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ORIGINAL ARTICLE

Sudden cardiac death in athletes: A 20-year analysis in Portugal

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KEYWORDS
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Abstract
Introduction and objectives: Sudden cardiac death (SCD) in athletes is a tragic event, with some evidence remaining controversial. The aim of this study was to evaluate cases of SCD in athletes in Portugal within the last 20 years.
Methods: An advanced Google search using a combination of several keywords and systematic searches on websites of national newspapers/television stations was conducted. Additionally, 54 Portuguese sports federations and the Portuguese Institute of Sports and Youth were contacted by email and/or phone. All sports-related SCD cases in competitive athletes, occurring between 2003 and 2023 in Portugal, were included. The total number of athletes at risk used for the calculation of SCD incidence, was collected from official national records.
Results: A total of 42 SCD cases in athletes were identified, with a median age of 27 [18;42] years, and the great majority were male (n=39; 93%). Most events occurred in outdoor sports (n=28; 67%), especially in football (n=13; 31%), athletics (n=4; 10%) and trail running (n=4; 10%), and during competition or training sessions (n=27; 64%). The higher number of cases were reported in 2021 and 2022, while in several years no occurrences were found. The yearly average SCD incidence was 0.39 cases per 100 000 athletes/year.

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Conclusions: The incidence of SCD in athletes in Portugal is very low, mainly occurring in male, outdoor sports and during competitions or training sessions. Due to the limitations of passive data collection, prospective registries are needed, with standardization of the most relevant data, especially regarding their etiology and circumstances.

PALAVRAS-CHAVE
Morte súbita cardíaca;
Atletas;
Incidência;
Nível competitivo;
Prevenção

Morte súbita cardíaca em atletas: uma análise dos últimos 20 anos em Portugal

Resumo
Introdução e objetivos: A morte súbita cardíaca (MSC) em atletas é um evento trágico, apresentando ainda alguma evidência controversa. O objetivo desta análise foi avaliar os casos de MSC em atletas, em Portugal, durante 20 anos.
Métodos: Foi realizada uma pesquisa avançada com várias palavras-chave no motor de busca *Google* e em *websites* de jornais nacionais/estações televisivas. Adicionalmente, foram contactadas, por *e-mail* e/ou telefone, 54 Federações Desportivas Portuguesas e o Instituto Português do Desporto e da Juventude. Todos os casos de MSC em atletas de nível competitivo, ocorridos entre 2003 e 2023 em Portugal, foram incluídos. O número total de atletas em risco usado para calcular a incidência de MSC foi obtido em registos estatísticos oficiais.
Resultados: Identificaram-se 42 casos de MSC em atletas, com idade mediana de 27 [18;42] anos, maioritariamente do sexo masculino (N = 39; 93%). A maioria ocorreu em desportos *outdoor* (N = 28; 67%), particularmente no futebol (N = 13; 31%), atletismo (N = 4; 10%) e *trail running* (N = 4; 10%), e durante competição ou treino (N = 27; 64%). Em vários anos não foram reportados casos de MSC, enquanto em 2022 e 2021 se verificaram o maior número de eventos. A incidência anual de MSC foi 0,39 casos por 100 000-atletas/ano.
Conclusões: A incidência de MSC em atletas em Portugal é muito baixa, ocorrendo principalmente no sexo masculino, desportos *outdoor* e durante competição ou treino. Devido às limitações inerentes à metodologia utilizada são necessários registos prospetivos com padronização dos dados mais relevantes, particularmente em relação à etiologia e circunstâncias destes eventos.

Introduction

The benefits of physical activity and regular exercise training for cardiovascular disease (CVD) prevention are widely described.[1–3] However, sudden cardiac death (SCD), a tragic and highly visible event, may occur in apparently healthy athletes.[1,2] Both sudden cardiac arrest (SCA) and SCD are the leading cause of death in young athletes during exercise.[4] While coronary artery disease is the most common cause of SCD in veteran athletes (over 35 years), inherited cardiac conditions and sudden unexplained death (presumably electrical cardiac abnormalities) have been reported as predominant among younger individuals.[1–3]

