

Characteristics and Outcomes of Sudden Cardiac Arrest During Sports in Women

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Background—No specific data are available on characteristics and outcome of sudden cardiac death (SCD) during sport activities among women in the general population.

Methods and Results—From a prospective 5-year national survey, involving 820 subjects 10 to 75 years old who presented with SCD (resuscitated or not) during competitive or recreational sport activities, 43 (5.2%) such events occurred in women, principally during jogging, cycling, and swimming. The level of activity at the time of SCD was moderate to vigorous in 35 cases (81.4%). The overall incidence of sport-related SCD, among 15- to 75-year-old women, was estimated as 0.59 (95% confidence interval [CI], 0.39–0.79) to 2.17 (95% CI, 1.38–2.96) per year per million female sports participants for the 80th and 20th percentiles of reporting districts, respectively. Compared with men, the incidence of SCDs in women was dramatically lower, particularly in the 45- to 54-year range (relative risk, 0.033; 95% CI, 0.015–0.075). Despite similar circumstances of occurrence, survival at hospital admission (46.5%; 95% CI, 31.0–60.0) was significantly higher than that for men (30.0%; 95% CI, 26.8–33.2; $P=0.02$), although this did not reach statistical significance for hospital discharge. Favorable neurological outcomes were similar (80%). Cause of death seemed less likely to be associated with structural heart disease in women compared with men (58.3% versus 95.8%; $P=0.003$).

Conclusions—Sports-related SCDs in women participants seems dramatically less common (up to 30-fold less frequent) compared with men. Our results also suggest a higher likelihood of successful resuscitation as well as less frequency of structural heart disease in women compared with men. (*Circ Arrhythm Electrophysiol.* 2013;6:1185–1191.)

Key Words: cardiopulmonary resuscitation ■ death, sudden ■ exercise ■ incidence ■ sex ■ survival ■ ventricular fibrillation

The risk of heart disease in women has likely been underestimated in the past, possibly partly because of a perception that women are protected against cardiovascular disease, particularly in young and middle age groups. Women have been and still are underrepresented in research in many important areas of cardiology, and guidelines often include recommendations that are based on research performed predominantly in men.¹

death (SCD), have been well demonstrated.^{2,3} However, sports activity itself has been shown to confer some risk, particularly when vigorous exertion is undertaken abruptly by untrained persons, or in the presence of serious underlying heart disease. Recently, we have demonstrated that the majority of sports-related SCDs occurred in middle-aged adults, and that only a minority of such events occurred in young competitive athletes⁴; this latter group, however, has been the focus of the majority of publications until now. Although pre-sports screening strategies have been adopted for many years among young competitive athletes,⁵ it has been recently suggested that preparticipation screening programs might also

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The medium- and long-term benefits of regular physical exercise on cardiovascular events, including sudden cardiac

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be worthwhile in the general population.⁶ However, the evidence-base for a rational approach in the general population is lacking, although the identification of particularly high- or low-risk groups would seem to be a logical first step. In this context, although SCD (not specifically during sports) has been addressed among women,^{7–10} there is, to the best of our knowledge, no available specific data concerning SCD during sport activities among women in the general population.

In the present article, using a large prospective national 5-year registry of SCD occurring during competitive and recreational sports activities in the community, we assessed the extent to which sports-related SCDs in women differs from that in men, in terms of overall and age-specific characteristics and outcomes.

Methods

Setting, Survey Methods, and Collected Data

The study design and population have been described previously.^{4,11,12} Briefly, this 5-year prospective study was performed according to Utstein guidelines, in France between April 2005 and April 2010. To the best of our knowledge, this registry is the first prospective national database offering a complete overview of SCD during sports, including cases from recreational as well as competitive sports. Overall, 60 French administrative districts participated involving a population of ≈35 million inhabitants (see Appendix 1 in the online-only Data Supplement for Participating Centers). SCD in the setting of sport activities was defined as death occurring during or within 1 hour of cessation of sports activity.^{13,14} Sports-related SCDs related to trauma (other than for cases of commotio cordis) were excluded. Subjects between 10 and 75 years old were included in the study because the context of physical activity can be difficult to assess in the very young or in those >75 years who rarely participate in sports.

