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Cross-country skiing and the risk of acute myocardial infarction: a prospective cohort study

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Compared with moderate-intensity physical activity (PA) (energy expenditure of 3.0-6.0 METs), vigorous- or high-intensity (HIPA) (energy expenditure of >6.0 METS) has more pronounced health benefits on adverse vascular and non-vascular outcomes.[1] Cross-country skiing, a seasonal HIPA commonly undertaken during the winter months, is considered to be one of the most demanding of aerobic endurance activities that requires both upper and lower-body work to different extents. It is also associated with the highest recorded levels of cardiorespiratory fitness,[2] which is established to be inversely and independently associated with CVD and mortality.[3] Cross-country skiing can be undertaken as a leisure-time activity or long-term endurance competitive sport and evidence suggests both types of activity are associated with reduction in the risk of hypertension, cardiovascular disease (CVD) outcomes, as well as all-cause mortality.[4-6] Although several HIPAs, if regularly performed, have been demonstrated to be associated with a reduced risk of acute myocardial infarction (AMI),[7] evidence on the role of cross-country skiing in reducing the risk of AMI is limited and uncertain. Using a large general population-based sample of middle-aged Finnish men, we examined the associations of the total volume and duration of leisure-time cross-country skiing with the risk of incident AMI.

The data used in this study were derived from the Kuopio Ischemic Heart Disease Risk Factor (KIHD) study, which is a long-term prospective follow-up study on risk factors for CVD and other health outcomes in a population sample of middle-aged men from eastern Finland.[8] Full details of recruitment methods and measurements of risk markers have been described previously.[8] Briefly, baseline assessments and examinations were performed between March 20, 1984 and December 5, 1989. Cross-country skiing activity habits as well as total PA were assessed using a 12-month PA questionnaire modified from the Minnesota Leisure-Time PA Questionnaire. We included all incident cases of AMI that occurred from study entry until the end of 2014. There were no losses to follow-up. The diagnostic classification of AMI was based on symptoms of coronary heart disease, electrocardiographic findings, cardiac enzyme elevations, and autopsy outcomes.[9] The KIHD study received the approval of the Research Ethics Committee of the University of Kuopio, Kuopio, Finland in line with the Helsinki Declaration. Written informed consents were provided by all participants. The final cohort for the present analysis is based on 2,589 men with no missing data on cross-country skiing activity habits, total PA, relevant covariates, and AMI. Cox proportional hazard models were used to calculate hazard ratios (HRs) with 95% confidence intervals (CIs). All statistical analyses were conducted using Stata version 15 (Stata Corp, College Station, Texas, USA).

The overall mean (standard deviation, SD) age and body mass index of participants at baseline was 53 (5) years and 26.9 (3.6) kg/m^2 respectively. The baseline median [interquartile, (IQR); minimum-maximum] total volume and duration of cross-country skiing was 40.0 (0.0-190.0; 0-3,375) MET hours per year and 60 (60-90; 0-480) minutes per week respectively. A total of 808 AMI events were recorded during a median (IQR) follow-up of 23.6 (12.3-27.2) years. The high incidence of AMI reflects the high prevalence and incidence of atherosclerotic vascular disease in Finland.[10] A restricted cubic spline curve suggested there may be a trend for a linear relationship between total volume of cross-country skiing and AMI risk (p-value for nonlinearity=0.295) (**Figure**); but given the wide 95% CIs, further work is required to characterize the shape that better describes the relationship. Compared to men with no cross-country skiing activity, the age-adjusted HRs (95% CIs) for AMI were 0.77 (0.66-0.90) and 0.58 (0.48-0.70) for men who did 1-200 and > 200 MET hours per year of cross-country skiing respectively (**Table**). Following further adjustment for body mass index, systolic blood pressure, smoking status, history of diabetes, history of coronary heart disease, total cholesterol, high-density lipoprotein cholesterol, alcohol consumption, and total PA, the corresponding HRs (95% CIs) were attenuated to 0.96 (0.81-1.12) and 0.81 (0.66-0.98) for 1-200 and > 200 MET hours per year of cross-country skiing respectively. In analysis that adjusted for age, compared to men with no cross-country skiing activity, the HRs (95% CIs) of AMI were 0.73 (0.63-0.86) and 0.63 (0.52-0.76) for men who did 1-60 and > 60 mins per week of cross-country skiing (**Table**). The corresponding HRs (95% CIs) were 0.93 (0.79-1.10) and 0.84 (0.69-1.02) following further adjustment for several confounders.

