Original Article

# An Eight Year Review of Exercise-related Cardiac Arrests

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## Abstract

**Introduction: Exercise-related cardiac arrest is uncommon, however it is devastating when it occurs in otherwise healthy adults. This study aims to identify the characteristics of exercise-related cardiac arrest in the study population and estimate the overall survival rate. Materials and Methods: This is a retrospective observational study of exercise-related cardiac arrest in Singapore. Patients with exercise-related out of hospital cardiac arrest (OHCA) were selected from the Cardiac Arrest and Resuscitation Epidemiology (CARE) database, which is a prospective cardiac arrest registry, derived from ambulance records, emergency department and hospital discharge records. Patient characteristics, cardiac arrest circumstances and outcomes were studied. Results: Fifty-five cases of exercise-related cardiac arrests were identified from December 2001 to January 2008. Mean age was 50.9 years with a male predominance of 96.4%. Eighty percent of the exercise-related cardiac arrests were witnessed, however only 58.2% of the patients received bystander cardiopulmonary resuscitation (CPR). The first presenting rhythm was ventricular fibrillation (VF) in 40% of the patients, followed by asystole (38.2%). Of 96.2% of the patients who died from cardiac causes, coronary artery disease was the main etiology for 54%. The 30-day survival rate was 5.5%. Conclusion: We found that exercise-related cardiac arrest causes significant mortality in our community. Increased CPR training among the public, easy access to defibrillators and faster emergency medical service (EMS) response time could improve the outcome of exercise-related cardiac arrests. A comprehensive pre-participation screening for competitive exercises should be outlined for primary prevention of exercise-related cardiac arrest. A better reporting system for exercise-related cardiac arrest is needed.**

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**Key words: Sudden death, Survival**

## Introduction

Exercise-related cardiac arrest is uncommon, however it is devastating when it occurs in otherwise healthy adults. In young adults, vigorous physical exercise trigger cardiac arrest in those affected by silent congenital cardiovascular conditions. In older adults, sudden vigorous physical exercise increases the incidence of acute coronary events in those with underlying ischaemic heart disease.[1-3]

Most studies focus on exercise-related cardiac arrest in young athletes. The incidence of sudden death in athletes varies widely due to incomplete data collection and lack of reporting systems.[4] Recently, a 27-year registry of sudden death in athletes in the United States estimated the frequency of sudden death in young athletes to be at 0.61 death per 100 000 person-years. Fifty-six percent of the deaths were judged to be probably or definitely due to cardiovascular causes. The most common cause being hypertrophic cardiomyopathy followed by coronary-artery anomalies. Several other cardiovascular diseases include myocarditis, arrythmogenic right ventricular cardiomyopathy, and ion channelopathies (long-QT syndrome and Brugada syndrome).[5] This differs from the demographics of athletes in the Veneto region of northeastern Italy where arrythmogenic right ventricular cardiomyopathy is reported to be the most common cause of death among athletes.[6] This difference is attributed to the national screening programme of all young athletes before participation in organised sports resulting in identification and disqualification from competition of disproportionately fewer athletes with arrythmogenic right ventricular cardiomyopathy compared to those with

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more readily identifiable disease such as hypertrophic cardiomyopathy.[1,6,7]

The incidence of exercise-related cardiac arrest in Singapore was previously unknown. The purpose of this study is to identify the characteristics of exercise-related cardiac arrest in the general population in Singapore as well as to estimate the overall survival rate. We also aim to identify areas of intervention needed to reduce mortality from exercise-related cardiac arrest.

## Materials and Methods

This is a retrospective observational case-series of exercise-related cardiac arrests in Singapore. Patients with out of hospital cardiac arrest (OHCA) were obtained from the CARE (Cardiac Arrest and Resuscitation Epidemiology) database from December 2001 to January 2008. Institutional review board approval was obtained for the study.

Singapore is a city-state with a land area of 707.1 square kilometres and a population of 4.58 million. The population is multiracial with the major ethnic groups being Chinese, Malay and Indian. The Emergency Medical Service (EMS) is run by the Singapore Civil Defence Force (SCDF) using computer aided dispatch and medical dispatch protocol in a single-tier system. The ambulances in Singapore are manned by specifically trained paramedics who are able to provide basic life support and defibrillation with automated external defibrillators (AED) in a 'shock first' protocol.[8-11]

Patients above 16 years of age were included. Exercise-related cardiac arrest was defined as cardiac arrest occurring during or within 30 minutes of completing an exercise. Cases not thought to be exercise-related were excluded. Patient characteristics, cardiac arrest circumstances, Electrocardiogram (ECG) rhythms, use of defibrillator, and EMS response time were obtained from the SCDF and emergency department records.