We obtained close collaboration from the French system of Emergency Medical Services (EMS; in France, Service d'Aide Médicale Urgente) as well as from different intensive care units throughout the 60 participating districts. Because of the expected difficulty in case ascertainment through this community-based approach during the study period, we used 2 complementary independent methods to optimize case detection: (1) a classical approach based on prospective case reporting system from different EMS units, which systematically attended cases of cardiac arrest or sudden collapse; (2) a media search for cases, using a Web-based monitoring via a Web-based search engine (Google Reader), performed continuously by a specific working group checking on a daily basis. All press releases not reported by EMS prompted further contact with the local EMS and local hospital Intensive Care Unit teams for collection of detailed data on resuscitation provided in the field, hospital care, as well as survival status at hospital discharge.

Variables collected for each Case Report File were detailed in Appendix 2 in the online-only Data Supplement. Files were prospectively and regularly reviewed (every 6 months) by an independent events committee.

Statistical Analysis

Characteristics of the overall 10–75 year population of 820 SCDs (including 43 women) occurring during or immediately after sports were described as mean±SD, proportions, and median and interquartile ranges, as appropriate. Qualitative variables were compared using the χ^2 and Fisher exact tests, whereas quantitative variables were compared by Mann–Whitney tests. Ninety-five percentage confidence intervals (CI) for proportion were calculated, and relative risk (RR; men versus women) and their 95% CI were provided.

For estimations of incidences (defined by the number of events per million sports participants and per year), we considered only SCD cases 15 to 75 years old (N=810, including 42 women). The population considered as being at risk was the 15- to 75-year-old French population participating to sport activities (28 279 915) and was estimated

from the 2000 National Survey on Sports Practices (Appendix 3 in the online-only Data Supplement).¹⁵ In addition, for the assessment of incidences, we considered only cases during moderate or vigorous exertion (N=775 among the 15- to 75-year-old SCD cases, including 35 cases in women) because the triggering effect of exercise has been established only for moderate- and vigorous-level physical activities.¹⁶ Comparison between subjects >35 years and those <35 years was performed.¹⁷ Finally, because variability of incidences reported across different districts most likely reflected a variable degree of under-reporting bias, we considered that the most accurate estimation was achieved by presenting range of incidence rates based on the incidence rates from the 80th and 20th percentiles of the reported incidences of sports-related SCDs across different districts in France.

All covariates that reached a significance level of $P<0.15$ for survival were then included in an initial multivariable regression model. Odds ratios and their 95% CI were calculated. All tests were 2-tailed, and P values <0.05 were considered to indicate statistical significance. All tests were 2-tailed, and P values <0.05 were considered to indicate statistical significance. All data were analyzed at INSERM, Unit 970, Cardiovascular Epidemiology and Sudden Death, Paris, using STATA software version v11.0 (Lakeway Drive, TX). The authors had full access to the data and take full responsibility for its integrity. All authors have read and agreed to the article as written.

