

Leisure-time cross-country skiing and risk of atrial fibrillation and stroke: a prospective cohort study

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Table [2]

Physical activity (PA) is consistently associated with reduced risk of vascular and non-vascular outcomes as well as mortality.¹ Vigorous- or high-intensity PA (HIPA) (defined as energy expenditure of >6.0 METS) is associated with substantial improvements in cardiovascular risk factors such as cardiorespiratory fitness (CRF) and larger reductions in the risk of vascular outcomes.² Cross-country skiing is a seasonal HIPA which is undertaken as a leisure time PA or long-term endurance sport; it is recognized as one of the most demanding aerobic endurance activities requiring good CRF. Emerging data suggests that cross-country skiing either undertaken as a leisure-time or endurance training and competitive activity, is associated with reduced risk of vascular diseases, as well as mortality.³⁻⁵ There are suggestions that HIPA might be associated with potential toxic effects such as abnormalities in biochemical markers and cardiac dysfunction and arrhythmias, especially in endurance running and cycling.⁶ However, it has been reported that this evidence is not consistent or strong enough to recommend avoiding heavy endurance exercise or sports.⁶ Some reports suggest that cross-country skiing may be associated with an increased risk of acute cardiac events as well as common cardiac arrhythmias such as atrial fibrillation (AF).^{7, 8} Similarly these findings have been inconsistent; whereas some studies have shown an increased risk of AF with cross-country skiing,^{7, 8} others have shown decreased or no difference in risk.^{3, 9} In this context, our primary objective was to evaluate the associations of total volume and duration of leisure-time cross-country skiing with the risk of incident AF in a large general population-based sample of middle-aged Finnish men aged 42-61 years at baseline. Secondary objectives included (i) assessing the associations of leisure-time cross-country skiing habits with the risk of incident stroke and (ii) assessing the joint associations of leisure-time cross-country skiing habits and CRF with the risk of incident AF and stroke.

Data employed for this analysis came from the Kuopio Ischemic Heart Disease Risk Factor (KIHD) study, a prospective population-based cohort study designed to investigate potential risk factors for atherosclerotic CVD and other related chronic disease outcomes. Methods for participant recruitment, baseline examinations and measurements have been described previously.⁴ Baseline measurements were performed between March 20, 1984 and December 5, 1989. Leisure-time cross-country skiing activity

habits were assessed using a 12-month PA questionnaire modified from the Minnesota Leisure-Time PA Questionnaire.⁴ All incident cases of AF and stroke from study entry through to 2017 were included and no losses to follow-up were recorded. The diagnostic classification of AF cases was conducted according to ICD-10 codes (I48.0-I48.9). A stroke event was classified according to ICD-10 codes I60–I68 and G45–G46]. The protocol was approved by the Research Ethics Committee of the University of Eastern Finland in line with the Helsinki Declaration and every participant provided written informed consent. Hazard ratios (HRs) with their 95% confidence intervals (CIs) for outcomes were calculated using Cox proportional hazard models. All statistical analyses were conducted using Stata version MP 16 (Stata Corp, College Station, Texas, USA).

The overall mean (standard deviation, SD) age of men at baseline was 53 (5) years. The baseline median (interquartile range, (IQR)) of total volume and duration of cross-country skiing was 49.6 (0.0–200.0) MET hours per year and 60 (60–90) minutes per week respectively. The prevalence of AF in cross-country skiers was 1.07% (13/1,211) and that for non-skiers was 1.05% (8/759). A total of 428 AF events were recorded during a median (IQR) follow-up of 25.2 (16.4–29.3) years in 1,949 men without a history of AF at baseline. Compared to men with no cross-country skiing activity, the multivariable-adjusted HRs (95% CIs) for AF were 1.05 (0.84–1.32) and 1.13 (0.87–1.76) for men who did 1–200 and > 200 MET hours per year of cross-country skiing respectively (**Table 1**). The corresponding adjusted HRs (95% CIs) of AF were 1.11 (0.88–1.39) and 1.04 (0.80–1.34) for men who did 1–60 and > 60 mins per week of cross-country skiing (**Table 1**). During a median (IQR) follow-up of 26.5 (16.3–30.3) years in 1,970 men, 329 stroke events were recorded. There were no statistically significant multivariable-adjusted associations of cross-country skiing habits (total volume and duration) with the risk of stroke outcomes (**Table 1**). The associations remained consistent when men with a history of AF were excluded. On the joint association analyses of cross-country skiing habits and CRF levels with the risk of AF and stroke, no statistically significant associations were observed in multivariable analyses (**Table 2**).

