PRE-PARTICIPATION EVALUATION OF MALAYSIAN UNIVERSITY ATHLETES – THE IMPORTANCE OF CARDIOVASCULAR SCREENING

Zhuang Li Lim*, Abdul Halim Mokhtar, and Muhammad Rahmani Jaffar

Department of Sports Medicine, University Malaya Medical Centre, Malaysia

*Email: zllim@ummc.edu.my
(Received 14 June 2017; accepted 21 June 2017; published online 27 July 2017)

To cite this article: *Lim, Z. L., Mokhtar, A. H., & Jaffar, M. R. (2017). Pre-participation evaluation of Malaysian university athletes – the importance of cardiovascular screening. Movement, Health & Exercise, 6(2), 83-96. http://dx.doi.org/10.15282/mohe.v6i2.152*
Link to this article: *http://dx.doi.org/10.15282/mohe.v6i2.152*

Abstract

Background: Sudden cardiac arrest and death (SCA/D) remains the leading cause of mortality among athletes. Contemporary standards of identifying normal physiological cardiac adaptations and remodeling from regular athletic training based on certain ECG morphology have been clearly defined by the 'Seattle Criteria' in 2012, with an updated 'International Consensus' in 2017. In heterogenous Asia, regional SCA/D preponderance data is still lacking. This study aims to report on the detection of potentially dangerous cardiovascular conditions in Malaysian university athletes via pre-participation evaluation. **Methods:** All 176 Malaysian athletes competing in the 18th ASEAN University Games 2016 were requested to attend a centralised pre-participation evaluation (PPE) prior to the games. The PPE included history, physical examination and a resting ECG. Participating sports and the corresponding number of athletes were athletics (40), basketball (26), football (24), silat (16), rugby (14), badminton (14), table tennis (12), shooting (12), fencing (10) and petanque (8). **Results:** A hundred and thirteen athletes (64.2%) attended and completed the PPE. The highest percentages of athletes screened were from shooting, fencing and petanque (100% respectively), whilst the lowest were from the basketball team (23.1%). Three abnormal ECGs were identified: a multiple premature ventricular contractions, an atrial tachyarrhythmia and a ventricular pre-excitation. These three athletes were referred for subsequent investigations. Two of them were allowed to resume play. The latter athlete was diagnosed with Wolff-Parkinson-White syndrome and was advised against competing until definitive management was instituted. **Conclusion:** Only a fair number of Malaysian university athletes completed the medical screening. This reflects their unawareness of the importance of PPE. Despite the small sample size, three cases were singled out requiring further investigation and interventional studies. No screening program provides absolute protection against death. Thus, more evidence-based research and constant updates on

the best practice guidelines are vital to foster safe sports participation to ultimately reduce incidence of SCA/D among the athletic population. Athletes need to be aware and give full cooperation for PPE to ensure early detection of high-risk cardiovascular conditions especially those related to sudden death in sports.

Keywords: Athlete, Malaysia, pre-participation evaluation (PPE), sudden cardiac arrest and death (SCA/D).

Introduction

Pre-participation evaluation (PPE), also contemporarily identified as pre-competition medical assessment or pre-participation screening, is the systematic practice of medically screening the health of an athlete to optimise safe sports participation and to assess other potential health risks and morbidities (Drezner et al., 2016). The current PPE model as recommended by the International Olympic Council, utilises a comprehensive personal and family history questionnaire, physical examination encompassing cardiovascular and other systemic issues, musculoskeletal, concussion, dental health and women-specific conditions (Ljungqvist et al., 2009).

As cardiovascular-related sudden death remains the main cause of mortality among young athletes, screening strategies tend to be cardiac-centric in nature (Maron, et al., 2009). Conducted as a stand-alone or any part thereof a comprehensive PPE, cardiovascular screening aims to identify underlying cardiac disorders that predispose athletes to sudden cardiac arrest and death (SCA/D) (Drezner et al., 2016). Hypertrophic cardiomyopathy is the single most common cause of sudden death in young athletes below the age of 35 in the USA, accounting for 40% of athletic death (Maron, Gohman, & Aeppli, 1998). Other rare but notable conditions include congenital coronary abnormalities, arrhythmogenic right ventricular dysplasia, dilated cardiomyopathies, channelopathies (e.g. long QT syndrome and Brugada syndrome) and Marfan's syndrome. Conversely, coronary artery disease is the main contributory factor in athletes over the age of 35 (Chugh and Weiss, 2015).