In this prospective cohort study evaluating the associations of leisure-time cross-country skiing habits with the risk of AMI in middle-aged Finnish men, total volume of cross-country skiing was inversely associated with risk of AMI and this was independent of several established and emerging coronary risk factors. The association of average duration of cross-country skiing with risk of AMI was however modest. There is established evidence that HIPAs are associated with reduced risk of AMI[7] and there is emerging evidence that cross-country skiing may be protective of CVD outcomes as well as all-cause mortality.[4-6] There is however limited evidence on whether cross-country skiing may play a role in reducing the risk of AMI. When a large cohort of cross-country skiers with a first MI were compared with their non-skier counterparts, the skiers had a 24% reduced risk of recurrent MI in analysis adjusted for several confounders.[11] In this first population-based cohort study, we have shown that higher volumes of leisure-time cross-country skiing (>200 MET hours/year) may reduce the risk of a first MI in a middle-aged population.

Compared to common aerobic activities, such as walking, running, and cycling, cross-country skiing places greater metabolic demands on the cardiovascular and respiratory systems. Just like other HIPAs, cross-country skiing may reduce the risk of AMI via multiple pathways described previously,[5, 12] such as (i) improvements in cardiovascular risk factors including body weight, blood pressure, glucose tolerance, endothelial function, and lipid profile and (ii) anti-inflammatory effects. The inability to demonstrate an association of average duration of cross-country skiing with the risk of AMI, may reflect the fact that the total volume of PA is a more important determinant of health benefits than the intensity, duration, or frequency.[13] An appropriate intensity, frequency, and duration, which comprise the volume, is essential to maximally benefit from PA.

These novel findings add to the growing evidence that leisure-time cross country skiing has beneficial effects on adverse vascular outcomes. Other highlighted strengths of our study include the representative population-based sample of men with long-term follow-up with no losses to follow-up. However, there are some weaknesses of the study that deserve consideration, such as (i) the non-inclusion of women; (ii) the specific age range of the participants; (iii) the assessment of cross-country skiing habits using self-reported questionnaires; (iv) inability to demonstrate if cross-country skiing could provoke AMI due to lack of relevant data; and (v) the inability to infer a cause-and-effect relationship given the observational design. There is a possibility that since cross-country skiing is just a seasonal HIPA, its protective effect on AMI may reflect the high level of PA over the years and superior lifestyle of cross-country skiers. However, our analyses accounted for total PA.

In conclusion, total volume but not duration of leisure-time cross-country skiing is inversely associated with the risk of AMI in a middle-aged male Caucasian population. Further is required to demonstrate the optimal cross-country skiing intensity, frequency, and duration needed for AMI prevention.

Author contribution

JAL, TAL, BAO, SK, and SKK contributed to the conception and design of the work. All authors contributed to the acquisition, analysis, or interpretation of data for the work. JAL, BAO, and SKK drafted the manuscript. All authors critically revised the manuscript. All authors gave final approval and agree to be accountable for all aspects of the work ensuring integrity and accuracy.

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Declaration of conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Table. Associations of total volume and duration of leisure-time cross-country skiing with acute myocardial infarction

