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Sudden Cardiac Death in Athletes

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Abstract: ***Background:*** **Sudden cardiac death (SCD) is a main leading cause of death in athletes. It is an unexpected and life-threatening event that occurs suddenly and even without any clinical presentation. Usually, it occurs due to malfunction in electro-physiology of the heart or if the athlete has an underlying cardiac condition, which leads to ventricular arrhythmias immediately post vigorous exercise or training. It is most common in recreational or competitive sports and has higher incidence of cases in younger athletes (<35 years) and older athletes (> 35years) with an underlying cardiac condition. Though it has a rare chance of occurrence, but it can have a crucial impact on the sports community. In efforts to anticipate sudden cardiac death in athletes, highly recommended preventive measures such as pre-participation screening are used. The present review of literature includes the causes, epidemiology, pathophysiology and preventive measures to avoid sudden cardiac death among athletes.**

Methods: **Multiple database and search engines such as Google scholar, PubMed and Scopus were used to search for relevant literature with the keywords such as sudden cardiac death, athletes, sudden cardiac arrest, adaptations to exercise, causes and prevention of SCD.**

Results: **From the reviewed literature, cardiac causes were found to be the main source of SCD. However, causes other than cardiac ones, and vigorous exercise were also found to be a major factor for SCD. Higher incidence was observed in cases with a coexisting cardiac issue. Both young and old aged athletes were found to be affected by SCD.**

Conclusion: **SCD incidence varies among athletes according to their age, sex or type and intensity of sports. Preventive measures such as pre-participation screening (PPS) are highly recommended for athletes.**

Keywords: Athletes, Sudden cardiac arrest, Sudden cardiac death, Sports-related death, Vigorous exercise.

I. Introduction

Sudden cardiac death (SCD) in athletes is an unfortunate and threatening episode that occurs during or immediately exercises [1]. It is a major leading cause of death in athletes [2]. SCD presents as an unexpected and lifethreatening episode that occurs suddenly without any warning signs and symptoms. It has a rare chance of occurrence, but it can have a crucial impact on the sports community on a widespread scale [3].

It usually occurs when there is a malfunction in the electro-physiology of the heart, resulting in arrhythmia, followed by sudden loss of responsiveness and abnormal breathing. With disrupted pumping action of left ventricle of heart, the heart is not able to pump blood to the tissues, muscles, organs and whole body [4]. As a result, body does not receive enough amount of oxygen as per athlete's body demand during sports activity or while performing exercise training [5]. As a result, a sports person gets faint without any pulse. Death ensues in a very short span (within minutes) if the survivor doesn't get immediate medical aid.

Numerous factors have been found to be responsible for SCD among athletes, even among those who appear asymptomatic. Both cardiac and non-cardiac causes have been found to be directly associated with SCD. The common factors include hypertrophic cardiomyopathy, abnormalities of coronary arteries, cardiomyopathies, heart failure, valve disease, congenital heart disease and inherited conditions such as long QT syndrome [6]. Non-cardiac causes of SCD in athletes include cerebrovascular accident, drug abuse, severe disturbance of electrolytes in body, massive pulmonary embolus, aortic dissection, severe hypoglycemia and other metabolic disorders. However, cardiac-related conditions or causes remain the primary concern.

In efforts to anticipate SCD in athletes, pre participation screening (PPS) must be done to enhance and strengthen the awareness about alarming signs and symptoms. PPS involves medical evaluations, including a detailed subjective and objective assessment involving personal, family medical history, physical examination, some additional tests like electrocardiograms (ECGs) or echocardiograms, if found required during the examination. PPS allows to detect even for conditions previously not diagnosed. Regular basis re-examination or re-evaluation is significant to identify any

anomalies in an athlete's heart status [7]. The present review is undertaken to find the underlying causes, epidemiology and preventive measures for developing SCD.

