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Review

Improvement of cardiac screening in amateur athletes

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Abstract Although not performing on a professional level, amateur athletes, nevertheless, are participating in competitive sports and thus underlie a relevant risk for exercise-related SCD which implicates the need for an adequate pre-competition cardiac screening. As many amateur athletes belong to the category of "older" individuals, particularly CAD among male athletes with risk factors has to be targeted by the screening. However, the detection of clinically silent underlying coronary heart disease is challenging and cannot be accurately achieved by a standard screening provided to young athletes (history, clinical status, ECG). An extended work-up, at least, mandates the detection of cholesterol levels to estimate the individual cardiovascular risk. The fact that only less than 10% of Swiss amateur athletes have undergone cardiac screening led to various promising approaches to improve the awareness of the issue. Exemplarily, we successfully invented an "on-site" prevention campaign that positively influenced the attitude of the athletes towards cardiac screening.

Introduction and scope of the problem

Although there is striking evidence that regular physical exercise leads to various health benefits, particularly regarding cardiovascular morbidity and mortality, it is a well-known fact that exertion can serve as a trigger for sudden cardiac death (SCD), particularly in case of an underlying cardiovascular disease [1,2]. The culprit disease is often clinically silent and unlikely to be suspected or diagnosed on the basis of spontaneous symptoms. Thus, systematic pre-participation screening of athletes had the potential to identify those at risk and to reduce mortality [3]. However, the ideal screening strategy is a matter of debate. As such, the use of an electrocardiogram in primary screening is controversial. In addition, there is an ongoing discussion regarding the specific population of physically active individuals that should undergo such a cardiac screening.

"Competitive" versus "non-competitive" physical exercise

Current guidelines and recommendations aim to classify physically active individuals to estimate the individual risk for cardiac events of a specific sub-group [1,4]. One exemplary definition comes from Corrado and colleagues defining a competitive athlete as one "that is engaged in exercise in a regular fashion as well as participating in official athletic competitions. Competition is intended as an organized team or individual sport event, placing high premium on athletic excellence and achievement. Characteristics of competitive athletes are their strong inclination to extend themselves physically to their limits and to improve performance [1]." This is, without a doubt, a reasonable approach, as the risk of fatal cardiac events in athletes increases according to the level of intensity [1]. However, these definitions also harbor a major pitfall: As one consequence of this definition the screening seems to primarily target competitive athletes, while "non-competitive" athletes are supposed not to underlie a relevant risk for SCD.

But what is a "non-competitive" athlete? Are there any "non-competitive", particularly young athletes, at all? According to the current definitions, as the one above, it has to be proposed – no, there are no "non-competitive" young athletes, as this appears as a contradiction in itself. It is hard to imagine an athletic young person that would not have "the ambition to improve performance" (as noted in the current definition of competitive sports). Thus, just per definition, an accurate pre-competition cardiac screening should not be withheld for any physically active person and the classification of competitive versus "non-competitive" is potentially fatal.

Young versus older athletes – the impact of age on cardiac screening

Transferring this critical issue particularly to the population of "older" athletes, the direction is less clear. However, it is a fact that many "older" athletes perform competitive "amateur sports" on a high level [2]. Nevertheless, the "age

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cutoff" to classify an athlete as older, according to his risk to suffer from relevant coronary artery disease (CAD) has not been definitely detected.

Recent data suggest that the established cutoff of 30 to 35 years for "older" might even be too high [5]. Thus, there are many "older" athletes performing at a very high level although their risk of suffering from acute myocardial infarction due to underlying CAD is increasing. On the other hand, it might be reasonable to label an older individual "non-competitive" if physical activity is restricted to low-intensity, strictly recreational sports (e.g. golf, bowling or riflery).

In 2001, the AHA introduced recommendations for pre-participation screening and the assessment of cardiovascular disease in masters athletes defining them as older individuals (particularly >40 years of age) entering, resuming, or continuing in organized sports competition [6]. The document stated that the primary responsibility rests with the masters athlete to identify and initiate contact with an appropriate physician for the purpose of a pre-participation CV evaluation to include blood pressure measurement and risk factor analysis (with exercise ECG testing, if indicated). The AHA also recommended that personnel trained in both cardiopulmonary resuscitation and automatic external defibrillators should be available at all approved masters' sports events [6].