Emergency physicians from the respective receiving hospitals assisted with data collection. Research co-coordinators assisted in reviewing case notes and data entry. Patient outcome was measured as survival 30-day post-cardiac arrest. The causes of deaths were obtained from a review of emergency department records, hospital inpatient records, death certificates, post-mortem results and coroner's reports. Data analysis was performed using the SPSS version 14.0 for Windows (Chicago, USA). Descriptive statistics were used as appropriate.

## Results

From 9th December 2001 to 20th January 2008, 55 patients with exercise-related cardiac arrest were identified.

Table 1 shows the characteristics of the patients with exercise-related cardiac arrest. The patients were predominantly male (96.4%). Majority of the patients were Chinese (69.1%), followed by other races (14.5%). A total of 38.2% of the patients had past medical problems, of which 20% had documented heart disease. Forty percent of the first presenting rhythm was ventricular fibrillation (VF) followed by 38.2% in asystole. Of those in VF, all but 1 was given pre-hospital defibrillation (reasons not known). Of the 5 (9.1%) who survived to hospital admission, only 3 (5.5%) survived beyond 30 days. All but 2 of the patients

Table 1. Characteristics of Patients with Exercise-related Cardiac Arrest

| **Characteristics** | **n = 55 (%)** |
|---|---|
| Mean age | 50.94 ± 15.44 |
| Sex | |
| Male | 53 (96.4) |
| Female | 2 (3.6) |
| Race | |
| Chinese | 38 (69.1) |
| Malay | 4 (7.3) |
| Indian | 5 (9.1) |
| Others | 8 (14.5) |
| Past medical history | |
| Yes# | 21 (38.2) |
| No | 8 (14.5) |
| Unknown | 26 (47.3) |
| Arrest witnessed | 44 (80.0) |
| Bystander CPR | 32 (58.2) |
| Cause of death | |
| Cardiac | 50 (90.9) |
| Non cardiac* | 2 (3.6) |
| Survival | |
| Survive beyond ED | 5 (9.1) |
| 30-day survival | 3 (5.5) |
| Presenting rhythm | |
| Ventricular Fibrillation | 22 (40.0) |
| Ventricular Tachycardia | 1 (1.8) |
| Asystole | 21 (38.2) |
| Pulseless Electrical Activity | 5 (9.1) |
| Unknown | 6 (10.9) |
| Response time** | |
| 5 mins | 7 (12.7) |
| 5-10 mins | 10 (18.2) |
| >10mins | 32 (58.2) |
| Unknown | 6 (10.9) |

# 11 (20%) had known heart disease
* One drowned, one had heat stroke, 3 survived
** Time of call to ambulance arrival

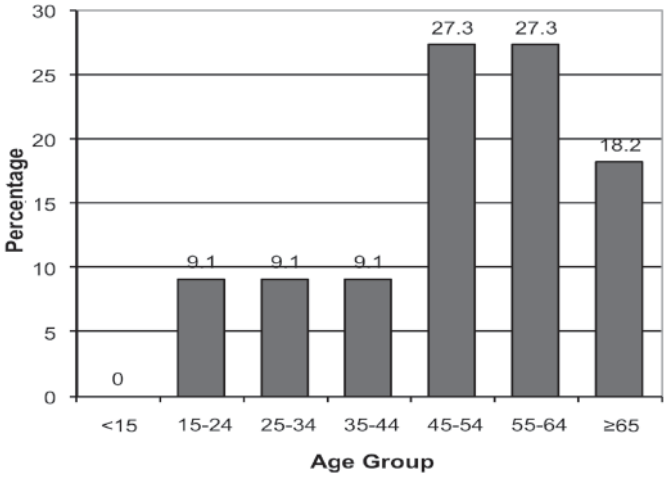


Fig. 1. Age distribution for exercise-related cardiac arrest.

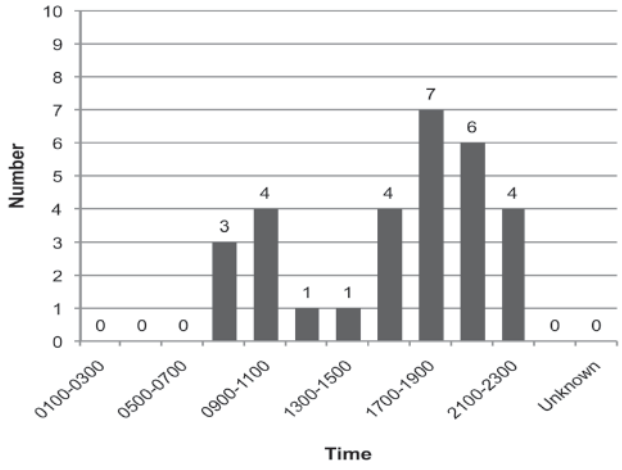


Fig. 3. Cases with ambulance response time above 10 minutes.

