Journal of the Hong Kong College of Cardiology

Volume 29 | Issue 1 Article 7

Pre-participation cardiovascular screening in athletes with a focus on Asia

Tee Joo Yeo
National University Heart Centre Singapore, tee_joo_yeo@nuhs.edu.sg

Recommended Citation

Tee Joo Yeo, Pre-participation cardiovascular screening in athletes with a focus on Asia *Journal of the Hong Kong College of Cardiology* 2022;29(1):18-22 https://doi.org/10.55503/2790-6744.1071

REVIEW ARTICLE

Pre-participation Cardiovascular Screening in Athletes with a Focus on Asia

Tee Joo Yeo*

National University Heart Centre Singapore, Singapore

Abstract

Pre-participation screening (PPS) in young competitive athletes aims to identify conditions associated with sudden cardiac death (SCD) in this population, with a view to appropriate management and potential mitigation of risk. A medical history questionnaire and physical examination are standard components of a PPS programme, whereas controversy still exists regarding mandatory utilisation of resting 12-lead electrocardiogram as a screening tool. Apart from a landmark study from Italy attributing the reduction of SCD rates in athletes to the implementation of a mandatory PPS programme, there remains no additional compelling evidence for similar outcomes to date. Nonetheless, comprehensive PPS programmes when carried out systematically, are efficacious in detection of cardiac pathology and cost-effective. While the incidence rate of SCD in athletes from Western countries is estimated to be around 1:50,000, comparable data in Asian athletes remain lacking. Prospective registries are much needed to accurately determine the magnitude of this issue in Asia and recent recommendations on PPS in young Asian athletes have been published to increase awareness and encourage collaboration. To further reduce SCD events, prompt recognition of sudden cardiac arrests and early defibrillation are vital components in the spectrum of SCD prevention. This review aims to outline the rationale, current status and efficacy of PPS in athletes, with a focus on Asia.

Keywords: Asian athlete, Pre-participation screening, Sudden cardiac death, Electrocardiogram

The story of Pheidippides, a Greek messenger who ran from Marathon to Athens to announce victory over Persia, was the inspiration for the modern-day marathon race [1]. Pheidippides was said to have collapsed and died upon delivering the news, making this possibly the first ever documented case of exercise-related sudden cardiac death (SCD). With Sports Cardiology establishing itself as a bona fide subspecialty over the last decade, there is now a much better understanding of SCD, as well as the role of pre-participation screening (PPS) in the prevention of SCD [2–4].

Incidence of sudden cardiac death in athletes

The rationale for PPS in athletes is primarily to identify cardiac conditions that may be associated with SCD, in order to modify and reduce an individual's SCD risk through targeted management, including potential disqualification from competitive sport [5–7]. SCD is a devastating event and is particularly tragic when occurring in young (age 35 years and below) athletes at the peak of their physical capabilities. Athletes are also at an almost 3-fold higher risk of SCD compared to non-athletes [8]. Reported rates of SCD in the athletic population

Received 15 February 2022; Revised & accepted: 4 March 2022.
Available online 29 March 2022

* National University Health System Tower Block, Level 9, Cardiac Department, 1E Kent Ridge Road, 119228, Singapore. Fax: +65 6872 2998.
E-mail address: tee_joo_yeo@nuhs.edu.sg.

https://doi.org/10.55503/2790-6744.1071

vary widely due to differing methods of data collection, with few structured registries available. Taking into consideration of the above, as well as gender, ethnic and geographical variation, an accepted range of SCD incidence in young athletes falls between 1:40,000 to 1:80,000 [9].

Cardiac pathology associated with sudden cardiac death

Cardiac conditions that may lead to SCD in young athletes can be categorised into structural, electrical and acquired causes [10–12]. Amongst structural heart diseases, hypertrophic cardiomyopathy has historically been a leading cause of SCD in young athletes, with arrhythmogenic cardiomyopathy more common in certain geographic regions such as Italy [13,14]. Less common but equally important structural pathologies include anomalous coronary artery origin and dilated cardiomyopathy. More recently, there has been increased awareness of entities such as idiopathic left ventricular hypertrophy and idiopathic fibrosis contributing to SCD [15].

