

CHARACTERISTICS OF RESTING ECG AMONG SABAH PROFESSIONAL MALE FOOTBALLERS

Mohamad Azwan Bin Aziz*, Redzal Abu Hanifah*

Sports Medicine Unit, Hospital Queen Elizabeth, Kota Kinabalu, Sabah

*Email: kassemkoya69@gmail.com

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Abstract

The purpose of this study is to describe the resting electrocardiogram (ECG) seen among 176 professional male footballers from Sabah Football Association Club during preparticipation evaluation. Data were analysed retrospectively from 2017 to 2019. Majority of the players were Sabah natives (n=153, 87%) while the remaining were Malay footballers (n=23, 13%). Mean age of the players was 19.9 ± 3.1 , mean body mass index was $22.6 \text{ kg/m}^2 \pm 7$, mean resting heart rate was $53.6 \text{ beats per minute} \pm 9.4$, mean systolic blood pressure was $122.3 \text{ mmHg} \pm 12$, and mean diastolic blood pressure was $65.1 \text{ mmHg} \pm 8.8$. Using the International Criteria for ECG Interpretation in Athletes 2017 consensus guidelines, 8.5% (n=15) had abnormal ECG while 2.8% (n=5) had borderline ECG. The most common ECG changes seen in the normal findings were sinus bradycardia (n=123, 69.9%), early repolarization (n=115, 65.3%) and left ventricular hypertrophy (n=83, 47.2%). Abnormal ECGs were abnormal t wave inversion (n=7, 4.0%) and pre-excitation syndrome (n=5, 2.9%). All footballers with abnormal ECG findings were subjected to further evaluation by a cardiologist using echocardiography assessment and exercise stress test. They passed the cardiology assessment; thus, they were deemed fit to play. ECG is a valuable tool for pre-participation health screening prior to exercise or sports participation, as it is vital for a physician to identify any abnormal ECG to minimise the risk of sudden cardiac death during exercise due to cardiac pathology.

Keywords: Electrocardiogram, international criteria, athlete, footballers

Introduction

The major cause of death during exercise is due to sudden cardiac death (SCD) (Harmon et al., 2011; Maron et al., 2009; Maron et al., 2016). For older adults, the main causes of SCD are due to occult coronary artery disease whereas, for adolescents and young adults, the main cause of death is due to structural heart disease, coronary artery anomalies or conduction abnormality of the heart (Harmon et al., 2011; Maron et al., 2009; Maron et al., 2016). A recent study by Malhotra et al. (2018) on the outcomes of cardiac screening in 11,000 teenage footballers revealed that the incidence of SCD is closer to 6.8 per 100,000 athletes. In Malaysia, the incidence of SCD in the exercising population varied from 1 per 10,000 active exercisers to 1 per 200,000 in children and young adults (Murty et al., 2007).

The clinical knowledge of athletic heart syndrome has been expanded considerably in recent decades due to the advancement of echocardiography studies and cardiac imaging. Systematic training or exercise leads to physiological adaptation of the cardiovascular system with benign hypertrophy of cardiac mass as well as physiological alterations of the circulatory system and cardiac morphology (Maron, 2003; Maron et al., 1995; Morganroth et al., 1975). As a result of this, prolonged conditioning of training or exercise will have an impact on cardiac remodelling, which in turn mimics certain structural or conductive defect of the heart which can lead to SCD during strenuous activities (Maron, 2003; Maron et al., 1995; Morganroth et al., 1975).

Health screening enables early detection of underlying cardiovascular disease, as well as management with lifestyle modification and therapeutic interventions. A pre-participation screening programme comprised of history, physical examination, and 12-lead ECG as recommended by the American Heart Association and the American College of Sports Medicine (Thompson, 1995). In young athletes less than 35 years old, International Criteria for Electrocardiographic Interpretation in athletes are used as a guideline during pre-participation health screening (Drezner et al., 2017). It is used to differentiate between physiological adaptation and pathological condition of the heart based on electrocardiogram (Drezner et al., 2017). A study by Corrado et al. (2006) showed an 89% reduction in SCD, primarily due to improved identification of cardiomyopathy through cessation of ongoing competitive physical activity in Italian athletes.

ECG changes vary based on types of training, such as strengthening, endurance training, and high-intensity training. Football consists of large aerobic activities with most of the training involving high intensity combined with repetitive pressure and volume loading in isometric and isotonic exercise (Krustrup et al. 2009). To the author's knowledge, there is no study done for baseline characteristics of ECG among professional footballers in Sabah, the northern part of the island of Borneo, Malaysia. The main objective of this study is to describe the characteristic of resting ECG among professional footballers in Sabah.

Methods and Materials

Study design

This study is a descriptive, retrospective study of Sabah Football Association (SAFA) footballers from the Youth League, President League and Premiere League teams. Inclusion criteria were of the age of at least 16 years, Malaysian nationality, and competing at a regional/national level.

