



SUDDEN CARDIAC DEATH (SCD) IN PROFESSIONAL ATHLETES: A REVIEW

MARTA ŽUPAN, DIANA ARANZA*

Coronary artery disease (CAD) and structural cardiomyopathies are leading causes of sudden cardiac death (SCD) among athletes, despite the common perception of athletes as paragons of health. While the incidence of SCD in professional athletes remains low, its impact is profound, particularly given its occurrence in young, high-performing individuals. This review explores the relationship between high-intensity physical activity and SCD, with emphasis on etiological differences based on age, sex, and sport type. Based on a review of 19 relevant studies, the paper underscores the necessity of standardized screening, early detection of cardiac abnormalities, and the implementation of emergency interventions such as automated external defibrillators (AEDs). Though preventive efforts have advanced, further research and policy development are needed to improve outcomes in this unique population.

Keywords: SUDDEN CARDIAC DEATH, CORONARY DISEASE, PROFESSIONAL ATHLETES, ATHLETES

INTRODUCTION

Today, athletes, especially professionals, are expected to achieve excellence, with only minimal differences between competitors. This increases the need to control all factors that may influence performance, leading to significant mental and physical exhaustion among athletes. Although it is well known that regular physical activity brings numerous health benefits, including the prevention and control of cardiovascular risk factors, a reduction in the number of acute coronary events, and improved survival rates, athletes of all ages continue to face various clinical challenges. With the rise in the number of individuals regularly engaging in sports activities, the athlete population has expanded. Although generally considered a healthy population, athletes are not immune to serious clinical conditions. The most critical event is sudden cardiac death (SCD), which, al-

though rare, represents one of the most significant challenges due to its sudden and fatal outcome (1, 2). It is important to note that the etiology of SCD varies significantly depending on the athlete's age, with different pathophysiological mechanisms in younger and older individuals. In the literature, the age threshold of 35 years is most commonly used to distinguish these groups (3-5).

In athletes younger than 35 years, the most common cause of SCD is hypertrophic cardiomyopathy (HCM), characterized by thickening of the left ventricular wall and considered a major risk factor for malignant arrhythmias such as ventricular fibrillation - the leading cause of SCD (3-5). Other frequently reported congenital heart conditions include abnormal origin of the coronary arteries and primary electrical disorders of the heart. Among acquired causes in this age group, myocarditis - most commonly of viral origin - stands out. Athletes often return to intense physical activity prematurely after illness, which can result in fatal outcomes (6).

In older athletes, the leading cause of SCD is atherosclerotic coronary artery disease (3-5). A high-calorie diet, train-

ing of varying intensity, genetic predisposition to atherosclerosis, and other known risk factors can contribute to the development of atherosclerotic plaques in the coronary arteries. These plaques can cause acute coronary syndrome, particularly during physical exertion when myocardial oxygen demand increases and the risk of acute plaque rupture rises. Under such conditions, the likelihood of SCD significantly increases (7).

Physical exertion in both younger and older athletes acts as a trigger for malignant arrhythmias and, consequently, for SCD. Timely identification of individuals at risk through systematic preventive screenings and education of athletes and sports personnel - is a key step in preventing SCD (8). It is important to emphasize that physical activity itself is not a direct cause of death; however, it can act as a trigger in individuals with previously undiagnosed heart conditions. In this context, prevention through regular medical check-ups becomes critically important. Nonetheless, it remains unclear when high-intensity physical activity serves as a risk factor for coronary disease and when it functions as a means of its prevention (2).

*University of Split,
Faculty of Health Sciences, Split, Croatia

Corresponding author:
Marta Župan, RN
University of Split,
Faculty of Health Sciences, Split, Croatia
E-mail: martazupan10@gmail.com

METHODS

For writing this article the MEDLINE database through the PubMed platform was used. The search was conducted in February 2025 using the keywords "coronary disease" and "professional athletes," with the use of the Boolean operator AND. Additionally, a filter for free full-text availability ("free full text") was applied, resulting in 6 available articles. Subsequently, using the keyword "sudden cardiac death" in combination with "athletes" and applying a publication date filter (last 5 years), 320 articles were found, of which 19 were selected.