Channelopathies such as Brugada syndrome, long QT syndrome and catecholaminergic polymorphic ventricular tachycardia may also precipitate SCD. These arrhythmogenic syndromes have been identified as the predominant diagnosis in almost 50% of deaths due to sudden arrhythmic death syndrome (SADS), which is now one of the most prevalent causes of SCD in young athletes [15]. SADS is a diagnosis of exclusion where the heart is structurally normal with no abnormal toxicology findings [16].

Acquired conditions leading to SCD include abuse of performance enhancing drugs, direct cardiac trauma (commotio cordis) and myocarditis, particularly in the current climate of the COVID-19 pandemic [17,18].

Is pre-participation screening effective in preventing sudden cardiac death?

A landmark study on the effect of mandatory PPS was carried out in the Veneto region of Italy. All competitive athletes were required by law from 1982 to undergo PPS that comprised of history, physical examination and 12-lead electrocardiogram (ECG) [19]. Analysis of SCDs in the region over a period of 26 years saw a substantial reduction in annual incidence of SCD by 89% in athletes attributed to systematic PPS, whereas the SCD rates in the unscreened general population remained unchanged. This compelling data has been the cornerstone for supporting PPS in athletes [6,7,20–22]. Notably, a more recent attempt to validate the efficacy of PPS in preventing SCD in Israel has been unsuccessful as identification of SCD was performed via retrospective searching of newspapers rather than a systematic national death registry [23].

Basic components of pre-participation screening

The basic components of a PPS include assessment of personal and family history, as well as physical examination. The International Olympic Committee, Federation Internationale de Football Association, European Society of Cardiology and American Heart Association are amongst major institutions utilising questionnaires to evaluate for potentially sinister symptoms such as chest pain, syncope, shortness of breath and palpitations, as well as any family history of inheritable cardiac conditions [6,21]. Physical examination focuses on identification of abnormal signs that warrant further evaluation, such as cardiac murmurs, irregular heart rhythm and manifestations of systemic disease (eg. Marfan's syndrome). However, there is limited utility of depending wholly on the history and physical examination as up to 80% of young athletes presenting with SCD do not manifest any prior symptoms [11].

The 12-lead electrocardiogram as a part of pre-participation screening

Utilisation of the 12-lead ECG in PPS remains controversial and there are differing recommendations in America as compared to Europe. As a screening tool, the ECG was reported to be 5 times more sensitive than clinical history and 10 times more sensitive than physical examination [24,25]. The ECG is abnormal in more than 90% of patients with hypertrophic cardiomyopathy, and abnormal T wave inversions form part of the diagnostic criteria for arrhythmogenic cardiomyopathy [26–28]. It also facilitates risk stratification in channelopathies like long QT syndrome and Brugada syndrome [29].

Evidence-based contemporary ECG interpretation criteria in athletes have also led to substantial reduction in abnormally classified ECGs while preserving sensitivity in detecting pathology. These refinements have in turn improved cost-effectiveness of ECG-based PPS [30–32]. For these reasons, multiple sporting societies in Europe have opted to include the ECG as part of their PPS [6].

It must be acknowledged that the resting 12-lead ECG is not foolproof, as there are conditions that cannot be identified by this method, such as

anomalous coronary artery origin and coronary artery disease [6]. Comprehensive understanding of an athlete's ECG also requires training and expertise that may not be available in certain settings. Indeed, there are a multitude of ECG changes that may occur both in athletes following long term physical training as well as in non-athletes with cardiac pathology. This overlap is deemed the "gray area" and leads to diagnostic challenges [33]. Athletes may be forced to undergo multiple additional investigations or even be erroneously disqualified from competitive sport due to abnormal ECG findings, leading to reduced time for training and even mental distress [34,35]. Finally, the resources (financial, manpower, logistics) required to carry out mandatory ECG screening for all athletes can prove overwhelming, with lack of conclusive evidence demonstrating successful reduction in SCD for ECG screened athletes [36,37]. These factors are the main considerations for the lack of endorsement by the American Heart Association for mandatory screening ECGs in athletes [38].

