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ORIGINAL ARTICLE

Identifying Electrocardiogram Pattern Changes and Their Association with Echocardiography among Malaysian Footballers Attending Pre-Participation Evaluation

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ABSTRACT

Introduction: Sudden cardiac death is the most common medical cause of death in athletes. The aim of this study was to identify the electrocardiogram (ECG) pattern changes and its association with echocardiography among Malaysian footballers during a pre-participation evaluation (PPE). **Methods:** A retrospective study was conducted on footballers attending a PPE at a primary care centre. Secondary data collection was conducted and the proforma included clinical history, physical examination, ECG, Echocardiogram and cardiovascular risk factors assessment such as heart rate, blood pressure, lipid profile, fasting blood sugar and creatinine. Data were extracted from the medical records, echocardiogram report and the original ECG. The ECG patterns were analysed according to the International consensus for ECG interpretation in athletes to determine physiological versus pathological changes. The data was analysed using SPSS v24. **Results:** This study included 85 male Malaysian footballers with a mean age of 20.1 ± 3.0 years. The mean resting heart rate was 55.2 ± 9.3 beats per minute. Abnormal ECG changes were found in 20% of the participants, which were higher compared to that reported in other studies (14% – 17.3%). The normal ECG findings in athletes were sinus bradycardia (76.5%), J-point elevation (68.2%), prolonged PR interval (3.5%) and incomplete right bundle branch block (4.7%). The abnormal ECG changes were multiple T wave inversions (5.9%), hypertrophy (2.4%), and deep Q-waves (8.2%). Four abnormal ECGs were consistent with abnormal echocardiography findings and out of these, two ECGs with hypertrophic changes were consistent with mild inter atrial septal bulging and apical hypertrophy. **Conclusions:** Malaysian footballers have ECG changes that are consistent with physiological changes in athlete's heart. The positive association between ECG and Echocardiogram findings are useful in confirming pathological ECG changes. Physicians should be trained in PPE protocol and ECG interpretation in athletes in order to improve identification of those at risk of sudden cardiac death.

KEYWORDS: Electrocardiogram, footballers, preparticipation evaluation, screening, echocardiography, Malaysian.

INTRODUCTION

Electrocardiogram (ECG) changes in athletes are common and these reflect the structural and electrical remodelling of the heart following intense and regular physical exercise [1,2]. The paradox of intense physical exercise is that despite the known health benefits, it can increase the risk of sudden cardiac death. Sudden cardiac death (SCD) is an unexpected death without obvious extra-cardiac cause occurring with a rapid witnessed collapse or if unwitnessed, occurring within 1 hour of onset of cardiac symptoms such as chest pain or palpitation [3]. It is estimated that the risk of SCD doubles during physical activity [4] and that athletes with underlying cardiovascular disease have 2.5 times higher risk of SCD than non-athletes [5,6,7].

Cardiovascular risk factors (CRF) assessment is a major component in the pre-participation evaluation (PPE) [8,9]. There has been a lengthy debate on the role of ECG in PPE. The American Heart Association (AHA) recommends the use of a health questionnaire and physical examination but does not include a 12-lead

ECG assessment [10]. On the other hand, the European Society of Cardiology (ESC) has included the 12-lead ECG in its recommendation [11] and many studies have shown that ECG is reliable to identify underlying cardiovascular abnormalities among athletes [7,12,13].

The term athlete's heart represents the following physiological changes, which include structural, such as increase in heart size, and changes in the heart's electrical activity, such as innocent arrhythmias due to increase in vagal tone caused by intense physical exercise [1]. The challenge for physicians is to be able to interpret these changes and to detect the pathology. Over the past decade, various studies and guidelines have been produced to aid the physician [14-16].

In 2010, the ESC produced a recommendation for interpretation of ECG in athletes [14]. In 2012, the 'Seattle criteria' was developed in a summit represented by the American Medical Society for Sports Medicine (AMSSM), ESC and other interest groups [15]. In 2015, this group reconvened in Seattle with the endorsement of other sports medicine and cardiology societies worldwide to produce the International consensus for ECG interpretation in athletes [16]. The recommendation also included the use of echocardiography to evaluate those athletes with abnormal ECG findings [16].

Although this consensus on ECG interpretation can be applied in general to all athletes, it is known that the extent of the ECG changes is also dependent on the athlete's ethnicity, age, gender, sporting discipline and level of training and competition [17]. Furthermore, most studies were conducted among Caucasian and Black athletes and ECG data from South East Asian athletes are scarce, therefore, the objective of this study is to identify the ECG pattern changes and its association with echocardiography findings among Malaysian footballers during a pre-participation evaluation (PPE).

METHODOLOGY

Study Design and Definitions

This retrospective study looked at footballers who attended a mandatory PPE for the purpose of registering with the Football Association of Malaysia (FAM). The PPE was conducted in a primary care centre from the 1st to the 28th of February 2018 and all participants who attended the PPE were included in the study.

PPE is defined as medical evaluation for those who intend to participate in competitive sport [10,17,18]. It aims to evaluate the athlete's general health, and screen for any life-threatening condition or those that predispose to disability or injury [8]. PPE is recommended once a year, at the start of each season and is not intended to replace the athlete's regular health care needs [8].