The earliest SCA/D recorded in an athlete was Pheidippides, a young Greek long-distance messenger in 490 BC. He collapsed and died after reporting defeat of the Persian army (Koster, 2001). Incidence of SCA/D in athletes varies slightly due to lack of systematic reporting. Annual incidence in the USA is approximately in the ratio of 1 to 80000 among high school athletes and 1 to 50000 among collegiate athletes (Glover et al., 2007; Harmon, et al., 2011). In Italy, incidence was noted to be in the ratio of 1 to 28000 among young competitive athletes prior to implementation of yearly screening exercise (Corrado et al., 2006). Risks of SCA/D are also found to be higher among males, African-Americans and basketball athletes (Maron et al., 2014; Harmon et al., 2015). In heterogenous Asia however, epidemiological data of SCA/D remains scarce especially in developing nations. Certain pathologies such as arrythmogenic right ventricular dysplasia in Korea (Cho et al., 2015) and Brugada-type pattern in Japan and Iran are thought to be more common than among Western population (Miyasaka et al., 2001; Bigi, Aslani, & Shahrzad, 2007). In Malaysia, the only study looking into sudden

death during recreational sports from post-mortem specimens concluded that 80% of deaths were attributed to ischaemic heart disease (Murty et al., 2007). Over the recent years, notable cases of sports-related deaths were reported in the local media involving Jacky Ng, a national basketballer, Siah Kim Huatt, a recreational marathoner, and more recently, T-Team footballer David Oniya (Kng, 2013; Cheng, 2015; Samuel, 2015). These tragedies stirred the emotions among Malaysians as it was ironic that the young and fit could simply drop dead.

PPE has substantially reduced the incidence of SCA/D by 89% among competitive athletes in Italy, contributing to the basis of the European Society of Cardiology (ESC) screening guidelines (Corrado et al., 2005). Although screening has been universally mandated in countries such as Italy, Japan, Israel and the USA, optimal screening strategy remains unknown due to the absence of clear outcome-based evidence (Tanaka et al., 2006; Steinvil et al., 2011). The addition of a resting 12-lead electrocardiogram (ECG) in the centers with experience in athlete ECG screening has demonstrated improved sensitivity towards detecting cardiovascular anomalies (Corrado et al., 2006; Maron et al., 2014). Having said so, the objectivity of an ECG is still being debated due to subjective interpretation, high false positive rates and low cost-benefit outcome (Fuller et al., 2016). This has led to significant differences between the North American and European screening guidelines with the latter routinely advocating a resting 12-lead ECG for all young athletes. Nevertheless, usage of standardised ECG evaluation criteria such as the 'Seattle Criteria' (Drezner et al., 2013) and the recently updated 'International Criteria' (Drezner et al., 2017) has helped to improve accuracy in ECG interpretation.

At present, Malaysian national athletes undergo PPE at the National Sports Institute annually and also six months prior to a major meet such as the Asian Games. Athletes staying away from centralised training are recommended to undergo once, although not mandatory (Murugappan, 2013). Paucity of published local statistics on the adherence to and clinical outcomes of PPE have led to this review. The aim of this study is to report on the detection of potentially dangerous cardiovascular conditions among Malaysian university athletes via pre-participation evaluation.

Methods

This is a cross-sectional descriptive study involving all 176 Malaysian university athletes competing in the 18th ASEAN University Games 2016. This study has the ethical approval from the Medical Research Ethic Committee of University Malaya. All athletes were requested to attend a formal PPE prior to the games, with written informed consent given. Medical evaluation was conducted by an experienced Sports Physician and two Medical Officers from the Sports Medicine Department who have prior knowledge in performing sports clearance examinations. Structured assessment encompassing anthropometric and vital sign recordings, self and relevant family history, focused physical examination involving assessment of cardiovascular, respiratory, musculoskeletal, abdominal region and stigmata of Marfan's syndrome were conducted. A resting ECG was performed using standard 12-lead placement and equipment (MAC 1600, GE Healthcare, Milwaukee, Wisconsin). The 2017 'International Criteria' was

adopted as the common standard for ECG interpretation among athletes. Mean values, percentages and standard deviations were determined using Microsoft Excel®.

Results

One hundred and thirteen athletes attended the PPE session. This reflects a screening completion rate of 64.2%. Baseline characteristics were on average age of 22 years (SD = 2.20, range 19-28 years), average height of 167 cm (SD = 9.18, range 149 - 196 cm), average weight of 67 kg (SD = 13.61, range 43.6 – 129.1 kg) and average body mass index of 23.7 kg/m^2 (SD = 3.859, range 15.67 – 44.41 kg/m^2). Three teams (shooting, fencing, and petanque) achieved 100% screening rates, whilst the basketball team merely achieved a 23.1% completion rate (Table 1).

From the medical history, seven athletes had underlying medical conditions. Three of them were known to have asthma (Table 2). All the athletes denied any family history of SCA/D. Thirty nine athletes (34.5%) were currently taking medications or supplements. Fifteen among them were taking vitamin-supplements and mineral-based products, four on botanical-based products, sixteen on sports nutrition-based products and two on weight-management products. Interestingly, five of the fifteen silat athletes (33%) were self-prescribing bisacodyl, a stimulant laxative.