Master athletes

Coronary artery disease is the culprit in over 80% of SCDs in master (aged above 35 years) athletes [39–42]. Coronary atherosclerosis progresses due to a greater prevalence of elevated coronary calcium scores, increased plaque burden and myocardial fibrosis, particularly in master athletes engaging in long term endurance activity [43]. In this population, the main purpose for PPS is to identify the presence of myocardial ischemia, which may be unmasked by strenuous physical activity [44]. Nonetheless, the use of routine exercise or stress testing is not recommended to screen for ischemia in master athletes due to high false positive rates [45]. Instead, guidelines recommend targeted evaluation of master athletes based on the presence of suggestive symptoms, as well as those at high risk of coronary artery disease based on validated risk scores. Evaluation in these individuals consist of maximal exercise testing with a view to proceed to invasive coronary angiography if high risk features are detected. For individuals with equivocal or uninterpretable ECG, functional imaging or coronary computed tomography angiography should be considered [45]. Current PPS recommendations for young athletes (medical history, physical examination and ECG) can still be applied to master athletes with reasonable sensitivity in detecting the aforementioned structural and electrical causes for SCD [46].

Asian athletes

Existing recommendations on PPS contain specific evidence-based ECG thresholds for both White and Black athletes. For instance, anterior T wave inversions (ATWI) $\geq$1 mm in depth in leads V2 and V3 are deemed abnormal in White athletes, whereas in Black athletes, AWTI with J point elevation and convex ST segment elevation up to V4 may still be considered normal. In contrast, there is a paucity of evidence in athletes from Africa, the Middle East and Asia, largely due to incomplete epidemiological data on SCD prevalence, as well as on physiological limits of cardiac remodeling [47,48].

In light of significant Asian representation in international sport, the Asian Pacific Society of Cardiology has recently published a set of consensus recommendations for PPS in young athletes [49]. These first-in-Asia recommendations aimed to provide guidance on the following:- categorisation of traditional Asian sports based on degree of dynamic and static contribution - recommendation of standardised history and physical examination for PPS in young competitive athletes engaging in moderate to high cardiovascular intensity sports - inclusion of 12-lead ECG for PPS only if resources are available, including capacity for mass screening, expertise for ECG interpretation and consistent ECG quality - utilisation of the International Criteria for ECG interpretation with subsequent referral for appropriate evaluation in the event any abnormal finding is identified.

This pragmatic approach attempts to balance optimal detection of conditions associated with SCD, while ensuring sustainable healthcare resources particularly in low to medium income countries. This document raises awareness of Sports Cardiology in Asia, particularly on the need for systematic registries to ascertain the magnitude and aetiology of SCD in the continent.

Other strategies for the prevention of SCD

Despite substantial improvements in PPS strategies over the last few decades, there remain instances of sudden cardiac arrest (SCA) leading to SCD that screening is unable to identify. Consequently, attention to downstream management of SCA is vital, including early recognition of SCA, early initiation of cardiopulmonary resuscitation and easy access to automated external defibrillators (AED) in sporting arenas [11]. In Japan, a system of mobile teams consisting of paramedics on bicycles carrying AEDs during road races successfully attended to 28 instances of witnessed SCA over 12

years [50]. SCD was prevented in all affected runners with median time to initiation of CPR at 0.8 minutes and median interval from collapse to first AED shock at 2.2 minutes. Favourable neurological outcomes were maintained at 1 year, demonstrating the vital importance of early recognition and intervention in SCA.

Conclusion

Pre-participation screening in young athletes provides the foundation for detection of significant cardiovascular diseases associated with SCD, with the combination of history, physical examination and ECG being embraced by a vast majority of sporting institutions worldwide. There remains a pressing need to establish systematic SCD registries, especially in Asian countries, in order to obtain accurate incidence data and validate the efficacy of PPS in the reduction of SCD.

Ethics approval

Not applicable for this review.

Conflict of interest

None declared.

Declaration of funding statement

No funding was obtained for this review.

