

Prior Myocardial Infarction is the Major Risk Factor Associated with Sudden Cardiac Death During Downhill Skiing

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More than 90% of all sudden cardiac deaths (SCDs) during downhill skiing, the most popular winter sport world-wide, are attributed to men over the age of 34. However, no data exist on additional risk factors and triggers for SCD related to downhill skiing. Therefore risk factor profiles of 68 males who died from SCD during downhill skiing were compared to those of 204 matched controls. Skiers who suffered SCD had much more frequently prior myocardial infarction (MI) (41% vs. 1.5%; $p < 0.001$), hypertension (50% vs. 17%; $p < 0.001$), known coronary heart disease (CHD) without prior MI (9% vs. 3%; $p = 0.05$) and were less engaged in strenuous exercise (4% vs. 15%; $p < 0.05$) when compared to controls. Multivariate analyses even enhanced the importance of these risk factors. Downhill skiing is considered to be a serious trigger for SCD especially in skiers with prior MI but also for those with hypertension, known CHD without prior MI, or insufficient adaptation to strenuous exercise. Skiing-related increased sympathetic activity might well disturb the autonomic balance with subsequent arrhythmias and/or may increase cardiac work and platelet aggregability with possible plaque rupture and coronary thrombosis. Therefore adaptation to high intensity exercise and therapeutic interventions or abstinence from skiing in certain cases should be considered for downhill skiers at high risk.

Key words: Sudden cardiac death, downhill skiing, risk factors, prior myocardial infarction, hypertension, physical activity.

Introduction

Downhill skiing has become the most popular winter sport world-wide. About 8 million skiers visit Austria each year [2]. Downhill skiing is associated with a relatively low death rate amounting to less than 1 death per 100 000 skiers annually [3]. However, about 40% of all fatalities during downhill skiing are SCDs [3]. More than 90% of these fatalities occur in men over the age of 34. The risk of death clearly increases with age and is higher in skiers who are habitually sedentary [4]. However, there are no data available regarding additional risk factors and triggers associated with SCD during downhill skiing. For the identification of high-risk individuals and the development of effective preventive measures, such information would be of great value. Therefore a case-control analysis between skiers who died suddenly during skiing and randomly selected controls was carried out.

Material and Methods

Cases

All deaths which occurred during downhill skiing in Austria from 1985 through 1993 were recorded by members of the Ministry of the Interior utilising standardised forms [2]. Male skiers > 34 years of age who suffered SCD during downhill skiing and who were residents of Austria or Germany were eligible for inclusion in the study. SCD was defined as unexpected, non-traumatic death in persons with or without pre-existing disease who died within 1 hour of the onset of symptoms [4, 5]. Rare cases in which cardiovascular processes such as intracerebral hemorrhage, pulmonary embolism, and dissecting aortic aneurysm were demonstrated were excluded. Out of a total of 157 cases with SCD 104 fulfilled the inclusion criteria. Fifty-three cases were excluded because of nationality other than Austrian or German or due to an age < 34 or female gender. For data collection on risk factor profiles addresses of spouses or close relatives of skiers who suffered sudden death were available in 85 cases. Sixty-eight questionnaires (80%) were returned, and after subsequent telephone interviews for data completion all of them were included for analyses (Table 1).

Table 1 Characteristics and odds ratios regarding the prevalence of risk factors among skiers who suffered sudden cardiac death as compared with controls

