

Can ECG screening prevent sudden death in athletes?

Mandatory electrocardiographic screening of athletes would detect heart problems and save lives, argue **Antonio Pelliccia** and **Domenico Corrado**, but **Roald Bahr** claims that the diagnostic accuracy is questionable



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YES The European Society of Cardiology has supported electrocardiography based screening for competitive athletes since 2005, and the International Olympic Committee endorsed a similar approach in a policy statement in 2009.¹⁻² These position statements have raised interest in the scientific community and general public, and fuelled the current debate regarding the efficacy of pre-participation electrocardiographic screening to detect the risk of cardiovascular diseases in young athletes and to reduce deaths.

Effect of screening on mortality

Scientific data supporting the efficacy of electrocardiography derive from Italy, the only country where pre-participation screening is required by law and where a mass screening programme with electrocardiography has been in place for almost 30 years. This population based and long term programme has provided evidence of the efficacy of screening in

identifying athletes with clinically silent cardiomyopathies, primarily hypertrophic cardiomyopathy.³⁻⁵

The incidence of sudden deaths before and after implementation of screening fell by 89%—from 3.6/100 000 athlete years before screening to 0.4/100 000 athlete years after 25 years of screening.³ Moreover, no deaths were recorded among athletes disqualified from competition because of hypertrophic cardiomyopathy, supporting the idea that timely identification of affected athletes offers the possibility to improve survival.³

Although this study was a preventive medical programme implemented in the real world and not a randomised clinical trial, the evidence for a cause and effect relation between electrocardiographic screening and reduction of mortality is supported by the following observations. Firstly, the fall in deaths among young athletes coincided with the implementation of the screening programme. Secondly, the incidence of sudden cardiac death did not change during the study period among the unscreened, non-athletic population of the same region and age range. Finally, the reduced incidence of sudden death was mostly attributable to fewer deaths from

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NO Some facts are undisputed. Every year, athletes die tragically during exercise. Although regular physical activity is beneficial for most, vigorous exercise transiently increases the risk of sudden cardiac death in people with underlying cardiovascular disease—for example, hypertrophic cardiomyopathy, arrhythmogenic right ventricular cardiomyopathy, ion channelopathies, or coronary artery anomalies.¹ Sudden death during exercise is often the first manifestation of heart disease.² Screening with 12-lead electrocardiography can identify some people with underlying heart disease.³⁻⁴

Proponents argue that these facts support making electrocardiographic screening a prerequisite for participation in organised sports to prevent sudden death.⁵ The cornerstone of their argument is a 25 year prospective study (1979-2004) from the Veneto region in Italy. This showed that the introduction of a mandatory screening programme for all athletes aged between 12 and 35 who wanted to participate in organised sports reduced the annual incidence

of sudden cardiac deaths among athletes by 89%, while the incidence for non-athletic people of the same age remained unchanged. The main explanation was that athletes with cardiomyopathies were screened out of competitive sports, and deaths attributed to cardiomyopathies decreased.⁶

Criteria for screening

Screening is a public health strategy to detect a disease in individuals without signs or symptoms of that disease. The goal is to enable earlier intervention and thus reduce future morbidity and mortality. Although screening may lead to an earlier diagnosis, not all screening programmes are beneficial. The World Health Organization developed the Wilson-Jungner criteria for appraising a screening programme.⁷

Although WHO says all 10 criteria must be met, two criteria are particularly important. The first is that the condition being screened for is an important health problem (which depends not only on how serious the condition is but also how common it is), and the second is that a suitable screening test is available to detect early disease with acceptable sensitivity (detects all those with increased risk) and specificity (detects only those with increased risk).

Evidence from Norway

Let us consider the arguments for electrocardiographic screening using these criteria as

“Electrocardiographic screening of athletes fails accepted public health criteria for screening programmes on several counts”

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cardiomyopathies and was paralleled by the increase in young athletes identified with these cardiomyopathies and disqualified from competition during the same period.

No other studies have prospectively investigated consecutive series of sudden deaths in young people occurring in a well defined geographical area within a homogeneous ethnic group. Moreover, the strength of the Italian study was the reliability of pathological data, because the heart of each person with sudden death was collected and examined by a team of experienced cardiovascular pathologists according to a standard protocol.³

It took 25 years to generate the Italian data showing the efficacy of the pre-participation screening on mortality. Until data from other studies of comparable study design, size of cohort, and duration of follow-up are obtained, the Italian experience remains the best available evidence of efficacy of electrocardiographic screening on mortality in young athletes.