Results

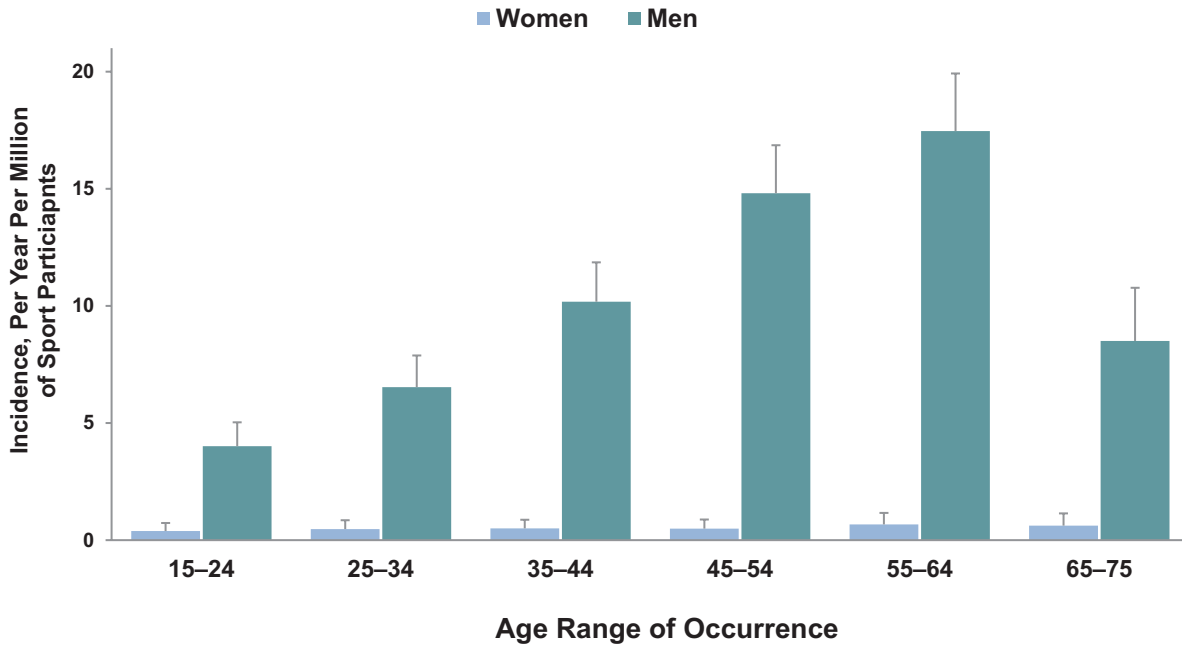
Incidence Considerations

Overall, among the 820 SCD cases registered during 5 years, only 43 (5.2%) were women. The overall mean incidence of sport-related SCDs in 15- to 75-year-old women was estimated as 0.59 (95% CI, 0.39–0.79) to 2.17 (95% CI, 1.38–2.96) per year per million female sports participants for the 80th and 20th percentiles of reporting districts, respectively. The female-related incidence for SCDs during sports seemed dramatically lower as compared with men, in whom the overall mean incidence was calculated from 11.24 (95% CI, 10.39–12.10) to 33.84 (95% CI, 30.87–36.81) per year per million participants. We observed no significant difference between the rate of SCDs reported by EMS among women compared with that of men (56% versus 51%; $P=0.53$).

Specific incidences by sex and age group are represented on the Figure. Analysis through the six 10-year age ranges demonstrated that the incidence among women did not significantly differ across age groups ($P=0.68$). We observed no particular lower incidence in older women (>65 year) compared with 35- to 65-year-old women, with an RR of 1.15 (95% CI, 0.39–3.36). In considering women >35 years, the RR for SCD was 1.29 (95% CI, 0.63–2.63) compared with the group <35 years. By contrast, the incidence of sports-related SCD in men significantly increased over age categories ($P<0.0001$), and incidence rates were substantially higher in men >35 years old than men ≤35 years (RR, 2.51; 95% CI, 2.10–3.01). In addition, a significantly lower incidence was observed among men >65 years compared with 35- to 65-year-old men with an RR of 0.61 (95% CI, 0.46–0.81). Overall, the incidence of sports-related SCDs in women was significantly lower than that in men in all age groups, particularly in the range of 45 to 54 years (RR, 0.033; 95% CI, 0.015–0.075).

Characteristics of Cases

Characteristics of the 43 women are summarized in Table 1. The average age of SCD occurrence in women was 43.9±17 years, not statistically different from that in men. The



	15-24		25-34		35-44		45-54		55-64		65-75	
	W	M	W	M	W	M	W	M	W	M	W	M
Overall	0.39 (0.05-0.73)	4.01 (2.99-5.03)	0.47 (0.09-0.85)	6.53 (5.18-7.88)	0.50 (0.13-0.87)	10.18 (8.51-11.86)	0.49 (0.10-0.88)	14.81 (12.77-16.86)	0.67 (0.17-1.16)	17.46 (15.00-19.92)	0.62 (0.01-1.24)	8.50 (6.23-10.77)
80 th percentile [§]	0.49 (0.06-0.91)	4.60 (3.39-5.82)	0.64 (0.13-1.15)	7.21 (5.63-8.79)	0.54 (0.11-0.97)	11.10 (9.16-13.05)	0.61 (0.12-1.11)	16.51 (14.10-18.93)	0.70 (0.14-1.25)	19.54 (16.65-22.44)	0.58 (0.01-1.15)	10.11 (7.41-12.81)
20 th percentile [¶]	1.54 (0.03-3.04)	13.26 (9.15-17.37)	2.45 (0.49-4.41)	21.98 (16.42-27.54)	1.49 (0.03-2.95)	32.60 (25.86-39.33)	2.65 (0.53-4.77)	45.61 (37.77-53.45)	2.95 (0.59-5.31)	67.62 (56.61-78.62)	2.22 (0.00-4.74)	27.49 (18.38-36.60)

