

DOCTOR IS MY KID'S HEART FIT FOR THE CROSS COUNTRY RUN? (PRE-PARTICIPATION CARDIOVASCULAR ASSESSMENT OF YOUNG AMATEUR ATHLETES - AGE 12 TO 30)

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*"The time you won your town the race
We chaired you through the marketplace;
Man and boy stood cheering by,
And home we brought you shoulder high.*

*Today, the road all runners come,
Shoulder-high we bring you home,
And set you at your threshold down,
Townsmen of a stiffer town."*

*To An Athlete Dying Young
Alfred Edward Housmann, 1895*

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INTRODUCTION

Singapore as a nation is emphasising sports. The Sports School is up and running and the first Youth Olympic Games was hosted here. Primary and Secondary School students are encouraged to take up sports as a co curricular activity and their stamina and endurance are tested with gruelling training sessions. However, frequently we are confronted with tragic news articles of the sudden death of young athletes while exercising. These athletes are in the prime of their lives, often school and national heroes. The question on everyone's mind is, could this be prevented? The Family Physician is often asked to certify fitness to participate in sports and even physically strenuous activities like Outward Bound Course. As with any form of mass screening, the majority are normal. However, missing the athlete at risk can result in tragedy and possible litigation. This review aims to give an overview on causes and screening guidelines for pre-participation cardiovascular assessment in young athletes. Musculoskeletal screening and factors that can limit performance like drugs and anaemia will not be included.

Methodology

A Pubmed Search for 'preparticipation cardiovascular screening in athletes' with limits of English language, Humans, Age Child 6-12, Adolescent 13-18 and Adult 19-44 was conducted. A total of 40 indexed articles were obtained of which there were 12 review articles. All articles were reviewed.

The recommendations of the Singapore Sports Safety Committee in 2007 were also reviewed.

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Incidence and Causes of Sudden Cardiac Death in Young Athletes

The incidence of sudden cardiac deaths is not well established, and only a few studies are available. Maron et al reported an incidence of 0.7/100,000 high school athletes/year in Minnesota, USA.¹ European figures estimate 2.1/100,000 athletes/year.² No prospective studies have been done in Singapore, but the Singapore Sports Safety Council estimates the incidence as 1 in 239,000 people/year who exercised at least once a week.³

Sudden cardiac death in the young athlete is usually a result of ventricular tachyarrhythmias in an electrically unstable and unpredictable myocardium. Vigorous exercise in persons with underlying cardiac disorders increases sudden death. This has been shown in a study from Italy by Corrado et al, which shows rate of sudden cardiac death as 0.8/100 000 person years in non athletes and 2.3/100 000 person years in athletes.² There is a definite male predilection with a male: female athlete ratio of 10:1.² This can be partly explained by a lower number of female athletes, but in even after correction, male gender itself is a risk factor for sudden cardiac death.

Hypertrophic cardiomyopathy is reportedly the commonest cause of sudden cardiac death amongst young athletes in America¹. However, the European studies have reported coronary artery disease as the commonest cause of sudden cardiac death amongst these athletes². As mentioned earlier, local Singapore data is presently unavailable.

The pre-participation cardiovascular assessment aims to detect asymptomatic athletes who have potentially lethal cardiovascular abnormalities, and to protect them from the risk of sudden cardiac death by disqualification from competitive sports. Early pick up of certain arrhythmogenic diseases like hypertrophic cardiomyopathies can be treated with implantable cardio-verter defibrillators. More importantly these persons should be advised to refrain from strenuous sporting activities, intense training and competitive sports that predisposes to sudden death.² Table 1 lists the common causes of sudden death among the young population.

Hypertrophic Cardiomyopathy

Hypertrophic cardiomyopathy is the commonest cause of sudden cardiac death among young athletes, accounting for about 1 in 3 cases.⁶ This is a genetic condition with an incidence of 1:500 persons.⁷ There is often a personal or family history

Table 1: Cardiovascular Causes of Sudden Death in Young Athletes (12 –35 years)⁴

- based on a study of sudden death in 387 young athletes in USA. (Maron et al)

Hypertrophic Cardiomyopathy
Coronary artery anomalies
Commotio cordis – blunt trauma to chest resulting in ventricular fibrillation
Left ventricular hypertrophy
Myocarditis
Marfan syndrome – aortic root dilatation, aneurysm with subsequent rupture
Arrhythmogenic right ventricular cardiomyopathy
Tunnelled coronary artery
Aortic stenosis
Dilated cardiomyopathy
Myxomatous mitral valve degeneration
Mitral valve prolapse
Drug abuse
Long QT syndrome
Cardiac sarcoidosis
Brugada syndrome – genetic syndrome of myocardial sodium channels

Brugada syndrome will likely be commoner in our population in Singapore.⁵

of exertional dyspnea, syncope or palpitations. The physical examination can range from normal to a displaced apex beat with cardiac murmurs. The ECG is abnormal in 95% of cases, showing left ventricular hypertrophy, ST segment elevations and T inversions. Sudden death is a result of ventricular fibrillation.