References

[1] Wikipedia Pheidippides. Wikipedia; 2022. Available from: https://en.wikipedia.org/wiki/Pheidippides.
[2] Heidbuchel H, Papadakis M, Panhuyzen-Goedkoop N, Carré F, Dugmore D, Mellwig KP, et al. Position paper: proposal for a core curriculum for a European Sports Cardiology qualification. Eur J Prev Cardiol 2013;20(5):889–903.
[3] Baggish AL, Battle RW, Beckerman JG, Bove AA, Lampert RJ, Levine BD, et al. Sports cardiology: core curriculum for providing cardiovascular care to competitive athletes and highly active people. J Am Coll Cardiol 2017;70(15):1902–18.
[4] Wilhelm M, Abreu A, Adami PE, Ambrosetti M, Antonopoulou M, Biffi A, et al. EAPC core curriculum for preventive cardiology. Eur J Prev Cardiol 2022 Feb 19;29(1):251–74.
[5] Hainline B, Drezner JA, Baggish A, Harmon KG, Emery MS, Myerburg RJ, et al. Interassociation consensus statement on cardiovascular care of college student-athletes. J Am Coll Cardiol 2016;67(25):2981–95.
[6] Mont L, Pelliccia A, Sharma S, Biffi A, Borjesson M, Brugada Terradellas J, et al. Pre-participation cardiovascular evaluation for athletic participants to prevent sudden death: position paper from the EHRA and the EACPR, branches of the ESC. Endorsed by APHRS, HRS, and SOLAECE. Eur J Prev Cardiol 2017;24(1):41–69.
[7] Drezner JA, O'Connor FG, Harmon KG, Fields KB, Asplund CA, Asif IM, et al. AMSSM position statement on cardiovascular preparticipation screening in athletes: current evidence, knowledge gaps, recommendations and future directions. Br J Sports Med 2017;51(3):153–67.
[8] Corrado D, Basso C, Rizzoli G, Schiavon M, Thiene G. Does sports activity enhance the risk of sudden death in adolescents and young adults? J Am Coll Cardiol 2003;42(11):1959–63.
[9] Harmon KG, Drezner JA, Wilson MG, Sharma S. Incidence of sudden cardiac death in athletes: a state-of-the-art review. Heart 2014;100(16):1227–34.
[10] Chandra N, Bastiaenen R, Papadakis M, Sharma S. Sudden cardiac death in young athletes: practical challenges and diagnostic dilemmas. J Am Coll Cardiol 2013;61(10):1027–40.
[11] Corrado D, Drezner J, Basso C, Pelliccia A, Thiene G. Strategies for the prevention of sudden cardiac death during sports. Eur J Cardiovasc Prev Rehabil 2011;18(2):197–208.
[12] Maron BJ. Sudden death in young athletes. N Engl J Med 2003;349(11):1064–75.
[13] Harmon KG, Asif IM, Maleszewski JJ, Owens DS, Prutkin JM, Salerno JC, et al. Incidence, cause, and comparative frequency of sudden cardiac death in national collegiate athletic association athletes: a decade in review. Circulation 2015;132(1):10–9.
[14] Corrado D, Basso C, Judge DP. Arrhythmogenic cardiomyopathy. Circ Res 2017;121(7):784–802.
[15] Finocchiaro G, Papadakis M, Robertus JL, Dhutia H, Steriotis AK, Tome M, et al. Etiology of sudden death in sports: insights from a United Kingdom regional registry. J Am Coll Cardiol 2016;67(18):2108–15.
[16] Papadakis M, Raju H, Behr ER, De Noronha SV, Spath N, Kouloubinis A, et al. Sudden cardiac death with autopsy findings of uncertain significance: potential for erroneous interpretation. Circ Arrhythm Electrophysiol 2013;6(3):588–96.
[17] Adami PE, Koutlianos N, Baggish A, Bermon S, Cavarretta E, Deligiannis A, et al. Cardiovascular effects of doping substances, commonly prescribed medications and ergogenic aids in relation to sports: a position statement of the sport cardiology and exercise nucleus of the European Association of Preventive Cardiology. Eur J Prev Cardiol 2022 Jan 27:zwab198. (online ahead of print).
[18] Massoullié G, Boyer B, Sapin V, Jean F, Andronache M, Peoc'h M, et al. Sudden cardiac death risk in contact sports increased by myocarditis: a case series. Eur Heart J Case Rep 2021;5(3).
[19] Corrado D, Basso C, Pavei A, Michieli P, Schiavon M, Thiene G. Trends in sudden cardiovascular death in young competitive athletes after implementation of a preparticipation screening program. JAMA 2006;296(13):1593–601.
[20] Fritsch P, Ehringer-Schetitska D, Dalla Pozza R, Jokinen E, Herceg-Cavrak V, Hidvegi E, et al. Cardiovascular preparticipation screening in young athletes: recommendations of the association of European paediatric cardiology. Cardiol Young 2017;27(9):1655–60.
[21] Ljungqvist A, Jenoure P, Engebretsen L, Alonso JM, Bahr R, Clough A, et al. The international olympic committee (IOC) consensus statement on periodic health evaluation of elite athletes march 2009. Br J Sports Med 2009;43(9):631–43.
[22] Corrado D, Pelliccia A, Bjørnstad HH, Vanhees L, Biffi A, Borjesson M, et al. Cardiovascular pre-participation screening of young competitive athletes for prevention of sudden death: proposal for a common European protocol. Consensus statement of the study group of sport cardiology of the working group of cardiac rehabilitation and exercise physiology and the working group of myocardial and pericardial diseases of the European society of cardiology. Eur Heart J 2005;26(5):516–24.
[23] Steinvil A, Chundadze T, Zeltser D, Rogowski O, Halkin A, Galily Y, et al. Mandatory electrocardiographic screening of athletes to reduce their risk for sudden death proven fact or wishful thinking? J Am Coll Cardiol 2011;57(11):1291–6.
[24] Harmon KG, Zigman M, Drezner JA. The effectiveness of screening history, physical exam, and ECG to detect potentially lethal cardiac disorders in athletes: a systematic review/meta-analysis. J Electrocardiol 2015;48(3):329–38.