Systolic blood pressure was on average 121mmHg (SD = 11.89, range 92 – 145mmHg) whilst mean diastolic blood pressure was 71mmHg (SD = 9.63, range 54 – 91mmHg). Four athletes had elevated systolic and/or diastolic blood pressure. A repeat blood pressure reading was performed at a later date and they were all found to be within normal range. No obvious cardiovascular, respiratory or abdominal systems abnormalities were detected. Nine (8.0%) musculoskeletal injuries were identified during screening (anterior cruciate ligament injury = 4, quadriceps contusion = 1, de Quervain's tenosynovitis = 1, lateral epicondylitis = 1, PFJS = 1, phalangeal ligamentous injury = 1). Follow-up review was provided to the athletes accordingly.

Table 3 shows the ECG-integrated screening findings that suggests physiological adaptations among athletes, borderline changes and abnormal findings. Of the training-related ECG alterations, sinus arrhythmia (42.5%), sinus bradycardia (34.5%) and early repolarisation changes (21.2%) were most commonly seen. Isolated borderline ECG findings (RAD = 10, LAD = 1) did not necessitate other evaluation. The ECG screening identified three (2.7%) athletes with abnormal training-unrelated changes requiring further investigations. These three cases were reviewed by a Cardiologist and are discussed below:

Table 1: Sports- specific Screening Compliance

Sports	Total athletes, (n = 176)	Numbers screened, n (%)
Shooting	12	12 (100)
Fencing	10	10 (100)
Petanque	8	8 (100)
Silat	16	15 (93.8)
Rugby	14	12 (85.7)
Table Tennis	12	10 (83.3)
Football	24	19 (79.2)
Badminton	14	8 (57.1)
Athletics	40	13 (32.5)
Basketball	26	6 (23.1)
Total		113 (64.2)

Table 2: Findings During Pre-participation Physical Evaluation (PPE)

Findings	Positive findings n (%)
Personal medical history	
Underlying diabetes / hypertension / cardiovascular disease / asthma / tuberculosis / other medical conditions	7 (6.2)
Exertional chest pain or discomfort	0
Chest pain at rest	0
Excessive or unexplained exertional dyspnoea and fatigue	0
Known allergy	8 (7.1)
Prior surgery	6 (5.3)
Currently taking medications / herbal or other supplements	39 (34.5)
Family medical history	
Premature (sudden or unexpected) death of ≥1 relative before age 50 years due to heart disease	0
Physical examination	
Elevated systolic and /or diastolic blood pressure	4 (3.5)
Heart rate, rhythm, volume	1 (0.9)
Vision and ENT	0
Cardiovascular	0
Respiratory	0
Abdominal	0
Musculoskeletal	9 (8.0)
Stigmata of Marfan's syndrome	0

Table 3: Findings on 12-lead ECG During Pre-participation Physical Evaluation (PPE)

	Basketball (N = 6)	*Shooting (N = 12)*	*Fencing (N = 10)*	*Athletics (N = 13)*	*Football (N = 19)*	*Silat (N = 15)*	*Petanque (N = 8)*	*Table Tennis (N=10)*	*Badminton (N = 8)*	*Rugby (N = 12)*	*Positive findings n (%)*
Normal ECG findings in athletes [ϕ]											
Sinus bradycardia	4	2	2	7	6	4	-	1	5	8	39 (34.5)
Sinus arrhythmia	3	4	6	6	8	4	4	3	5	5	48 (42.5)
Ectopic atrial rhythm	-	1	-	-	-	-	-	1	-	-	2 (1.8)
Junctional escape rhythm	-	-	-	-	-	-	-	-	-	-	0
1° atrioventricular block	-	-	-	-	-	-	-	-	-	1	1 (0.9)
Mobitz type 1 (Wenckebach) 2° atrioventricular block	-	-	-	-	-	-	-	-	-	-	0
Incomplete right bundle branch block	3	1	4	1	4	1	1	2	2	4	23 (20.4)
Increased QRS voltage	2	-	2	-	3	1	-	-	1	3	12 (10.6)
Early repolarization	2	-	3	4	4	3	1	2	2	3	24 (21.2)
Borderline ECG findings [λ]											
Right axis deviation (RAD)	-	-	-	-	4	2	1	2	1	-	10 (8.8)
Left axis deviation (LAD)	1	-	-	-	-	-	-	-	-	-	1 (0.9)
Abnormal ECG findings [ǂ]											
Ventricular pre-excitation	1	-	-	-	-	-	-	-	-	-	3 (2.7)*
Premature ventricular complexes	1	-	-	-	-	-	-	-	-	-	**of total abnormalities*
Atrial tachyarrhythmia	-	1	-	-	-	-	-	-	-	-	

[ϕ]These training-related ECG alterations are physiological adaptations to regular exercise, considered normal variants in athletes and do not require further evaluation in asymptomatic athletes with no significant family history; [λ]These ECG findings in isolation likely do not represent pathological cardiovascular disease in athletes, but the presence of two or more borderline findings may warrant additional analysis until further data become available; [ǂ]These ECG findings are unrelated to regular training or expected physiological adaptation to exercise, may suggest presence of pathological cardiovascular disease and require further diagnostic investigation. Adapted from *Drezner et al. (2017).*