In a cohort of middle-aged Finnish men, male skiers had a similar prevalence of AF to that of non-skiers at study entry. On evaluation of the relationships of leisure-time cross-country skiing habits with

the risk of incident AF, no significant associations were observed, and these findings are consistent with some previous reports.^{3,9} In a large study of 208,654 skiers of the Vasaloppet skiing study matched to 527,448 non-skiers, male cross-country skiers had a similar incidence of AF to that of non-skiers.⁹ In another cohort of 399,630 skiers and non-skiers, no differences in the risk of AF were found between the two groups.³ On the other hand, our null findings on the relation between cross-country skiing habits and risk of stroke are in contrast to findings of previous studies which have shown lower incidence of stroke among skiers.^{3,9} Given that cross-country skiers have the highest recorded levels of CRF,¹⁰ we hypothesized that there may be an interaction between cross-country skiing activity and objectively measured CRF on the outcomes of AF and stroke. However, our detailed evaluation of the impact of cross-country skiing and CRF on outcomes showed no significant evidence of associations. Since majority of studies reporting an increased risk of AF with cross-country skiing are based on long-term endurance cross-country skiers, the null association observed between leisure-time cross-country skiing and AF in our study may reflect important pathophysiologic differences between the two types of activities in the pathogenesis of AF. It has been suggested that the dose of endurance exercise plays a role in the pathophysiology of atrial arrhythmias.¹¹ Indeed, the intensity and volume of endurance cross-country skiing far exceeds those proposed by general population guideline recommendations compared with leisure-time cross-country skiing; these excessive doses may be associated with cardiac injury, increased inflammation, atrial remodeling, and autonomic imbalance, which are suggested mechanisms underlying the development of AF. Research evidence also indicates that there is a J-shaped association between AF and the broad range of PA and exercise; whereas prolonged endurance exercise increases the prevalence and incidence of AF, modest PA is associated with a decreased risk of AF.¹² In a large prospective evaluation of 7,018 participants, total and types of PA such as walking, cycling, domestic work, gardening and sports, were demonstrated not to be associated with an increased or decreased risk of AF.¹³ If there is any association between leisure-time cross-country skiing habits and AF at all, it would more likely be a beneficial one given the overall existing evidence, plausible mechanistic pathways and the direction of effect of our findings. Nevertheless, the null findings could also be due to confounding

and differences in factors such as age, sex, genetic background of the population; and study design characteristics such as follow-up duration.

Strengths of the current study include the large sample which was representative of the general population of middle-aged men, zero loss to follow-up, long-term follow-up, and adjustment for a comprehensive panel of confounders. Weaknesses of the study include inability to generalize the findings to women and other age groups, inability to assess associations between skiers with AF and stroke because of the low numbers, the assessment of cross-country skiing habits using self-reported questionnaires, and biases inherent to observational study designs such as residual confounding and reverse causation bias.

In conclusion, leisure-time cross-country skiing is not associated with an increased risk of AF or stroke in middle-aged Caucasian males. These findings extend the evidence on the overall safety of HIPAs.