II. Etiology and Pathophysiology

It is essential to have a knowledge about the causes or risk factors of SCD in athletes for reducing the risk of SCD [2].

Etiological factors behind sudden cardiac death can be categorized as given below:

- Cardiac Causes
- Non-Cardiac Causes

Cardiac causes include coronary artery disease (CAD), coronary artery vasospasm, and anomalous coronary origin, cardiomyopathies, heart failure with ejection fraction less than 30% of left ventricle, valve disease such as aortic stenosis and mitral valve prolapse, inherited channelopathies as well as congenital heart disease such as tetralogy of fallot (TOF) [8] (Fig. 1). In most cases of SCD in athletes, an underlying cardiac cause and malfunction of electro-physiology of heart is reported [9].

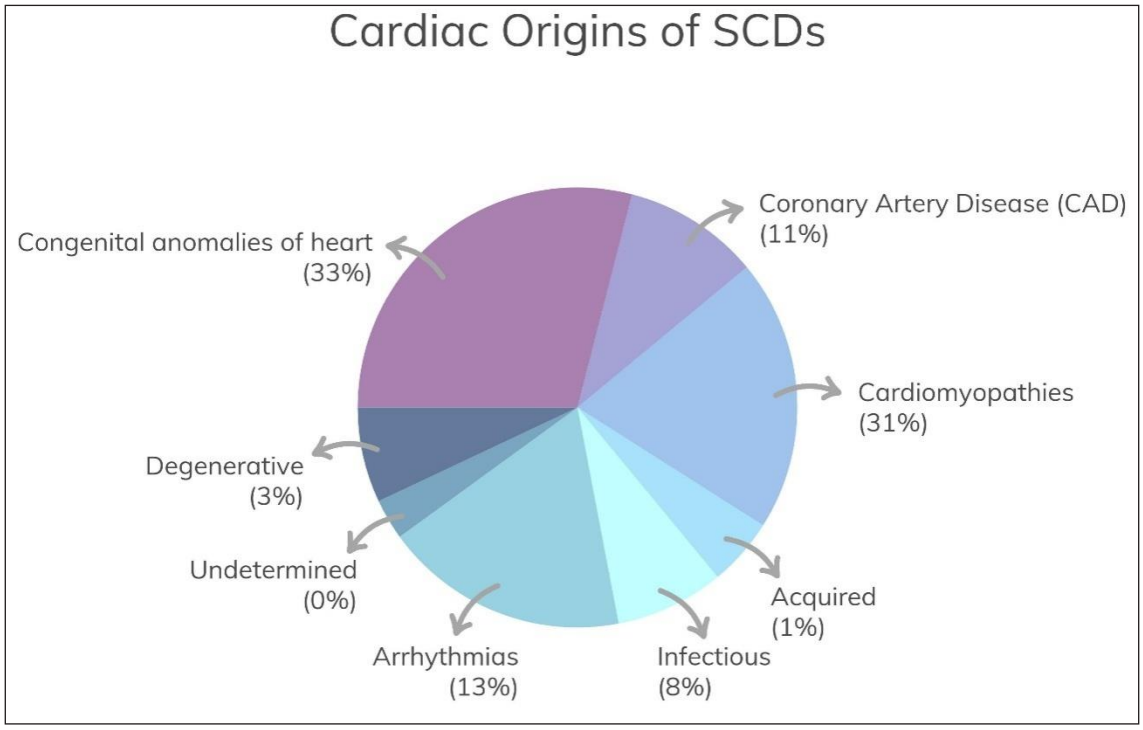

Fig. 1: Common Cardiac Causes of SCDs [10]

Non-cardiac causes of SCD includes dehydration, adrenergic surge, severe imbalance of electrolytes and acid/base disturbance. These may cause fatal arrhythmias in individuals with an underlying electrophysiological malfunction, structural or genetic pathology of heart. Other non-cardiac causes accounted for SCD include drug overdose, metabolic disorders such as severe hypoglycaemia, respiratory causes such as massive pulmonary embolus and neurological causes such as cerebrovascular accident.