[25] Harmon KG, Suchsland MZ, Prutkin JM, Owens DS, Aukerman DF, Hwang CE, et al. Comparison of cardiovascular screening in college athletes by history and physical examination with and without an electrocardiogram: efficacy and cost. Heart Rhythm 2020;17(10):1649−55.
[26] Maron BJ. Hypertrophic cardiomyopathy: a systematic review. JAMA 2002;287(10):1308−20.
[27] Sheikh N, Papadakis M, Schnell F, Panoulas V, Malhotra A, Wilson M, et al. Clinical profile of athletes with hypertrophic cardiomyopathy. Circ Cardiovasc Imaging 2015;8(7):e003454.
[28] Corrado D, Perazzolo Marra M, Zorzi A, Beffagna G, Cipriani A, Lazzari M, et al. Diagnosis of arrhythmogenic cardiomyopathy: the Padua criteria. Int J Cardiol 2020;319:106−14.
[29] Drezner JA, Sharma S, Baggish A, Papadakis M, Wilson MG, Prutkin JM, et al. International criteria for electrocardiographic interpretation in athletes: consensus statement. Br J Sports Med 2017;51(9):704−31.
[30] Dhutia H, Malhotra A, Finocchiaro G, Parpia S, Bhatia R, D'Silva A, et al. Diagnostic yield and financial implications of a nationwide electrocardiographic screening programme to detect cardiac disease in the young. Europace 2021;23(8):1295−301.
[31] Dhutia H, Malhotra A, Finocchiaro G, Merghani A, Papadakis M, Naci H, et al. Impact of the international recommendations for electrocardiographic interpretation on cardiovascular screening in young athletes. J Am Coll Cardiol 2017;70(6):805−7.
[32] Vessella T, Zorzi A, Merlo L, Pegoraro C, Giorgiano F, Trevisanato M, et al. The Italian preparticipation evaluation programme: diagnostic yield, rate of disqualification and cost analysis. Br J Sports Med 2020;54(4):231−7.
[33] Lampert R. ECG screening in athletes: differing views from two sides of the Atlantic. Heart 2018;104(12):1037−43.
[34] Asif IM, Price DE, Ewing A, Rao AL, Harmon KG, Drezner JA. The impact of diagnosis: measuring the psychological response to being diagnosed with serious or potentially lethal cardiac disease in young competitive athletes. Br J Sports Med 2016;50(3):163−6.
[35] Van Brabandt H, Desomer A, Gerkens S, Neyt M. Harms and benefits of screening young people to prevent sudden cardiac death. BMJ 2016;353:i1156.
[36] Lear A, Patel N, Mullen C, Simonson M, Leone V, Koshiaris C, et al. Screening electrocardiogram in young athletes and military members: a systematic review and meta-analysis. J Athl Train 2021 May 26. (online ahead of print).
[37] Asplund CA, O'Connor FG. The evidence against cardiac screening using electrocardiogram in athletes. Curr Sports Med Rep 2016;15(2):81−5.