	Skiers with sudden death N = 68	Controls N = 204	Odds Ratio (95% CI) Univariate	p-Value	Odds Ratio (95% CI) Multivariate	p-Value
Age, yrs	58.6 (± 10.5)	58.5 (± 8.3)				
Height, cm	176.2 (± 6.5)	177.0 (± 6.9)				
Weight, kg	79.0 (± 10.5)	81.1 (± 10.9)				
Body mass index, kg/m ² , > 25 (%)	33 (49)	82 (40)	1.4 (0.8–2.4)	0.23	0.54 (0.25–1.17)	0.12
Prior MI, Yes (%)	28 (41)	3 (1.5)	46.9 (13.6–161.8)	<0.001	92.8 (22.8–379.1)	<0.001
Known CHD without prior MI, Yes (%)	6 (9)	6 (3)	3.2 (1.0–10.3)	0.05	4.8 (1.1–21.2)	0.04
Hypertension, Yes (%)	34 (50)	34 (17)	5.0 (2.7–9.1)	<0.001	9.0 (4.0–20.6)	<0.001
Hypercholesterinemia, Yes (%)	22 (32)	61 (30)	1.1 (0.6–2.0)	0.7	0.59 (0.23–1.53)	0.28
Diabetes, Yes (%)	2 (3)	6 (3)	1.0 (0.2–5.1)	1.0	1.1 (0.12–9.5)	0.94
Smoking, Yes (%)	17 (25)	38 (19)	1.5 (0.8–2.8)	0.3	2.0 (0.78–4.9)	0.15
SCD in family history, Yes (%)	15 (22)	48 (24)	0.9 (0.5–1.8)	0.8	0.63 (0.25–1.6)	0.33
Light to moderate physical activities > 3 times per week, (%)	23 (34)	80 (39)	0.79 (0.4–1.4)	0.4	2.0 (0.82–4.6)	0.13
High intensity exercise > 1 time per week, (%)	3 (4)	30 (15)	0.27 (0.08–0.9)	<0.05	0.17 (0.04–0.74)	0.02
Mountain sports activities > 2 weeks per year, (%)	30 (44)	94 (46)	0.92 (0.5–1.6)	0.8	1.2 (0.55–2.6)	0.65

Data are presented as means (± SD), frequencies (percentages).

Univariate analyses were conducted using the Chi-square or Fisher's exact test.

Adjusted odds ratios (and confidence intervals, CI) were derived by conditional logistic-regression analysis

Controls

Control subjects were recruited from the population of male skiers from Austria and Germany (Table 1). In the winter seasons of 1995/96 and 1996/97 720 skiers were interviewed with a similar standardised questionnaire as used for cases. Inquiries were carried out in three Austrian ski resorts on three holidays when sudden cardiac deaths were observed most frequently. On those days data from all male skiers over the age of 34 years entering the ski area were recorded successively for a certain period in the morning and the afternoon. Less than 10% of skiers refused the inquiry. Afterwards controls were matched to the cases in terms of age, nationality, and frequency of mountain sports activities. Three controls were selected for each case.

Data collection

The questionnaire employed was tested in a preceding pilot study and was revised to improve clarity and facilitate statistical analysis. This questionnaire covered demographic variables, cardiovascular risk factors, medical history, physical activity, and additionally symptoms and circumstances of sudden death for cases. Trained interviewers were responsible for the data collections. Habitual physical activity was classified as mild to moderate and strenuous activity. Mild to moderate activity was defined as needing up to 5 metabolic equivalents (METs; 1 MET = 3.5 ml/kg/min oxygen uptake) and strenuous activities of 6 or more METs [7]. A list of such activities was provided. We asked about the usual frequency of physical activities which the subjects participated in as a weekly basis with a minimum duration of 15 minutes.

Statistical analysis

Due to the study design the primary statistical approach was a case-control analysis between skiers who died suddenly during skiing and randomly selected controls. Differences in cardiovascular risk factors, physical activity and demographic characteristics were evaluated univariately by Mann-Whitney, Chi-square or Fisher's exact tests. Logistic-regression analysis was used to estimate adjusted odds ratios and their 95% confidence intervals for cardiac death outcome. The final regression model included body mass index, prior MI, known CHD without prior MI, hypertension, hypercholesterinemia, diabetes, smoking, SCD in family history, and usual physical activities. We did not add interaction terms to the final model because there were no statistical significance. All p values were two-tailed, and values below 0.05 were considered to indicate statistical significance.