Figure. Mean incidences rates (per year per million of sport participants) of sports-related sudden cardiac death cases according to sex and age among the general population. The I bars indicate the superior limit of 95% confidence intervals. Data from 775 women and men between 15 and 75 years old.

majority of cases occurred during moderate-to-vigorous physical activity, with however, significantly more rates during light exertion in women (16.7% versus 3.2% in men; $P<0.001$). Among women, only 2.3% of SCD (one case) occurred in a young competitive athlete. History of heart disease and the presence of >1 cardiovascular risk factor were relatively uncommon, observed in 7.1%, including one case of coronary heart disease and one case of heart valve disease (Barlow disease), both previously identified. The majority of cases in women occurred in the setting of individual rather than team sports: jogging, cycling, and swimming accounted for >90% of situations, whereas hiking, basketball, diving, and handball accounted for the rest. Half of the SCDs in women (22 cases) occurred inside public sports facilities (such as a gymnasium, stadium, or fitness center).

Circumstances of Occurrence, Initial and Advanced Intensive Care Management

Data on management of SCDs on site, as well as mortality rates according to sex, are shown in Table 2. In women, 90.7% of cases occurred during sport (collapse during sports activity), whereas 9.3% cases took place in the following 60 minutes. One or more witnesses were present and directly assisted during the collapse in 92.8% of cases. Cardiopulmonary resuscitation (CPR) was initiated before EMS arrival in 16 cases (37.2%). Distribution of initial rhythm at the arrival of EMS was not statistically different between women and men: pulseless electric

activity was observed in 16.2% of women (versus 10.5% in men) and ventricular fibrillation or unstable ventricular tachycardia in 41.9% (versus 46.9% in men). The overall proportion of shockable cardiac rhythm after advanced CPR was 44.2% of cases compared with 61.1% in men ($P=0.03$). Overall, public use of automatic external defibrillators before EMS arrival was not initiated in any female subject compared with <1% in men (5 cases). The median collapse-to-call, collapse-to-CPR initiation, and collapse-to-first defibrillator shock times were 1.8 (0.4-3.8), 4.9 (1.1-8.8), 13.1 (10.4-15.7) minutes, respectively, in women, similar to the values observed in the men population.

Of the 43 women, 20 subjects were alive at hospital admission, giving a survival rate at hospital admission of 46.6% (95% CI, 31.0-60.0), significantly higher than survival rate at hospital admission observed in men (30.0%; 95% CI, 26.8-33.2; $P=0.02$). In multivariate analysis, sex (women versus men) was independently associated with survival at hospital admission (odds ratio, 5.0; 95% CI, 1.81-14.1; $P=0.002$). This better survival at hospital admission, however, did not reach statistical significance for hospital discharge survival rates, which were 24.3% (95% CI, 10.7-38.1) in women compared with 15.2% (95% CI, 12.7-17.8) in men ($P=0.21$; Table 2). The majority of women (8 out of the 10 for whom neurological assessment was reported, 80.0%) had a favorable neurological outcome (defined as a CPC [Cerebral Performance Categories-Appendix 2] scoring grade 1 or 2), similar to that observed in men (CPC 1-2 in 81.9%).

