

Improving electrocardiogram interpretation in Asian athletes: A call to action

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The field of sports cardiology has evolved substantially over the past 2 decades due to improved understanding of the athlete's heart, causes of sudden cardiac death (SCD) in athletes, as well as differentiation between physiological cardiac remodelling and pathological cardiac conditions in athletic individuals. Application of this knowledge forms the basis of pre-participation screening (PPS) in athletes, where the primary aim is to identify conditions predisposing to SCD and mitigate risk to the athlete by appropriate management.

Traditional PPS in athletes comprise a thorough questionnaire on personal and family history and presence of symptoms as well as physical examination. With the 12-lead electrocardiogram (ECG) demonstrating superior sensitivity compared to clinical history and physical examination, it has become a vital tool in PPS for athletes and its importance cannot be understated. This is reflected by the progression of ECG interpretation criteria for athletes over the last 15 years. Early iterations for ECG interpretation in athletes outlined ECG characteristics of specific conditions (e.g. hypertrophic cardiomyopathy) and were derived from the general population. Subsequent accumulation of athlete-specific evidence has facilitated substantial refinements in the years thereafter. These include improved understanding of ECG changes reflecting physiological cardiac remodelling, for instance, the voltage criteria for left ventricular hypertrophy and incomplete right bundle branch block. The impact of age, sex and ethnicity on athletes' ECGs were also recognised, whereby juvenile T wave inversions, gender differences in corrected QT intervals and differences in repolarisation between white and black athletes were incorporated into ECG interpretation criteria. Four major ECG interpretation criteria have been published to date: the European Society of Cardiology (ESC) criteria in 2010, the Seattle Criteria in 2013, the Refined Criteria in 2014 and the International Criteria in 2017.¹⁻⁴

Throughout the evolution of athletes' ECG interpretation criteria, there is a notable absence of evidence from Asian athletes. This is in spite of Asia being the largest and most populous continent in the world with significant representation in international sport. More specifically, while some inroads have been made in West Asian athletes, there remains a dearth of epidemiological data on sudden cardiac death and physiological limits of cardiac remodelling in the diverse population of East, Central and South Asian athletes.⁵ This can be attributed to multiple barriers which exist within Asia, including disparity in healthcare resources and access to medical services. Most notably, Asia's unique geography, myriad of ethnicities and cultural diversity may have varying implications with regards to implementation of PPS, SCD risks, and conduct of research in sports cardiology.

Despite these challenges, data from Southeast Asia is emerging, highlighting parallels in the degree of exercise-induced cardiac remodelling between Southeast Asian and white athletes, albeit of smaller magnitudes.^{6,7} More recently, the Asian Pacific Society of Cardiology (APSC) recommended using the resting 12-lead ECG for PPS in young competitive athletes, with ECG interpretation via the International Criteria.⁸ This was based on available evidence demonstrating high specificity, preserved sensitivity and low interobserver variability in different athletic cohorts. Utilisation of the International Criteria for PPS in athletes also reduced false positive rates compared to older criteria. This is especially pertinent in competitive athletes as a false positive result during screening may lead to unnecessary and costly additional evaluation, delays in resumption of training and even inappropriate stress to the athlete. At the time of publication, performance of the International Criteria in a population of Asian athletes was yet to be evaluated.

In this issue of *Annals*, Lim et al. reviewed the electrocardiograms and echocardiograms of 270 elite

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Southeast Asian athletes who underwent PPS over a period of 7 years.⁹ These athletes were young (81% ≤ 35 years) and male (88%), with football as the predominant sporting discipline (74%). Each ECG was interpreted using four ECG criteria (ESC, Seattle, Refined and International), and the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) for each criterion in detecting echocardiographic abnormalities were calculated.

There was a substantial reduction in proportion of abnormal ECG from 35% using the ESC criteria to 3% using the International Criteria. In total, 20 athletes were found to have abnormal echocardiographic findings ranging from mitral valve prolapse, patent foramen ovale to pulmonary hypertension, among others. Among the four ECG interpretation criteria, the International Criteria yielded the best performance with highest specificity (97%), PPV (11%) and NPV (93%) along with lowest false positive rate (3%). These results remained consistent after exclusion of master athletes (12%) from analysis. Sensitivity for all four criteria was poor, achieving 20% at best (by ESC and Refined Criteria).

It should be noted that echocardiograms in the study cohort were performed due to abnormal ECG, physical findings or presence of symptoms rather than part of routine PPS. While routine echocardiographic screening as part of a robust PPS algorithm would indeed be useful, the resources required for mass screening are potentially prohibitive for widespread implementation, especially if the incidence of pathology detectable by echocardiogram is low. These resources include manpower (technicians required to screen, trained healthcare professionals to interpret echocardiographic findings), finances (for purchase of hardware, peripherals, consumables) and time (by the athlete to attend the screening and undergo evaluation). It is unsurprising that the requirement for routine echocardiographic evaluation is limited to larger sporting institutions such as the National Basketball Association (NBA) and Fédération Internationale de Football Association (FIFA). Nonetheless, with point-of-care ultrasound systems becoming more accessible, portable and easy to operate, targeted echocardiography as part of PPS for athletes may be likely in the future.

The applicability of the study findings is also limited by the under-representation of endurance and strength disciplines, as well as female athletes. However, the predominant population of footballers in this study is reflective of football being one of the most popular and

common sports in Asia. It is categorised as a largely dynamic sport by the American College of Cardiology and grouped together with sports such as long distance running and tennis, whereas the European Society of Cardiology deems football a mixed sport similar to basketball and hockey. The common theme is the dynamic/endurance component of football leading to a moderate degree of cardiac remodelling. Comparatively, strength/power sports are less common in Asia and also result in lesser degrees of cardiac remodelling. The population of strength-trained athletes remains poorly evaluated and should be considered in future studies.

While structural heart diseases such as hypertrophic cardiomyopathy are historically the most commonly cited causes of SCD in young athletes, there is increasing recognition of sudden arrhythmic death syndrome (SADS) as the predominant culprit in this population.¹⁰ Comprehensive evaluation, including genetic testing, of families with SADS deaths (termed molecular autopsy) revealed a significant proportion of arrhythmic conditions and inherited channelopathies. Prospective SCD registries in Asian athletes are urgently needed to identify the magnitude of SADS in this population, as this finding may have profound implications regarding our understanding of SCD, the conduct of PPS and how ECG criteria are utilised. These include potential modifications to PPS such as more detailed emphasis on palpitations and syncope during history taking as well as lowering the threshold to evaluate athletes with a family history of sudden cardiac death and/or unexplained syncope.

This study by Lim et al.⁹ has reinforced that the International Criteria is currently the most appropriate tool in guiding ECG interpretation for Asian athletes based on its highest specificity, NPV and lowest false positive rate compared to other ECG criteria, which is consistent with prevailing APSC consensus recommendations. It has also highlighted the pressing need for further evidence-based refinement of contemporary ECG criteria to improve poor sensitivity and false negative rates, as well as evaluating long-term outcomes based on such a screening protocol in Asian athletes.

The authors deserve commendation for laying the foundation for increased awareness of the Asian athlete's heart. There remains much to be done in Asian athletes: identifying ECG and echocardiographic changes from intensive physical training, and prevalence of pathological cardiac conditions or the true incidence

and predominant causes of SCD. Ethnicity-specific guidelines and recommendations for Asian athletes are overdue, and this call to action aims to encourage systematic research such as prospective PPS and SCD registries focusing on Asian athletes, among the sports cardiology community.

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