An athlete is defined as a person who engages in regular exercise or training for sports. Physiological changes to the heart are more commonly seen in athletes exercising intensely for a minimum of 4 hours per week [16].

Assessment and Measures

The footballers who attended the primary care clinic for PPE were given a self-administered medical questionnaire and an informed consent was obtained. The PPE was scheduled according to a proforma provided by the Football Association of Malaysia (FAM). The proforma has three sections: medical history, physical examination and investigations, which were conducted according to the usual clinical protocol. Physical examination included heart rate, blood pressure measurements and systems examinations. The investigations included bloods, ECG and echocardiography. For blood investigation, the participants were asked to fast overnight and blood was taken following non-traumatic venepuncture from the antecubital fossa. The blood samples were sent to the Centre for Pathology and Diagnostic Research Laboratory (CPDRL, UITM) and analysed for lipid profile (total cholesterol, high density lipoprotein, low density lipoprotein and triglyceride), fasting blood sugar and creatinine. ECG and echocardiography were performed at the Non-Invasive Cardiac Laboratory (NICL, UITM). A standard 12-lead ECG using ECG Philip Trim III was performed on each participant in the supine position during quiet breathing and were recorded at 25 mm/s. The ECG tracings obtained were printed and scanned into the participant's medical records. Echocardiography was conducted using Echo

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GE Vivid I automated cardiac two-dimensional quantification with an adult probe. The echocardiography was reported without prior knowledge of the participant's ECG tracing.

Data Collection and PPE Protocol

The study process involved secondary data collection. Data were obtained from the participants' medical records and their original ECG tracing. The PPE protocol included an initial assessment such as taking a history and physical examination by a primary care physician. This was followed by a review of the investigation results and assessment of the footballers' eligibility to participate in competitive sports. Those with abnormal ECG or echocardiography results were sent for further investigations such as exercise stress test (EST) or referred to the Cardiologist for further management.

For the ECG interpretation and analysis, it was done by a primary care physician and a cardiologist according to the International consensus standards for ECG interpretation in athletes [16]. The ECGs were divided into normal, physiological adaptations to regular exercise and abnormal changes among athletes [16,17]. These changes are summarized in Table 1. The abnormal ECG findings were compared to the participants' echocardiography results.

Table 1 Normal physiological ECG changes due to adaptations to regular exercise and abnormal ECG changes in athletes based on the international consensus standards for ECG interpretation in athletes [16,17]

ECG changes that are normal physiological adaptations to regular exercise
1. Isolated increased QRS voltage for left ventricular hypertrophy or right ventricular hypertrophy (with no other abnormal changes such as T-wave inversions)
2. Incomplete right bundle branch block (iRBBB)
3. Early repolarization / ST segment elevation
4. Isolated T-wave inversions (TWI) in leads III or IV
5. Sinus bradycardia or sinus arrhythmia (sinus bradycardia defined as heart rate < 60 beats per minute)
6. First-degree AV block
7. Ectopic atrial or junctional rhythm
8. Mobitz Type 1 second degree AV block
ECG changes that are considered abnormal in athletes
1. Left axis deviation or right axis deviation with other criteria such as left or right atrial enlargement or complete RBBB.
2. Multiple T-wave inversions (TWI) in the inferolateral leads or isolated inferior leads or anterior leads, ST segment depression, pathological Q waves, epsilon waves and complete left bundle branch block (LBBB) (these represent hypertrophic changes)
3. Prolonged QT (represent conduction problems)
4. Profound sinus bradycardia defined as heart rate < 30 beats per minute.
5. Brugada Type 1 pattern
6. Mobitz Type II second degree AV block and atrial tachycardia.

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Ethical approval to use the data and conduct the study was obtained from the University Ethics Committee. Data were analysed using SPSS v24. Descriptive analysis was used to describe socio-demographic characteristics, cardiovascular risk factor parameters, ECG and Echocardiogram findings and data are presented as mean ± standard deviation (SD) and percentages (%). Association between ECG changes and Echocardiogram findings were analysed using cross-tabulation.

RESULTS

A total of 85 footballers who participated in the PPE were included in the study. Their mean age was 20.1±3.0 years. All participants were male. None of the participants had a history of cardiovascular risk factors (CRF) such as diabetes mellitus, hypertension, or family history of premature heart disease or sudden cardiac death.

Table 2 highlights the results of the participants' heart rate, blood pressure, lipid profile, fasting blood sugar and creatinine. Most of the participant had sinus bradycardia (76.5%) and none had heart rate less than 30 beats per minute. All participants had normal fasting blood sugar, diastolic blood pressure and pulse. However, among the footballers, 4.7% had high systolic blood pressure, 14.3% had high total cholesterol, 9.5% had high LDL, 2.4% had high HDL, 3.6% had high TG and 10.6% had high creatinine levels.