Table 1. Subjects' Characteristics and Circumstances of Occurrence of Sudden Cardiac Death During Sports According to Sex

	Women	Men	<i>P</i>
Number of collected cases	43	777	
Demographic data			
Age, y			
Mean±SD	43.9±17	46.3±15	0.33
IQR	29–57	37–57	
Young competitive athlete	1 (2.3)	49 (6.3)	0.51
History of known heart disease/>1 CVRF*	3 (7.1)	91 (12.0)	0.46
Time of occurrence			
Season			0.06
Winter	5 (11.6)	153 (19.7)	
Spring	15 (34.9)	243 (31.3)	
Summer	19 (44.2)	224 (28.8)	
Autumn	4 (9.3)	157 (20.2)	
Week			
Week-end	21 (48.8)	315 (40.5)	0.28
Day, h			0.005
Morning (6–12)	22 (51.2)	265 (34.1)	
Afternoon (12–18)	19 (44.2)	340 (43.7)	
Evening (18–24)	2 (4.6)	172 (22.1)	
Sport setting			
Sport activities			<0.0001
Team sports	2 (4.7)	271 (34.9)	
Individual sports	41 (95.3)	506 (65.1)	
Location of occurrence			0.89
Sport facilities	22 (51.1)	404 (52.0)	
Others	21 (48.9)	373 (48.0)	
Intensity of exercise			<0.001
Light	7 (16.7)	25 (3.2)	
Moderate	25 (59.5)	433 (56.3)	
Vigorous	10 (23.8)	312 (40.5)	

Data are number (%), unless otherwise specified. Data were missing on history of known heart disease (for 8 subjects), cardiovascular risk factors (for 11 subjects), and intensity of exercise (for 8 subjects). Percentages were calculated on the basis of the total number of known events. CVRF indicates cardiovascular risk factors; and IQR, interquartile range.

*Cardiovascular risk factor included known/treated diabetes mellitus, dyslipidemia, systemic hypertension, obesity, current smoker, and family history of premature coronary heart disease.

The cause of SCD could be ascertained in 12 (27.9%) women (compared with 24.6% in men), of which 5 (41.7%) cases occurred in the absence of structural abnormalities (1 long QT syndrome, 1 early repolarization syndrome, 1 malignant accessory pathway, and 2 idiopathic ventricular fibrillation) compared with 4.2% in men ($P=0.003$). Coronary heart disease was found in 4 women (33.3%) of the documented cases in women compared with 77.5% in men ($P<0.001$). The 3 remaining causes were related to dilated cardiomyopathy, hypertrophic cardiomyopathy, and 1 case of acute myocarditis.

Table 2. Management of Sudden Cardiac Death in the Field and Mortality Rates According to Sex

	Women	Men	<i>P</i>
Sudden death witnessed	39 (92.8)	717 (92.6)	0.97
Bystander CPR	16 (37.2)	236 (30.4)	0.37
First monitored rhythm			0.47
Ventricular fibrillation/tachycardia	18 (41.9)	359 (46.9)	
Asystole	18 (41.8)	325 (42.5)	
Pulseless electric activity	7 (16.2)	80 (10.5)	
Sinus rhythm	0 (0)	1 (0.1)	
Shock by external defibrillator	19 (44.2)	475 (61.1)	0.03
Delay, median (IQR), min			
Collapse-to-call received	1.8 (0.4–3.8)	2.1 (0.5–4.6)	0.76
Collapse-to-start of CPR	4.9 (1.1–8.8)	4.8 (1.2–8.5)	0.88
Collapse-to-first defibrillator shock	13.1 (10.4–15.7)	12.3 (10.3–15.4)	0.64
Survival, % (95% CI)			
Hospital admission	46.5 (31.0–60.0)	30.0 (26.8–33.2)	0.02
Hospital discharge	24.3 (10.7–38.1)	15.2 (12.7–17.8)	0.21

Data are number (%), unless otherwise specified. Data were missing on presence of witness (4), monitored rhythm (12). Percentages were calculated on the basis of the total number of known events. CI indicates confidence interval; CPR, cardiopulmonary resuscitation; and IQR, interquartile range.

Discussion

These first data from the general population demonstrate the extent to which SCD pattern during sports activity differ according to sex. SCD seems extremely rare among women participants (compared with men), particularly in the middle age group (up to 30-fold less frequent). The underlying mechanisms behind these findings remain unclear although interesting hypotheses include possible sex differences in coronary heart disease, cardiac electrophysiology, and autonomic tone. Behavioral and psychological factors may also be playing a role. Our results also suggest a higher likelihood of successful resuscitation in women, as well as a higher proportion of cases without structural heart disease compared with men.