Although the cases of SCD are relatively rare, its true incidence remains unknown, varying across the several studies, mainly due to the heterogeneity of the analyzed populations and methodological limitations.[1,2,5] In fact, even the definition of ''athlete'' is controversial.[1] These differences lead to a broad range of SCD incidence reported in athletes, between 0.1 and 13 cases per 100 000 athletes per year.[4] A study in from the United States that used a national college database, found an incidence of 1.9 per 100 000 athletes per year.[1] On the other hand, a prospective study in the Veneto region in Italy after the application of preparticipation screening programs, set an incidence of 0.4 per 100 000 athletes per year.[1,2] Also in Europe, a Danish national study reported an incidence between 0.47 and 1.21 per 100 000 athletes per year and 6.64 per 100 000 athletes per year, in people aged under and above 35 years, respectively.[1] The study by Malhotra et al., on adolescent football players, reported an incidence of 6.8 per 100 000 athletes per year.[6] A state-of-the-art review settled on an incidence of 1:50 000 in college athletes.[5] To the best of our knowledge there are not studies addressing the incidence of SCD in athletes in Portugal.

Understanding these events, especially victims' characteristics, risk factors, epidemiology, and sports circumstances is of the utmost importance to improve preventive strategies. In this context, improving preparticipation screening programs and especially emergency support and resuscitation conditions, with rapid initiation of

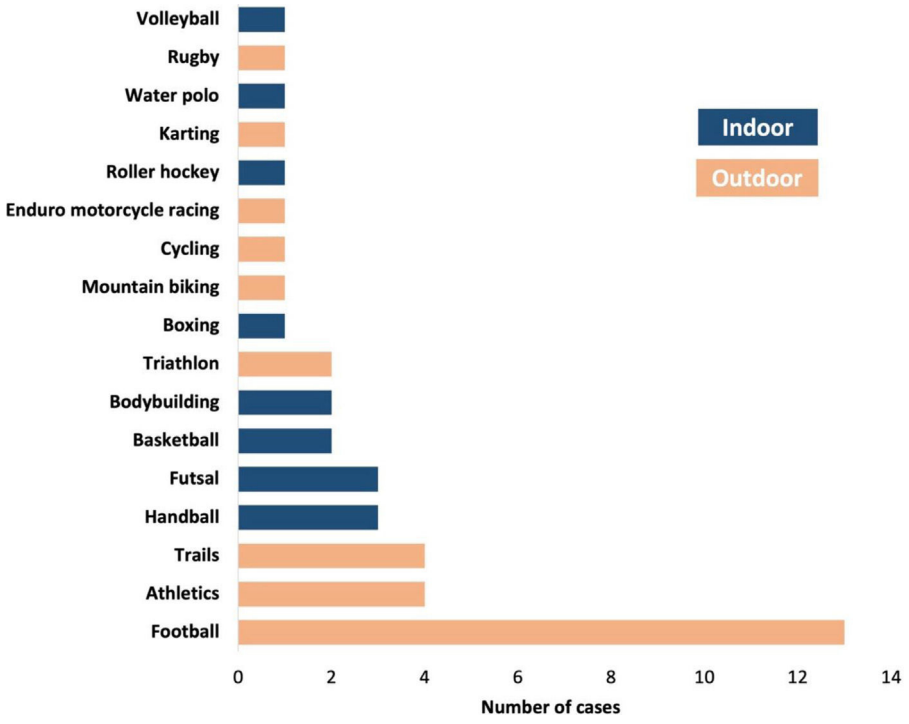

Figure 1 Distribution of number of cases by sports modalities.

cardiopulmonary resuscitation and automated external defibrillators, are essential measures.[1,2]

Objectives

The aim of the current study was to evaluate the cases of SCD in athletes in Portugal over a 20-year period.

Methods

Population and design

An extensive media search using advanced Google search (https://www.google.com/advanced_search) with several keywords in Portuguese, such as ''death,'' ''sudden,'' ''sport,'' and ''athlete'' as mandatory words, was conducted. Several non-mandatory words, such as ''football,'' ''basketball,'' ''running,'' ''marathon,'' ''match,'' ''race,'' ''training,'' ''certificate,'' and ''autopsy'', were also included. Furthermore, a search on the websites of national newspapers (sports and general) and television stations was performed. Additionally, all the Portuguese sports federations (a total of 54), as well as the Portuguese Institute of Sports and Youth, were contacted by email or phone, while alternatively a Google Form was sent (https://forms.gle/dm8XwKrfe64DZeQJ7). All the identified and presumed sports-related SCD occurring between 2003 and 2023 in Portugal were included. For each SCD case found or reported, the available information regarding demographics and circumstances of the event was collected. The events with proven non-cardiac causes, such as traumatic deaths, were excluded from this analysis.

