Screening

Preparticipation screening for the detection of cardiovascular abnormalities that may cause sudden death in competitive athletes

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Preparticipation screening may prevent sudden cardiac deaths in sporting events

The American Board of Medical Specialties lists sports medicine as a broad area of health care that includes:

(1) exercise as an essential component of health care throughout life;

(2) medical management and supervision of recreational and competitive athletes and others who exercise on a regular basis;

(3) exercise for prevention and treatment of disease and injury.

It combines disciplines from applied physiology to those encompassing clinical, therapeutic, and rehabilitative topics. The preventive aspects of sports medicine are coming of age. Sport is a vehicle for wellbeing and prevention and treatment of diseases, although it can sometimes also represent a risk to health in cases of unacknowledged or asymptomatic pathologies, the most dramatic resulting in sudden cardiac death (SCD) which occasionally strikes apparently healthy athletes.[1 2] SCD is a most tragic event, stirring public opinion and commanding a high profile. It is rare, and identifying athletes at risk is a daunting problem. By considering the epidemiology of SCD in athletes and using preparticipation screening (PPS),[3–5] as well as estimating the efficacy of instrumental investigations, adequate prevention can be implemented.

BACKGROUND

Compared with the risk of sudden death in general, the incidence of sports related SCD is low—about 1 event per 100 000 adult athletes per year. The risk increases with age and is more common in men.

There are striking geographical differences. In North America, hypertrophic cardiomyopathy (HCM) is the leading cause of SCD in athletes. In Italy, the most common cause is right ventricular cardiomyopathy. In Germany, there is a high proportion of myocarditis. In China, a major cause is Marfan syndrome. In athletes younger than 35, the most common cause is almost invariably severe coronary artery disease.

A primary goal for prevention should be to identify cardiac pathology through PPS. Recent interest has focused on the strategies and results of PPS in athletes as an instrument for (*a*) early identification of structural cardiac disease associated with sudden death and (*b*) reduction of the risk of disease progression associated with athletic training and competition.

Recommendations on eligibility to participate in sport should follow precise guidelines, such as those set by the Bethesda Conference or the Italian Guidelines (COCIS). Doctors with a knowledge of an individual athlete, including the severity of the condition and the physiological and psychological response to competition, may elect to modify these recommendations in selected subjects.

As an increasing number of people at risk, particularly elderly men, participate in sports events, PPS should limit the occurrence of fatal cardiac accident, adequately informing the participants on the risks to their health.

The American Heart Association[6] originally proposed a protocol including medical history taking and physical examination. However, although it seemed to be cost effective and easy to administer on a large sale, it was unable to clinically detect serious cardiovascular diseases. Evaluation of the efficacy of history taking and physical examination in PPS of athletes is not easy, as no prospective data on a national basis are available. Indeed, correct diagnosis of cardiac diseases based only on clinical history and physical examination in PPS is low.

In Italy, since 1950 it has been mandatory for all professional and amateur athletes to obtain medical certification of their eligibility to participate in their sport. In 1971, the government introduced laws intended to safeguard the health of all those practising sport at both competitive and non-competitive levels[7] and that regulate preventive PPS.[8] Competitive athletes must undergo a yearly preventive screening protocol including a past medical history, clinical evaluation, urinalysis, electrocardiogram (ECG) at rest and after a step test, and pulmonary function tests. This evaluation can only be performed by doctors holding a diploma of specialist in sports medicine and registered with the Italian Sports Medicine Foundation (FIMS). These professionals are legally responsible for the accuracy of this assessment, being the final judges of the subject's eligibility to participate in sport.

At present, in Italy, about 5 million people undergo the cardiovascular PPS each year.

EFFICACY OF THE SCREENING PROGRAMME

The efficacy of preventive screening is shown by recent studies showing a high prevalence (more than 70%) of cardiac diseases as the reason for non-eligibility to participate in sport. The most common are: arrhythmias, mitral valve prolapse, arterial hypertension, arrhythmogenic cardiomyopathy, myocarditis, coronary artery diseases, and valvular heart disease.