Vigorous exercise training can be a contributing factor to SCD in athletes as cardiac output gets high which lowers the heart rate (30 beats per minute) and oxygen demand also gets higher in athlete's body in comparison to normal individual [11]. According to regular exercise training and participation in sports, an athlete's heart gets adapted to physiological changes of heart i.e. left ventricular hypertrophy of heart occurs [12-14]. So, there is great load on left ventricle during pumping action while performing vigorous exercise training for prolonged time periods. This can create sudden overload on left ventricle leading to SCD in athletes [15].

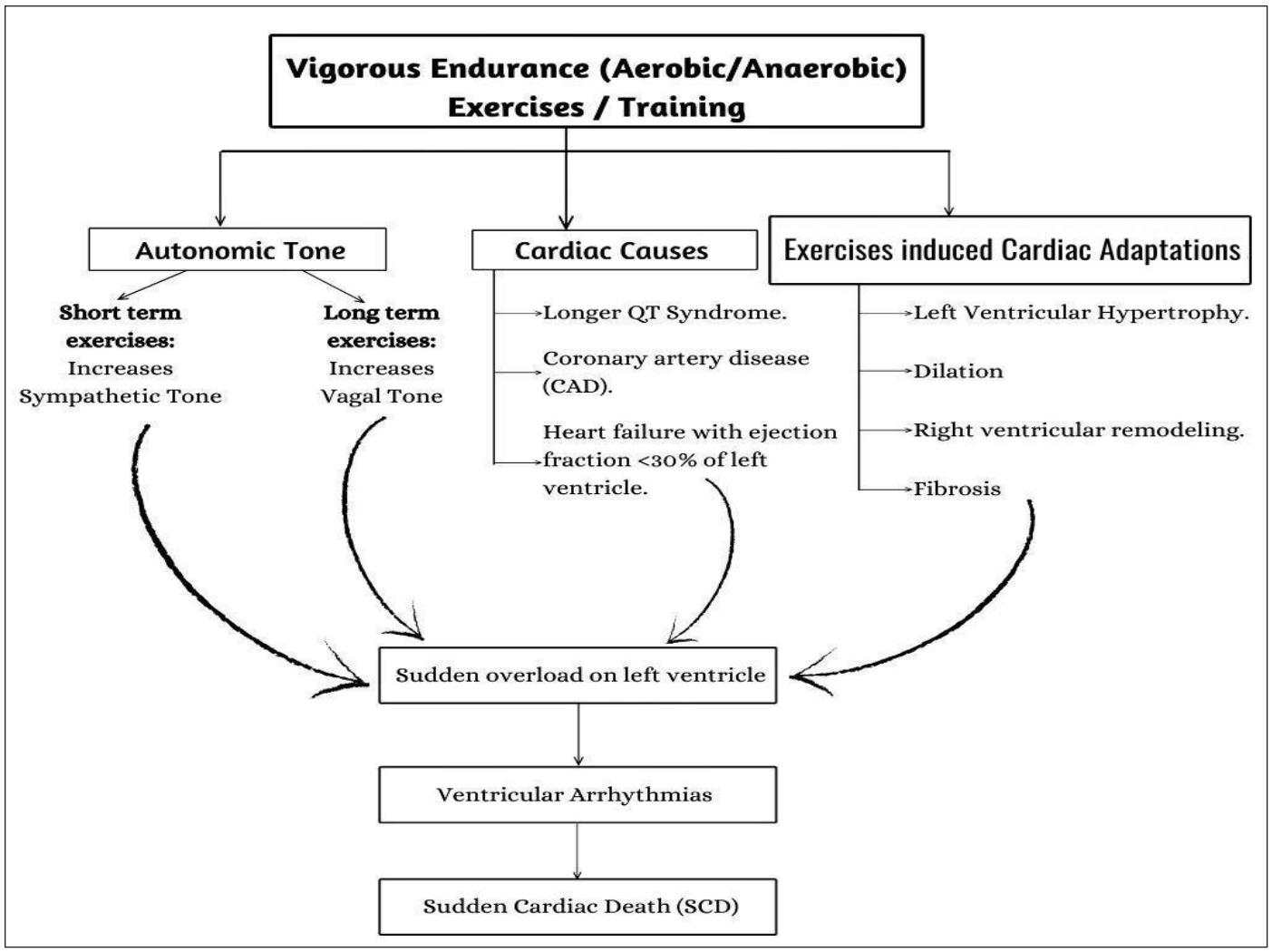

Fig. 2: Pathophysiology of SCD

III. Epidemiology

Regular exercise or training has been related to minimizing the cardiovascular events ina large number of the studies. At the same time, in spite of several advantages, the risk of SCD increases during and after vigorous exercise or training. The relation between vigorous exercise or training and SCD has been reported in both general population and athletes. The percentage of SCD in relation with vigorous exertion ranges widely, ranging from 3% to 26%, relying on factors such as age, sex, intensity, type of sports. Commonly, the percentage of SCDs found during vigorous exertion is relatively higher in younger age groups i.e. 39% in less than 18 years of age, 13% in young adults i.e. 19-25 years of age and 7% in older adults i.e. 26-35 years of age [16]. Higher incidence also gets noted among older adults (>35 years) due to an underlying cardiac condition.

IV. SCD Incidence in Relation to Age

A higher incidence of SCD is seen with increase in age during competitive and non-competitive sports. Recent years have seen older athletes (age >35 years) participating in competitive sports [17]. For instance, in 2013, USA reported 54% of the competitive running race participants were older (>35 years of age). The estimated incidence of SCD was 