Sample

In this study, there were 270 Pre-Participation Examination (PPE) forms from the year 2017 to 2019, comprising a total of 183 young male footballers (age: 17–33 years) who came for pre-participation screening in the period. Data were retrospectively collected using a convenient sample approach and analysed. A total of 7 import (non-Malaysian) footballers were excluded from the study. Thus, only 176 footballers were included in this study.

All PPE forms were traced from the medical records units. A standardised Pre-Participation Examination (PPE) form was used, which included sociodemographic data, medical history, family history, anthropometric assessment, vital signs, physical examination, electrocardiogram, and blood investigation. A standard 12-lead ECG of the footballers was interpreted by Sports Physicians based on the International criteria 2017. History of referral to a cardiologist and echocardiography findings were recorded in this study. Some of the footballers have repeated PPE from the year 2017 to the year 2019. We choose the latest ECG findings or ECG that has been evaluated by the cardiologist with cardiac assessment. This study was approved by the Malaysian Research Ethics Committee.

Statistical analysis

A descriptive data analysis was performed using SPSS version 22 and were expressed using mean and standard deviation (SD).

Results

A total of 176 Malaysian footballers were included in this study. Out of 176, 29 footballers were from the premiere league team, 73 were from the president team, and 74 were from the youth team. Majority of the footballers were Sabah natives (n=153, 87%) while the remaining were Malay footballers (n=23, 13%).

Table 1 shows the characteristics of footballers. Mean age of the footballers was 19.9 ± 3.1 , mean body mass index was $22.6 \text{ kg/m}^2 \pm 7$, mean resting heart rate was 53.6 beats per minute ± 9.4 , mean systolic blood pressure

was $122.3 \text{ mmHg} \pm 12$, and mean diastolic blood pressure was $65.1 \text{ mmHg} \pm 8.8$. A total of 15 footballers (8.5%) had no ECG changes, 28 footballers (15.9%) had single ECG changes, 46 footballers (26.1%) had two ECG changes, 61 footballers (34.7%) had three ECG changes, 24 footballers (13.6%) had four ECG changes and two footballers (1.1%) had five ECG changes. According to the International criteria for ECG Interpretation in Athletes 2017 consensus guidelines, 92% (n=162) had normal ECG for athletes, 5.1% (n=9) had abnormal ECG while 2.8% (n=5) had borderline ECG. 9 footballers with abnormal ECG detected during Pre-Participation examination were referred to the cardiologist during that time for further cardiac assessment by echocardiography study and exercise treadmill stress test. None of the footballers had structural abnormalities, and one athlete was diagnosed as Wolf Parkinson White Syndrome. Nevertheless, he was declared fit to play as he is asymptomatic.

Table 2 shows the types of ECG findings. The most common normal ECG changes were sinus bradycardia (n=123, 69.9%), early repolarization (n=115,65.3%), and left ventricular hypertrophy (n=83,47.2%). Abnormal ECGs were abnormal t wave inversion (n=13,7.4%) and pre-excitation syndrome (n=5,2.3%).

Baseline characteristic	Range	Mean	SD
Age (years)	17 – 33	19.9	3.1
Height (metres)	110 – 182	168.7	6.7
Weight (kilogram)	50 – 89	64.2	7.4
BMI (kg/m ²)	16 – 29	22.6	7
Systolic Blood Pressure (mmHg)	100 – 155	122.3	12
Diastolic Blood Pressure (mmHg)	44 – 88	65.1	8.8
Heart Rate (beats per minute)	34 – 77	53.7	9.4
PR Interval (ms)	80 – 290	170.5	32.3
QRS (ms)	80 – 154	98.8	10
QT Interval (ms)	366 – 628	437	37
QTc (ms)	353 – 580	418	28.1

Table 1: characteristics of the anthropometric assessment, blood pressure and ECG of footballers
SD = Standard deviation

kg = kilogram

m = meter

ms= millisecond

1.	Sinus Bradycardia	123	69.9
2	Early repolarisation	115	65.3
3	Isolated QRS Voltage Criteria For Left Ventricular Hypertrophy	83	47.2
4	Incomplete Right Bundle Block	33	18.7
5	First Degree Heart Block	26	14.8
6	Right Axis Deviation	10	5.7
7	Abnormal T wave inversion	7	4.0
8	Ventricular Pre Excitation	5	2.9
9	Mobitz Type 1	2	1.1
10	Complete Right Bundle Bunch Block	2	1.1
11	ST – Elevation	2	1.1
12	Prolong QTc	1	0.6

Discussion

Numerous researches are published regarding characteristics of ECG in athletes (Bohm et al., 2013; Bessem, de Bruijn & Nieuwland, 2009; Crouse et al., 2009; Drezner et al., 2017; Lim, Mokhtar & Jaffar, 2017; Malhotra et al., 2015). However, there are limited studies done in Malaysia. One study by Lim et al. (2017) examined the importance of preparticipation health screening among Malaysian athletes competing in the 18th ASEAN University Games 2016 and noted that only 65% of the competing athletes completed the PPE prior to the tournament, reflecting the poor recognition of the Malaysian athletes on the importance of PPE as a preventive strategy to reduce the number of SCD. Nevertheless, most sports physicians trained in Malaysia utilised preparticipation health screening with electrocardiogram prior to exercise prescription and prior to competitive sports to facilitate the detection of conditions at risk for sudden cardiac death.