Table 2 Descriptive analysis of the participants' cardiovascular risk factors including heart rate, blood pressure and lipid profile. (N = 85)

Parameters (units)			Range (Min – Max)	Mean	Standard Deviation
Age (years)			16 – 29	20.1	3.0
	Normal N (%)	Abnormal N (%)	Range (Min – Max)	Mean	Standard Deviation
Heart rate (beats per minute)	85 (100)	0 (0)	38 – 86	55.2	9.3
BP systolic (mmHg)	81 (95.3)	4 (4.7)	105 – 146	123.7	9.6
BP diastolic (mmHg)	85 (100)	0 (0)	40 – 86	70.6	8.2
*TC (mmol/L)	72 (85.7)	12 (14.3)	2.9 – 6.7	4.5	0.8
*LDL (mmol/L)	76 (90.5)	8 (9.5)	1.1 – 4.3	2.5	0.7
*HDL (mmol/L)	82 (97.6)	2 (2.4)	0.9 – 2.9	1.6	0.4
*TG (mmol/L)	81 (96.4)	3 (3.6)	0.4 – 2	0.9	0.4
FBG (mmol/L)	85 (100)	0 (0)	3.6 – 5.6	4.7	0.4
Creatinine (umol/L)	76 (89.4)	9 (10.6)	70 – 118	89.7	11.2

Abbreviations and abnormal levels: Blood pressure (BP) systolic > 140 diastolic > 90; total cholesterol (TC) > 5.2; Low Density Lipoprotein (LDL) > 3.4; High Density Lipoprotein (HDL) < 1.0; Triglyceride (TG) > 1.7; Fasting blood glucose (FBG) > 5.6; creatinine > 106.

**parameter with missing data*

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Table 3 Descriptive analysis of the participant's normal vs abnormal ECG changes. (N=85)

	Type of changes	Frequency (percentage, %)
ECG interpretation	Normal findings	68 (80)
	Abnormal changes	17 (20)
Normal athlete's heart changes	Sinus bradycardia	65 (76.5)
	Sinus arrhythmia (irregular HR)	37 (43.5)
	T inversion in lead III and /or V1	72 (84.7)
	J-point elevation	58 (68.2)
	Incomplete RBBB (iRBBB)	4 (4.7)
Abnormal ECG changes suggestive of pathology	Multiple T wave inversions (TWI)	5 (5.9)
	Pathological Q waves	7 (8.2)
	Hypertrophy	2 (2.4)
Echocardiogram	Normal	79 (92.9)
	Abnormal	6 (7.1)
Abnormal echocardiogram changes suggestive of pathology	Mild PR and/or TR	3 (3.5)
	Mild AR	1 (1.2)
	Mild IAS bulging	1 (1.2)
	Apical hypertrophy	1 (1.2)
Comparing ECG and echocardiogram changes	Normal ECG and normal Echo	68 (80)
	Normal ECG and abnormal Echo	2 (2.4)
	Abnormal ECG and normal Echo	11(12.9)
	Abnormal ECG and abnormal Echo	4 (4.7)

PR = pulmonary regurgitation; TR = tricuspid regurgitation; AR = aortic regurgitation; IAS = inter atrial septal.

Table 3 shows the results of participants' ECG findings. It was found that 80% of participants had ECG alterations that are physiological adaptations to exercise and considered normal variants in athletes. It is worth noting that none of the participants had completely normal ECG and that all ECGs showed physiological changes related to exercise. Twenty percent of the participants had abnormal ECG. These abnormal ECG changes included multiple TWI (5.9%) in inferolateral leads or isolated inferior leads or anterior leads and ST segment depression (2.4%), and pathological Q waves defined as Q/R ratio of 20.25 or >40 millisecond (ms) duration in two or more leads, except leads III and aVR (8.2%). Echocardiogram abnormalities were found in 7.1% athletes.

Table 3 also shows the comparison between ECG changes with echocardiogram findings. From the 68 normal ECG findings, two had abnormal echocardiogram findings, which were mild tricuspid regurgitation (TR) and/or pulmonary regurgitation (PR). From the 11 abnormal ECG findings, four had abnormalities in their echocardiogram, which were mild PR and TR, mild aortic regurgitation (AR), mild inter-atrial septal (IAS) bulging and apical hypertrophy. Hypertrophy refers to the enlargement or thickening of the heart muscle, either due to increase in cardiomyocyte size, mass or numbers. Hypertrophic cardiomyopathy (HCM) is associated with SCD in young athletes [5,6]. The ECG changes in HCM can mimic other changes such as left ventricular hypertrophy (LVH) [5,6]. There were two ECGs changes that were consistent with hypertrophy. One participant had ECG changes consistent with left ventricular hypertrophy (LVH), where the

