential confounders. The associations of both total volume and duration of cross-country skiing with all-cause mortality risk remained consistent in analyses that excluded the first five years of follow-up.

Associations of cross-country skiing with all-cause mortality in subgroups

Figure 2 shows the associations of total volume and average duration of cross-country skiing with all-cause mortality in clinically relevant subgroups. Except for evidence of statistically significant interactions by BMI (p for interaction for all < 0.05) and history of diabetes (p for interaction = 0.025) for the associations of total volume and duration of cross-country skiing with all-cause mortality, there was no modification of the associations by other clinically relevant characteristics. For the associations of both total volume and duration of cross-country skiing with risk of all-cause mortality, statistically significant inverse associations were observed in men with lower BMI (< 26.5 kg/m²) compared with a non-significant association in men with a higher BMI (≥ 26.5 kg/m²). A statistically significant inverse association was found in men with no history of diabetes, while a trend towards a positive association was observed in men with a history of diabetes for the respective association between the total volume of cross-country skiing and all-cause mortality risk.

DISCUSSION

Key findings

In the first prospective analysis of the associations of leisure-time cross-country skiing habits and the risk of all-cause mortality in a middle-aged Caucasian population, we found inverse associations of both the total volume and average duration of cross-country skiing with the risk of all-cause mortality outcomes. The associations were independent of several established risk factors as well as a number of other potential confounders. There were weak inverse correlations of the total volume of cross-country skiing with several

risk factors and physiological measures. As expected, a strong correlation was observed with duration of cross-country skiing and the total amount of physical activity. Except for evidence of effect modification by BMI and history of diabetes, the associations of total volume and duration of cross-country skiing with all-cause mortality were not modified by several clinically relevant characteristics. Both total volume and duration of cross-country skiing were strongly and inversely associated with all-cause mortality risk in men with lower BMI compared with less robust associations in men with higher BMI. This observation might reflect evidence that people with low BMI are usually more likely to be active individuals participating in high-intensity physical exercise, have better metabolic profiles, and a lower mortality risk. The same explanation might also be applicable to the stronger protective effect of total volume of cross-country skiing on the risk of all-cause mortality in men without a history of diabetes, which is an opposite finding to the trend towards an increased mortality in men with prevalent diabetes. These findings from subgroup analyses however need replication in further studies given the multiple statistical tests for interaction conducted.

Comparison with previous work and implications of findings

Substantial evidence shows that high- or vigorous-intensity physical activity is associated with reduced risk of all-cause mortality.¹⁻³ A recently published cohort study of 80,306 British adults found robust associations between participation in certain types of sport activities and mortality; substantial reductions in both cardiovascular and all-cause mortality were observed for aerobics, swimming and racquet sports.²⁵ The specific associations of cross-country skiing habits with overall mortality has however been less widely studied in general population. Our overall results show that cross-country skiing, a high-intensity conditioning physical activity, is associated with a reduced risk of mortality from all causes. However, there has been some evidence that vigorous physical activity might cause some harms as well as exercise-related deaths. Indeed, biochemical as well as echocardiographic evidence of cardiac injury have been observed in both high endurance recreational runners and athletes.²⁶⁻²⁸ There is increased short-term risk of sudden coronary events during high-intensity exercise. It has been reported that participants in long-distance ski races have an increased risk of acute cardiovascular events.^{29 30} Among male participants of a 90 km Swedish cross-country skiing event, a faster finishing time and a high number of completed races were associated with higher risk of arrhythmias.²⁹ However, it can be argued that since physically active people spend only a

small amount of their time in these competitive races, the short-term adverse effects or excess mortality during these periods is by far outweighed by the long-term beneficial effects of regular high-intensity exercise such as cross-country skiing.

Possible explanations for findings

Multiple mechanisms have been postulated to underpin the protective effects of physical activity on adverse outcomes such as CVD, diabetes, and cancer, which eventually lead to death, and these involve both physiological and metabolic processes. Since cross-country skiing is a high-intensity physical activity, it is hypothesized that these same processes may underlie the associations demonstrated. Physical activity exerts beneficial effects on cardiovascular function through (i) improvements in endothelial function and levels of cardiovascular risk factors such as blood pressure, natriuretic peptides, lipoproteins, glucose tolerance, hemostatic factors, and cardiac troponin T.³¹⁻³⁴ (ii) its anti-inflammatory effects;³⁵ and (iii) enhancement of cardiac function.³⁶⁻³⁷ Physical activity may also reduce cancer risk via its effect on obesity, which modulates circulating levels of adipokines and cytokines.³⁸ Direct effects of physical activity on target organs and tissues have also been reported.³⁸ Furthermore, it is possible that increasing cardiorespiratory fitness (CRF) through aerobic physical activity such as cross-country skiing could be the key mechanism in reducing mortality risk. Indeed, CRF has been consistently shown to be strongly and robustly associated with reduced risk of all-cause mortality.³⁹ Though CRF is largely determined by physical activity, it has been reported that genetic factors account for 25-40% of the variation in CRF.⁴⁰ Emerging evidence from both animal and human studies indicate that the same genetic factors influence physical activity levels, CRF, and the risk of mortality, leading to the suggestion that genetic pleiotropy might partly explain the observed associations between high baseline physical activity and reduced mortality in long-term observational follow-up studies such as ours.⁴¹