New scientific evidence

Two recent studies have provided support for the efficacy of pre-participation screening. Baggish and colleagues examined the effect of cardiovascular screening with and without

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electrocardiography in 510 US college athletes.⁶ Including electrocardiography in the screening increased the recognition of cardiomyopathies and improved the sensitivity compared with no electrocardiography from 45.5% to 90.9% and the negative predictive value from 98.7% to 99.8%.^{6,7}

In a second article, Wheeler and colleagues applied a theoretical model to project the costs and survival rates of US high school and college athletes who had pre-participation screening.⁸ Adding electrocardiography to history and physical examination saved 2.1 life years per 1000 athletes screened. The incremental cost effectiveness ratio of adding electrocardiography to history and physical examination was \$42 000 (£27 000; €33 000) per life year saved.⁸ The authors concluded that electrocardiography based screening is more cost effective than relying on history and physical examination alone.

conditions, such as coronary atherosclerosis or coronary anomalies, are likely to be remain undetected. The conditions that cause sudden cardiac death also differ substantially between populations, with myocardial infarction and coronary atherosclerosis accounting for half of exercise related sudden deaths in Norway.⁹

In fact, no more than one third of the deaths observed in the Norwegian study could have been detected by electrocardiographic screening—that is, only one of the three deaths that occur each year. This contrasts with Italy, where arrhythmogenic right ventricular cardiomyopathy dominates,¹ and the United States, where hypertrophic cardiomyopathy is the leading cause of sudden death.¹⁰ In other words, a screening programme that has successfully captured cardiomyopathies in Italy, will not necessarily be effective in Norway, where this seems to be a rare cause of sudden death.

Another factor to consider is that the false positive rates of screening can be as high as 40%.³ This is partly because of the grey area between potentially malignant electrocardiographic changes and physiological adaptations to intensive training. Although a recent study showed that including electrocardiography in cardiovascular screening increases sensitivity, the cost is reduced specificity (false positive rate 16.9% versus 5.5% for history and examination alone).¹¹ US studies of high school athletes found 10% had abnormalities detected by

Clinical implications

According to the American Heart Association and the European Society of Cardiology,^{1,9} cardiovascular screening for young competitive athletes is justifiable on ethical, legal, and medical grounds. Moreover, the current scientific evidence suggests that screening with electrocardiography represents best clinical practice to prevent or reduce the risk of sudden cardiac death in young athletes. We therefore believe that competitive athletes (and their families) should be fully informed about the limitations of history and physical examination, and the additional value of electrocardiography, and should not be deprived of the opportunity to be screened by electrocardiography if they consider this to be of value. We also believe that high schools, colleges, and international sport federations share the implicit ethical and legal obligation to ensure that their young affiliates are screened according to the current best clinical practice.¹⁰

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the yardstick and Norway as an example. Should national electrocardiographic screening for athletes be mandatory?

Firstly, what is the size of the problem? Norway's population of about 4.9 million is fairly active. Norwegian adolescents, for example, were found to be the most active among nationally representative samples from Denmark, Norway, Estonia, and Portugal.⁸ An eight year review (1990-7) of sudden death from the Norwegian Cause of Death Registry found 23 exercise related deaths among 15-34 year olds—that is, an average of three a year.⁹ The population at risk is difficult to estimate, but many of those who died were not involved in competitive exercise. In fact, there were no deaths of elite athletes during this period. Thus, the authors estimate the population at risk is about 325 000, corresponding to 0.9 deaths/100 000 a year, an incidence in the mid-range of rates reported in previous studies.⁹

The implication is that 325 000 Norwegians would need to be screened routinely to save three deaths a year, assuming that everyone at risk can be identified and all deaths prevented.

So can everyone at risk be identified? The overall sensitivity of electrocardiographic screening to detect any cardiovascular disease in asymptomatic athletes seems to be about 50%.³ However, the diagnostic accuracy varies among conditions. Although the sensitivity for cardiomyopathies is acceptable, other

electrocardiography that required specialist examinations.^{12,13} If we use this conservative estimate, as many as 36 000 Norwegians would need further follow-up (usually echocardiography, sometimes cardiac magnetic resonance imaging) to rule out underlying cardiovascular disease.

No justification

Electrocardiographic screening of athletes fails accepted public health criteria for screening programmes on several counts. Although sudden cardiac death is tragic, it is also rare. The diagnostic accuracy is also low and depends on which cardiac conditions are the main causes of sudden death in the population being screened. The recent US recommendations are right.¹⁰ Screening of hundreds of thousands of athletes to save possibly only one life a year, as would be the case in Norway, cannot be justified.

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