Although a filter for articles published in the last five years was used during the search, due to the lack of newer sources and to gather a larger number of relevant information, the search was expanded. A manual search of documents and their references was carried out to identify additional literature, including articles up to ten years old. Moreover, in cases where the data was particularly significant for understanding certain aspects, older studies were included, with the earliest being from 1986. The key criterion for including studies in the analysis was the clear definition of the group of athletes. All studies that did not contain this information or dealt with the general population without clear categorization of athletes were excluded. Studies included in the analysis were those addressing sudden cardiac death (SCD) in both professional and recreational/amateur athletes, allowing for a comparison of SCD among different categories of athletes. Only articles from peer-reviewed scientific journals, as well as data from reliable registries and reports from professional organizations such as cardiology societies and sports associations, were considered. Additionally, only studies published in English that addressed the frequency, etiology, risk factors, diagnostics, prevention, and outcomes of SCD were included.

On the other hand, studies that focused on the general population without clearly defined athlete categories, studies on SCD caused by trauma without a connection to cardiovascular conditions, as

well as non-peer-reviewed sources such as opinions, comments, and letters to the editor, were excluded. Literature that was not available in full text was also excluded.

RESULTS AND DISCUSSION

Prevalence and Etiology of Sudden Cardiac Death in Athletes

A review of numerous studies reveals that coronary diseases in professional athletes are most often mentioned in the context of sudden cardiac death (SCD), which is often the first symptom of cardiovascular diseases in asymptomatic athletes. The occurrence of SCD among athletes varies, with studies showing an extremely variable incidence of 1:40,000 to 1:80,000, depending on the methodology and the definition of "athletes." Differences in incidence are often due to varying research approaches, including the use of media reports or national registries (9).

A study based on media reports, focusing only on cases of professional athletes, highlighted the most important cases of sudden cardiac death recommended by key American sports medicine organizations (10). Media attention to SCD began in 1993 after the death of basketball player Reggie Lewis, followed by cases of professional athletes such as Zeno Ray, Marc-Vivien Foé, Miklós Fehér, and Antonio Puerta, whose deaths were primarily linked to hypertrophic cardiomyopathy and consequently to ventricular tachycardia. Other athletes, such as Hank Gathers, Wes Leonard, Flo Hyman, Sergei Grinkov, Pete Maravich, Alexander Dale Oen, and Darryl Kile, died from various heart diseases, including different types of cardiomyopathies, aortic dissection, and myocardial infarction. Although the mentioned study shows the heterogeneity of the causes of SCD, a higher incidence of hypertrophic cardiomyopathy is noted (10).

According to research conducted by Maron and colleagues, hypertrophic cardiomyopathy has been identified as a common cause of sudden cardiac death (SCD) among athletes from various sports (3, 4). The authors state that

hypertrophic cardiomyopathy is the most frequent cause of SCD in athletes, with the athlete's age playing a significant role-those under the age of 35 most commonly die due to hypertrophic cardiomyopathy, whereas in older athletes, coronary artery disease is more frequently the cause of death.

These findings are supported by a four-year study conducted by FIFA, which analyzed 617 football players from 67 countries (5).

Gender differences

Studies have shown that SCD is more common in men than in women. A study (11) involving over 110,000 athletes indicates a higher incidence of SCD in men, and similar data comes from other studies, which report that only 11% or 13% of all SCD cases occur in women (12, 13). Although the number of women in sports is increasing, the incidence of SCD among female athletes remains lower, which can be explained by physiological, hormonal, and psychological factors that reduce the risk in women (14).

Type and Intensity of Sport

High-intensity sports activities in professional athletes increase the risk of SCD. A comparison with amateur athletes shows that professionals have a higher risk, as confirmed by studies which show a higher rate of SCD among professionals than recreational athletes (8, 15).