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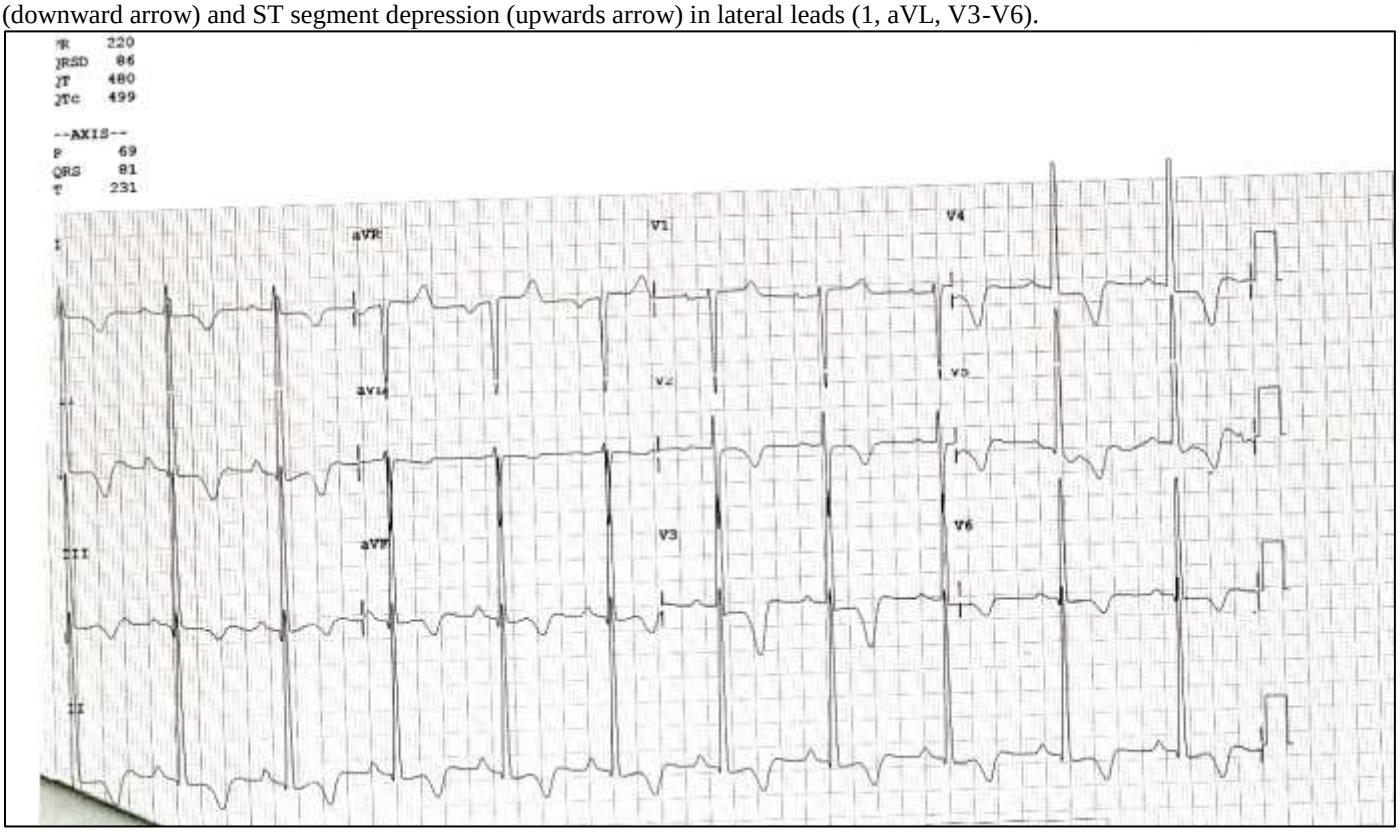
corresponding echocardiography report found mild IAS bulging, with no other abnormalities. Another participant had ECG changes consistent with hypertrophic cardiomyopathy (Figure 1), which includes QRS voltage criteria for LVH in association with deep multiple TWI and ST segment depression in lateral leads (I, aVL, V3-V6). The corresponding echocardiography report confirmed apical hypertrophic cardiomyopathy (HCM).

Figure 1 Hypertrophic cardiomyopathy in an athlete with QRS voltage criteria for LVH (circle) in association with deep TWI (downward arrow) and ST segment depression (upwards arrow) in lateral leads (1, aVL, V3-V6).



DISCUSSION

This study found that many of these footballers had no CRFs and had normal fasting blood glucose. A small number of them had mildly raised cholesterol and creatinine levels. These mildly raised lipid profile could be attributed to dietary or other factors e.g. genetics. The participants were advised accordingly. Further studies on this are recommended.

This study also identified that in Malaysian footballers; the normal ECG related to physiological changes to intensive exercise were common and were representative of an athlete's heart. The most common physiological change was sinus bradycardia, which was present in 76.5% of the participants. This is comparable to the current literature that sinus bradycardia is present in up to 80% of highly trained athletes [17]. It was also noted that none of the participants had a heart rate of < 30 beats per minute (bpm). Heart rates of ≥ 30 bpm are considered normal in highly trained athletes and are due to increase in vagal tone [17].

Increase in vagal tone can also cause sinus arrhythmia and early repolarization. The heart rate usually increases slightly during inspiration and decreases slightly during expiration. This response known as sinus arrhythmia can be exaggerated in highly trained athletes leading to irregular sinus rhythm at rest, which resolves with physical exercise [2,16,17]. This study showed 43.5% participants displaying sinus arrhythmias. It is important for physicians to be able to identify this normal pattern from pathological arrhythmias.

