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REVIEW

Causal factors of sudden death in young athletes

Factores causales de muerte súbita en deportistas jóvenes

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ABSTRACT

Introduction: it is undeniable that physical activity provides multiple benefits, both for general health and cardiovascular health, but on rare occasions, sudden cardiac death can occur in athletes even without previous symptoms. Regarding the causes and incidences, there are different studies from various countries and regions that present different results, due to the cultural variations in each country and their practiced sports. Moreover, in some countries, like Italy for example, screenings for conditions such as hypertrophic cardiomyopathy are implemented more frequently compared to other countries. Sudden death involves a broad spectrum of associated pathologies, and in athletes or individuals under 35 years old, the most common causes are primary cardiomyopathies, cardiac channelopathies, and congenital anomalies of the coronary arteries.
Objective: to know the main causes of sudden cardiac death in young athletes.
Method: this work is a systematic review of the literature, where different studies and articles will be analyzed to compile the most relevant and up-to-date information regarding the main causes of sudden death in young athletes. The search will be conducted through databases such as PubMed, SciELO, and the Argentine Society of Cardiology's website.
Results: based on the results obtained, it was observed that the most common causes of sudden death in young athletes vary depending on the region where the studies were conducted. This variation is mainly due to sociocultural factors that influence how a given society behaves and which sports are practiced.
Conclusion: although it is a rare event with low incidence, sudden cardiac death is a catastrophic event that, in most cases, leads to death. However, it is an event that can be prevented, and with the correct therapeutic intervention in the first few minutes, it can be successfully reversed. But to achieve this, it is necessary to understand the topic and be aware of its main causes to act correctly and efficiently.

Keywords: Sudden; Cardiac; Death; Athletes; Exercise.

RESUMEN

Introducción: es innegable que la actividad física aporta múltiples beneficios, tanto para la salud general como para la salud cardiovascular, pero en raras ocasiones la muerte súbita cardiaca puede ocurrir en atletas mismo sin síntomas previos. Con respecto a las causas y incidencias existen diferentes estudios de distintos países y regiones que presentan distintos resultados, eso se da por el cambio cultural de cada país y sus deportes practicados, además en algunos países como, por ejemplo, Italia, los screening para patologías como las miocardiopatías hipertróficas son implementadas con mayor frecuencia en comparación con otros países. La muerte súbita conta con un amplio espectro de patologías asociadas, en atletas o deportistas menores de 35 años tenemos como causas más comunes las miocardiopatías primarias, las canalopatías cardíacas y anomalías congénitas de las arterias coronarias.

Objetivos: conocer las principales causas de muerte súbita cardiaca en deportistas jóvenes.
Método: en este trabajo se trata de una revisión sistemática de la literatura donde se analizarán distintos estudios y artículos para recopilar lo más relevante y actualizado cuanto las principales causas de muerte súbita en deportistas jóvenes. La búsqueda será efectuada por buscadores como PubMed, sciELO y por la página de la sociedad argentina de cardiología.
Resultados: con base en los resultados obtenidos, se pudo percibir que las causas más frecuentes de muerte súbita en deportistas jóvenes varían según la región que se hicieron los estudios, esta variación está dada principalmente por los factores socioculturales que influyen en como determinada sociedad se comporta y cuales deportes practican.
Conclusión: aunque sea un evento raro con baja incidencia, la muerte súbita cardiaca es un evento catastrófico y que en la gran mayoría de los casos lleva a la muerte, pero es un evento que puede ser evitado por medio de la prevención y con la correcta terapéutica en los primeros minutos puede ser revertido con suceso. Pero para eso es necesario conocer el tema y conocer sus principales causas para poder actuar correctamente y de manera eficiente.

Palabras clave: Muerte Súbita; Cardíaca; Deportistas; Ejercicio.