Coronary Artery Abnormalities

In this disorder, the coronary artery arises from the wrong aortic sinus. Typically the left main coronary artery arises from left sinus of Valsalva. There may however be several variations in the number, shape, and location of the ostia or origins of the coronary arteries. Most of these variations appear to be of no clinical significance

In certain pathological variants, especially lesions which include origin of the left main coronary artery or LAD from the right sinus of Valsalva or RCA, referred to as anomalous aortic origin of a coronary artery (AAOCA). The subsequent course between the aorta and pulmonary artery to the left ventricle may result in compression of the vessel, myocardial ischemia during exercise, and sudden death in both adults and teenagers. An index of suspicion is required to pick up this condition. This condition should be considered in young athletes with exercise related chest pains or syncope. A cardiac CT angiogram will be useful to pick up this condition which may be surgically correctable.

Other Structural Abnormalities

Atrial Septal Defect (ASD) and Aortic Stenosis⁶ are the commoner of undetected congenital cardiac diseases which may be picked up on preparticipation assessments.

Marfan's Syndrome

Marfan's syndrome is associated with aortic root dilatation resulting in aortic aneurysm rupture and dissection leading to sudden death.⁸ All athletes should be screened for Marfan's syndrome and suspected patients should be referred for ECG, slit lamp examination and cardiac referral to exclude aortic root dilatation.⁹ In fact the American Heart association (AHA) recommendation is that all male athletes, taller than 1.83m and female athletes, taller than 1.78m with 2 or more features of Marfan's syndrome should be assessed. As height is an advantage in certain sports like basket ball, a higher than average proportion of person's with Marfan's syndrome will be athletes. Features of Marfan's syndrome are listed in Table 2.

Conduction Abnormalities

Wolf-Parkinson White (WPW) Syndrome, Prolonged QT syndrome and Brugada Syndrome are the commoner conduction abnormalities. WPW is due to an aberrant conduction pathway. The Brugada syndrome¹⁰ and prolonged QT syndrome are ion channel abnormalities. These are rare, accounting for about 2% of sudden deaths among athletes in the West. Brugada may be commoner in South East Asia.⁵

These conditions are usually asymptomatic and are picked up on screening ECG.

The Pre-participation Cardiovascular Assessment

The young adolescent athlete is often unlikely to volunteer symptoms. Therefore, the assessment should ideally be carried out with his or her parents present, so that history can be verified.

The history and physical examination should be focussed and, to avoid potential litigation, well documented. In fact the American Heart Association (AHA) recommends a 12 element preparticipation cardiovascular screening for competitive athletes.¹¹ The American Academy of Family Physicians recommends the use of a standardised questionnaire for the history; Table 3 lists the screening questions recommended by the AHA in their guidelines.

Parental verification is recommended for high school and middle school athletes.¹¹

In the American experience, most athletes are sent for further evaluation based on the history.

Table 2: Features of Marfan's Syndrome

• Arm span > Body Ht	• Eye abnormalities - myopia and lens dislocation
• Arachnodactyly	• Aortic insufficiency murmur
• High arched palate	• MVP
• Skeletal abnormalities-kyphosis, scoliosis and pectus excavatum	• Thumb sign
	• Wrist sign

Table 3: I^{1,12} Cardiovascular Screening Questionnaire for Pre-participation Assessment

PERSONAL HISTORY

- Have you passed out or nearly passed out during or after exercise?
- Have you ever had chest pain, discomfort or pressure during exercise?
- Does your heart race or skip a beat?
- Has a doctor ever told you that you have high blood pressure, heart murmur, heart infection or high cholesterol?
- Has a doctor ever ordered an ECG or Echo for your heart?

FAMILY HISTORY

- Has anyone in your family died for no apparent reason?
- Does anyone in your family have a heart problem?
- Has anyone in your family died of heart problem or of sudden death before the age of 50?
- Does anyone in your family have Marfan's syndrome?

Physical Examination

The examination should be focussed and include:¹¹

1. Blood pressure assessment with the patient seated.
2. Palpation of radial pulse with assessment of rate and rhythm and radio-femoral delay.
3. Assessment of nature and position of apex beat, and cardiac auscultation, specifically assessing for the heart sounds, nature of split of second sound and cardiac murmurs.
4. Assessment of features of Marfan's syndrome.