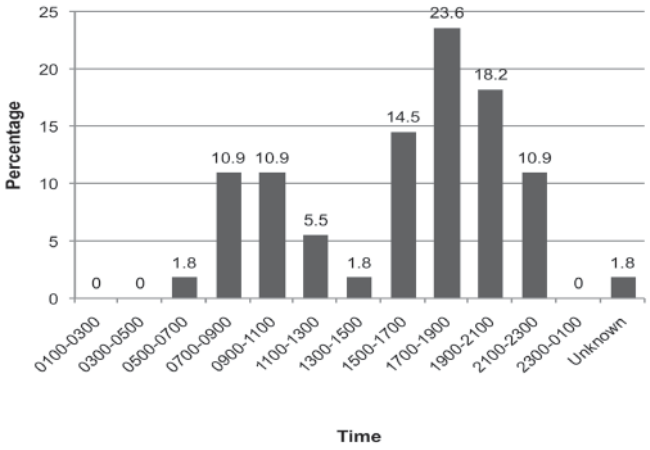


Fig. 2. Time of day distribution for exercise-related cardiac arrest.

Table 2. Location of Exercise-related Cardiac Arrest

| Location | Frequency |
|---|---|
| | n = **55 (%)** |
| Sports Hall | 14 (25.5) |
| School | 5 (9.1) |
| Private Sports Facility | 20 (36.4) |
| Army Facility | 3 (5.5) |
| Public parks | 4 (7.3) |
| Others * | 9 (16.3) |

* town centre (1), roadside - unspecified (8)

Table 3. Type of Activity Prior to Cardiac Arrest

| Activity | Frequency |
|---|---|
| | n = **55 (%)** |
| Running/Jogging | 11 (20.0) |
| Badminton | 10 (18.2) |
| Soccer | 5 (9.1) |
| Golf | 4 (7.3) |
| Cycling | 3 (5.5) |
| Tennis | 2 (3.6) |
| Swimming | 2 (3.6) |
| Squash | 1 (1.8) |
| Others* | 7 (12.7) |
| Unknown** | 10 (18.2) |

* Army training (2), bowling, ballroom dancing, exercising with fitness ball, table tennis, playing Frisbee.

** Exercising (not specified)

died from cardiac causes. These included those reported as sudden deaths, which were assumed to be cardiac in origin.

The mean age was 50.9 years with the majority of exercise-related cardiac arrest occurring amongst those above 45 years of age (72.7%) (Fig. 1). More than half of exercise-related cardiac arrests occurs after 1700 hours, with almost a quarter of them occurring between 1700 to 1900 hours (23.6%) (Fig. 2). Private sports facilities and sports halls were the main locations for exercise-related cardiac arrests, 25.5% and 36.4%, respectively (Table 2). Most of the patients were running (20%), playing badminton (18.2%) or playing soccer (9.1%) at the time of cardiac arrest (Table 3). Although 80% of the cardiac arrests were witnessed, only 58.2% of the patients received bystander CPR.

Most of the patients were transported via the SCDF ambulance (90.9%), while the others were transported by private or army ambulance. More than half of the EMS response time was above 10 minutes (58.2%), which corresponds to the peak hours for exercise-related cardiac arrest (Fig. 3).

The majority of the patients who died from cardiac causes had coronary artery disease (54%). Coroner's reports were unavailable for 32% of those classified as Sudden Deaths (not specified) (Table 4).

Table 4. Cardiac Aetiology

| Aetiology | Frequency n = 50 (%) |
|---|---|
| Coronary artery disease | 27 (54) |
| Myocarditis | 1 (2) |
| Dilated Cardiomyopathy | 1 (2) |
| Commotio Cordis | 1 (2) |
| Hypertensive Heart Disease | 3 (6) |
| Cardiac Arrhythmia (not specified) | 1 (2) |
| Sudden Death (not specified) | 16 (32) |

## Discussion

In this study, we found that exercise-related cardiac arrest is an important cause of mortality in Singapore. It affects mainly previously healthy, economically productive individuals in the prime of their life. Most exercise-related cardiac arrests are caused by underlying cardiac disease. The majority of them had VF as the initial presenting rhythm, which may have contributed to the higher survival rate.

Sudden cardiac death is defined by the American Heart Association (AHA) as death resulting from an abrupt loss of heart function. The person may not have previously diagnosed heart disease. The time and mode of death are unexpected. It occurs within minutes after symptoms appear.

