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## **Sudden Cardiac Arrest during Participation in Competitive Sports-systematic Review**

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### **Highlights:**

- \*The introduction of screening tests such as ECG enables early detection of heart diseases, which in the future may contribute to sudden cardiac arrest in athletes.
- \*In sudden cardiac arrest, the most important factor is time, the sooner help is provided, the greater the probability of recovery.
- \*Intensive training causes many changes in the athletes' bodies, including the reconstruction of the heart muscle.

### **Abstract:**

**Introduction:** Sudden cardiac arrest during sporting events always arouses strong emotions. No one expects that sudden cardiac arrest could occur in a young, athletic person. There are about 90 cases of sudden cardiac arrest in Poland every day. It may seem that mainly elderly, sick people are at risk of sudden cardiac arrest. Theoretically, this problem should not concern young, athletic people who take part in sports competitions. Numerous screening tests and check-ups should eliminate the risk of sudden cardiac arrest in athletes, but the reality is different. The aim of the following paper is to review the literature on cardiac arrests in athletes during sporting events.

### **Material and methods:**

We have gathered the available materials and scientific reports, analyzing and summarizing them in a single study

**Aim of study: Study objective:** The aim of our study was to summarize the latest knowledge on sudden cardiac arrest in athletes during sports events.

**Conclusions:** Screening tests reduce the incidence of sudden cardiac arrest in athletes. The most common cause is previously unrecognized heart defects - hypertrophic cardiomyopathy.

Football players are most at risk of sudden cardiac arrest. The most important factor influencing survival in sudden cardiac arrest is time

### **Introduction:**

Sudden cardiac arrest, or an unexpected cessation of the heart's hemodynamic function. There are four rhythms of cardiac arrest: two defibrillatory rhythms: ventricular fibrillation, pulseless ventricular tachycardia, and two non-defibrillatory rhythms: asphyxia and pulseless electrical activity of the heart. In each case of cardiac arrest, it is important to start resuscitation as soon as possible. To increase the chances of survival of a patient who has a cardiac arrest in a defibrillatory rhythm, defibrillation should be performed as soon as possible. It is estimated that the probability of survival decreases by 10% per minute of a patient who has ventricular fibrillation. There are about 90 cases of sudden cardiac arrest in Poland every day. It may seem that mainly elderly, sick people are at risk of sudden cardiac arrest. Theoretically, this problem should not concern young, athletic people who take part in sports competitions. Numerous screening tests and check-ups should eliminate the risk of sudden cardiac arrest in athletes, but the reality is different. The aim of the following paper is to review the literature on cardiac arrests in athletes during sporting events.

### **Risk of sudden death in athletes:**

It has been proven that competitive sports practice increases the risk of sudden cardiac arrest. A group of people practicing recreational sports, competitive sports, and people who did not practice any sports were compared. [21] The results of a French study from 2011 show that the risk of sudden cardiac arrest in professional athletes is 4.5 times higher compared to people of the same age who practiced sports for recreational purposes. [22] On the other hand, Italian researchers published a study that was conducted in the province of Veneto. The population of that area is about 4 million people, of which over 40 thousand residents aged 12-35 declared that they practiced sports. [23] Based on research conducted in the USA, the conclusions were obtained that the risk of sudden cardiac arrest in a young, actively training athlete is 3.5 times higher than in a person of the same age who does not practice sports. It has been estimated that a sudden cardiac arrest occurs every 3 days in the United States, or 1-2/100,000 athletes per year.[24,25]

### **Adaptive changes, heart remodeling in athletes:**

The athlete's body is exposed to increased physical effort. Cardiac arrhythmias were studied in actively training individuals. The place where conduction disorders most often occur is the right ventricle. Long-term effort leads to a temporary deterioration of the right ventricular contractility, which results in an increase in the level of necrosis markers. Computed tomography and magnetic resonance imaging are helpful in conducting research. Imaging studies make it possible to assess the fibrosis of the heart tissue. It has been proven that competitive athletes more often experience fibrosis of the left ventricular muscle, which results in a decrease in heart contractility. [26]Experiments were conducted on rats, which proved the

effect of intensive effort on the remodeling of the heart muscle, which in turn caused arrhythmias. [27] Competitive athletes diagnosed with complex arrhythmias were analyzed. The data show that 20% of them suffered from sudden cardiac arrest. In most of them, as many as 89%, damage to the right ventricle was found. [28]

### **Causes of SCA in athletes:**

Athletes who have suffered SCA have been divided into two groups: competitive sports such as (racing or football) and non-competitive (weight training in the gym, running). It has been proven that athletes who practice competitive sports, during which there is a high level of endurance effort, which is associated with the release of adrenaline, are most at risk of SCA. [1] The causes of SCA in athletes can be divided into: cardiological, non-cardiac. It has been established that the main cause of SCA in athletes aged 16-35 was structural heart defects such as hypertrophic cardiomyopathy, arrhythmogenic right ventricular dysplasia, congenital abnormalities of the coronary arteries, while in people aged 35-40 it was coronary artery disease. [2,3,29] In most cases of SCA, it is impossible to determine the cause. It is estimated that structural heart diseases are responsible for 60-95% of SCA. The studies were conducted in the USA and Italy. [4,5] In young baseball athletes under the age of 16, the most common cause of cardiac arrest is considered to be traumatic - Commotio cordis. Cardiac contusion, or blunt trauma to the precordial area, which leads to ventricular fibrillation. This most often occurs during a collision of players running towards the ball or by a strong blow with a small object.[6]