Blood Pressure

A seated brachial blood pressure of >99th percentile + 5 for age or 160/100 (age >18) with evidence of end organ damage warrants discontinuation of athletic participation pending further evaluation. BP >140/90 will require further evaluation.^{13,14}

Pulse

The pulse volume will give clues to underlying pathology. A large amplitude, rapidly rising water hammer pulse will suggest aortic regurgitation, hypertrophic cardiomyopathy, severe mitral regurgitation or patent ductus arteriosus. A small amplitude, slow raising pulse suggests aortic stenosis or low output cardiac failure. An irregular rhythm would suggest a conduction disturbance like atrial fibrillation.

The femoral pulses should be assessed especially for radio-femoral delay which together with an increase in blood pressure would suggest coarctation of the aorta.

Pre-cordial Findings

Precordial palpation should assess for apical and parasternal heaves to look for left and right ventricular hypertrophy.

Auscultation should be done in a quiet room. The physical examination should not be a perfunctory one, but rather a careful search for findings that might include a low grade heart murmur that accentuates with Valsalva's maneuver (suggestive of hypertrophic cardiomyopathy, the leading cause of sudden death in a competitive athlete).¹⁵

Assessing the heart sounds and extra sounds is as important as listening for murmurs. The second heart sound is caused by closure of the aortic and pulmonary valves. On inspiration, as more blood flows into the pulmonary circulation, the pulmonary valve closes later. The split in the second heart sound is more obvious on inspiration (physiologic split). However, a fixed split would suggest an atrial septal defect (ASD) and a paradoxical split i.e. shorter split on inspiration would suggest hypertrophic cardiomyopathy or a left bundle branch block.

Murmurs should be assessed based on intensity, timing, location and character. It is important that we get the patient to squat and stand and perform the Valsalva manoeuvre. Standing and the Valsalva cause a decrease in venous return and murmurs should get softer. However, if a murmur gets louder or is only heard after these manoeuvres, a hypertrophic cardiomyopathy or mitral valve prolapse should be suspected. Characteristics of pathological murmurs are listed in Table 5.

Screening for Marfan's Syndrome has been discussed above. All patients with abnormalities picked up should be evaluated further.

The American Heart association has been recommending standardising the clinical history and physical examination. However, with increase in legislation, the preparticipation assessment has become compulsory. Ironically, increase in legislation has lead to assessment being conducted by non physicians including chiropractors and naturopathic clinicians.¹⁶ In Singapore, at this moment we have no standardised national screening protocol.

Table 4: The 12-Element AHA Recommendations for Pre-participation Cardiovascular Screening for Competitive athletes¹¹

MEDICAL HISTORY

Personal History

- Exertional chest pain / discomfort
- Unexplained syncope
- Excessive exertional and unexplained dyspnoea/fatigue, associated with exercise
- Prior recognition of heart murmur
- Elevated systolic blood pressure

Family History

- Premature death (sudden and unexpected before age 50) due to heart disease in >= 1 relative
- Disability from heart disease in a close relative < 50 years of age
- Specific knowledge of certain cardiac conditions in family members: hypertrophic or dilated cardiomyopathy, long QT or ion channelopathies, Marfan's syndrome or clinically important arrhythmias

PHYSICAL EXAMINATION

- Heart murmur.
- Femoral pulse to exclude coarctation
- Physical stigmata of Marfan's syndrome
- Brachial blood pressure (sitting position)

Table 5: Clinical features of pathological murmurs

- Apical or para-sternal heave
- Associated arrhythmias
- Assn raised JVP, abnormal pulse
- Increase in intensity with maneuvers (Valsalva / squat to stand)
- Diastolic murmur
- Long duration involving late systole
- Loud Grade 3 and more
- Other abnormal sounds, gallop, clicks
- Positive family history
- Assn symptoms - chest pain, dyspnoea, syncope
- Radiation to axilla

Is Routine ECG Screening Recommended?

Routine ECG for pre-participation cardiovascular evaluation is a controversial issue. At present, the American Heart Association does not recommend routine ECG as such screening has not been fruitful in the USA. This is partly due to the ECG in normal athlete's heart, due to training and conditioning, showing abnormalities. However, increasingly the American strategy of basing the assessment solely on history and physical examination has come under fire as hypertrophic cardiomyopathy and conduction abnormalities have been missed.

Training results in physiological hypertrophy of the cardiac chambers with left ventricular hypertrophy a common finding in ECGs in competitive athletes. This isolated QRS voltage criteria for left ventricular hypertrophy (LVH) with no other ECG and clinical findings is an unusual pattern in hypertrophic cardiomyopathy.¹⁷ Other minor alterations in the athletes' ECG that are considered normal include increased PR interval (> 0.2 s), increase in R or S wave voltage (25-29 mm), early repolarisation (ST elevations >2 mm in >2 leads), incomplete right bundle branch block pattern and sinus bradycardia of < 60 beats per minute.¹⁸