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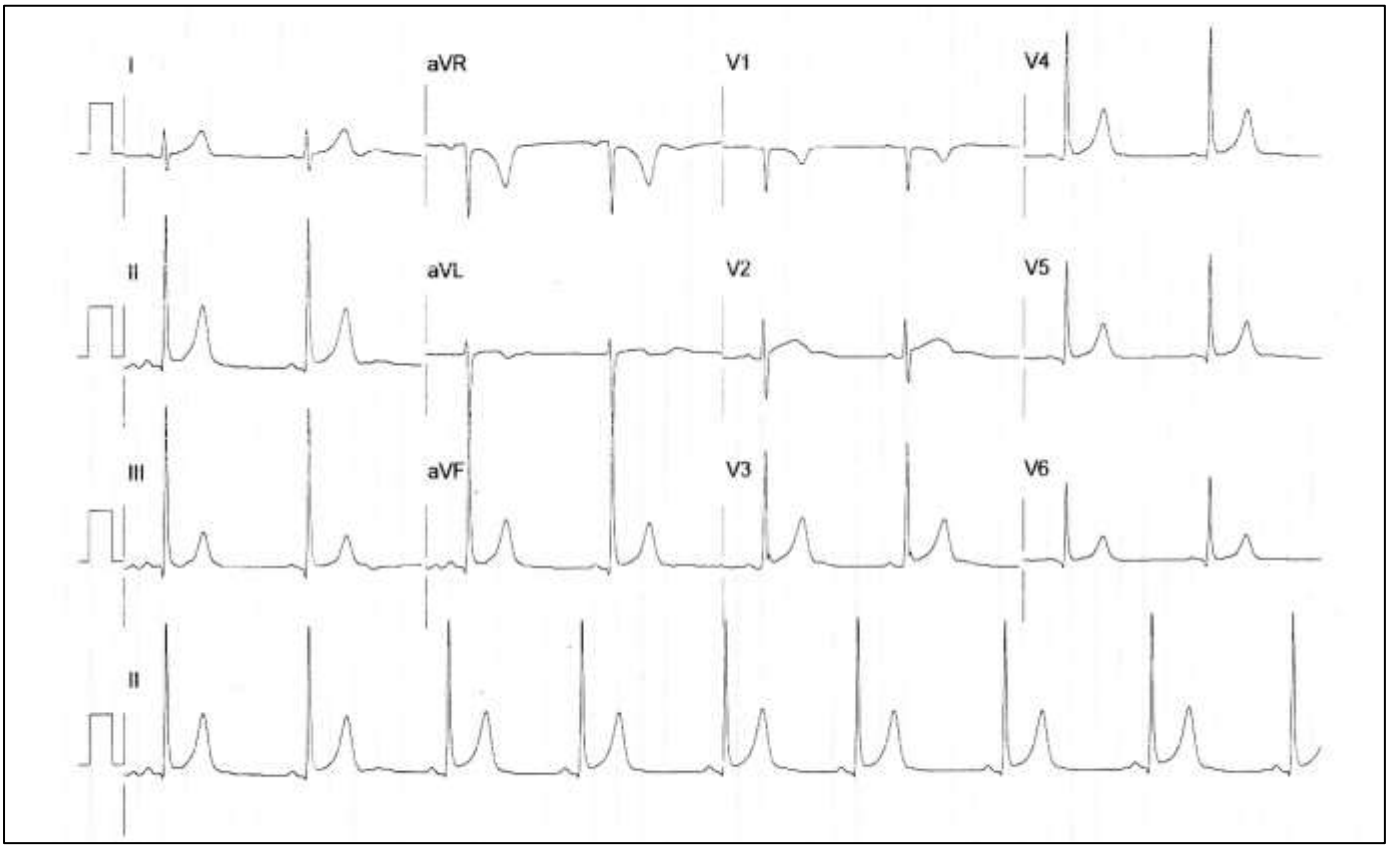
Figure 2 ECG from athlete with physiological changes including TWI (downward arrow) in lead V1 and J-point elevation (upward arrow).



Early repolarization is typically benign among athletes. It is present in around 45% of Caucasian athletes and 63-91% of African-Caribbean athletes [2,17]. Early repolarization is featured by an elevation of the QRS-ST junction known as J-point elevation and this typically occurs in the precordial leads (Figure 2). The study found that 68.2% of participants demonstrated early repolarization. This is interesting and important information since the participants were of South East Asian descent and such data are scarce [6]. A study on participants attending PPE for ASEAN university games found that only 21.2% had early repolarization [19]. This could be due to the lower intensity training among the participants as compared to the highly trained footballers in this study. Larger studies involving South East Asian athletes may shed further light on whether high prevalence of early repolarization is typical within this population.

Incomplete right bundle branch block (iRBBB) was found in 4.7% of participants, which was much lower than the 12-32% found in other studies [17]. iRBBB can be present in athletes and is due to increase in right ventricular size secondary to intense regular training. T-wave inversion (TWI) in leads III and/or V1 is a common feature and does not warrant further investigation [16]. The abnormal ECG changes were found in 20% of the participants and this was higher in comparison to other studies where 14-17.3% abnormal ECG changes were identified [20,21]. The abnormal changes found in this study were multiple TWI, pathological Q-waves and hypertrophic changes, including high QRS voltage, multiple TWI and ST-depression. Although prolonged PR interval of > 200ms is considered a normal physiological change [16] but, in the 3.5% of the participants, prolonged PR interval was associated with multiple TWI, which is an indication of cardiac abnormality. Multiple TWI was present in 5.9% of participants (Figure 3).