Author contribution

SKK, JAL, SK, TM, and HK contributed to the conception and design of the work. All authors contributed to the acquisition, analysis, or interpretation of data for the work. SKK, JAL, TM, and HK 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 1. Associations of total volume and duration of leisure-time cross-country skiing with atrial fibrillation and stroke

Cross-country skiing exposure	Events/Total	Model 1		Model 2	
		HR (95% CI)	P-value	HR (95% CI)	P-value
Atrial fibrillation					
Total volume (MET hours/year)					
0	157 / 751	ref		ref	
1-200	159 / 722	0.79 (0.75 to 1.16)	0.54	1.05 (0.84 to 1.32)	0.66
> 200	112 / 476	0.65 (0.74 to 1.21)	0.66	1.13 (0.87 to 1.46)	0.36
Duration (mins/week)					
0	157 / 751	ref		ref	
1-60	168 / 725	0.98 (0.79 to 1.22)	0.87	1.11 (0.88 to 1.39)	0.37
> 60	103 / 473	0.88 (0.68 to 1.13)	0.30	1.04 (0.80 to 1.34)	0.78
Stroke					
Total volume (MET hours/year)					
0	145 / 759	ref		ref	
1-200	117 / 730	0.73 (0.57 to 0.94)	0.012	0.86 (0.67 to 1.11)	0.26
> 200	67 / 481	0.60 (0.45 to 0.81)	0.001	0.74 (0.55 to 1.01)	0.056
Duration (mins/week)					
0	145 / 759	ref		ref	
1-60	115 / 730	0.71 (0.56 to 0.91)	0.007	0.86 (0.67 to 1.11)	0.25
> 60	69 / 481	0.63 (0.47 to 0.84)	0.002	0.77 (0.57 to 1.03)	0.08

For the association between cross-country skiing and atrial fibrillation, men with a baseline history of atrial fibrillation were excluded.

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, use of cholesterol medication, alcohol consumption, resting heart rate, and cardiorespiratory fitness

Table 2. Joint associations of leisure-time cross-country skiing and cardiorespiratory fitness with atrial fibrillation and stroke

Exposure	Events/Total	Model 1		Model 2	
		HR (95% CI)	P-value	HR (95% CI)	P-value
Atrial fibrillation					
Total volume of cross-country skiing and CRF					
Low ski volume & Low CRF	86 / 342	ref		ref	
Low ski volume & High CRF	48 / 264	0.66 (0.46 to 0.95)	0.02	0.79 (0.54 to 1.15)	0.22
High ski volume & Low CRF	66 / 258	0.96 (0.70 to 1.33)	0.81	0.95 (0.69 to 1.32)	0.76
High ski volume & High CRF	72 / 335	0.74 (0.54 to 1.01)	0.06	0.94 (0.67 to 1.33)	0.74
Duration of cross-country skiing and CRF					
Low ski duration & Low CRF	97 / 377	ref		ref	
Low ski duration & High CRF	72 / 349	0.71 (0.52 to 0.96)	0.03	0.85 (0.61 to 1.18)	0.33
High ski duration & Low CRF	55 / 223	0.88 (0.63 to 1.22)	0.44	0.89 (0.64 to 1.24)	0.49
High ski duration & High CRF	48 / 250	0.65 (0.46 to 0.92)	0.02	0.86 (0.59 to 1.25)	0.44
Stroke					
Total volume of cross-country skiing and CRF					
Low ski volume & Low CRF	63 / 346	ref		ref	
Low ski volume & High CRF	37 / 266	0.75 (0.50 to 1.13)	0.16	0.98 (0.63 to 1.51)	0.92
High ski volume & Low CRF	38 / 260	0.73 (0.49 to 1.10)	0.13	0.73 (0.49 to 1.10)	0.14
High ski volume & High CRF	46 / 340	0.69 (0.47 to 1.02)	0.064	0.98 (0.65 to 1.49)	0.92
Duration of cross-country skiing and CRF					
Low ski duration & Low CRF	69 / 381	ref		ref	
Low ski duration & High CRF	46 / 350	0.69 (0.47 to 1.02)	0.06	0.91 (0.60 to 1.36)	0.63
High ski duration & Low CRF	32 / 225	0.73 (0.48 to 1.12)	0.15	0.67 (0.44 to 1.03)	0.068
High ski duration & High CRF	37 / 256	0.77 (0.51 to 1.16)	0.22	1.07 (0.69 to 1.65)	0.76

For atrial fibrillation outcome, men with a baseline history of atrial fibrillation were excluded; CRF, cardiorespiratory fitness

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, use of cholesterol medication, alcohol consumption, and resting heart rate