Studies also show that specific sports, such as basketball and football, are more frequently associated with SCD, which may be due to the higher popularity of these sports and the larger number of athletes participating in them (3, 9, 16).

Preventive Strategies and Screening

The prevention of coronary diseases among professional athletes involves a combination of primary and secondary prevention. Identifying at-risk athle-

tes through regular screenings, such as ECGs, is key to reducing the incidence of SCD, as confirmed by data from Italy. A study on the incidence of SCD among young athletes over 26 years showed a 90% reduction in mortality after the introduction of a national screening program (17). The decrease in mortality was associated with a lower frequency of SCD caused by cardiomyopathies, which are detected through ECGs, a screening method that was first made mandatory for athletes in Italy (17).

Studies show that the introduction of mandatory screenings and the use of automatic external defibrillators (AEDs) can significantly reduce mortality from SCD (10, 17). Cases such as those of footballer Christian Eriksen and American football player Damar Hamlin highlight the importance of early intervention, including cardiopulmonary resuscitation (CPR) and the use of AEDs (16). For example, a study by Valenzuela and colleagues found that 74% of patients with ventricular fibrillation survived when defibrillation was performed within 3 minutes, compared to a survival rate of 49% for those who received defibrillation after 3 minutes (18).

One of the reviewed studies claims that over 70% of respondents failed to recognize cardiac arrest (19). To improve the recognition of cardiac arrest and response times, FIFA has launched practical courses for medical staff and developed mobile applications that provide training and videos related to treatment (20). After the training, individuals showed the fastest response times and increased survival rates.

Although efforts and a desire for progress in this area have been observed, some studies provide concerning data. In cases of cardiac arrest, only 40% of bystanders initiate CPR, and only 6% use an AED (21).

CONCLUSION

While rare, sudden cardiac death among professional athletes remains a devastating event with complex etiologies. The leading causes - hypertrophic cardiomyopathy in younger athletes and

coronary artery disease in older individuals - highlight the importance of age-tailored prevention strategies. Although high-intensity training generally improves cardiovascular health, it may unmask latent conditions in predisposed individuals.

Mandatory cardiac screening, widespread AED access, and improved CPR training are essential to reducing mortality. Continued research and athlete-specific preventive policies, particularly those accounting for gender, sport type, and age, are urgently needed to mitigate this silent threat.

NOVČANA POTPORA/FUNDING
Nema/None

ETIČKO ODOBRENJE/ETHICAL APPROVAL
Nije potrebno/None

SUKOB INTERESA/CONFLICT OF INTEREST
Autori su popunili *the Unified Competing Interest form* na www.icmje.org/doi_disclosure.pdf (dostupno na zahtjev) obrazac i izjavljuju: nemaju potporu niti jedne organizacije za objavljeni rad; nemaju finansijsku potporu niti jedne organizacije koja bi mogla imati interes za objavu ovog rada u posljednje 3 godine; nemaju drugih veza ili aktivnosti koje bi mogle utjecati na objavljeni rad./ *All authors have completed the Unified Competing Interest form at www.icmje.org/doi_disclosure.pdf (available on request from the corresponding author) and declare: no support from any organization for the submitted work; no financial relationships with any organizations that might have an interest in the submitted work in the previous 3 years; no other relationships or activities that could appear to have influenced the submitted work.*

LITERATURE

1. Barić R, Tandarić R. How much do coaches need sports psychologists? In: Zarevski P, Jurin T, Modić Stanke K, editors. 22nd Days of Ramir and Zoran Bujas: Abstracts of Communications. Zagreb: Faculty of Philosophy, University of Zagreb; 2015; p. 56-x.
2. Dore H, de Araújo Gonçalves P, Cardim N, Neuparth N. Coronary artery disease in athletes: An adverse effect of intense exercise? Rev Port Cardiol (Engl Ed). 2018 Jan; 37 (1): 77-85. English, Portuguese. doi: 10.1016/j.repc.2017.06.006. Epub 2018 Jan 8. PMID: 29325803.
3. Maron BJ, Shirani J, Poliac LC, Mathenge R, Roberts WC, Mueller FO. Sudden death in young competitive athletes. Clinical, demographic, and pathological profiles. JAMA. 1996 Jul 17; 276 (3): 199-204. PMID: 8667563.