INTRODUCTION

In the 2022 European Society of Cardiology Guidelines on Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death, sudden cardiac death was defined as an unexpected, non-traumatic death occurring within the first hour of symptom onset or in the absence of witnesses when the deceased had been seen in good condition less than 24 hours before being found dead. In autopsied cases, it was defined as an unexpected natural death from an unexplained or cardiac cause.[1,2,3,4]

A wide range of diseases can cause sudden cardiac death,[5,6,7,8,9] and the prevalence varies depending on the demographics of the victims and the circumstances under which death occurs.[10] Common physiological effects of intense exercise, such as dehydration, electrolyte imbalance, increased adrenaline, and acid-base problems, can be dangerous for athletes who have electrical or structural problems in the heart, causing arrhythmias that can be fatal.[11]

In young athletes (<35 years), the main causes of sudden death are cardiomyopathies, cardiac channelopathies, and congenital coronary artery anomalies.[10,12,13,14,15,16,17,18,19]

Structural Cardiovascular Anomalies

- Hypertrophic cardiomyopathy
- Arrhythmogenic cardiomyopathy
- Dilated cardiomyopathy
- Coronary artery abnormalities
- Marfan syndrome
- Mitral valve prolapse
- Aortic stenosis

Electrical Cardiac Abnormalities and Channelopathies

- Wolf-Parkinson-White
- Congenital long QT syndrome
- Brugada syndrome
- Catecholamine polymorphic ventricular tachycardia
- Idiopathic ventricular fibrillation
- Congenital short QT syndrome

Acquired Cardiovascular Anomalies

- Myocarditis
- Commotio Cordis
- Severe trauma to the neck or nape of the neck
- Toxicology
- Hypo and hyperthermia
- Atherosclerotic coronary artery disease

Although sudden cardiac death is a rare event with a low incidence, it is a catastrophic event that, in the

vast majority of cases, leads to death. It is an event that can be avoided through prevention, and with proper treatment in the first few minutes, it can be successfully reversed. However, to act correctly, it is essential to understand the subject and, above all, its main causes in order to act correctly and effectively.

What are the leading causes of sudden cardiac death in young athletes, and how can early identification contribute to effective prevention of these events?

Aim

To analyze the main causes of sudden cardiac death in young athletes and highlight the importance of awareness and early detection as fundamental tools for prevention.

METHOD

This work is a systematic literature review that analyzes various studies and articles to compile the most relevant and up-to-date information on the main causes of sudden death in young athletes. It allows for the analysis of a large number of primary studies and a systematic review of the evidence, identifying patterns, which allows for an understanding of the risk factors and causes associated with sudden death in sports. It also allows for a critical assessment of the studies, providing a clear synthesis of the available evidence.

The search was conducted using search engines such as PubMed, SciELO, Google Scholar, and the Argentine Society of Cardiology website. The following filters were used: Review, systematic review, in the last 10 years. The following keywords were used: death, sudden, athletes, exercise, cardiac, causes, etiology, epidemiology.

After finding and analyzing the different materials obtained from the search, those that contained the necessary information for the investigation were chosen and the process of data extraction and synthesis for this investigation began.

The study population is composed of athletes between 14 and 35 years of age, whether competitive or recreational, of both sexes, and the sports included are basketball, American football, cycling, soccer, running, and rugby.

The inclusion criteria used were the following:

- Studies (systematic reviews and reviews) that address sudden cardiac death in young athletes.
- Studies that report causes, incidences and/or epidemiological characteristics.
- Studies published in the last 10 years.
- Exclusion criteria were age over 35, individual case reports without statistical analysis, opinion pieces, editorials, and letters to the editor.

RESULTS

Based on the results obtained, it was observed that the most frequent causes of sudden death in young athletes vary according to the region where the studies were conducted. This variation is mainly due to sociocultural factors that influence how a given society behaves and which sports they practice.