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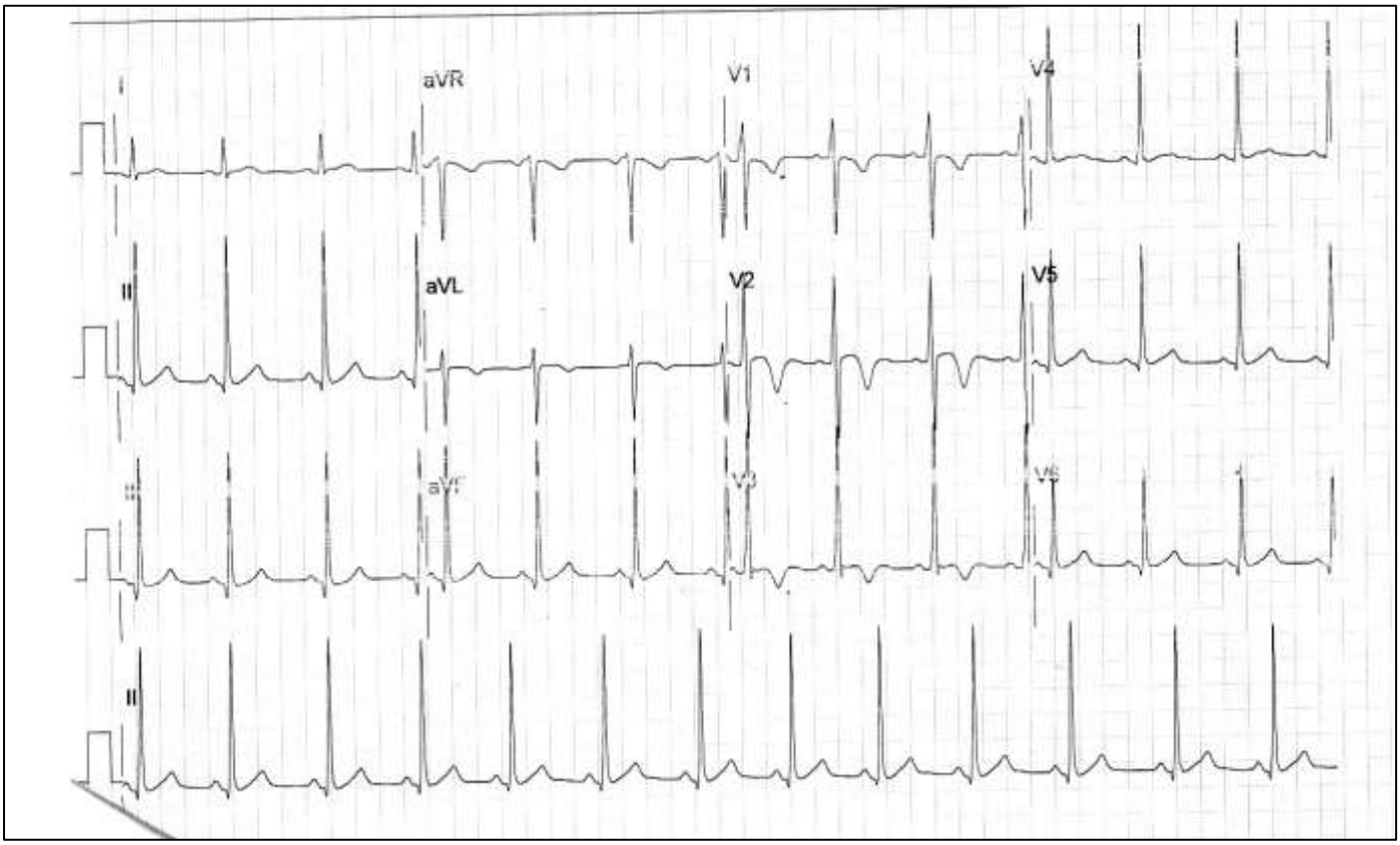
Figure 3 Abnormal ECG findings in athlete shows multiple T-wave inversions (downward arrow) in more than 2 leads in V1, V2 and V3 suggestive of pathology



T wave is the final waveform of the cardiac electrical cycle and is typically deflected upwards (positive) in most leads. The normal exceptions, where T waves are routinely deflected negatively include leads aVR, III and V1 [16]. The presence of TWI in other leads including anterior, lateral or inferior leads should prompt further assessment for underlying structural heart disease [16]. The presence of multiple TWI in 5.9% of participants was challenging since there are no comparable data available to ascertain whether these constitute normal variant changes within South East Asian athletes. With absence of any symptoms on exertion or at rest, as well as normal echocardiograms, these footballers are deemed eligible for intense physical exercise.

The study found two concerning ECG changes consistent with features of hypertrophy, which constituted 2.4% of the participants. The first ECG was consistent with left ventricular hypertrophy (LVH) and echocardiography reporting mild IAS bulging, but was otherwise normal. The second ECG had features consistent with HCM (Figure 1) and the echocardiography report found apical HCM. Both footballers were asymptomatic and had no CRF or family history of SCD. Both were referred for further cardiology evaluation. HCM is a known cause of sudden cardiac death in young athletes [22]. Fortunately, HCM is very rare among athletes and a study found that only 0.09% of young athletes had ECG suggestive of HCM[23]. In fact, these studies suggest that on further evaluation and diagnostic test, no definitive diagnosis of HCM was made [22,23]. Therefore, further investigation to obtain a definitive diagnosis is important to ensure the decision for their non-eligibility is appropriate and fair.