4. Maron BJ, Epstein SE, Roberts WC. Causes of sudden death in competitive athletes. J Am Coll Cardiol. 1986 Jan; 7 (1): 204-14. doi: 10.1016/s0735-1097(86)80283-2. PMID: 3510233.
5. Egger F, Scharhag J, Kästner A, Dvořák J, Böhm P, Meyer T. FIFA Sudden Death Registry (FIFA-SDR): a prospective, observational study of sudden death in worldwide football from 2014 to 2018. Br J Sports Med. 2022 Jan; 56 (2): 80-87. doi: 10.1136/bjsports-2020-102368. Epub 2020 Dec 23. PMID: 33361135.
6. Harris KM, Mackey-Bojack S, Bennett M, Nwaudo D, Duncanson E, Maron BJ. Sudden unexpected death due to myocarditis in young people, including athletes. Am J Cardiol. 2021; 143: 131-4. doi:10.1016/j.amjcard.2020.12.028.
7. Rai V. (2024). High-Fat Diet, Epigenetics, and Atherosclerosis: A Narrative Review. Nutrients, 17 (1), 127. <https://doi.org/10.3390/nu17010127>.
8. Sollazzo F, Palmieri V, Gervasi SF, Cuccaro F, Modica G, Narducci ML, et al. Sudden Cardiac Death in Athletes in Italy during 2019: Internet-Based Epidemiological Research. Medicina (Kaunas). 2021 Jan 12; 57 (1): 61. doi: 10.3390/medicina57010061. PMID: 33445447; PMCID: PMC7827560.
9. Harmon KG, Drezner JA, Wilson MG, Sharma S. Incidence of sudden cardiac death in athletes: a state-of-the-art review. Heart. 2014 Aug; 100 (16): 1227-34. doi: 10.1136/heartjnl-2014-093872.rep. PMID: 25049314.
10. Bickel T, Gunasekaran P, Murtaza G, Gopinathannair R, Gunda S, Lakkireddy D. Sudden Cardiac Death in Famous Athletes, Lessons Learned, Heterogeneity in Expert Recommendations and Pitfalls of Contemporary Screening Strategies. J Atr Fibrillation. 2019 Dec 31; 12 (4): 2193. doi: 10.4022/jafib.2193. PMID: 32435342; PMCID: PMC7237076.
11. Corrado D, Basso C, Rizzoli G, Schiavon M, Thiene G. Does sports activity enhance the risk of sudden death in adolescents and young adults? J Am Coll Cardiol. 2003 Dec 3; 42 (11): 1959-63. doi: 10.1016/j.jacc.2003.03.002. PMID: 14662259.
12. Maron BJ, Doerer JJ, Haas TS, Tierney DM, Mueller FO. Sudden deaths in young competitive athletes: analysis of 1866 deaths in the United States, 1980-2006. Circulation. 2009 Mar 3; 119 (8): 1085-92. doi: 10.1161/CIRCULATIONAHA.108.804617. Epub 2009 Feb 16. PMID: 19221222.
13. Finocchiaro G, Westaby J, Bhatia R, Malhotra A, Behr ER, Papadakis M, et al. Sudden Death in Female Athletes: Insights From a Large Regional Registry in the United Kingdom. Circulation. 2021; 144: 1827-9.
14. Haukilahti MAE, Holmström L, Vähätalo J, Kenttä T, Tikkanen J, Pakanen L, et al. Sudden Cardiac Death in Women. Circulation. 2019 Feb 19; 139 (8): 1012-21. doi: 10.1161/CIRCULATIONAHA.118.037702. PMID: 30779638.