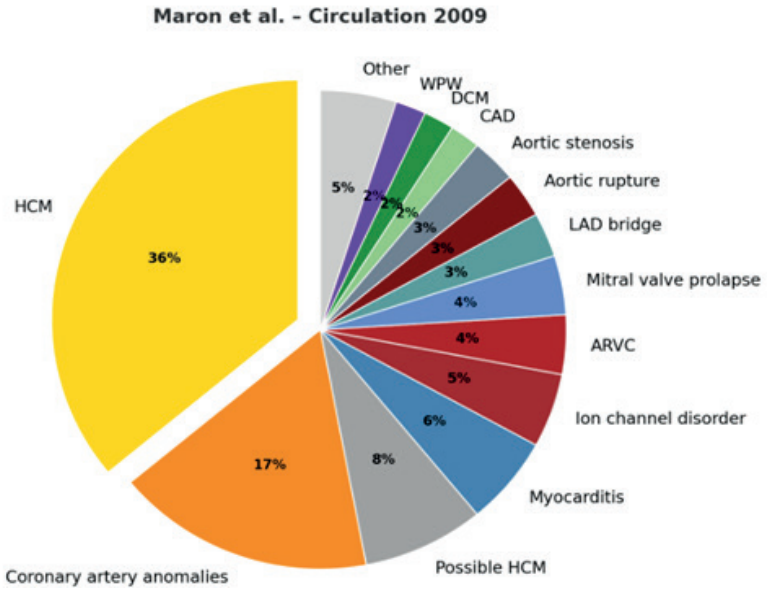

Figure 1. Results from Maron et al.[19]

According to Maron et al.[19] the following values were obtained:

- Hypertrophic cardiomyopathy: 36 %

- Congenital anomalies of the coronary arteries: 17 %
- Myocarditis: 8 %
- Arrhythmogenic right ventricular cardiomyopathy: 6 %
- Mitral valve prolapse: 4 %
- Aortic rupture: 4 %
- Aortic stenosis: 4 %
- WPW (Wolff-Parkinson-White): 3 %
- Channelopathies: 3 %
- Coronary Artery Disease: 2 %
- Dilated Cardiomyopathy: 2 %
- Others: 5 %

According to Corrado et al.[18]:

- Arrhythmogenic right ventricular cardiomyopathy: 23 %
- Coronary artery disease: 19 %
- Myocarditis: 14 %
- Hypertrophic cardiomyopathy: 12 %
- Pulmonary thromboembolism: 10 %
- Congenital anomalies of the coronary arteries: 8 %
- Dilated cardiomyopathy: 2 %
- Long QT: 2 %
- Others: 2 %