[38] Maron BJ, Friedman RA, Kligfield P, Levine BD, Viskin S, Chaitman BR, et al. Assessment of the 12-lead ECG as a screening test for detection of cardiovascular disease in healthy general populations of young people (12−25 Years of age). Circulation 2014;130(15):1303−34.
[39] Egger F, Scharhag J, Kästner A, Dvořák J, Bohm P, Meyer T. FIFA Sudden Death Registry (FIFA-SDR): a prospective, observational study of sudden death in worldwide football from 2014 to 2018. Br J Sports Med 2022;56(2):80−7.
[40] Gerardin B, Guedeney P, Bellemain-Appaix A, Levasseur T, Mustafic H, Benamer H, et al. Life-threatening and major cardiac events during long-distance races: updates from the prospective RACE PARIS registry with a systematic review and meta-analysis. Eur J Prev Cardiol 2021;28(6):679−86.
[41] Oh YZ, Lee CT, Lim AT, Tong KL. Sports-related sudden cardiac deaths in Singapore - an eleven-year review. Ann Acad Med Singapore 2019;48(5):156−60.
[42] Marijon E, Uy-Evanado A, Reinier K, Teodorescu C, Narayanan K, Jouven X, et al. Sudden cardiac arrest during sports activity in middle age. Circulation 2015;131(16):1384−91.
[43] Parry-Williams G, Gati S, Sharma S. The heart of the ageing endurance athlete: the role of chronic coronary stress. Eur Heart J 2021;42(28):2737−44.
[44] Chugh SS, Weiss JB. Sudden cardiac death in the older athlete. J Am Coll Cardiol 2015;65(5):493−502.
[45] Pelliccia A, Sharma S, Gati S, Bäck M, Börjesson M, Caselli S, et al. 2020 ESC Guidelines on sports cardiology and exercise in patients with cardiovascular disease: the Task Force on sports cardiology and exercise in patients with cardiovascular disease of the European Society of Cardiology (ESC). Eur Heart J 2020;42(1):17−96.
[46] Panhuyzen-Goedkoop NM, Wellens HJ, Verbeek AL, Jørstad HT, Smeets JR, Peters RJ. ECG criteria for the detection of high-risk cardiovascular conditions in master athletes. Eur J Prev Cardiol 2020;27(14):1529−38.
[47] Yeo TJ, Wang M, Grignani R, McKinney J, Koh LP, Tan FHY, et al. Electrocardiographic and echocardiographic insights from a prospective registry of Asian elite athletes. Front Cardiovasc Med 2021;8:799129.
[48] Dahlström Ö, Adami PE, Fagher K, Jacobsson J, Bargoria V, Gauffin H, et al. Efficacy of pre-participation cardiac evaluation recommendations among athletes participating in World Athletics Championships. Eur J Prev Cardiol 2020;27(14):1480−90.
[49] Wang L, Yeo TJ, Tan B, Destrube B, Tong KL, Tan SY, et al. Asian pacific society of cardiology consensus recommendations for pre-participation screening in young competitive athletes. Eur Cardiol 2021;16:e44.
[50] Kinoshi T, Tanaka S, Sagisaka R, Hara T, Shirakawa T, Sone E, et al. Mobile automated external defibrillator response system during road races. N Engl J Med 2018;379(5):488−9.