SUDDEN DEATH IN FOOTBALL

Football (soccer) is the most widely practiced sport worldwide. The highest governing body of football, FIFA (Fédération Internationale de Football Association), estimates that 265 million people participate in football at different levels. Given the high number of participants in different populations and age groups, sudden death (SD) is purely statistically to be expected. The risk for such a tragic event is especially high when apparently healthy athletes are unaware of their underlying cardiovascular disease and repeatedly expose themselves to high-intensity intermittent exercise such as football. In addition to cardiac related deaths (SCD/SCA), SD include traumatic deaths, which can be caused by unfortunate collisions between two players (high-impact-trauma) or seemingly minor injuries from the ball, such as a blow to the chest (low-impact-trauma). Recognizing the emergency situation and immediate initiation of cardiopulmonary resuscitation (CPR) are essential to saving an athlete’s life. Football is the sport which has taken the issue of exercise-related SD very seriously and has already launched a series of preventive measures.

CAUSES OF SUDDEN DEATH

Cardiovascular causes

In a large proportion of cases, the cause of SD is cardiovascular. The SD-associated structural abnormalities mainly include hypertrophic cardiomyopathy (CM), dilated cardiomyopathy (DCM), arrhythmogenic right ventricular cardiomyopathy (ARVC), non-compaction cardiomyopathy (NCM), coronary artery anomaly (CAA), valvular heart disease, myocarditis, myocardial fibrosis, and coronary artery disease. In contrast, a structurally normal heart may also be the substrate of malignant arrhythmia leading to SD. Some examples of these electrical heart diseases are inherited channelopathies such as long QT syndrome (LQTS), short QT syndrome (SQTS), Brugada syndrome and catecholaminergic polymorphic ventricular tachycardia (CPVT). Furthermore, an accessory electrical conduction pathway, a rare condition known as Wolff-Parkinson-White Syndrome, can lead to SD by preexcitation of the heart with the risk of inducing ventricular fibrillation.

Trauma-related causes

Due to the nature of football, with high-intensity sprints, quick changes of direction and hard tackles, life-threatening injuries are possible. In a large registry of young competitive US athletes, it was shown that in football 10% of all SDs resulted directly from blunt trauma. Among team sports, only American football reached a higher proportion of traumatic deaths, with 25% of all SDs. Apart from these high-impact traumas, low-impact traumas are also described for ball sports. A blunt blow to the chest without structural damage to the heart or chest wall can cause ventricular fibrillation during the repolarization phase of the cardiac cycle. This phenomenon is called commotio cordis (CC) and has been observed in sports with high projectile velocities such as ice hockey, lacrosse, baseball, and softball. Nevertheless, air-filled balls, such as footballs, were presumed to be safer because of their propensity to collapse. In a large CC registry, football, basketball and tennis were rarely implicated in projectile-related deaths. However, CC can also occur in a duel when a fist, shoulder or elbow blow is delivered to the chest.

SYSTEMATIC RECORDING OF SUDDEN DEATH IN FOOTBALL

Knowledge about SD in football was for a long time based on single case reports or a subgroup of national registries without football-specific analysis. Therefore, under the auspices of FIFA, the Institute of Sports and Preventive Medicine of Saarland University (Saarbrücken, Germany) implemented the first football-specific SD registry (FIFA SDR) in 2014 to capture cases of SD in worldwide amateur and professional sports.
football. The focus of this ongoing study is on both identifying the causes of SD and investigating the resuscitation measures implemented. The first results of the FIFA-SDR have previously been published4.

**FIFA SUDDEN DEATH REGISTRY (FIFA-SDR)**

**Methods**

The detection of worldwide SD cases was achieved through (I) an online reporting form (Fig. 1) translated into 11 languages for players, staff and other potential eyewitnesses of an SD case, (II) data synchronization with other institutions recording SD cases (19 FIFA Medical Centres of Excellence, 16 national SD registries, 2 SD foundations, and (III) a professional press monitoring (covering 238 countries, crawling on 3.1 million articles per day). The inclusion criterion was that SD occurred during a football-specific activity or up to 1 hour thereafter and that sufficient medical records or autopsy reports were available to research each case. The circumstances of resuscitation were examined with respect to timing, first responders, and the availability of an AED on the pitch.

**Results**

**Overview**

Over a 5-year period (2014-2018), a total of 617 cases of SD (mean age 34±16 years, range 5-76 years, 96% men) from 67 countries were captured, of which 142 (23%) cases survived (SCA). The vast majority of cases occurred at amateur level (95%), and only a small fraction at professional level (5%).

In 211 of 617 cases (34%) a definite diagnosis was possible on medical records (n=87) or autopsy reports (n=124). The distribution of causes was as follows: cardiovascular (82%), trauma-related (11%) and non-traumatic (7%).

**Cardiovascular causes in football players**

In young players aged ≤ 35 years, the most common cause was sudden unexplained death (SUD, 22%). This diagnosis refers to a structurally (grossly and histologically) normal heart at autopsy or a negative finding after survival and was also the most common finding in American college athletes in a previously published study with an observational period of 11 years5. The second most common cause in young players was cardiomyopathy (CM, 18%) followed by coronary artery anomaly (CAA, 9%) and premature coronary artery disease (pCAD, 9%). In players ≥35 years of age, regional patterns of the major causes were observed: CM in South America (42% of all cases in this continent), CAA in North America (33%), and SUD in Europe (26%).

**Trauma-related causes in football players**

High-impact trauma accounted for 11% of SDs with intracranial hemorrhage being the leading cause. The most frequent injury mechanisms related to high-impact trauma were collision with blow to the head (45%), abdomen (15%) or neck (10%).