Statistical analysis

In the descriptive analysis, normally distributed continuous variables were described using mean and standard deviation, whereas for non-normally distributed variables, median and interquartile range were used. Categorical variables were presented as frequencies and percentages. The incidence of SCD was calculated by dividing the total number of cases encountered by the total number of athletes, which was based on official national records of competitive athletes by year in Portugal (https://www.pordata.pt/). Statistical analysis was performed using IBM SPSS version 29.0 for Mac (IBM SPSS Statistics, Chicago, IL, USA).

Results

Between January 2003 and December 2023, a total of 42 SCD cases were identified. The athletes' median age was 27 [18;42] years, ranging from 12 to 70 years, and 93% were male (only three cases occurred in women).

The distribution of SCD events according to sports modality is presented in Figure 1. Most of the cases occurred in outdoor sports (n=28; 67%), especially in football (n=13; 31%), athletics (n=4; 10%) and trail running (n=4; 10%). Among indoor sports, the cases were mainly reported in handball (n=3; 7%), futsal (n=3; 7%) and basketball (n=2; 5%). Furthermore, the majority of the SCD cases occurred during competitions or training sessions (n=27; 64%).

The highest number of cases were reported in 2022 and 2021 (10 and 8, respectively), while in several years no events were found.

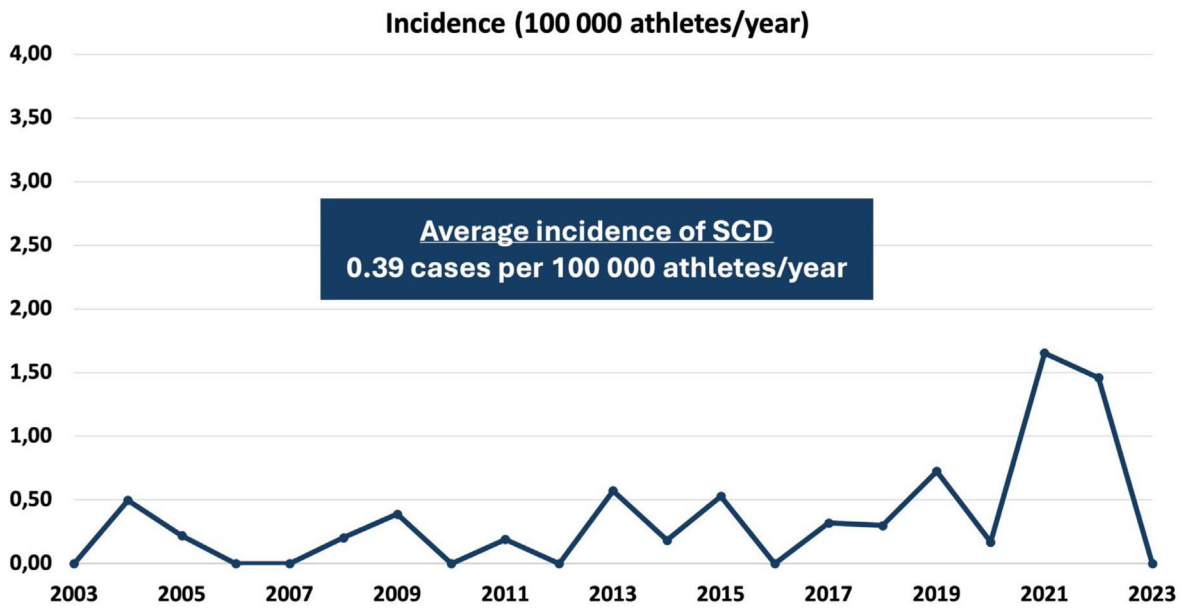

Figure 2 Incidence of sudden cardiac death per year.

Figure 2 shows the incidence of SCD in Portugal during the period of analysis. The average yearly incidence of SCD was 0.39 cases per 100 000 athletes, per year.

Discussion

The present study shows that the incidence of SCD in athletes in Portugal is very low. Although the methodology adopted was previously used in similar published studies based on retrospective analysis and passive data collection, it potentially underestimates the incidence calculation. On the other hand, and in line with the already known evidence, most of the reported SCD cases occurred in male athletes involved in outdoor sports and during competition or training sessions.

