

Sudden Death in Athletes: A Literature Review

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Abstract

Review Article

Sudden death in athletes is a rare but tragic event, typically occurring unexpectedly during or shortly after physical activity. This literature review aims to synthesize current knowledge on the epidemiology, causes, screening, prevention, and management of sudden death in athletes. Based on a comprehensive search of medical databases, we analyze data from epidemiological studies, autopsy reports, and international guidelines. The primary causes are cardiovascular, with genetic cardiomyopathies predominating in younger individuals and coronary artery disease in older individuals. Systematic screening, though controversial, shows potential benefits in certain contexts, such as Italy. Management related on immediate resuscitation and access to automated external defibrillators. Targeted prevention strategies could reduce incidence, but further cost-effectiveness studies are needed to guide public health policies.

Keywords: sudden cardiac death, athlete, screening, prevention, resuscitation.

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INTRODUCTION

Sudden death in athletes, though rare, garners significant emotional, social, and media attention due to its abrupt and unexpected nature. This event often occurs during or immediately following intense physical activity, typically revealing an underlying, previously asymptomatic cardiac condition. In France, approximately 1,100 to 1,500 cases are reported annually linked to sports, out of a total of 40,000 to 50,000 sudden deaths each year [1]. Despite a low incidence rate, estimated at 0.5 to 4 per 100,000 athletes annually, it predominantly affects males, with a marked prevalence among both young and older adults [2]. Advances in epidemiology, cardiac imaging, and resuscitation techniques have improved the understanding and management of this condition. However, controversies persist, particularly regarding the efficacy of systematic screening and optimal prevention strategies. This review incorporates the most recent data up to September 2025 to provide a comprehensive overview, aiming to inform clinicians, coaches, and policymakers. A multidisciplinary approach involving cardiologists, sports medicine specialists, and emergency physicians is critical to minimizing risks while promoting safe sports participation.

MATERIALS AND METHODS

This narrative literature review was conducted using a systematic methodology tailored for non-meta-analytic syntheses. The searched databases included PubMed/MEDLINE, Google Scholar, ScienceDirect, and Embase, covering the period from January 2000 to September 2025. Search terms included sudden cardiac death or sudden death combined with athlete, sports, or physical activity, alongside specific terms such as epidemiology, etiology, screening, prevention, and management. Articles in English and French, including reviews, observational studies, meta-analyses, and guidelines from learned societies such as the French Society of Cardiology (SFC), the American Heart Association (AHA), and the European Society of Cardiology (ESC), were prioritized. Inclusion criteria focused on studies involving individuals aged 12 years and older engaged in regular sports activity, with a focus on non-traumatic sudden death and peer-reviewed publications. Exclusions included pediatric non-athlete cases, sudden deaths unrelated to exercise, and isolated case reports without population-level analysis. Approximately 1,350 abstracts were screened, with 90 full-text articles selected for data extraction. Data were synthesized thematically across four domains: epidemiology (incidence and risk factors), etiologies (cause classification), screening and prevention (efficacy and costs), and management (protocols and outcomes). The level of evidence was assessed using the GRADE

system. Due to study heterogeneity, no meta-analysis was performed. Potential biases, such as under-reporting of cases or methodological variations across countries, were considered and discussed.

EPIDEMIOLOGY

The epidemiology of sudden death in athletes is complex due to variations in data collection methods and the lack of standardized registries. In France, an estimated 1,100 to 1,500 sports-related sudden deaths occur annually among a population of approximately 40 million occasional or regular sports participants [3]. The overall incidence is around 0.46 per 100,000 athletes per year, with fewer than 50 cases among those aged 12 to 35 years [4]. The average age of victims is 48 years, but approximately 33 percent of deaths occur in the 12–35 age group, with a strong male predominance (sex ratio of 2–3 in younger individuals, rising to 9–10 in those over 35) [3]. In the United States, the reported incidence ranges from 1 to 3 per 100,000 young athletes, while in Europe, it varies from 0.5 to 1 per 100,000 [4]. Risk factors include the intensity of effort, with running and cycling involved in 50 percent of cases, as well as seasonal factors (peaks in late winter and summer in France, or May–June in Germany) and environmental conditions such as cold, dehydration at temperatures above 30°C, or pollution [3]. Among elite athletes, only 5 percent of sudden deaths are reported, but their risk is three times higher than that of sedentary individuals due to intense training loads [5]. Recent studies from 2025 highlight tissue micro-abnormalities, undetected by conventional imaging, which accounts for 80 percent of cases through ventricular arrhythmias [6]. Over 90 percent of sudden deaths are cardiovascular in origin, with neurological or metabolic causes being rare [7]. Specific populations, such as Black athletes or basketball players in the United States, face a higher risk, while in Asia, Brugada syndrome is more prevalent [4]. These variations highlight the need for harmonized international registries to better quantify incidence and identify at-risk groups.