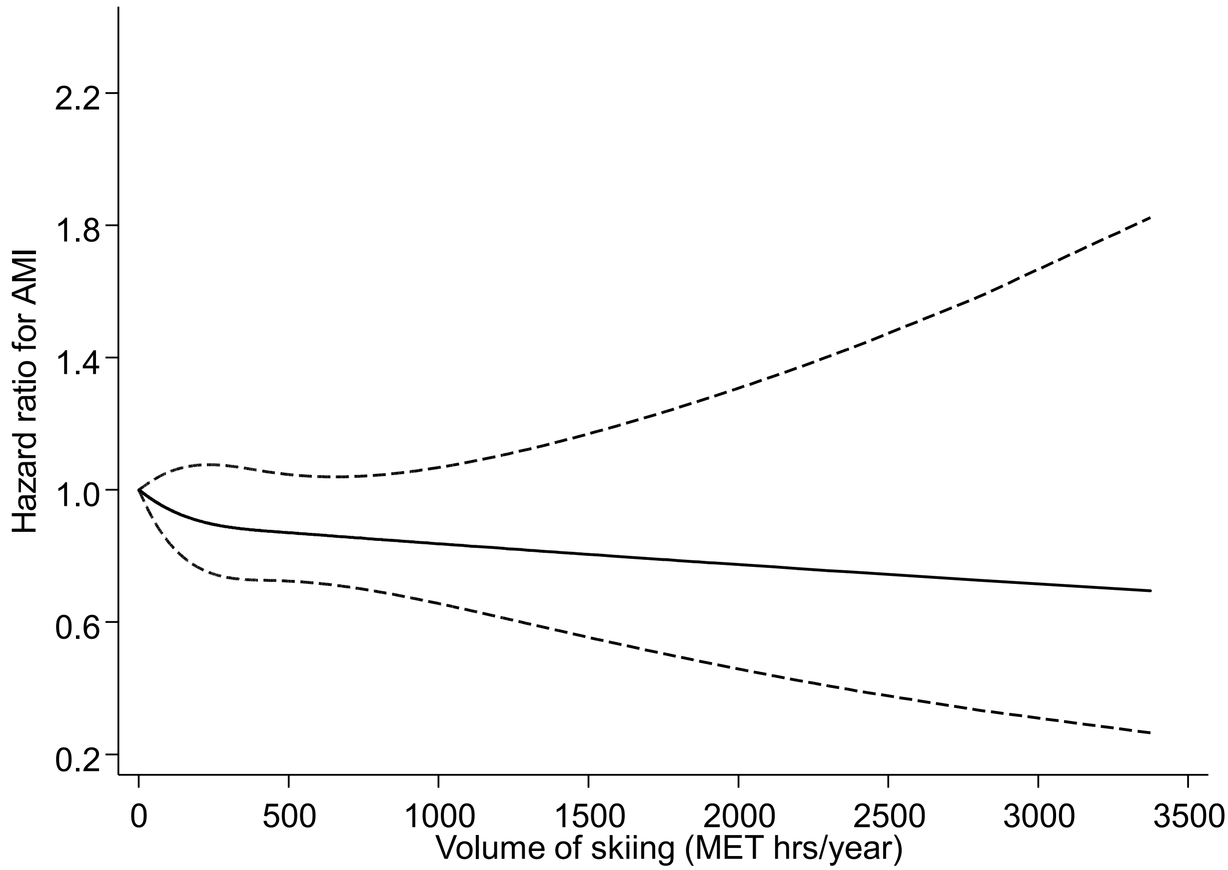
Cross-country skiing exposure	Events/ Total	Model 1		Model 2	
		HR (95% CI)	*P*-value	HR (95% CI)	*P*-value
Total volume (MET hours/year)					
0	382 / 1,067	ref		ref	
1-200	271 / 897	0.77 (0.66 to 0.90)	0.001	0.96 (0.81 to 1.12)	0.59
> 200	155 / 625	0.58 (0.48 to 0.70)	< 0.001	0.81 (0.66 to 0.98)	0.03
P-value for trend			< 0.001		0.04
Duration (mins/week)					
0	382 / 1,067	ref		ref	
1-60	268 / 914	0.73 (0.63 to 0.86)	< 0.001	0.93 (0.79 to 1.10)	0.41
> 60	158 / 608	0.63 (0.52 to 0.76)	< 0.001	0.84 (0.69 to 1.02)	0.07
P-value for trend			< 0.001		0.07

Model 1: Adjusted for age

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

Figure Legend

Figure Restricted cubic spline of the hazard ratios of acute myocardial infarction with total volume of leisure-time cross-country skiing



Models were adjusted for age, body mass index, systolic blood pressure, smoking status, history of diabetes, history of coronary heart disease, total cholesterol, high-density lipoprotein cholesterol, alcohol consumption, and total physical activity; AMI, acute myocardial infarction

Broken lines represent 95% confidence intervals