In the young CC was associated with 9% of SDs. This figure is remarkable considering that previous studies assumed that air-filled projectiles, such as footballs, were less likely to induce ventricular fibrillation when they hit the precordium than solid projectiles (such as baseballs)3. In 11 of 14 CC cases (79%), the ball hit the chest, and in 3 cases (19%), a tackle occurred, in which a blow to the precordium with the opponent’s elbow or fist was reported. CC was survived in 6 of 14 cases (43%).

**Out-of-hospital cardiopulmonary resuscitation (CPR) in football players**

In 76% of all cases information about CPR was reported to the FIFA-SDR. CPR was initiated promptly in 68% of cases. Prompt CPR resulted in a survival rate of 35% and 50% when performed by lay persons and CPR-trained staff (physicians, nurses, firefighters, paramedics, lifeguards), respectively. Survival rate even increased to 85% when CPR was initiated by trained staff and an automated external defibrillator (AED) was used. Importantly, players themselves performed CPR most frequently before emergency medical services arrived (Figure 2). This clearly demonstrates that players are the most important first responders and the survival rate of CPR depends on them. After a 5-minute delay in CPR, irreversible damage to the brain occurs in the absence of blood flow6. This “no-flow time” (time from cardiac arrest to CPR) significantly determines the overall outcome of the victim and can be kept very low if the players are well trained in CPR, which means being able to recognize a cardiac arrest and immediately start sufficient chest compressions. A recent study found that the likelihood of a favorable outcome in CPR decreases by 13% for every additional minute of no-flow time until high-quality CPR is performed. In the FIFA-SDR delayed CPR (inactivity until the arrival of paramedics or first responders)
was observed due to misinterpretation of symptoms or unawareness. Only one case survived delayed CPR but retained irreversible neurologic damage.

WHAT ARE THE CHALLENGES OF THE FIFA-SDR?

For the first time, the FIFA-SDR describes regional and age distribution patterns of SD-associated diseases in football and provides information on the circumstances of player resuscitation on the pitch. Nevertheless, some of the results should be regarded as preliminary, because of the heterogeneous reporting of cases from different countries and continents. Moreover, the majority of SCD/SCA remained undiagnosed and reported causes might be altered if more complete data were available. Therefore, higher detection rates are urgently needed to provide a clearer picture of the global distribution of SD cases and their causes in worldwide football. However, although underreporting remains a general problem for most SD registries, some patterns are potentially less influenced from reporting inaccuracies such as disease distributions and possible survival rates (no systematic influence to be expected from different reporting). The efficiency of a worldwide registry relies on the organization of cooperating national registries that capture SD cases as comprehensively as possible. This requires a well-functioning network of football associations, medical professionals and researchers in compliance with national data protection guidelines.

HOW TO SETUP AN SD REGISTRY IN YOUR COUNTRY AND COOPERATE WITH FIFA-SDR?

An important first step on national level would be to share the link of the FIFA-SDR multilingual online form (https://www.uni-saarland.de/fifa) via social media and national football websites. This would involve minimal effort, as reported cases would be automatically analyzed by FIFA-SDR researchers, while reducing national underreporting. The second step would be to have one or more individuals take primary responsibility for tracking national SD cases through regular communications with local football associations and medical institutions. In addition, regular media screening of local news and communication with national SD foundations (which also receive SD case reports) can increase the detection rate, a task that is manageable and requires only a small investment of time. In addition, the involvement of an active or former player (high social media reach) can be integrated into the promotion of the FIFA-SDR at national level. The gold standard in establishing a national SD registry would be an ambulance-based data collection in close cooperation with the emergency medical services to capture all SDs and resuscitations in national football. In Sweden, such a registry exists with an estimated detection rate of almost 100%.

SD IN FOOTBALL DURING COVID-19 PANDEMIC

During the COVID-19 pandemic, disinformation appeared on social media and in the tabloid press claiming the incidence of cardiac events and deaths in football had increased dramatically with the onset of COVID-19 vaccination. The cases listed often did not distinguish whether the observed syncope or symptoms were due to extracardiac causes, preexisting cardiac disease, or, in the case of possible myocarditis, preceded by infection. In addition, no comprehensible reference was given for the alleged...

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Report a case

Figure 1: The FIFA-SDR online form, translated into 11 languages, for players, staff and other potential eyewitnesses to a sudden death in football.
increased incidence. In summary, the evidence was anecdotal at best and lacked a basic scientific approach.

The FIFA-SDR was launched in 2014 with the aim of providing a worldwide overview of both the regional distribution patterns of SD causes and the resuscitation measures performed on the pitch. Due to the methodological limitations mentioned above, it is not possible to capture incidences similarly to a national public health agency. Furthermore, there is no obligation to report SD cases in football. Thus, the FIFA-SDR currently represents the best possible approach to capture SD cases according to scientific standards and has the largest amount of data available in worldwide football. Since the publication of the 2014-2018 results, the methodology has been further optimized and 5 more national registries have been implemented (Serbia, Macedonia, Croatia, Bosnia, Montenegro) and 2 more registries (South Africa and Israel) are planned. Despite the expansion of the FIFA SDR, with the intention of increasing the detection rate even before the COVID-19 pandemic, there has been no numerical or statistical increase in SD cases from 2019 to date.

PROSPECTS

The FIFA SDR will continue and expand to better inform prevention measures in football. Every scientist and soccer interested person is welcome to implement an SD registry on a national level or to report SD cases directly to the FIFA SDR. However, the most important contribution to the research of sudden cardiac death is to raise awareness of the FIFA-SDR in the football community.

References