15. Toresdahl BG, Rao AL, Harmon KG, Drezner JA. Incidence of sudden cardiac arrest in high school student athletes on school campus. *Heart Rhythm*. 2014 Jul; 11 (7): 1190-4. doi: 10.1016/j.hrthm.2014.04.017. Epub 2014 Apr 13. PMID: 24732370.
16. Drezner JA, Peterson DF, Siebert DM, Thomas LC, Lopez-Anderson M, Suchsland MZ, Harmon KG, Kucera KL. Survival After Exercise-Related Sudden Cardiac Arrest in Young Athletes: Can We Do Better? *Sports Health*. 2019 Jan/Feb; 11 (1): 91-8. doi: 10.1177/1941738118799084. Epub 2018 Sep 11. PMID: 30204540; PMCID: PMC6299352.
17. Corrado D, Basso C, Pavei A, Michieli P, Schiavon M, Thiene G. Trends in sudden cardiovascular death in young competitive athletes after implementation of a preparticipation screening program. *JAMA*. 2006 Oct 4; 296 (13): 1593-601. doi: 10.1001/jama.296.13.1593. PMID: 17018804.
18. Valenzuela TD, Roe DJ, Nichol G, Clark LL, Spaite DW, Hardman RG. Outcomes of rapid defibrillation by security officers after cardiac arrest in casinos. *N Engl J Med*. 2000 Oct 26; 343 (17): 1206-9. doi: 10.1056/NEJM200010263431701. PMID: 11071670.
19. Viskin D, Rosso R, Havakuk O, Yankelson L, Viskin S. Attempts to prevent "tongue swallowing" may be the main obstacle to successful resuscitation of athletes with cardiac arrest observed by bystanders. *Heart Rhythm*. 2017; 14: 1729-34.
20. Serratos, Luis & Kramer, Efraim & Pereira, Hélder & Dvorak, Jiri & Ripoll, Pedro. (2016). CPR 11: A mobile application that can help in saving lives (Mobile App User Guide). *British Journal of Sports Medicine*. 50. 10.1136/bjsports-2015-095895.
21. Tsao CW, Aday AW, Almarzooq ZI, et al. Heart disease and stroke statistics - 2022 update: A report from the American Heart Association. *Circulation*. 2022; 145: e145. doi:10.1161/CIR.0000000000001052.

Sažetak

IZNENADNA SRČANA SMRT (SCD) KOD PROFESIONALNIH SPORTAŠA: PREGLEDNI RAD

Marta Župan, Diana Aranza

Koronarna bolest srca i strukturne kardiomiopatije vodeći su uzroci iznenadne srčane smrti među sportašima, unatoč uobičajenoj percepciji sportaša kao oličenja zdravlja. Iako je incidencija iznenadne srčane smrti kod profesionalnih sportaša i dalje niska, njezin utjecaj je dubok, posebno s obzirom na njezinu pojavu kod mladih, visokoučinkovitih pojedinaca. Ovaj pregled istražuje odnos između tjelesne aktivnosti visokog intenziteta i iznenadne srčane smrti s naglaskom na etiološke razlike na temelju dobi, spola i vrste sporta. Na temelju pregleda 19 relevantnih studija, rad naglašava potrebu standardiziranog probira, ranog otkrivanja srčanih abnormalnosti i provedbe hitnih intervencija poput automatskih vanjskih defibrilatora (AED). Iako su preventivni napori napredovali, potrebna su daljnja istraživanja i razvoj politika kako bi se poboljšali ishodi u ovoj jedinstvenoj populaciji.

Ključne riječi: IZNENADNA SRČANA SMRT, KORONARNA BOLEST, PROFESIONALNI SPORTAŠI, SPORTAŠI

Primljeno/Received: 14. 4. 2025.

Prihvaćeno/Accepted: 28. 5. 2025.