This study highlighted the importance of PPE and the use of ECG as a screening tool in identifying abnormal patterns in athletes. In 2006, the Lausanne recommendation suggested that every athlete should undergo PPE and that a 12-lead ECG should be offered if there was any suggestion of underlying cardiac abnormality [24]. This was reiterated in the Bethesda conference in 2008 [11]. Hence, ECG is still considered

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the best and most cost-effective modality to identify potential cardiac abnormalities [13,25]. The international consensus also suggested that further investigation using echocardiography for those with abnormal ECG findings [16]. In this study, there was a strong association between abnormal ECG and abnormal echocardiography especially among the two participants found to have hypertrophy.

For participants with abnormal ECG and echocardiography results, further investigations may include Holter-monitoring, exercise stress test and cardiac magnetic resonance imaging (MRI) to determine the definitive diagnosis. The decision to disqualify is intricate whereby the physician needs to ensure the safety of the athlete without causing unnecessary disadvantage to the athlete's career. The physician should explain to the athlete the risk of SCD and inform the athlete to look out for symptoms that might suggest cardiac-related problems. Preventative measures that have been recommended include implementation of PPE for athletes worldwide, genetic testing for inherited cardiac diseases, a national and international registry for all SCD in athletes and mandatory presence of cardiac defibrillator in all athletic fields [11,12,26,27]. Guidelines for eligibility and disqualification have also been produced in order to support the physicians in decision-making [12,24].

In many countries, mandatory PPE for athletes has not been introduced. However, when athletes become more aware of PPE and its importance, more will come forward to have it done. In countries such as the United States, primary care physicians often conduct PPE before referring to other specialists if any concerns or abnormalities are identified [12,28]. Therefore, it is recommended that primary care physicians undergo training on PPE protocol [9,12] and interpretation of ECG changes in athletes [16] in order to improve safety standards and to promote preventative measures in reducing sudden cardiac death among athletes.

STRENGTH AND LIMITATIONS OF STUDY

Although this is a small cohort, but the strength of the study is that the cohort represents those from South East Asian background, and such data are currently scarce. Most studies are conducted overseas with data representing Caucasian or Black athletes. The results from this study can add to the vast knowledge of normal and abnormal ECG changes among athletes. The limitations are that this is a descriptive analysis based on universal sampling of participants attending a mandatory PPE. It is restricted to one type of sporting discipline and the participants were all males.

CONCLUSION AND RECOMMENDATIONS

In conclusion, ECGs are useful in identifying potential cardiac abnormalities in the screening of athletes. Malaysian footballers within this study have ECG changes that are consistent with physiological changes in athlete's heart similar to studies conducted elsewhere. Identification of pathological ECG pattern among athletes is important in reducing the risk of sudden cardiac death. Physicians involved in PPE such as primary care physicians should be trained in PPE protocol and ECG interpretation in athletes. Recommendations include the need to create awareness among doctors, sport's governing bodies and those involved in vigorous exercise to promote PPE among athletes and to make PPE mandatory in professional sports.

Conflict of Interest

Authors declare none.

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Ethical Approval

Ethics approval was obtained from the University Research Ethics Committee with reference 600-IRMI (5/1/6).

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Authors' Contributions

Dr. Farnaza Ariffin was the principal researcher in this study, who coordinated the PPE, collected, analyzed and interpreted the data, and wrote the manuscript. Rizmy Najme Khir coordinated the non-invasive cardiac lab investigations for ECG and Echocardiogram, interpreted the data and contributed in the writing of the manuscript. Dr. Mohamed-Syarif Mohamed-Yassin, Dr. Noorhida Baharudin, Dr Ilham Ameera Ismail, Dr Hasidah Abdul-Hamid and Dr Haizlene Abd Halim aided in the evaluation of athletes during the PPE, interpreted the data and contributed in the writing of the manuscript.