Case 1: Multiple premature ventricular complexes (PVCs). Mr JJ, a 24-year-old male basketballer did not exhibit any positive symptoms or findings on clinical history. He had an occasionally irregular pulse rate of 68 bpm, whilst his ECG showed three large premature ventricular complexes, left ventricular strain pattern and partial right bundle branch block pattern on a 10-second tracing *(Figure 1)*. Subsequent echocardiogram showed normal ventricular wall thickness and motion with no evidence of myocardial hypertrophy or diastolic dysfunction. An exercise stress test (EST) via Bruce Protocol showed disappearance of PVCs with incremental exercise without any symptoms. A diagnosis of benign PVCs was made. Mr JJ was subsequently allowed to participate in the games and advised to go for yearly medical reviews.

Case 2: Ventricular pre-excitation. Ms NC, a 20-year-old female basketballer was diagnosed with an abnormal heart condition two years ago, though no written documentation was available at the time of review. She initially complained of racing heart rate and light-headedness after a game and was admitted to a medical centre for an overnight stay. Treadmill EST and an echocardiogram were allegedly found to be within normal limits. She was later discharged well. In the following year, she complained of a similar episode of transient palpitation post-game. During the current review, her ECG demonstrated classic findings of delta waves, shortened PR interval and broadened QRS complexes, characteristic of Wolff-Parkinson-White (WPW) pattern (Figure 2). Echocardiogram did not reveal any structural heart disease. A treadmill EST via Bruce Protocol showed persistence of pre-excitation waves even at maximal exertion though she remained asymptomatic throughout. A diagnosis of WPW syndrome was confirmed. In view of possible high-risk accessory pathway predisposing her to SCA/D particularly during exertional events, Ms NC was counselled and advised against playing until definitive management was instituted. In spite of this, the athlete chose to compete with an agreement that intervention studies be allowed after the games.

Case 3: Atrial tachyarrhythmia. Ms MG is a 22-year-old female shooter with no known medical illness. She denied any history of palpitation, syncopal attacks, dyspnoea, family history of SCA/D or taking stimulants. The physical examination performed was unremarkable, except for clinical tachycardia. An ECG showed atrial tachycardia with inverted P-wave at inferior leads indicating a non-sinus origin *(Figure 3).* Investigations comprising of full blood counts, renal, liver, and thyroid function tests as well as echocardiogram were otherwise found to be normal. She completed stage 3 EST via Bruce Protocol achieving 97% of predicted maximal heart rate. Of note, the persistent atrial tachyarrhythmia may confer her slightly elevated risk of having a supraventricular tachycardia which is also detrimental to her sporting performance (Drezner et al., 2017). She was counselled on the need for an electrophysiological study with the possibility of an ablation therapy explained. As her sport was low-intensity in nature, she was allowed to compete and have the pertaining interventions performed at an elective date.

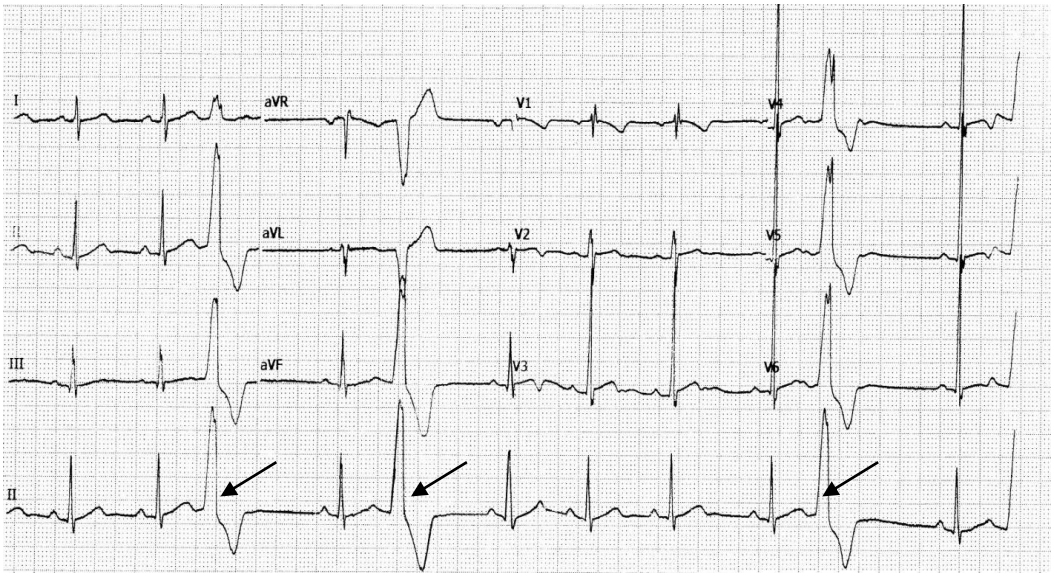

Figure 1: ECG in a basketballer showing multiple premature ventricular complexes (PVC) with partial right bundle branch block pattern.