Strengths and limitations

Several strengths of our study deserve mention. To our knowledge, this is the first comprehensive investigation of the observational epidemiological prospective association between cross-country skiing habits and all-cause mortality risk in the general male population. Other strengths include the prospective

cohort design; a homogenous community-based cohort which was a nationally representative sample of middle-aged Finnish men; large number of well-characterized participants and outcome events; the high participation rate and absence of loss to follow-up; the long-term follow-up of over 25 years; confirmation of outcomes by independent physician review; and measurements on a comprehensive panel of lifestyle and biological markers which permitted adequate adjustment for several potential confounders. Several limitations should be considered when interpreting our results. First, cross-country skiing habits as well as other physical activities were self-reported, leading to potential misclassification. Second, there is a possibility that the higher mortality rates in men who did not ski could be partly due to underlying chronic diseases (diagnosed or undiagnosed) which are associated with an increased risk of mortality (reverse causation). However, the associations remained robust in subgroup analyses and in a sensitivity analysis which involved exclusion of the first five years of follow-up. Third, residual confounding remains a potential alternative explanation because of the observational nature of the data. Fourth, participants in our study were middle-aged Caucasian men, so generalisability to other populations and age groups might be limited. Fifth, skiing as a physical activity is usually only possible in the winter months and therefore may reflect individuals' seasonal physical activity habits and the ability to perform high intensity physical activity. Finally, we could not correct for regression dilution bias which may have underestimated the associations demonstrated, as only baseline assessments of cross-country skiing habits were available. There is a possibility that skiing habits may have changed during follow-up. Our findings may be limited to aerobic exercise conducted during the winter months, as cross-country skiing cannot be performed all year-round in Eastern Finland. The amount of cross-country skiing may be related to the total amount of physical endurance exercise performed by study participants; which suggests that those who are active skiers during the winter months are the same people commonly undertaking other types of aerobic endurance exercise such as walking, cycling and running during the year. Thus, the protective effect of cross-country skiing may rather be due to total endurance physical activity. However, while this is possible, we adjusted for the total amount of physical activity in our analyses, thus emphasising an independent relationship between skiing amount and mortality. Furthermore, although cross-country skiing is mainly a high-intensity conditioning physical activity with an assigned mean intensity of 9.6 MET, participants may have skied at various intensities ranging from low to very high intensity. In this study, assessment of the intensity of cross-country

skiing was based on a well-known previously validated leisure-time physical activity questionnaire.
activity.^{18 19}

In conclusion, new data shows that total volume as well as duration of leisure-time cross-country skiing are each inversely and independently associated with all-cause mortality in a middle-aged Caucasian male population. The overall results add to accumulating evidence that conditioning high-intensity physical activity is associated with reduced risk of mortality.

What are the findings?
We found robust evidence that total volume as well as duration of leisure time cross-country skiing are each associated with reduced risk of all-cause mortality in a middle-aged Caucasian male population.

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Contributors: JL and TL conceived the idea for the study. JL, TL and SKK made a study plan. JL, TL and SKK contributed to the development of the data analysis design. SKK processed and analysed the data. JL and SKK drafted the manuscript. TL contributed to the writing of the manuscript. All authors contributed to drafting the rebuttal and revising the final draft of the manuscript.

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Figure Title and Legend

Figure 1: Cumulative Kaplan-Meier curves for all-cause mortality during follow-up according to total volume and duration of cross-country skiing

Figure 2: Associations of total volume and duration of cross-country skiing with all-cause mortality in clinically relevant subgroups

Hazard ratios were adjusted for age, body mass index, systolic blood pressure, high-density lipoprotein cholesterol, smoking status, alcohol consumption, prevalent coronary heart disease, history of diabetes mellitus, resting heart rate, and physical activity; BMI, body mass index; CHD, coronary heart disease; CI, confidence interval; HDL-C, high-density lipoprotein cholesterol; HR, hazard ratio; PA, physical activity; SBP, systolic blood pressure; *, *P*-value for interaction; cut-offs used for age, BMI, SBP, HDL-C, and total physical activity are median values. For total volume of cross-country skiing, HRs are reported comparing > 200 MET hours/year of cross-country skiing with no skiing activity; for duration of cross-country skiing, HRs are reported comparing > 60 minutes of cross-country skiing/week with no skiing activity.