ETIOLOGIES

The causes of sudden death in athletes are classified into five main categories, with age-dependent patterns. In those under 35 years, genetic cardiomyopathies account for 80 percent of cases, while in those over 35, acquired cardiac conditions dominate, also at 80 percent [3]. Among genetic causes, hypertrophic cardiomyopathy, with a prevalence of 1 in 500, is an absolute contraindication to competitive sports. Coronary artery anomalies (detected by coronary CT), arrhythmogenic right ventricular dysplasia (more common in certain ethnic groups), and long QT or Brugada syndromes (diagnosed by ECG) are also significant contributors [3]. Hypertrophic cardiomyopathy accounts for 36 percent of autopsies in young athletes [4]. In those over 35, coronary artery disease is the leading cause, exacerbated by factors such as high LDL levels, smoking, or dehydration. Viral

myopericarditis, preventable by an 8-day rest period post-infection, is another acquired cause [3]. Exercise conditions, such as sudden isometric efforts, extreme temperatures (cold or heat), fever, or commotio cordis (a rare chest trauma, mitigated by protective gear), also contribute to risk [3]. Doping, particularly with anabolic steroids or erythropoietin (EPO), increases risk through prothrombotic effects and myocardial hypertrophy [3]. Training load follows a U-shaped curve, with risk increasing beyond certain thresholds, though moderate exercise remains protective compared to sedentaryness [3]. Recent autopsy studies from 2025 reveal subtle tissue lesions, such as fibrosis or inflammation, undetectable by standard imaging, which explain fatal arrhythmias in many cases [8]. In younger athletes, congenital coronary anomalies and primary arrhythmic disorders are common, with a notable proportion of structurally normal hearts at autopsy [9]. In older athletes, coronary atherosclerosis predominates, often without plaque rupture but due to an oxygen supply-demand mismatch [9]. These etiological differences highlight the need for age- and profile-specific diagnostic approaches.

SCREENING AND PREVENTION

Preventive screening for sudden death in athletes is a contentious issue due to varying international guidelines. The French Society of Cardiology and the European Society of Cardiology recommend, for competitive athletes aged 12 to 35, a detailed history, clinical examination, and resting ECG every 3 to 5 years [10]. The American Heart Association provides a 14-point checklist for pre-participation screening, including family history of sudden death before age 50 [10]. The Italian experience from 1979 to 2004 demonstrated an 89 percent reduction in incidence (from 3.6 to 0.4 per 100,000 per year) with systematic ECG screening, with no significant impact on unscreened populations [10]. In contrast, Israel reported no significant benefit, with stable incidence rates (2.54 vs. 2.66 per 100,000 per year) [10]. The ECG has a sensitivity of 82 percent for detecting hypertrophic cardiomyopathy, but false positives reach 33 percent due to physiological heart adaptations, distinguishable using ESC 2010 criteria [10]. In France, pre-participation screening is neither standardized nor reimbursed for recreational athletes, with an estimated cost of 135 million euros annually for systematic ECG screening [10]. Secondary prevention includes installing automated external defibrillators (AEDs) in sports facilities, effective in over 70 percent of cases if used within 3 minutes, alongside training in cardiopulmonary resuscitation (CPR) and managing cardiovascular risk factors, such as a SCORE above 5 percent in men over 40 [3, 11]. Controversies surrounding systematic screening include the risk of unjustified disqualification, leading to a preference for shared decision-making [12]. For older athletes, exercise stress testing is recommended for those at high risk of coronary artery disease [9]. Community-based strategies, such as CPR training and

broader AED access, are critical to reducing sudden death incidence [9]. Emerging technologies, such as cardiac monitoring apps or artificial intelligence for ECG analysis, hold promise for improving screening efficiency [13].

MANAGEMENT

Immediate management of sudden death in athletes follows the cardiopulmonary resuscitation guidelines of the European Society of Cardiology and the American Heart Association. It involves stopping exercise, alerting emergency services (112 in Europe), performing CPR with 100–120 chest compressions per minute, and using an AED as soon as available, with a shock delivered for ventricular fibrillation or tachycardia [11, 14]. Among survivors, with survival rates of 20 to 50 percent with early AED use, priorities include managing post-arrest hemodynamic shock with norepinephrine and fluids, conducting a thorough etiological workup with ECG, troponin levels, coronary angiography, and cardiac MRI, and treating the underlying cause, such as beta-blockers for hypertrophic cardiomyopathy or an implantable cardioverter-defibrillator (ICD) for residual arrhythmic risk [11, 14]. The ESC 2022 guidelines recommend genetic testing (class I) and ICD implantation for left ventricular ejection fraction below 35 percent or recurrent syncope [15]. Return to sports requires a multidisciplinary evaluation after 3 to 6 months, with strict restrictions for high-risk conditions, such as limiting hypertrophic cardiomyopathy patients to low-intensity sports [12]. AED access, available in only 20 percent of French gyms in 2025, double survival chances if used promptly [3]. In young women, who account for only 5 percent of cases, the same algorithm applies, with a focus on familial long QT syndrome [16]. The simplified algorithm includes recognizing cardiac arrest, initiating CPR and AED use ideally within 3 minutes, transferring to emergency services with intubation and epinephrine, and, in post-resuscitation, therapeutic hypothermia for comatose patients followed by a comprehensive etiological workup [14]. Advances in CPR training and AED availability have significantly improved survival rates, but unequal access to these devices remains a major challenge [14]. Close coordination among medical teams, coaches, and event organizers is crucial for optimizing outcomes.

CONCLUSION

Sudden death in athletes remains a significant public health challenge despite its low incidence. Advances in epidemiology and diagnostic techniques have improved risk identification, but further efforts are needed to standardize screening and prevention strategies. While systematic ECG screening has proven effective in contexts like Italy, its high cost and limited accessibility in countries like France pose challenges. Universal AED access and CPR training are undisputed priorities for reducing mortality. Future research on biomarkers, artificial intelligence, and genetic testing

could revolutionize prevention and management approaches. A collaborative, individualized approach, balancing specific risks and societal benefits, is essential to promote safe and accessible sports participation.

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