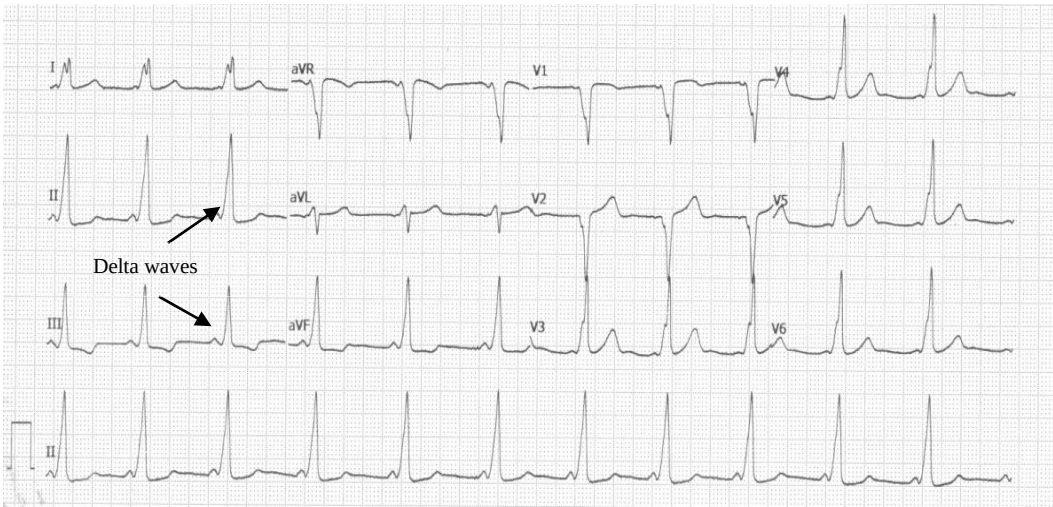

Figure 2: ECG demonstrating classic findings of Wolff-Parkinson-White pattern with delta waves (slurred QRS upstroke pattern), shortened PR interval (<120ms) and prolonged QRS (>120ms).

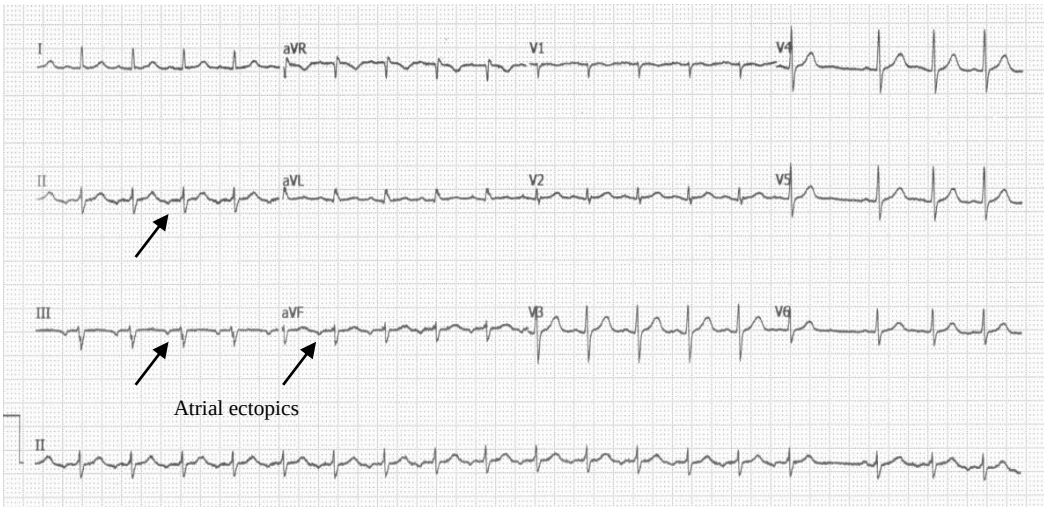

Figure 3: ECG showing sinus tachyarrhythmia with ectopics. The atrial rate is 111 beats/min and the P wave morphology is negative in leads II, III and aVF signifying an ectopic atrial rhythm.