0.47-1.21/100,000 person years in young age (<35 years) competitive athletes compared to 6.64 per 100,000 persons years in older age (>35 years) competitive athletes [18]. In high school athletes aged 12 to 19 years, the incidence was lower: 0.24 per 100,000 athlete years [19]. So, the incidence of SCD is remarkably higher in older athletes than younger ones.

V. SCD Incidence in Relation to Intensity of Exercise/Training

A high intensity of exercise/training may lead to developing fatal arrhythmias if there is presence of an underlying cardiac condition. It has been concluded through various studies that vigorous exercise performed by competitive athletes compared to recreational ones, has the capacity to lead to a higher incidence of SCD. A study showed a rate of 1 per 100,000 SCDs among competitive athletes compared to 0.32/100,000 in those practicing recreational sports [20]. Another study reported a relative risk of 3.6 SCD in high school athletes compared to their sedentary mates [21]. The occurrence is higher in sports requiring vigorous exertion and increased physical demands due to the dynamic and static nature of these sports as shown in Table I [22].

Table I: Nature of Sports and Physical Demands of IT

Examples	*Low Isotonic*	*Moderate Isotonic*	*High Isotonic*
Low Isometric	Golf	Volleyball	Soccer
Moderate Isometric	Equestrian	Running Sprint	Basketball
High Isometric	Gymnastics	Downhill Skiing	Cycling

VI. Incidence of SCD Related to Type of Sports

The type and nature of sports may lead to fatal arrhythmias in competitive athletes. For instance, in US, highest incidence of SCD has been reported in basketballers due to its demanding nature whereas in Europe, highest incidence was seen in football players [23-25]. According to a study, the incidence of SCD among football players was 6.8 per 100,000 athlete years [26]. An Italian study reported that 45% of SCD occurred among athletes while playing football, with a relevant percentage i.e. 39% reported in Israel [27, 28].