The most common methodologies used for the determination of SCD incidence in athletes are based on media searches, including professional press monitoring, retrospective registries, insurance claims, autopsy reports, death certificates, and national registries and databases.[2,4,5] A brief advanced literature search performed in PubMed, using the mandatory terms ''sudden cardiac death'' and ''athletes'', resulted in a total of 191 articles, of which 12 included media search in their methodology, as in our study. The characteristics of these studies are summarized in Table 1. Most were conducted in the United States of America, and the included populations were very heterogeneous. Furthermore, some studies only included events that occurred during or within one hour of sports, while others also included SCA.[7,9,11–16] Consequently, SCD incidence ranged between 0.02 and 2.6 per 100 000 persons per year.[10,16]

In fact, a media search underestimates the number of counted cases included in the incidence calculation. Studies from the United States addressing this issue found that media database reports identified 70% and 56% of the SCD events.[2] In a study performed in Denmark, a media search identified only 20% of the SCD cases.[5] In the setting of registries, correct completion has several biases, while insurance claims appear to miss even more cases.[5] Confounders include the definition of an athlete, the total number of athletes at risk used to calculate the SCD incidence, and the baseline characteristics (i.e., age, sex, comorbidities).[2,5] Even the definition of SCD is controversial; in some studies it includes all cases, while in others, only the deaths during and within one hour of sports or also SCA cases.[17] According to European guidelines, SCD is defined as a sudden death presumed to be cardiac, occurring within one hour of symptoms or within 24 hours of being seen alive.[18] Our study included all the presumed sports-related SCD in athletes, but not the SCA cases.

An Italian internet-based study analyzed both competitive and non-competitive athletes, defining the former as individuals participating in organized teams or engaging in regular competition against others, requiring systematic training.[17] This study found higher rates of SCD in football and athletics, and mostly during or immediately after practice (51% and 9.2%, respectively), in line with our results.[17] Studies from the United States report a higher incidence in Black athletes, three times the risk of white athletes, a variable not available in our study, and in basketball players.[2,7–11] These differences in sports disciplines, football in Europe and basketball in United States of America, could be explained by the regional disparities in the most frequent national sport. In a prospective French study performed in the general population, but also including young athletes, a higher incidence of SCD was found in cycling, running, and football, which are the most common sports practiced in this country.[15]

The denominator of the incidence equation (number of athletes at risk), also needs to be precise.[2,5] For example, an Italian study used data from both the Italian National Olympic Committee and the Italian National Institute of Statistics, while an American study performed in college athletes used various National Collegiate Athletic Association

Table 1 Summary of articles with similar methodology.

Author	Study design	Country	Years	Population	SCA	Methods*	Mean age (range)	Incidence
Petek[11]	Retrospective	US	2002–2022 (20Y)	College athletes	N	Databases Insurance claims Autopsies	20	1.6/100 000 per year
Sollazzo[17]	Prospective	Italy	2019 (1Y)	Athletes (competitive and non-competitive)	N	–	–	0.47/100 000 per year
Marijon[15]	Prospective	France	2005–2010 (5Y)	General population and young athletes (related to sports, during or within one hour)	Y	Collaboration with mobile intensive care units	46 (11–75)	0.46/100 000 per year (0.98/100 000 per year in young athletes)
Egger[14]	Prospective	Worldwide (67 countries)	2014–2018 (5Y)	Football (related to sports, during or within one hour, also traumatic)	Y	Professional press monitoring Online form Autopsy reports	34 (5–76)	Not calculated (617 cases)
Endres[10]	Retrospective	US	2007–2015 (8Y)	Young athletes (during exercise)	N	Professional press monitoring	13 (9–17)	0.02/100 000 per year
Davogustto[20]	Retrospective	Worldwide	2000–2013 (13Y)	Football (related to activity)	N	–	24 (13–34)	Not calculated (54 cases)
Steinvil[16]	Retrospective	Israel	1985–2009 (24Y)	Athletes	Y	–	24 (12–44)	2.6/100 000 per year
Choi[9]	Retrospective	US	2007–2008 (1Y)	Athletes (related to sports, during or within one hour)	N	Autopsy reports	17 (11–30)	Not calculated (69 cases)
Harmon[8]	Retrospective	US	2004–2008 (4Y)	College athletes	N	Databases Emails/Phone Insurance claims	–	2.3/100 000 per year
Holst[13]	Retrospective	Denmark	2000–2006 (6Y)	Young population and athletes (related to sports, during or within one hour)	N	Death certificates Autopsy reports Databases	28 (15–35)	1.21/100 000 per year
Maron[7]	Retrospective	US	1980–2006 (27Y)	Young athletes	Y	Public records Professional press monitoring Online form Databases	18 (8–39)	0.61/100 000 per year
Van Camp[12]	Retrospective	US	1983–1993 (10Y)	College and high school athletes (related to sports, during or within one hour)	N	Newspapers Databases Autopsy reports	–	0.7 vs. 0.1/100 000 per year (male/female)