Discussion

This study presents an outcome of the first data following a pre-participation evaluation involving Malaysian university athletes. In spite of the relatively small sample size, three athletes with cardiovascular pathologies requiring further evaluations were identified. The screening compliance rate of 64.2% is fair and in fact better than the American National Collegiate Athletic Association Division 1's completion rates of 47% (Coris et al., 2012). On the contrary, completion rates were notably higher among elite sports, with rates of 81% during the 2006 FIFA World Cup (Dvorak et al., 2009). A postal survey done in the UK by Fuller, Ojelade, and Taylor (2007) suggested that whilst over 90% of the English Premiership and Championship football teams performed a pre-employment PPE, hardly 50% of the rugby league clubs completed similar initiatives – representing a distinct lack of compliance even in high-level professional sports. Lack of awareness, cost constraints and inaccessibility to the medical facilities especially sports medicine services are probable contributory factors towards Malaysian university athletes' ignorance to the PPE. Departures from best practice guidelines and variations in standards of implementation between sports organizations may predispose athletes to certain morbidities which may otherwise have been identified from an egalitarian PPE (Madsen et al., 2014). Madsen, Drezner, and Salerno (2012) claimed that merely half of the American physicians themselves were aware of the American Heart Association's (AHA) 14-elements guidelines on PPE despite its unchanged iteration over the past 15 years. This shows that screening implementation itself may be highly operator-dependant despite the presence of widely-published recommendations.

An ideal cardiovascular PPE screening strategy is still very much debatable with great discussion centering on the inclusion of ECG into screening programs. In a recent meta-analysis by Harmon, Zigman, and Drezner (2015) involving 47137 athletes spanning 15

studies, the addition of ECG using current interpretation criteria increased sensitivity by five and ten-fold over clinical history and physical examination respectively. However, the presence of considerable study heterogeneity and the adoption of non-homogenous ECG standards preclude a universal endorsement of the ECG over traditional screening approach consisting of history and physical examination. Besides, the ECG is unable to detect anomalous aortic origin of coronary artery and aortic root dilatation, which are the two important causes of SCA/D among young athletes (Basso et al., 2000). The natural continuous advancements in medical equipment technology will eventually make screening more accurate, affordable, and mainstream. The impact of more 'positive cases' may not translate to a better preventive exercise, as till today, not all pathological cases will manifest as a terminal SCA/D event. Furthermore, these 'false positive' cases may incur inappropriate scrutiny and at worse, unlawful disqualification which treads onto the ethico-legal aspects of having a medical screening in the first place. Hence, it is prudent to call for more collaborative work between international stakeholders to establish a robust epidemiological data on the incidence, aetiology and long term outcomes of SCA/D worldwide, particularly in multi-ethnic Asia where a practical and compatible evaluation program within regional needs can be planned.

Nevertheless, the devastating nature of SCA/D coupled with the adage 'prevention is better than cure' lend a strong incentive for physicians to continue screening initiatives. Instead as viewing it as a hindrance to sports engagement, educating athletes on the importance of PPE as an element of periodic health evaluation should improve screening responses. For the fit and healthy, this may be the athlete's first encounter with a medical practitioner who may help identify other imminent risks for non-communicable diseases. Likewise, Sports Physicians should uphold a professional duty of care to advise all athletes with underlying cardiac anomalies against competing under an elevated risk of SCA/D until and unless cleared medically. On the other hand, if an athlete chooses to participate even though he/she has been made aware of the possible consequences, it is his/her autonomy that is to be respected. This applies also to the case of the WPW syndrome athlete.

On a side note, a third of the Silat athletes in this study seems to be consuming laxatives, which is something not uncommon in the realm of combat sports. Franchini, Brito, and Artioli (2012) suggest that up to 60% of jujitsu, karate, and taekwondo exponents engage in similar practices with those adopting more aggressive weight-reducing measures achieving higher classification success. More so, athletes need to be made aware of the potential physiological and psychological harmful effects of rapid weight-loss in addition to violations of doping regulations, particularly with diuretics abuse.

Certain limitations have been identified in this study. Firstly, the wide variety of sports included across varying intensity levels may not truly represent the inherent physiological adaptations seen in a sport-specific screening exercise. Next, our history questionnaire forms did not explore prior recognition of heart murmur or presence of specific inherited cardiac conditions, both strongly advocated by the AHA and ESC guidelines as this may be the sole indication for other vital evaluations. Following this, implementing a larger evidence-based review on the outcomes of screening among

Malaysian elite athletes using consistent present-day screening methodologies may help identify a definite local incidence of risk factors for SCA/D.

Conclusion

Only a fair number of Malaysian university athletes (64.2%) completed pre-participation evaluation prior to the 2016 Asian University Games. The screening PPE identified three athletes as having abnormal ECGs requiring additional investigations. In fact, one athlete was deemed not fit for participation due to a pre-existing cardiovascular condition conferring to elevated risk of SCA/D. No screening program provides absolute protection against death. Hence, it requires more evidence-based research, educational initiatives and continuous acquaintance into best screening strategies and management choices which may help establish safer sports participation and reduce incidences of SCA/D among the athletic population. As compulsory population-based national screening exercise will be too costly to justify in a developing country like Malaysia, all competitive Malaysian athletes are advocated to undergo yearly PPE by qualified Sports Physicians. This should include contents similar to the ESC or AHA questionnaire with the incorporation of routine ECG interpreted using up-to-date standards. Adequate working collaboration and access to cardiology expertise in conducting a secondary evaluation of ECG abnormalities should be established in order to facilitate further care.