Sports related SCD accounts for a consequential percentage of SCDs in younger age groups, with a higher episode in competitive athletes in comparison to non-athletes, mainly in an age group under 35 years old. Even with the higher episodes of vigorous exertion related SCDs in competitive athletes, the total numbers are higher during recreational sports such as Basketball, Football, American Football, Cycling, Marathon Running, Swimming, Skiing, Weightlifting, Volley-Ball, Gymnastics, Equestrian, Golf, Soccer and Running Sprint [29-42].

Prevalence of all of the above listed recreational sports is due to vigorous exertion and underlying cardiac causes or risk factors. SCDs reported cases in following type of competitive or recreational sports shown in Fig. 3 which shows that ball sports and running are the largest affected groups [43].

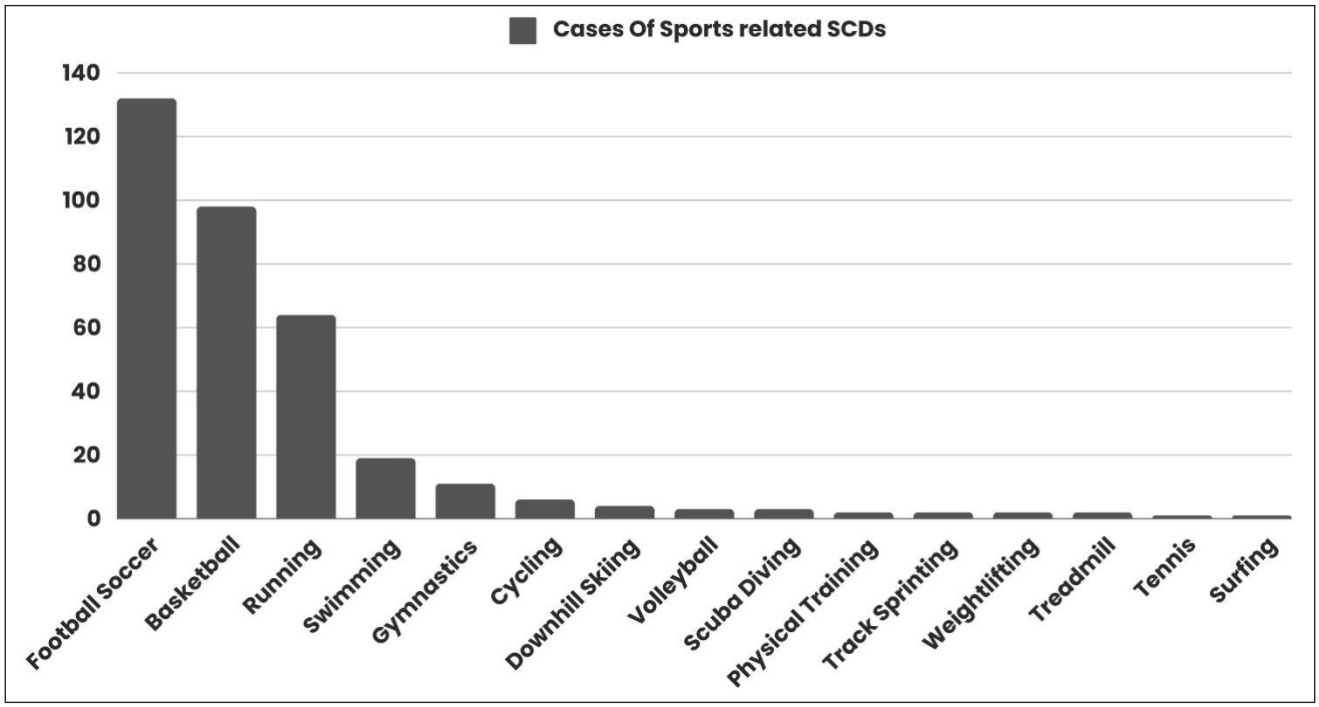

Fig. 3: Reported Cases of Sudden Cardiac Death in Different Sports

Acute myocardial infarction (AMI) can also occur with a greater frequency during or post period of vigorous exertion which accounts for 4.4% to 13.6% especially in men over an age of 30 years old, whereas exercise related SCDs are often associated with cardiac and non-cardiac causes or risk factors which accounts for 2% to 4% [16].