Results

Male skiers over the age of 34 who died suddenly during downhill skiing were much more likely to have had a prior MI, hypertension, and known CHD without prior MI and were engaged in less vigorous exercise compared with skiers from the control group. Forty-one percent of skiers who suffered SCD had a prior MI, 50% suffered from hypertension, 9% reported known CHD without prior MI, and only 4% had performed vigorous exercise more than once per week. The respective percentages reported in the control group were 1.5%, 17%, 3%, and 15%.

Logistic regression analysis showed those 4 variables to be significantly predictive for SCD outcome during downhill skiing. Skiers with a previous MI had a 92.9 (22.8 – 379.1) times higher adjusted SCD risk, skiers with hypertension a 9.0 (4.0 – 20.6) and those with known CHD without prior MI a 4.8 (1.1 – 21.2) fold increased risk. High intensity exercise more than once per week effected a marked risk reduction (0.17; 0.04 – 0.74).

Discussion

Prior MI was found to be the major risk factor associated with SCD during downhill skiing in males over the age of 34. Those persons had a more than 90 times higher SCD risk compared with skiers of the control group. Population based studies have shown an annual SCD rate of 2.6/1000 men over the age of 34 [5]. Within the high-risk group of men with prior MI an about 10-fold increase in this risk was reported [12]. Also if we have slightly underestimated the prevalence of MI in skiers, our findings indicate that prior MI remains an important risk factor associated with SCD during downhill skiing. Downhill skiing is characterised by intermittent bouts of intensive static-dynamic short term (1–3 minutes) work loads resulting in a sharp increase in sympathetic activation which might well trigger ischemia-related arrhythmias [2,14]. Additionally, low environmental temperature and rapid changes in altitude are usual in downhill skiing and could also contribute to sympathetic activation and SCD. The fact that downhill runs are often not preceded by warm-up exercise may enhance the risk of SCD. Sudden, vigorous exercise was shown to produce ST abnormalities even in healthy men, however, no such abnormalities occurred with prior warm-up exercise [11]. Beside prior MI we confirmed hypertension as an independent risk factor associated with SCD during downhill skiing. Cardiovascular responses, above all to static exercise, were increased in patients with hypertension and were supposed to provoke arrhythmic deaths probably by impaired baroreflex control [11,15]. Low baroreflex sensitivity and heart rate variability also increased the risk of SCD in patients with prior MI, and exercise training was able to reduce that risk by improvement of the autonomic balance [13]. Our findings also indicate that regular vigorous exercise was able to decrease the SCD risk during skiing. High intensity activities were shown to be associated with an overall decreased risk of cardiac arrest [14], and habitual vigorous exercise reduced CHD development, less by a lower prevalence of risk factors but by adaptation to these and enhancing exercise tolerance [10]. On the one hand, increase in sympathetic activation during downhill skiing can disturb the autonomic balance especially in persons with prior MI but also in those with hypertension or known CHD with consequent arrhythmias and SCD [13]. On the other hand, enhanced sympathoadrenergic activity by downhill skiing increases heart rate, blood pressure, and platelet aggregability and may cause plaque rupture and coronary thrombosis [9]. As preventive measures recommended to skiers at high risk, adaptation to high intensity exercise by an adequate training program and pharmacological interventions, e.g. antihypertensive drugs, beta blockers [8], and aspirin [6], should be considered. Warm-up exercise before starting the downhill run may be as important [1] as an adequate skiing intensity depending on individual conditions.

In conclusion, male skiers over the age of 34 who died suddenly during downhill skiing had much more frequently prior MI,

hypertension, or known CHD without prior MI and were less engaged in strenuous exercise when compared to skiers of the control group. Therefore adaptation to high intensity exercise and therapeutic interventions or abstinence from skiing in certain cases should be considered for downhill skiers at high risk.

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