Many studies have found that the incidence of (nonsports associated) SCDs increases with age in both sexes. However, important differences in SCD incidence have been demonstrated according to sex, with a lower incidence among women, representing not >25% to 30% of the total of SCDs occurring each year.^{18–20} By contrast, our results and other published data from specific sport activities, sports groups, and pathology series suggest a particularly low incidence of SCD in sports, in women compared with men, at 5% to 10%.^{13,14,21–26} Although this might partly reflect the lower participation rate of women in sports, our data derived from sports participation information (providing incidence per million of sport participants) suggest that this low incidence found of sports-related SCDs in women may not easily be attributed simply to lower participation rates. Consistent with this observation, the incidence of SCDs in women has been described as being transiently elevated during moderate-to-vigorous exertion but with an RR of only 2.38 (95% CI, 1.23 to 4.60), whereas being almost 20-fold higher (RR, 44.9; 95% CI, 26.7

to 75.4) during vigorous activity among men enrolled in the Physicians' Health Study.^{3,16} Similar sex difference have been also reported in smaller retrospective studies in Finland and in the United States.^{27,28}

The precise mechanism behind this dramatically low incidence of SCD among women during sports requires further studies, and our finding should be considered as hypothesis generating. This could include several factors: first, the total exposure time that may differ between men and women, although our calculation by million participants allowed us to exclude the issue of sport participation only.¹¹ Other potential disparities may involve sex differences in a vulnerable substrate (underlying structural or electric heart disorder), triggers, and autonomic modulators. The age-specific prevalence of coronary heart disease is known to be lower in young and middle-aged women, and a particularly low prevalence has been also observed among female victims of SCDs, suggesting that the primary cause of such cardiac arrest in women may be less likely to be myocardial ischemia.^{7,8,29,30} The precise mechanism linking coronary heart disease and SCD in women is an area of active research activity.²⁹ Although autopsy studies suggest that plaque rupture and acute coronary syndrome may explain only a proportion of SCD cases,^{19,31} the role of a plaque rupture-type mechanism seems particularly relevant in sports-associated acute coronary syndromes.³² Although in men, plaque rupture and subsequent thrombus formation seem more common, in women plaque erosions (leading to distal embolization of microemboli and dysfunction of the microvascular coronary system) are more often seen, suggesting a possibly different pattern of causation of acute coronary syndromes between the sexes.³¹ A potential role of circulating estrogens, known to promote vasodilatation and variations in platelet activity, is possible.³³ Vagal activation has been shown to be more common in women than in men during abrupt coronary occlusion and may have beneficial antiarrhythmic effects.^{34,35} Some common genetic variants have been shown to influence QT interval length in healthy individuals.^{36–38} Moreover, in such setting of physical activity, genetic variants encoding the beta2-adrenergic receptors seem a possibly relevant pathway.³⁹ It is also possible that men push harder during exercise, especially in competitive sports, although data to support this speculation are lacking. We also have not measured possible psychological factors in sports performance and potential effects on the occurrence of SCDs. Nutritional factors and adherence to a low-risk healthy lifestyle, frequently different by sex, may be implicated.^{40–42} Finally, the contribution of other medical conditions (comorbidities) and treatments received may also have played a role in this observed difference.

Until now, preparticipation medical evaluation has been specifically recommended only in young competitive athletes, both the American Heart Association (AHA) and the European Society of Cardiology (ESC) consensus panel recommendations agreed that some form of cardiovascular screening for young competitive athletes is justified. The identification of asymptomatic athletes who have potentially lethal cardiovascular abnormalities allows possible protection from SCDs through preclusion from competitive sports.^{43–45} The extension of systematic screening for recreational sports activity may

also be worthwhile.^{6,46} In this context, our data strongly suggest that we have to accept that large-scale screening in the near future should be performed differently in women versus men; the very low incidence of women could even raise the question of the efficiency of systematic screening among sporting women. Our data also suggest (in agreement with the literature) that structural heart disease is significantly less frequent among young and middle-aged women, and consequent identification by structural heart examination could be also more challenging in women.⁴⁷

From community-based studies, which aimed to specifically analyze survival factors by sex, women have relatively better survival rate compared with men.^{9,10,48,49} This has been observed despite a more frequent association with factors thought to confer a poor prognosis among women, principally nonshockable rhythm (with more frequent asystole and pulseless electric activity in women).⁵⁰ The usually low rate of CPR and longer time to intervention in women (related to a more frequent home setting) have been considered by some authors as a potential explanation for a more frequent nonshockable rhythm. In our study, we also observed this particularly low rate of shockable rhythm, whereas SCD setting, CPR initiation, and delay (including collapse-to-call times) were all similar between men and women, and raise the question of sex specificities in cardiac electrophysiology.