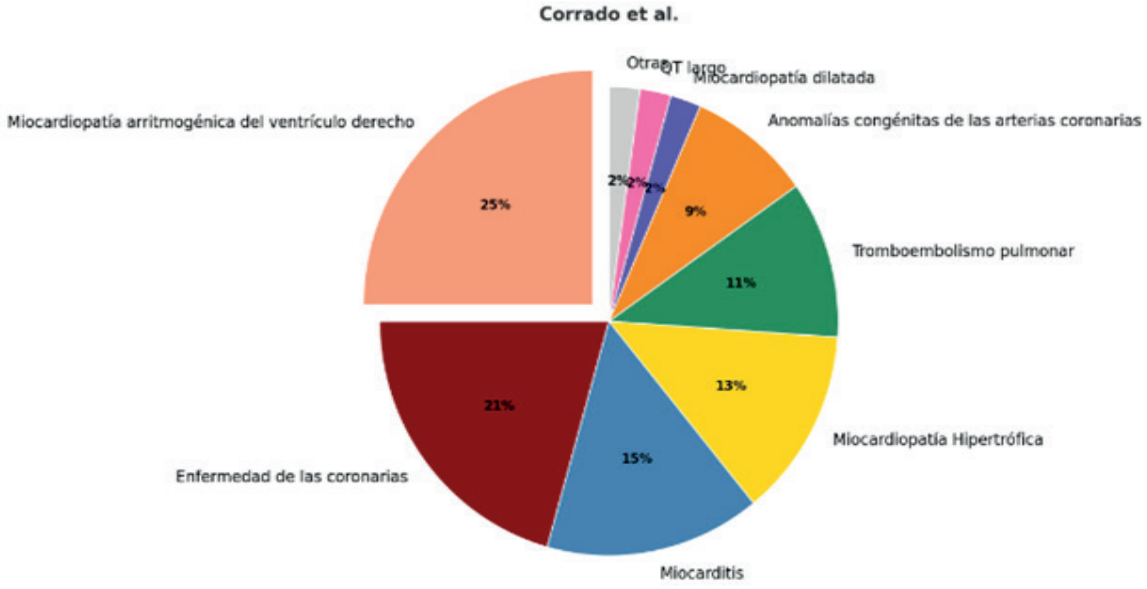

Figure 2. Results of Corrado et al.[18]

According to Harmon et al.[13]:

- SUD (Sudden Unexplained Death): 25 %
- Congenital anomalies of the coronary arteries: 11 %
- Myocarditis: 9 %
- Hypertrophic cardiomyopathy: 9 %
- Idiopathic left ventricular hypertrophy: 8 %
- Arrhythmogenic right ventricular cardiomyopathy: 8 %
- Coronary artery disease: 5 %
- Dilated cardiomyopathy: 3 %
- Aortic dissection: 3 %
- WPW (Wolff-Parkinson-White): 2 %
- Long QT: 2 %
- Commotio cordis: 1 %

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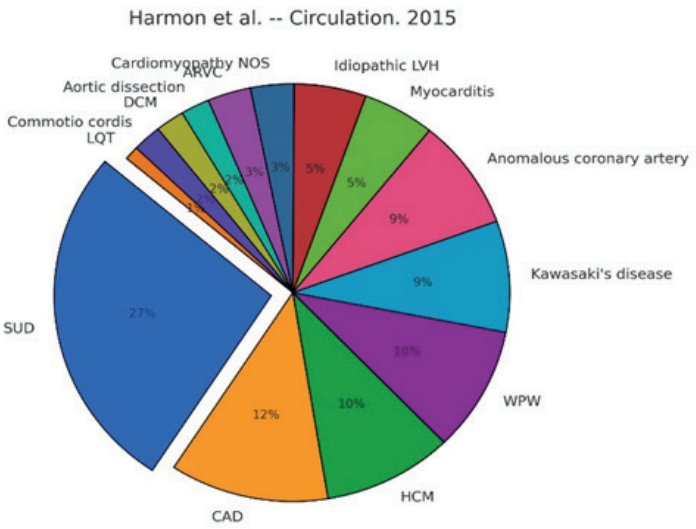

Figure 3. Results from Harmon et al.[13]

According to Finocchiaro et al. [10] :

- SADS (sudden arrhythmic death syndrome): 42 %
- Idiopathic left ventricular hypertrophy: 16 %
- Arrhythmogenic right ventricular cardiomyopathy: 13 %
- Congenital anomalies of the coronary arteries: 12 %
- Myocarditis: 6 %
- Hypertrophic cardiomyopathy: 5 %
- Dilated Cardiomyopathy: 2 %
- Others: 1 %