N: no; US: United States; Y: yes.
* Other than investigator media search.

reports and databases.[11,17] Our study relied only on the official online national records about the number of competitive athletes. More detailed data on this athletic population, both regarding demographic and exercise-related characteristics, is not available in Portugal.

The age of the athletes may also be a confounding factor because the incidence of SCD is higher in older individuals and many of these older deaths are unwitnessed.[3,5] Our study found a wide range of ages (median of 27), from 12 to 70 years, with 75% occurring in those aged or under 42 years. This is in contrast to an Italian study that found 61.2% of cases in athletes older than 35 years, although they do not report the age range.[17]

In several studies, males have three to five times a higher incidence of SCD.[2] This is in accordance with our analysis, showing only three cases in women (7%), which is in line with other internet-based studies.[10,11,14,17]

The incidence of SCD is also highly variable across studies with methodologies including media search. An Italian research study reported an incidence of 0.47 per 100 000 persons per year, in contrast with an Israel study that found an incidence of 2.6 per 100 000 persons per year.[16,17] In a Danish study the incidence of SCD in athletes was 1.21 per 100 000 per year and a 20-year study in college athletes found an incidence of 1 per 63 682 athlete-years, with a decrease over the study.[11,13] While an American one-year study found 69 cases, the *Fédération Internationale de Football Association* (FIFA) Sudden Death Registry included 617 cases in football players during a five-year prospective study.[9,14] Nevertheless, in our population, the incidence was even lower, roughly 0.39 cases per 100 000 athletes per year, with a slight increase in recent years. These findings could be attributed to the variation of media attention over the years, the ''agenda-setting effect'', and to the absence of mandatory reporting.[10] Therefore, the development of appropriate mandatory prospective registries is needed for studying SCD cases. This fact should be a priority because the overall number of athletes is increasing in Portugal.

Limitations

As mentioned above, our study has some limitations. Primarily, it is a media/internet-based study, with retrospective and passive data collection, which can possibly underestimate the number of SCD cases. Secondly, older cases may be missed due to undercoverage, while reporting in years with more visible and mediatic cases, could be more precise. Demographic characterization of the population was not available, and several relevant variables may have been missed. Additionally, it was not possible to determine the exact time of symptoms/event referred to in the above-mentioned definition of SCD, nor to access autopsy reports and death certificates, thus not enabling the analysis of the exact causes of death.

Lessons for the future

There is an urgent need for more structured information regarding SCD in athletes in Portugal. Mandatory reporting of these cases, as well as development of a national registry, are needed to better address this issue. All SCD and SCA cases should be thoroughly studied to determine their risk factors, etiology and proper management. Furthermore, expertise in cardiac pathology, with standardization of the autopsies and post-mortem genetic/molecular testing, as well as family evaluation of the SCD victims, is of the utmost importance. As it is not possible to reduce the risk of SCD to zero, the development of strategies to increase public awareness, community training in cardiopulmonary resuscitation and availability of automated external defibrillators are also essential points. Physicians should be aware of current challenges in Sports Cardiology, ensuring safe participation in sports, even in the presence of CVD, based on individualized exercise prescription and a shared decision-making process.[19]

Conclusions

The incidence of SCD in competitive athletes in Portugal is very low, 0.39 cases per 100 000 athletes per year, with 42 cases reported between 2003 and 2023. Most events occurred in males, involved in outdoor sports, and during competition or training sessions. Although the use of a previously tested search methodology, this incidence is probably underestimated. However, as there are no mandatory SCD reporting requirements in Portugal, there is no other method to identify these cases. Due to the limitations of this passive data collection, commonly used in studies about SCD in athletes, prospective registries are needed, with standardization of relevant data, especially regarding its etiology and circumstances. Understanding these events may help to identify high-risk groups of athletes and to improve preventive strategies.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used ChatGPT 3.5 in order to correct grammar errors. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Conflicts of interest

The authors have no conflicts of interest to declare.

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