Acknowledgement

The first author would like to graciously thank Siow-Yeh Chiew and Meng-Guat Lee for assistance with proofreading and editing prior to submission.

Competing interest

None declared.

References

Basso, C., Maron, B. J., Corrado, D., & Thiene, G. (2000). Clinical profile of congenital coronary artery anomalies with origin from the wrong aortic sinus leading to sudden death in young competitive athletes. *Journal of the American College of Cardiology*, *35*(6), 1493-1501.

Bigi, M. A. B., Aslani, A., & Shahrzad, S. (2007). Prevalence of Brugada sign in patients presenting with palpitation in southern Iran. *Europace*, *9*(4), 252-255.

Cheng, N. (2015, Apr 20). Marathon runner suffers heart attack 15km from finishing line. *The Star*. Retrieved from: <http://www.thestar.com.my/news/nation/2015/04/20/marathon-runner-suffers-heart-attack-15m-from-finish-line/>

Cho, Y., Park, T., Yang, D. H., Park, H. S., Chae, J., Chae, S. C., Jun, J. E., Kwak, J. S., & Park, W. H. (2003). Arrhythmogenic right ventricular cardiomyopathy and sudden cardiac death in young Koreans. *Circulation Journal*, *67*(11), 925-928.

Chugh, S. S. & Weiss, J. B. (2015). Sudden cardiac death in the older athlete. *Journal of the American College of Cardiology*, *65*(5), 493-502.

Coris, E. E., Sahebzamani, F., Curtis, A., Jennings, J., Walz, S. M., Nugent, D., Reese, E., Zwygart, K. K., Konin, J. G., Pescasio, M., & Drezner, J. A. (2013). Preparticipation cardiovascular screening among National Collegiate Athletic Association Division I institutions. *British Journal of Sports Medicine*, *47*(3), 182-184.

Corrado, D., Basso, C., Pavei, A., Michieli, P., Schiavon, M., & Thiene, G. (2006). Trends in sudden cardiovascular death in young competitive athletes after implementation of a preparticipation screening program. *JAMA*, *296*(13), 1593-1601.

Corrado, D., Pelliccia, A., Bjørnstad, H. H., Vanhees, L., Biffi, A., Borjesson, M., Panhuyzen-Goedkoop, N., DEligiannis, A., Solberg, E., Dugmore, D., & Mellwig, K. P. (2005). Cardiovascular pre-participation screening of young competitive athletes for prevention of sudden death: proposal for a common European protocol. *European Heart Journal*, *26*(5), 516-524.

Drezner, J. A., Ackerman, M. J., Anderson, J., Ashley, E., Asplund, C. A., Baggish, A. L., Borjesson, M., Cannon, B. C., Corrado, D., DiFiori, J. P., & Fischbach, P. (2013). Electrocardiographic interpretation in athletes: the 'Seattle criteria'. *British Journal of Sports Medicine*, *47*(3), 122-124.

Drezner, J. A., O'Connor, F. G., Harmon, K. G., Fields, K. B., Asplund, C. A., Asif, I. M., Price, D. E., Dimeff, R. J., Bernhardt, D. T., & Roberts, W. O. (2016). AMSSM Position Statement on Cardiovascular Preparticipation Screening in Athletes: current evidence, knowledge gaps, recommendations and future directions. *British Journal of Sports Medicine*, bjsports-2016.

Drezner, J. A., Sharma, S., Baggish, A., Papadakis, M., Wilson, M. G., Prutkin, J. M., La Gerche, A., Ackerman, M. J., Borkesson, M., Salerno, J. C., & Asif, I. M. (2017). International criteria for electrocardiographic interpretation in athletes. *British Journal of Sports Medicine*, bjsports-2016.

Dvorak, J., Grimm, K., Schmied, C., & Junge, A. (2009). Development and implementation of a standardized precompetition medical assessment of international elite football players-2006 FIFA World Cup Germany. *Clinical Journal of Sport Medicine*, *19*(4), 316-321.

Franchini, E., Brito, C. J., & Artioli, G. G. (2012). Weight loss in combat sports: physiological, psychological and performance effects. *Journal of the International Society of Sports Nutrition*, *9*(1), 52.

Fuller, C. W., Ojelade, E. O., & Taylor, A. (2007). Preparticipation medical evaluation in professional sport in the UK: theory or practice? *British Journal of Sports Medicine*, *41*(12), 890-896

Fuller, C. W., Scott, C., Hug-English, C., Yang, W., & Pasternak, A. (2016). Five-year experience with screening electrocardiograms in National Collegiate Athletic Association division I athletes. *Clinical Journal of Sport Medicine*, *26*(5), 369-375. Glover, D. W., Glover, D. W., & Maron, B. J. (2007). Evolution in the process of screening United States high school student-athletes for cardiovascular disease. *The American Journal of Cardiology*, *100*(11), 1709-1712.