Amateur athletes – the bottom of the iceberg

Currently, no other survey demonstrates the crucial role and at the same time the field of conflict of the so called "amateur athletes" regarding exercise-related SCD more impressively than the paper by Marijon and colleagues published in 2011 [2]. As most of the data regarding SCD in sport were gained from young competitive athletes [3,4] this large prospective 5-year survey was one of the first that focused on recreational "amateur" sports activities in the general population [7]. On the basis of a French national emergency reporting system (SAMU) and press reports, relevant cardiac events in regularly physically active individuals from 10 to 75 years were included. A death was considered to be "sports-related" and "sudden" if it occurred during sport or within 1 hour after cessation respectively within 1 hour of symptom onset [3,4,8]. Sudden cardiac arrests (SCA) that were survived were also included as "SCD" for the purpose of the survey but sports-related SCD that were clearly relatable to (non-cardiac) trauma were excluded. Strikingly, only 50 of 820 reported fatal events (6%) occurred in young competitive athletes (at a maximal age of 35 years), the group that traditionally stands in the focus of preventive measures. Impressively, more than 90% of fatal sports-related cardiac events occurred in amateur, recreational athletes. Still, compared to so-called "non-competitive" young athletes, competitive young athletes exhibited a higher risk of sports-related SCD (relative risk 4.5, 95% CI 2.3–8.7). However, as mentioned above, this classification is questionable, particularly in young individuals.

Focusing on the older population of French athletes (60 to 75 years) the incidence of SCD was 15.9 (95% CI 13.2–18.6) per million per year, while the overall incidence of sports-related SCD throughout France was calculated to be 5.4 and 16.7 cases per million per year, respectively. As such, this nicely designed study revealed a much higher prevalence of sports-related SCD in the general population than previously suspected and allowed the authors to estimate a yearly incidence of approximately 4250 cases in the United States or 800 cases in France in the group of 10- to 75-year-old physically active general individuals. So it can be concluded that although the overall risk for sports-related SCD remains highest in young competitive athletes, it only concerns a relatively small sub-group of physically active individuals, and thus the absolute risk appears to be higher for the general population.

Screening in amateur athletes

It is a reasonable consequence of these data that an accurate systematic cardiac screening should be accessible for the general population and should not be reserved to the relatively small and specific young, "top-level" athletes. This screening particularly has to target ischemic heart disease among male recreational sports participants with cardiovascular risk factors, as the mean age of sports-related SCD in this French study was 46 years [2]. This finding is in accordance to recent studies suggesting that CAD in younger athletes (e.g. 25 to 35 years) is of increasing importance [5]. Meyer and colleagues impressively showed that in a non-athletic population CAD was the cause of SCD in not less than 43% of fatal cardiac events in the group of 25 to 35 year olds [5]. Thus, the identification (and management) of CAD in asymptomatic athletes has become a crucial but still controversial issue and so far, no sufficient strategies have been developed to reduce the risk of exercise-related acute cardiovascular events in this group of athletes [9].

It is obvious that the *standard cardiac screening* (history, physical examination and ECG) is not adequate to detect CAD in asymptomatic athletes. Although several epidemiological studies reported the association between ECG abnormalities and an increased relative risk (1.5–2.5 fold) of mortality from CAD [10,11] the ECG's utility is very limited: Nearly half of individuals with angiographically normal coronary arteries show suspicious ECG changes, while approximately one third of those with CAD show normal basal ECG findings. Most importantly in this context: the vast majority of coronary events seem to occur in the absence of prior ECG abnormalities [12]. Because *exercise testing* has a well-established prognostic value, widespread availability and low cost, it would theoretically be the best available test for screening asymptomatic adults prior to an exercise program. As such, several studies reported an increase of the relative risk of coronary death (range 2–5), for those asymptomatic subjects with a positive exercise test [13,14]. However, the predictive value of exercise ECG testing regarding cardiovascular events, occurring specifically exercise related, is very limited. Siskovick et al. reported an 18% sensitivity and 92% specificity of a positive exercise testing to predict an exercise-related cardiovascular event in asymptomatic, hyper-cholesterolemic men (35–59 years) [13]. Laukkanen et al. could nicely reproduce these results in an athletic