### **Changes in the structure of the heart of competitive athletes:**

The heart of athletes who train intensively undergoes transformations under the influence of intensive training. In an unknown number of athletes, the development of the so-called "athlete's heart" has been proven. This type of physiological cardiac hypertrophy and mild forms of hypertrophic cardiomyopathy (HCM), the most common genetic disease of the cardiovascular system, overlap with a frequency of 0.2%. HCM is caused by mutations in 14 genes encoding sarcomere proteins. In the literature, as many as 50% of cases of sudden cardiac death (SCD) in younger athletes have been associated with hypertrophic cardiomyopathy. It is therefore the most common cause of SCD in well-trained young athletes. Due to this data, there is great interest in distinguishing between these two diagnoses[7]

More than 80% of athletes with sudden cardiac arrest have no symptoms before the cardiac arrest, which often occurs during intensive training or competition. It has been proven that cardiomyopathy is the main cause of SCA in young athletes. [8,9] Most athletes, or more precisely  $\frac{2}{3}$ , practiced sports in which they performed dynamic movements. [10]

Hypertrophic cardiomyopathy is an asymmetric hypertrophy of the septum with a maximum left ventricular wall thickness of  $\geq 15$  mm in adults or  $> 9$  Z points ( $> 2$  Z points in adolescents and children). [11] A group of athletes suffering from hypertrophic cardiomyopathy was examined and it was noted that their ECG showed T wave inversion. [12]

### **Early diagnosis of sudden cardiac arrest in athletes:**

It is estimated that the incidence rate of sudden cardiac arrest is 1:50,000 of all deaths.

It may seem that the problem of sudden cardiac arrest does not concern young, potentially healthy, athletic people. Athletes are subjected to screening tests and examinations that should eliminate the risk of cardiac arrest during sports competitions. Unfortunately, it is not always possible to detect all health problems that will later contribute to sudden cardiac arrest. Cardiac arrest in athletes during major sports events always arouses great emotions.

In the case of cardiac arrest, the most important factor that increases the chances of survival and recovery is time. It is worth mentioning the chain of survival. This is a scheme, the fulfillment of which of the subsequent stages increases the probability of survival of the person suffering a sudden cardiac arrest. The first three stages of the chain of survival depend on witnesses to the event, which is why it is important to educate the public about resuscitation[13]. Quickly starting cardiopulmonary resuscitation increases the chances of recovery of the person suffering a sudden cardiac arrest. This is perfectly illustrated by the case of sudden cardiac arrest during EURO 2020, which occurred in one of the Danish national football team players. The quick response of teammates and medical services meant that the player survived and returned to professional football training.

Numbers:

Sudden cardiac arrest is the leading cause of death in Europe. It affects approximately 350,000-700,000 people annually.[13] Every 45 seconds in the European Union countries, a sudden cardiac arrest occurs, the mortality rate of SCA is high at 95%. CPR by bystanders can save 100,000 people per year. [14]

For every 100,000 athletes who experience SCA worldwide, 0.6–2.85 athletes die. It has been proven that athletes are most at risk of SCA.

In the USA, the incidence of sudden cardiac arrest in young athletes was studied for 4 years. Over the 4 years, there were 331 sudden cardiac arrests, of which 158 survived, most were basketball players. The most common cause was hypertrophic cardiomyopathy. Coronary anomalies occurred in younger athletes.[15,16]

### **Death on the pitch:**

Competitive sports are associated with injuries, in team games there are often collisions between players, which can lead to falls. When the referee is close to the collision, he can easily assess the situation and stop the game so that the medical services can help the injured person.

One study analyzed six cases of sudden cardiac arrest in football players actively involved in the match. They were not injured before fainting. Two players fell to a sitting position. One player fell to his knees. One of the athletes walked to the side of the pitch and tried to sit up. Eventually, each of the four athletes lay on his back with his arms at his sides. The other two athletes fell face down. All six athletes had their eyes wide open and their pupils fixed. [17]

It is worth considering what can be done to reduce the number of sudden cardiac arrests during sports competitions. The introduction of screening tests for hypertrophic cardiomyopathy in young athletes in Italy contributed to a significant decrease in the number of cardiac deaths due to this cause. [18]Performing an electrocardiogram (ECG), echocardiography, and magnetic resonance imaging of the heart are helpful, but they are 100% effective in detecting athletes at risk of sudden cardiac arrest. It has been proven that athletes

who have suffered SCA have a 50-60% survival rate within 30 days. Survival factors were determined by previous screening tests. [19] In 2017, a study was conducted in the USA to check the state of knowledge of CPR among high school students. More and more students are undergoing CPR training. The results of this study show the need for standardization of CPR training, which could lead to increased CPR and survival rates for people after sudden cardiac arrest throughout the USA. [20]

In addition to the interview and medical examination, the athletes' family histories were analyzed. Each athlete underwent an ECG, the results were analyzed by cardiologists from the Center of Sports Medicine in Padua. Thanks to the ECG tests, 4,000 athletes were referred for further tests, 0.9% of them were diagnosed with heart disease, which disqualified them from further professional sports. The introduction of screening tests among athletes resulted in a 10-fold reduction in the mortality rate due to heart disease among athletes in Veneto.[29]

### **Conclusions:**

Screening tests reduce the incidence of sudden cardiac arrest in athletes. The most common cause is previously unrecognized heart defects - hypertrophic cardiomyopathy. Football players are most at risk of sudden cardiac arrest. The most important factor influencing survival in sudden cardiac arrest is time.

### **Authors contribution:**

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Consequently, there are no databases or data accessibility to outline. The details and conclusions presented in this review are derived from previously published studies, which can be accessed through their respective sources as mentioned in the references section.

Conflict of interest: The authors declare no conflict of interest

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