We acknowledge some limitations. First, because of the extremely low incidence of SCD cases among women, our results were based on a small number of events resulting in a lack of power for assessing certain differences in characteristics between men and women (eg, the lack of significant increase in incidence with age among women). Nevertheless, this is the largest series of sports-related SCDs yet reported in women, to the best of our knowledge. Second, it is possible that this apparently low proportion of sports-related SCDs in women represents a reporting bias. The very similar sex ratio of SCDs observed throughout all the districts in our study, however, makes this less likely. Finally, although the lower degree of participation of women in overall sport activity and the significant lower level of physical activity (compared with men) have both been integrated into our incidence calculation model, the exact time period spent in strenuous activities (exposure time) was not available.¹¹

In conclusion, SCD cases during sport activity is a very rare event in women, particularly in the middle age group, with a frequency up to 30-fold lower than that in men. This particularly low incidence among women remains relatively constant with increasing age. Because of the rarity of the event, our results should be considered in planning population screening in future. Finally, these data emphasize the need for more specific attention and research on aspects of cardiovascular diseases in women, particularly in the field of SCD, as well as illustrating the potential pitfalls of generalizing findings from a predominantly male population to women.

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Disclosures

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CLINICAL PERSPECTIVE

Women have been and still are underrepresented in research in many important areas of cardiology, and guidelines often include recommendations that are based on research performed predominantly in men. The mid- and long-term benefits of regular physical exercise on cardiovascular events, including sudden cardiac death (SCD), have been well demonstrated. However, physical activity has also been shown to confer some risk, particularly when vigorous exertion is undertaken abruptly by untrained persons, or in the presence of underlying heart disease. Although relatively strong sex specificities for SCDs have been suggested in the past, there are few data on characteristics and outcomes of SCD during sports activities among women in the general population. Using a large prospective community-based registry on sports-related SCDs (performed during a 5-year period in France), we demonstrated the dramatically lower SCD incidence among women, even after considering the potential differences in participation rates (compared with men), particularly in the middle age range (up to 30-fold less frequent). Our results also suggest a better chance of successful resuscitation in women despite similar management compared with men. Such information, in addition to emphasizing the importance of analyzing women separately from men in studies of heart disease, particularly for SCD, is of particular interest for planning evidence-based population-screening programs in future. The underlying mechanisms potentially include differences in psychological behavior as well as total exposure time in sports and sex disparities in coronary heart disease, cardiac electrophysiology, and autonomic tone.

Characteristics and Outcomes of Sudden Cardiac Arrest During Sports in Women

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SUPPLEMENTAL MATERIAL

Appendix 1. Participating Centers.

The investigators and coordinators participating in the study were as follows:

02 Aisne, *Dr F Degrootte*; 05 Hautes-Alpes, *Dr M Tashan*; 06 Côte d'Azur, *Dr D Grimaud*; 13 Bouches-du-Rhône, *Dr V Vig*; 14 Calvados, *Dr D Bonnieux*; 16 Charente, *Dr R Loyant*; 17 Charente-Maritime, *Dr F Mounios*; 18 Cher, *Dr F Bandaly*; 21 Côte-d'Or, *Dr M Freysz*; 22 Côtesd'Armor, *Dr C Hamon*; 24 Dordogne, *Dr M Gautron*; 25 Doubs, *Dr MC Maillot*; 26 Drôme, *Dr C Zamour*; 28 Eure-et-Loir, *Dr N Letellier*; 29 Finistère, *Dr C Lazou*; 31 Haute-Garonne, *Dr JL Ducasse*; 32 Gers, *Dr JM Guez*; 33 Gironde, *Dr M Thicoipe*; 34 Hérault, *Dr P Benatia*; 36 Indre, *Dr L Soulat*; 37 Indre-et-Loire, *Dr J Fusciardi*; 38 Isère, *Dr K Berthelot*; 39 Jura, *Dr A Elisseeff*; 40 Landes, *Dr R Ricard*; 41 Loir-et-Cher *Dr S Randriamalala*; 42 Loire, *Dr T Guerin*; 44 Loire Atlantique, *Dr V Debierre*; 45 Loiret, *Dr S Narcisse*; 48 Lozère, *Dr M Chassing*; 51 Marne, *Dr A Léon*; 52 Haute-Marne, *Dr J Milleron*; 55 Meuse, *Dr M Vedel*; 56 Morbihan, *Dr F Charland*; 59 Nord, *Dr N Benameur*; 60 Oise, *Dr T Ramaherison*; 62 Pas-de-Calais, *Dr L Hapka*; 63 Puy-de-Dôme, *Dr J Meyrieux*; 64 Pyrénées-Atlantiques, *Dr I Pouyanne*; 65 Hautes-Pyrénées, *Dr J Khazaka*; 67 Bas Rhin, *Dr JC Bartier*; 68 Haut-Rhin, *Dr B Goulesqueb*; 69 Rhône, *Dr PY Gueugniaud*; 70 Haute-Saône, *Dr T El Cadi*; 71 Saône-et-Loire, *Dr B Girardet*; 72 Sarthe, *Dr C Savio*; 75 Paris, *Dr D Jannière*; 76 Seine-Maritime, *Dr B Dureuil*; 77 Seine et Marne, *Dr JY Le Tarnec*; 78 Yvelines, *Dr C Cazenave*; 80 Somme, *Dr C Ammirati*; 81 Tarn, *Dr MG Vaissière*; 83 Var, *Dr JJ Raymond*; 84 Vaucluse, *Dr P Olivier*; 88 Vosges, *Dr H Tonnelier*; 89 Yonne, *Dr M Duche*; 90 Territoire-de-Belfort, *Dr A Kara*; 92 Hauts-de-Seine, *Dr M Baer*; 93 Seine-Saint-Denis, *Dr F Adnet*; 94 Val-de-Marne, *Dr C Vallier*; 95 Val-d'Oise, *Dr C Ramaut*.

Appendix 2. Collected data.

Variables collected for each Case Report File included demographic information and medical history (known heart disease, cardiovascular risk factors, cardiac symptoms during the preceding days), data regarding sports activities (type of sport, collective or individual practice, setting of occurrence, leisure or competitive event, level of exercise estimated at the time of collapse), as well as circumstances of collapse (with a particular attention on the collapse-to-call interval, presence of one/multiple witness and cardiopulmonary resuscitation initiation, initial cardiac rhythm recorded, defibrillator shocks delivered). Level of exertion was classified as light, moderate or high, by ambulance officers and/or hospital medical staff according to metabolic equivalents and a pre-specified scale.^{4,15} In addition, information regarding survival status at hospital admission were all collected after transmission of information by the Emergency Medical Services. Data regarding survival status at hospital discharge were recorded prospectively by the French National Institute of Health and Medical Research (INSERM) U970. For survivors, neurologic status at discharge was evaluated using the Cerebral Performance Categories (CPC) score — a lower CPC score (1–2) indicates a better neurologic outcome.⁵⁰ Files were prospectively and regularly reviewed (every 6 months) by an independent Events committee.

Appendix 3. French National Survey on Sport Practices.

The National Survey on Sport Practices was a household survey to obtain an overall picture of French attitudes to sports practice.¹⁴ This evaluation commissioned by the National Center for the Development of Sport (Centre National pour le Développement du Sport–CNDS), part of the Sports and Health French Ministry, has been carried out in 2000, by the Studies, Observation and Statistics Mission (Mission des Etudes, de l’Observation et des Statistiques–MEOS) and the National Institute of Sports and Physical Education (Institut National du Sport et de l’Éducation Physique–INSEP).¹⁴ Briefly, a random sample of 6,526 people aged between 15 and 75 years was selected across metropolitan France. The survey was conducted by telephone and sought to assess the practice rate of all types of sports practices, institutional and non-institutional (family-based, street sports, private clubs, etc.), by broad family of disciplines. All demographic data and sports habits (level, type, training, and frequency of sport activity during the last 12 months) were studied for 10-year range groups of age.