Overall, the regular exercise or training has significant long term cardiovascular benefits but there are also risks associated with vigorous exercise or training particularly in susceptible populations such as competitive athletes and older adults over an age of 35 years old [44].

VII. Preventive Measures

While considering vigorous exercise or training related SCDs, an individual should know about the risks associated with vigorous or high intensity exercise or training in addition to the advantages of regular physical activity. Regular physical exercise or training plays a crucial role for preventing health related conditions and decreasing overall mortality risk as per WHO and American Heart Association (AHA) guidelines. These organizations recommend particular frequency, intensity and duration of aerobic exercise per week. Adults aged 18-64 years, should be involved in not less than 150 minutes of moderate intensity of aerobic exercise or 75 minutes of vigorous intensity of aerobic exercise [45].

For addressing the risk of adverse episodes like SCDs during physical exercise or training, additional recommendations are needed to identify an individual at more risk during exercise or training. Various studies indicate that more than half of the middle aged individuals who suffered SCD episode exhibit alarming symptoms upto four weeks before the fatal event.

PPS is highly recommended by organizations such as AHA, European Society of Cardiology and the International Olympic Committee, as the most effective preventive method for SCD event. PPS involves assessment of individual's risk factors and educating them about performance goals and safe exercise practices. The screening basically includes family history, physical examinations and electrocardiograms (ECGs) for young individuals and assessing risk factors such as blood pressure, cholesterol levels and smoking history for adults [7]. Moreover, it is recommended that high risk individuals for cardiac events (especially elderly and middle aged individuals) undergoing moderate to vigorous exercise should have annual follow-ups and tests such as maximal exercise testing and other cardiac examinations such as electrocardiograms (ECGs). This comprehensive preventive strategy aims to ensure safe exercise participation and eliminate the risk of adverse cardiac events especially SCDs [44].

VIII. Discussion

Physical activity promotion is done in society for good physical and mental health. Healthcare professionals and education systems encourage the population to be active in sports. However, the increasing risk of exercise and sports related SCD has to be considered. A vigorous exercise training and competition associated with higher cardiovascular demands, increases the risk for athletes having underlying cardiac condition. For SCD, the ball games (football, basketball) and running are the largest affected sports probably due to their popularity and large group participation. Hence, these have the highest risk. The sports with the highest cardiovascular demands and an isotonic work remain therefore to be more at risk of SCD, but because of a smaller number of participants, have a smaller absolute number of SCD.

In view of suspicious and alarming signs and symptoms, athletes, coaches, and medical professionals should be educated and made aware about some of the symptoms that may denote a primary cardiac condition. These can involve angina pectoris or unease during exercise, sudden fainting, near-fainting, altered or irregular heartbeat (arrhythmia) and predisposing factors such as a family history of SCD or cardiac conditions.

Immediate identification and appropriate management are crucial to minimize the risk of SCD in athletes. Prompt access to automated external defibrillator (AED) at sporting fields, accompanied with cardiopulmonary resuscitation (CPR) team and emergency medical assistances on time, can remarkably improve survival rates in SDC [46]. It is must to recognize that SCD in athletes is a life threatening episode, the overall risk remains comparatively low for the athletes than the general population. Due to the benefits of regular exercise training, physical fitness, and regular participation in sports [14].

IX. Conclusion

Sudden Cardiac Death in athletes is an unfortunate and life threatening event that can be prevented by identifying the risk factors associated with it. Hence, screening methods such as pre participation screening should be used in routine to avoid the risk. Thus, pre-participation screening (PPS) is highly recommended as an effective strategy in preventing SCDs and aims to ensure safe exercise participation and eliminate the risk of SCDs.

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