Glover, D. W., Glover, D. W., & Maron, B. J. (2007). Evolution in the process of screening United States high school student-athletes for cardiovascular disease. *The American Journal of Cardiology*, *100*(11), 1709-1712.

Harmon, K. G., Asif, I. M., Klossner, D., & Drezner, J. A. (2011). Incidence of Sudden Cardiac Death in National Collegiate Athletic Association AthletesClinical Perspective. *Circulation*, *123*(15), 1594-1600.

Harmon, K. G., Asif, I. M., Maleszewski, J. J., Owens, D. S., Prutkin, J. M., Salerno, J. C., Zigman, M. L., Ellenbogen, R., Rao, A., Ackerman, M. J., & Drezner, J. A. (2015). Incidence, etiology, and comparative frequency of sudden cardiac death in NCAA athletes: a decade in review. *Circulation*, CIRCULATIONAHA-115.

Harmon, K. G., Zigman, M., & Drezner, J. A. (2015). The effectiveness of screening history, physical exam, and ECG to detect potentially lethal cardiac disorders in athletes: a systematic review/meta-analysis. *Journal of Electrocardiology*, *48*(3), 329-338.

Kng, Z. G. (2013, Jul 29). Update: Shock as national cager Jacky dies in China. *The Star*. Retrieved from: <http://www.thestar.com.my/sport/other-sport/2013/07/29/jacky-ng-heart-attack/>

Koester, M. C. (2001). A review of sudden cardiac death in young athletes and strategies for preparticipation cardiovascular screening. *Journal of Athletic Training*, *36*(2), 197.

Ljungqvist, A., Jenoure, P., Engebretsen, L., Alonso, J. M., Bahr, R., Clough, A., De Bondt, G., Dvorak, J., Maloley, R., Matheson, G., & Meeuwisse, W. (2009). The International Olympic Committee (IOC) Consensus Statement on periodic health evaluation of elite athletes March 2009. *British Journal of Sports Medicine*, *43*(9), 631-643.

Madsen, N. L., Drezner, J. A., & Salerno, J. C. (2012). Sudden cardiac death screening in adolescent athletes: an evaluation of compliance with national guidelines. *British Journal of Sports Medicine*, bjsports-2012.

Madsen, N. L., Drezner, J. A., & Salerno, J. C. (2014). The preparticipation physical evaluation: an analysis of clinical practice. *Clinical Journal of Sport Medicine*, *24*(2), 142-149.

Maron, B. J., Doerer, J. J., Haas, T. S., Tierney, D. M., & Mueller, F. O. (2009). Sudden deaths in young competitive athletes. *Circulation*, *119*(8), 1085-1092.

Maron, B. J., Gohman, T. E., & Aeppli, D. (1998). Prevalence of sudden cardiac death during competitive sports activities in Minnesota high school athletes. *Journal of the American College of Cardiology*, *32*(7), 1881-1884.

Maron, B. J., Haas, T. S., Murphy, C. J., Ahluwalia, A., & Rutten-Ramos, S. (2014). Incidence and causes of sudden death in US college athletes. *Journal of the American College of Cardiology*, *63*(16), 1636-1643.

Miyasaka, Y., Tsuji, H., Yamada, K., Tokunaga, S., Saito, D., Imuro, Y., Matsumoto, N., & Iwasaka, T. (2001). Prevalence and mortality of the Brugada-type electrocardiogram in one city in Japan. *Journal of the American College of Cardiology*, *38*(3), 771-774.

Murty, O. P., Agarwal, A., Murugiah, K. A., Rahman, S. N. A., & Bakar, K. A. A. (2007). Sudden death during sport activities: A Malaysian perspective pages. *Journal of Indian Academy of Forensic Medicine*, *29*(4), 122-126.

Murugappan, R. (2013). Making it compulsory. *The Star*. Retrieved from: <http://www.thestar.com.my/lifestyle/health/fitness/2013/08/18/making-it-compulsory/>

Samuel, E. (2015, Jun 13). T-Team player Oniya dead after collapsing on field. *The Star*. Retrieved from: <http://www.thestar.com.my/sport/football/2015/06/13/t-team-import-had-heart-attack-on-field/>

Steinvil, A., Chundadze, T., Zeltser, D., Rogowski, O., Halkin, A., Galily, Y., Perluk, H., & Viskin, S. (2011). Mandatory electrocardiographic screening of athletes to reduce their risk for sudden death: proven fact or wishful thinking? *Journal of the American College of Cardiology*, *57*(11), 1291-1296.

Tanaka, Y., Yoshinaga, M. A. S. A. O., Anan, R. Y. U. I. C. H. I. R. O., Nomura, Y., Oku, S., Nishi, S., Kawano, Y., Tei, C., & Arima, K. (2006). Usefulness and cost effectiveness of cardiovascular screening of young adolescents. *Medicine and Science in Sports and Exercise*, *38*(1), 2-6.