The screening programme includes a 12 lead ECG. This has increased the diagnostic efficacy of screening, and it has been extensively implemented for almost 20 years in national screening programmes for competitive athletes. However, its efficacy for detecting cardiac abnormalities that may result in SCD has not yet been investigated. ECG alterations in elite athletes are mostly T wave changes, ST segment elevation, and increases in R and/or S wave voltage. These are thought to be a consequence of long term intensive athletic training. As these alterations can also be found in patients suffering from structural cardiac diseases such as HCM and arrhythmogenic right ventricular cardiomyopathy (ARVC), which are responsible for SCD during physical exertion, and in those with physiological cardiac adaptations occurring as a consequence of systematic physical training, they may lead to questions about possible differential diagnoses.[9–11]

A recent study[12] has compared the ECG patterns with cardiac morphology and function (assessed by echocardiography) in the same athletes, including

Abbreviations: PPS, preparticipation screening; SCD, sudden cardiac death; HCM, hypertrophic cardiomyopathy; ECG, electrocardiogram; ARVC, arrhythmogenic right ventricular cardiomyopathy

1005 trained subjects, engaged in different sport disciplines. Some 60% of the athletes had ECGs that were either completely normal or showed only minor changes considered typical of the athlete's heart (such as incomplete right bundle branch block, early repolarisation, and slightly increased R or S wave voltages). However, 40% of the athletes showed abnormal ECGs which raised clinical suspicion for structural cardiac disease, including about 15% with distinctly abnormal and sometimes bizarre patterns.

However, structural cardiovascular abnormalities were rarely responsible for the abnormal ECGs in the athletes tested. In only 5% were cardiac abnormalities identified clinically and/or at echocardiography. The extent of morphological cardiac remodelling with training was a major determinant of ECG changes. Those athletes with the most pronounced ECG abnormalities showed the greatest dimensional increase in left ventricular cavity wall thickness and mass as well as left atrial size. In addition, participation in some endurance sports (such as cycling, rowing, canoeing, and cross country skiing) was most commonly associated with the presence of abnormal ECG patterns. Of particular interest was a small but meaningful number of athletes showing ECG abnormalities strongly suggestive of HCM, with diffuse symmetric and pronounced T wave inversion, associated with increased R or S wave voltages or deep Q wave, but without clinical and echocardiographic evidence of this disease. A few others showed ECG patterns suggestive of ARVC with T wave inversion in V1 to V3 (or V4), but in the absence of familial occurrence, clinical, or echocardiographic features of ARVC. Therefore, chronic training may considerably alter the ECG pattern in some athletes, even in the absence of appreciable morphological cardiac remodelling.[13 14]

The usefulness of 12 lead ECG for identifying cardiovascular disease in highly trained athletes during cardiovascular PPS is limited. Based on the large proportion of false positive abnormal ECGs found in the athletic population (about 40%) in Italy, the diagnostic power of the ECG for identifying cardiac disease was low (sensitivity 50%, positive predictive value 7%).

These results are in agreement with those of Corrado *et al*[5] from a study on cardiovascular PPS carried out in the Veneto region (Italy) in 1979–1996. In a population of 33 000 young athletes subjected to cardiovascular PPS, 9% raised clinical suspicion of cardiovascular disease, further to detection of ECG abnormalities, and were then subjected to further echocardiographic investigations. In 2% of the athletes, cardiovascular diseases were identified, and in 22 of them HCM was found for the first time. These athletes were recommended to suspend sporting activity. An eight year clinical and echocardiographic follow up showed these young athletes to be free of symptoms and without evidence of structural cardiac disease.

The routine use of echocardiography in the cardiovascular evaluation increases the possibility of identifying cardiac diseases that may cause sudden death.[15]

CONCLUSIONS

The surveys reported suggest that PPS with a 12 lead ECG is a valuable and relatively inexpensive test to improve the limited diagnostic efficacy of history taking and physical examination, even though limitations in detecting cardiovascular diseases in highly trained athletes were apparent. In fact, false positive ECG results due to morphological alterations resulting in ECG abnormalities suggestive of cardiac diseases may represent a limitation to the routine use of ECG as part of PPS. However, normal ECGs proved to be highly predictive of the absence of cardiovascular diseases and effective in detecting HCM in many athletes.

PPS for cardiovascular disease in athletes is an ambitious and difficult programme, especially in terms of costs, feasibility, and availability of qualified personnel. However, the long standing Italian experience with medical screening implemented through state law is noteworthy for the positive results that it has produced.

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