REFERENCES

1. Maron BJ, Pelliccia A. The heart of trained athletes cardiac remodeling and the risks of sports, including sudden death. Circulation. 2006;114:1633-1644.
2. Corrado D, Biffi A, Basso C, Pelliccia A, Thiene G. 12-lead ECG in the athlete: physiological versus pathological abnormalities. Br J Sports Med. 2009;43:669-676.
3. Fishman GI, Chugh SS, DiMarco JP, Albert CM, Anderson ME, Bonow RO, Buxton AE, Chen PS, Estes M, Jouven X, Kwong R. Sudden cardiac death prediction and prevention: report from a National Heart, Lung, and Blood Institute and Heart Rhythm Society Workshop. Circulation. 2010;122(22):2335-2348.
4. Schmied C, Borjesson M. Sudden cardiac death in athletes. J Intern Med. 2014; 275:93-103.
5. Ferreira M, Santos-Silva PR, de Abreu LC, Valenti VE, Crispim V, Imaizumi C, Ferreira Filho C, Murad N, Meneghini A, Riera AR, de Carvalho TD. Sudden cardiac death athletes: a systematic review. BMC Sports Sci Med. 2010;2(1):19. doi:10.1186/1758-2555-2-19
6. Halabchi F, Seif-Barghi T, Mazaheri R. Sudden cardiac death in young athletes; a literature review and special considerations in Asia. Asian J Sports Med. 2011;2(1):1-15.
7. 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):1227-1234.
8. Sanders B, Blackburn TA, Boucher B. Preparticipation screening – the sports physical therapy perspective. Int J Sports Phys Ther. 2013;8(2):180-193.
9. Asif IM, Roberts WO, Fredericson M, Froelicher V. The cardiovascular preparticipation evaluation (PPE) for the primary care and sports medicine physician, Part I. Curr Sports Med Rep. 2015;14(3).
10. Maron BJ, Levine BD, Washington RL, Baggish AL, Kovacs RJ, Maron MS. Eligibility and disqualification recommendations for competitive athletes with cardiovascular abnormalities: task force 2: preparticipation screening for cardiovascular disease in competitive athletes: a scientific statement from the American Heart Association and American College of Cardiology. J Am Coll Cardiol. 2015; 66(21):2356-2361.
11. Pelliccia A, Zipes DP, Maron BJ. Bethesda conference #36 and the European Society of Cardiology consensus recommendations revisited. A comparison of U.S and European criteria for eligibility and disqualification of competitive athletes with cardiovascular abnormalities. J Am Coll Cardiol. 2008; 52(24):1990-1996.
12. Morse E, Funk M. Preparticipation screening and prevention of sudden cardiac death in athletes: implications for primary care. J Am Acad Nurse Pract. 2012; 24:63-69.
13. Wheeler MT, Heidenreich PA, Froelicher VF, Hlatky MA, Ashley EA. Cost effectiveness of preparticipation screening for prevention of sudden cardiac death in young athletes. Ann Intern Med. 2010; 152:276-286.
14. Corrado D, Pelliccia A, Heidbuchel H, Sharma S, Link M, Basso C, Biffi A, Buja G, Delise P, Gussac I, Anastasakis A. Recommendations for interpretation of 12-lead electrocardiogram in the athlete. Eur Heart J. 2010; 31(2):243-259.
15. Drezner JA, Ackerman MJ, Anderson J, Ashley E, Asplund CA, Baggish AL, Börjesson M, Cannon BC, Corrado D, DiFiori JP, Fischbach P. Electrocardiographic interpretation in athletes: the 'Seattle criteria'. Br J Sports Med. 2013; 47(3):122-124.
16. Drezner JA, Sharma S, Baggish A, Papadakis M, Wilson MG, Prutkin JM, La Gerche A, Ackerman MJ, Borjesson M, Salerno JC, Asif IM. International criteria for electrocardiographic interpretation in athletes:

Consensus statement. Br J Sports Med. 2017; 51(9):704-731.
17. Drezner JA, Fischbach P, Froelicher V, Marek J, Pelliccia A, Prutkin JM, Schmied CM, Sharma S, Wilson MG, Ackerman MJ, Anderson J. Normal electrocardiographic findings: recognising physiological adaptations in athletes. Br J Sports Med. 2013; 47(3):125-36.
18. Mirabelli MH, Devine MJ, Singh J. The pre-participation sports evaluation. Am Fam Physician. 2015;92(5):371-376.
19. Lim ZL, Mokhtar AH, Jaffar MR. Pre-participation evaluation of Malaysian university athletes – the importance of cardiovascular screening. Malaysian Journal of Movement, Health & Exercise. 2017; 6(2):67-76.
20. Brosnan M, La Gerche A, Kalman J, Lo W, Fallon K, MacIsaac A, Prior D. The Seattle Criteria increase the specificity of preparticipation ECG screening among elite athletes. Br J Sports Med. 2014; 48(15):1144-1150.
21. Pelliccia A, Maron BJ, Culasso F, Di Paolo FM, Spataro A, Biffi A, Caselli G, Piovano P. Clinical significance of abnormal electrocardiographic patterns in trained athletes. Circulation 2000;102:278-284.
22. Martín M, Rodríguez-Reguero JJ, Calvo D, de la Torre A, Fernández A, García-Castro M, del Valle M, de la Tassa CM. Usefulness of the ECG in the sports screening of footballers affiliated to a regional sports federation. Rev Esp Cardiol (Engl Ed). 2008; 61(4):426-429.
23. Basavarajaiah S, Wilson M, Whyte G, Shah A, McKenna W, Sharma S. Prevalence of hypertrophic cardiomyopathy in highly trained athletes: relevance to pre-participation screening. J Am Coll Cardiol. 2008; 51(10):1033-1039.
24. Bille K, Figueiras D, Schamasch P, Kappenberger L, Brenner JI, Meijboom FJ, Meijboom EJ. Sudden cardiac death in athletes: the Lausanne Recommendations. Eur J Cardiovasc Prev Rehabil. 2006; 13(6):859-75.
25 Harmon KG, Zigman M, Drezner JA. The efectiveness of screening history, physical exam, and ECG to detect potentially lethal cardiac disorders in athlete: A systematic review/meta-analysis. J Electrocardiol. 2015; 48:329-338.
26. 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. 2010; 18(2):197-208.
27. Jorstad HT. Preparticipation screening-the way forward is smart screening. Neth Heart J. 2018; 26:120-12
28. Maron BJ, Thompson PD, Ackerman MJ, Balady G, Berger S, Cohen D, Dimeff R, Douglas PS, Glover DW, Hutter Jr AM, Krauss MD. Recommendations and considerations related to preparticipation screening for cardiovascular abnormalities in competitive athletes: 2007 Update. Circulation 2007; 115:1643-1655.

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