Table 1. Baseline participant characteristics and correlates of total volume of cross-country skiing

	Mean (SD), median (IQR), or %	Pearson correlation r (95% CI) ^a
Total volume of skiing (MET hours/year) [†]	42.5 (0-195.5)	-
Duration of skiing (min/week) [†]	60 (60-90)	0.43 (0.38, 0.47)***
Questionnaire/Prevalent conditions		
Age at survey (years)	52.6 (5.2)	-0.02 (-0.06, 0.02)
Alcohol consumption (g/week)	76.8 (140.5)	-0.04 (-0.09, -0.00)*
History of diabetes		
No	96.3	-
Yes	3.7	-
Smoking status		
Other	67.9	-
Current	32.1	-
History of hypertension		
No	69.3	-
Yes	30.7	-
History of CHD		
No	75.4	-
Yes	24.6	-
Use of anti-hypertensives		
No	78.5	-
Yes	21.5	-
Medication for dyslipidemia		
No	99.4	-
Yes	0.6	-
Physical measurements		
BMI (kg/m ²)	26.9 (3.6)	-0.07 (-0.11, -0.03)**
SBP (mmHg)	134.2 (16.8)	-0.03 (-0.07, 0.01)
DBP (mmHg)	89.1 (10.5)	-0.05 (-0.09, -0.01)*
Resting heart rate (bpm)	62.5 (10.8)	-0.08 (-0.13, -0.04)***
Total physical activity (kcal/day)	368.1 (359.7)	0.40 (0.36, 0.44)***
Lipid markers		
Total cholesterol (mmol/l)	5.93 (1.08)	-0.01 (-0.05, 0.04)
HDL-C (mmol/l)	1.28 (0.30)	0.08 (0.04, 0.12)***
Triglycerides (mmol/l)	1.10 (0.80-1.56)	-0.09 (-0.13, -0.04)***
Metabolic and renal markers		
Fasting plasma glucose (mmol/l)	5.35 (1.28)	-0.03 (-0.07, 0.01)
Serum creatinine (μmol/l)	89.5 (22.0)	0.02 (-0.03, 0.06)
Estimated GFR (ml/min/1.73 m ²)	87.5 (17.5)	-0.05 (-0.09, -0.00)*

BMI, body mass index; CHD, coronary heart disease; DBP, diastolic blood pressure; GFR, glomerular filtration rate; HDL-C, high-density lipoprotein cholesterol; IQR, interquartile range; SBP, systolic blood pressure; ^a, Pearson correlation coefficients between duration of skiing and the row variables; asterisks indicate the level of statistical significance:

*, p<0.05; **, p<0.01; ***, p<0.001

[†], Volume and duration of cross-country skiing is estimated based on the frequency, average duration, and intensity of cross-country skiing during the winter months

Table 2. Associations of total volume of cross-country skiing with all-cause mortality

Total volume of cross-country skiing (MET hours/year)*	Events/ Total	Model 1		Model 2	
		HR (95% CI)	P-value	HR (95% CI)	P-value
0	480 / 821	ref		ref	
1-200	337 / 759	0.67 (0.58 to 0.77)	< 0.001	0.84 (0.73 to 0.97)	0.020
> 200	211 / 507	0.60 (0.51 to 0.70)	< 0.001	0.80 (0.67 to 0.96)	0.015
P-value for trend			< 0.001		0.007

Model 1: Adjusted for age

Model 2: Model 1 plus body mass index, systolic blood pressure, high-density lipoprotein cholesterol, smoking status, alcohol consumption, prevalent coronary heart disease, history of diabetes mellitus, resting heart rate, and total physical activity

*, Total volume of cross-country skiing in METhours per year is based on cross-country skiing during the winter months

Table 3. Associations of duration of cross-country skiing with all-cause mortality

Duration of cross-country skiing (mins/week)*	Events/ Total	Model 1		Model 2	
		HR (95% CI)	P-value	HR (95% CI)	P-value
0	480 / 821	ref		ref	
1-60	330 / 761	0.65 (0.56 to 0.75)	< 0.001	0.84 (0.72 to 0.97)	0.017
> 60	218 / 505	0.62 (0.53 to 0.73)	< 0.001	0.82 (0.69 to 0.97)	0.019
P-value for trend			< 0.001		0.010

Model 1: Adjusted for age

Model 2: Model 1 plus body mass index, systolic blood pressure, high-density lipoprotein cholesterol, smoking status, alcohol consumption, prevalent coronary heart disease, history of diabetes mellitus, resting heart rate, and total physical activity

*, Duration of cross-country skiing is based on cross-country skiing during the winter months