In fact, a study reported by Corrado et al, showed that in hypertrophic cardiomyopathy, 94% of patients had an abnormal ECG, but the same study also showed that 81.4% of normal athletes also showed abnormalities. This could lead to unnecessary investigation of greater than 80% of normal athletes. However, on further evaluation of the study, the predominant ECG abnormality in athletes was isolated left ventricular hypertrophy on voltage criteria. However, in hypertrophic cardiomyopathy isolated voltage criteria LVH was seen in only less than 1% of patients. The pre-dominant ECG abnormalities were ST segment and T wave abnormalities, pathological Q waves and left atrial enlargement.¹⁷ The Italian group classified isolated voltage criteria LVH as normal for athletes. Corrado et al reports of 42,386 patients screened in one centre with history questionnaire, physical examination and 12 lead ECG, only 9% were referred for further evaluation and 2% were ultimately disqualified from sports.¹⁹

In the 1970s, the Italian government passed a Medical Protection of Athletic Activities Act, requiring annual medical clearance of all athletes participating in organised sports.²⁰ This included a 12 lead ECG. Reports of their 25 year experience suggests that the annual incidence of sudden cardiovascular death in athletes decreased by 89% (from 3.6/100,000 person-years in 1979-1980 to 0.4/100,000 person-years in 2003-2004; P for trend <.001), whereas the incidence of sudden death among the unscreened nonathletic population did not change significantly.¹⁹ The 0.4/100,000 incidence of sudden cardiac death in the athletic population is actually better than the 0.8/100,000 non-athletes or the unscreened population. These figures are definitely impressive. The cost of screening was 30 euros per athlete screened was borne by the Italian government.

The Study group of Sports cardiology from the European Society of Cardiologist have published a consensus statement to reinforce the principle of the need for pre-participation medical clearance of all young athletes involved in organized sports programmes, on the basis of (i) the proven efficacy of systematic screening by 12-lead ECG (in addition to history and physical examination) to identify hypertrophic cardiomyopathy-the leading cause of sports-related sudden death-and to prevent athletic field fatalities; (ii) the potential screening ability in detecting other lethal cardiovascular diseases presenting with ECG abnormalities.²¹

However, the American's concern regarding routine ECG screening for all athletes stem from lack of randomized trial data. It is important to note that the Italian study, though impressive is population based and not a randomised controlled trial. Other concerns have been cost of screening; lack of a clear standard for ECG interpretation in the athlete; the likelihood that asymptomatic athletes with underlying lethal conditions might differ significantly from symptomatic individuals with the same conditions; and concern that ECG screening might actually increase the death rate, via treatment-related procedural complication.²²

Routine echocardiography is not recommended as part of pre-participation cardiovascular assessment.

Singapore at Present

In Singapore, at present, compulsory mandatory screening is only for perceived high risk athletes. They include all carded athletes (athletes receiving national grants), S-league and other professional players and students in the Singapore Sports School. These assessments are done by sports physicians and include history, physical examination and 12 lead ECG.

Those attending certain courses like outward bound school, lifeguard proficiency tests and national service enlistees and Armed Forces regulars also require medical

examination. However, due to large numbers involved, there is no compulsory screening for school or club representatives and other recreational athletes. However, they are advised to undergo assessment. This is usually done by the Family Physician/General Practitioner.

Limitation of Screening

The family practitioner should understand the limits of screening. As the incidence of conditions that lead to sudden death is low, large populations need to be screened to prevent sudden death. Further, screening has limited value in preventing environmental causes of sudden death like heat stroke and viral myocarditis and traumatic injuries.

However, the screening medical examination would give a valuable opportunity for the Family Physician to educate the adolescent regarding adequate hydration, injury prevention and abstaining from exercise when he or she is unwell. This is also an ideal setting for screening and education on smoking, and abuse of alcohol, cocaine and other drugs.

SUMMARY

Pre-participation cardiovascular assessment should add value i.e. as physicians we should be focussed and screen for rare but deadly diseases that can prematurely take away the life of a young person. A cursory medical examination is inadequate. The American Heart Association's recommendation is to use a standardised questionnaire to obtain history and carry out a focussed physical examination. We should aim for this amongst all the General Practitioners/Family Physicians in Singapore. We could follow the American Heart Association recommended questionnaire, until a local Clinical Practice Guideline is available.

Routine ECG, according to the Italian experience, would be ideal, but we will need to increase the awareness levels amongst doctors of ECG norms for athletes to prevent over investigation and unnecessary cost and anxiety. Additional considerations include litigation and cost. The Italian adolescents were screened by physicians in sports facilities. They were well trained in differentiating abnormal ECG from ECG changes in the athletes' heart. The cost of training the physicians and of the ECG was borne by the government. In Singapore, the cost of the ECG will most probably be borne by the patient.

I recommend that at this point in time, Singapore should have a standardised history and physical examination questionnaire for conducting pre-participation examinations. There is not enough evidence to suggest that routine ECG for every pre-participation medical examination is cost effective.

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