Singapore Emergency Departments attend to about 600 non-traumatic cardiac arrests a year.[8,9] An average of 5 to 10 cases of exercise-related cardiac arrests were recorded each year from this study. This would give rise to an estimated frequency of exercise-related cardiac arrest to be at 0.25 to 0.125 per 100 000 person-years. The actual figures may be higher as this is not a population-based cohort study. Comparatively in the United States, the frequency of sudden death in young athletes is reported as 0.61 deaths per 100 000 person-years.[5]

Most exercise-related cardiac arrest occurs in men. This could be due to the fact that cardiac arrest is more common in men. The distribution of exercise-related cardiac arrest among the 3 main races in Singapore are similar to the general population, except for a slight peak in frequency among those of other races (14.5%) who usually consist of only 2.8% of the population.[11] However this may not be representative as this is an opportunistic case series, not cohort study. Up to 40% of the population studied had prior medical history of which half of them were documented to have heart disease.

Most exercise-related cardiac arrest occur in private sports facilities and sports halls during peak exercise hours and therefore have high witness rate and higher than usual bystander CPR.

Comparing with the epidemiological data in the CARE 1 Study of OHCA, survival rate following exercise-related cardiac arrest is higher (5% vs 2%). The patients are younger (mean age 50.9 years vs 62.2 years) with fewer medical problems. Exercise-related cardiac arrests are also more likely to be witnessed (80% vs 64.5%) with a higher proportion of them receiving bystander CPR (58.2% vs 20.6%) and a higher rate of VF as the first presenting rhythm (40% vs 19.6%).[8]

The survival rate for exercise-related cardiac arrest in Singapore is still poor compared to other countries which estimate survival rates of up to 10%.[4-5] This may be due to the fact that OHCA in Singapore relies mainly on conventional EMS response.

In this study, we found that EMS response time was frequently more than 10 minutes at the peak hours of exercise-related cardiac arrests from 1700 to 1900 hours. This corresponds to the peak period of cardiac arrests occurring throughout the day from the PADS study.[10] There were no cases where public access defibrillators (PAD) were used. Previous research has shown that a higher survival rate is possible with prompt recognition of sudden cardiac arrest, bystander CPR and easy access to AED to provide early defibrillation.[12-16] We believe that faster EMS response rate and dispatcher aided AED or PAD may improve the survival of exercise-related cardiac arrest.

With increasing incidence of exercise-related cardiac arrest, this is a significant public health problem and a cost-effective strategy for primary and secondary prevention should be outlined. Primary prevention includes optimising pre-participation screening and utilisation of disqualification criteria for individuals who want to be involved in competitive sports activities. The American Heart Association (AHA) recommends that pre-participation screening for young adults include personal and family history with physical examination focused on detecting conditions associated with exercise-related events. The AHA does not recommend routine electrocardiograms (ECG). However the European Society of Cardiology (ESC) recommends that routine ECG should be obtained on all athletes as part of the pre-participation evaluation. Addition of routine ECG for screening is still controversial.[17-20] With more than 25 years of experience in pre-participation screening of young athletes including family and personal history, physical examination and 12-lead ECG, the incidence of sudden cardiac death in Italy has declined substantially.[6,7,21,22] The other group, which consists of high-risk adults, and those with cardiovascular abnormalities should have exercise testing before beginning vigorous exercise in accordance with the 36th Bethesda Conference Guidelines.[23,24]

Secondary prevention to increase the availability of

automated external defibrillators may result in better survival of these patients as they have been proven to save lives in the community by eliciting rapid response and early defibrillation.[14-16] Increase CPR training among the public and faster EMS respond time will probably improve the outcome of exercised-related cardiac arrests.

*Study Limitations*

This study is a retrospective case-series and may not be a representative sample of all the exercise related cardiac arrests during the period studied. With a complete registry to record all cases of exercise-related cardiac arrests, the incidence and the importance of ERCA may be placed in a better perspective.

Details of exercising conditions were frequently not reported in this retrospective study. Formal autopsy reports were mostly unavailable. Not all of the suspected cardiac deaths can be confirmed as cardiac in origin. Although we have identified non-cardiac caused deaths such as heat stroke and drowning, there were still 16 cases of sudden death in this study where the details of the cause of death were not specified. A more detailed autopsy report may give us a better idea on the various causes of death or congenital cardiac anomalies which may help in drafting a screening programme.

Also, a large proportion of the patients may have been in ventricular fibrillation/ventricular tachycardia initially, which degenerates into pulseless electrical activity or asystole by the time the EMS team arrives. The number of potential patients saved if public access defibrillators are available may be much higher given that there is a higher chance of 'shockable' rhythm at the initial arrest state.

## Conclusion

We found that exercise-related cardiac arrest results in significant mortality in our community. Increased CPR training among the public, easy access to defibrillators and faster EMS response time could improve the outcome of exercise related cardiac arrests. A comprehensive pre-participation screening for competitive exercises should be outlined for primary prevention of exercise-related cardiac arrest. A better reporting system for exercise-related cardiac arrest is needed.

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