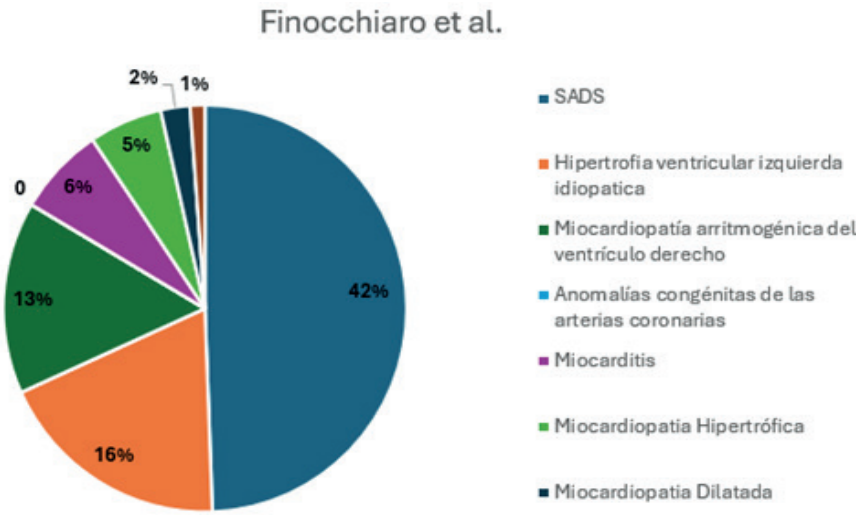

Figure 4. Results of Finocchiaron et al.[10]

DISCUSSION

As can be seen from the results obtained, these vary depending on the region and population in which the studies were conducted. Furthermore, we can observe a certain discrepancy between the most recent studies and the more classic ones, but this is likely related to how each country and region conducts studies and diagnoses for this specific population.

We can observe that, in young athletes, the main causes of sudden death are congenital anomalies of the coronary arteries, cardiomyopathies, and electrical abnormalities.

Within the group of cardiomyopathies we have hypertrophic cardiomyopathy (HCM), which is characterized by left ventricular hypertrophy that cannot be attributed to load alterations (such as hypertension or valvular disease).[20,21,22] HCM is caused by a mutation in the genes that encode myocytes.[23] Historically, it is known as the main cause of sudden cardiac death (SCD) in patients under 35 years of age; according to Maron et al.,

HCM was responsible for 36 % of sudden cardiac death cases.[18] On the other hand, in a very similar study by Finocchiaro et al., HCM was diagnosed in only 5 % of SCD cases.

We have arrhythmogenic right ventricular cardiomyopathy (ARVC), which is a genetic disease that causes the replacement of the myocardium by adipose or fibroadipose tissue, which occurs most frequently in the right ventricle, but can affect the left ventricle or both.[24,25,26,27] According to Corrado et al., this pathology corresponds to 23 % of SCD cases, but, on the other hand, for Maron et al. it corresponds to only 6 % of SCD cases.

Anomalous origin of the coronary arteries, which according to the Texas Heart Institute is defined as a defect in one or more of the coronary arteries of the heart and may be related to the origin or location of the coronary artery. [28,29,30] The mechanism that generates SCD is a ventricular arrhythmia triggered by ischemia due to compression of the coronary artery.[31,32,33] According to data obtained by Maron et al., anomalous origin of the coronary arteries corresponds to 17 % of SCD cases, but for Corrado et al. this entity corresponds to 8 % of SCD cases.

Myocarditis is defined as an inflammation of the myocardium diagnosed by histological, immunological and immunohistochemical criteria.[34,35,36,37,38] Its main origin is infections, within the infections the viral ones are the most frequent, but myocarditis can also be generated by drugs, toxic substances and autoimmune diseases.[39,40] According to Corrado et al. myocarditis was the cause of SCD in 14 % of cases, on the other hand, Finocchiaro et al. obtained a number of 6 % of SCD cases due to myocarditis.

CONCLUSIONS

After analyzing the data obtained, it was concluded that these vary according to the region and the population analyzed. Furthermore, the complexity of evaluating cases of sudden cardiac death directly influences the number of studies and research available on the topic, primarily studies based in Latin America and Argentina. This is a topic that deserves special attention in our country. With greater education on the subject, early diagnosis, and increased surveillance, we can ensure that cases of sudden cardiac death in young athletes continue to decrease.

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FINANCING

None.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORSHIP CONTRIBUTION

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