One of the latest guideline recommended for ECG interpretation in athletes is the International Criteria for ECG Interpretation in Athletes 2017 consensus guidelines, which replaces the electrocardiographic interpretation in athletes: the 'Seattle Criteria' 2013 to refined specificity for ECG-detectable pathological conditions associated with SCD while maintaining sensitivity (Drezner, 2019; Drezner et al., 2017). The most prominent changes seen were the introduction of borderline ECG classification, the new definition of pathological Q wave, and T wave inversion as a normal finding in athletes less than 16 years old (Drezner, 2019). The age recommendation for these criteria is from 16 to 35 years old (Drezner et al., 2017).

In this research, the most common physiological cardiac adaptation changes in ECG were sinus bradycardia (69.9%), early repolarisation (65.3%), isolated QRS voltage criteria for left ventricular hypertrophy (47.2%), incomplete right bundle branch block (18%), and first-degree heart block (14.8%). The percentage of sinus bradycardia in our research were comparable to the Dutch footballers (56%), trained endurance Indian athletes (42%), European footballers (55%), and Malaysian university athletes (34.5%) (Bohm et al. 2013; Bessem, de Bruijn & Nieuwland, 2009; Crouse et al., 2009; Lim, Mokhtar & Jaffar, 2017; Malhotra et al., 2015). Asymptomatic sinus bradyarrhythmia with a heart rate of 30 – 59 beats per minute is a normal physiological adaptation often attributed to increased vagal tone and possible structural atrial remodelling (Drezner et al., 2017). However, recent studies have suggested that it may result from the remodelling of pacemaker ion channels and resetting of the intrinsic heart rate (Bahrainy et al., 2016; D'souza et al., 2014). Sabah footballers demonstrated a slightly lower mean resting heart rate (53 beats per minute) compared to Indian athletes (61.92 beats per minute), European athletes (59 beats per minute), Caucasian American athletes (76 beats per minute), and African American athletes (69 beats per minute) (Bohm et al., 2013; Crouse et al., 2009; Malhotra et al., 2015).

On the other hand, the percentage of early repolarisation (65.3%) was far higher than the Dutch junior footballers of age more than 16 years old (5%) and Malaysian university athletes (21.2%) (Bohm, Ditzel & Ditzel, 2013; Lim, Mokhtar & Jaffar, 2017). Early repolarisations are closely related to exercise training and fitness level (Drezner et al., 2017). Moreover, the Malaysian university athletes were competing in a variety of sports from low intensity (18%) to high-intensity sports. Other than that, the research of the Dutch junior footballers was of a smaller size (n=41) as compared to the Sabah footballers. Early repolarisation was also a common ECG finding in the general population with a prevalence range of 2% to 44% in a healthy population and is more prevalent in athletes, young individuals, males, and black ethnicity (Tikkanen et al., 2009; Tikkanen et al., 2011). In the International criteria 2017, all patterns of early repolarisation are considered benign when present in isolation and without clinical markers of pathology (Drezner et al., 2017). However, early repolarisation with J wave may predispose athletes to malignant ventricular arrhythmia but not seen in any of the ECG during this study (Aagaard et al., 2016).

There are no respiratory sinus arrhythmias found during our preparticipation screening compared to Dutch footballers (20%), trained endurance Indian athletes (12%), and Malaysian university athletes (42.5%) (Bohm et al., 2013; Bessem, de Bruijn & Nieuwland, 2009; Lim, Mokhtar & Jaffar, 2017; Malhotra et al., 2015). Absent of respiratory sinus arrhythmias in this study could be explained as athletes were required to perform ECG procedure in quiet respiration. Thus, we were unable to see the difference in heart rhythm during inspiration and expiration. Presence of respiratory sinus arrhythmias indicates a healthy, fit cardiorespiratory fitness, and young in age (Melvin, 2020). Left atrial enlargement is predominantly seen in American footballers (48.1%) mainly among African Americans and is not seen in this study nor in the Malaysian university athletes (Crouse et al., 2009; Lim, Mokhtar & Jaffar, 2017). A systematic review suggested that left atrial enlargement

is commonly seen in elite endurance athletes (Iskandar, Mujtaba & Thompson, 2015). Chandra et al. (2014) showed that athletes of black ethnicity were associated with a higher prevalence of abnormal ECG, including left atrial enlargement irrespective of athlete status. Moreover, higher body surface area could increase left atrial size, which could explain the high number of left atrial enlargement findings in African American athletes as compared to Malaysian athletes (Crouse et al., 2009). Furthermore, their training consisted of high-intensity resistance training and activities that require short bursts of high-intensity and whole-body movements among the American Footballers which predisposes to left atrial enlargement (Crouse et al., 2009; Iskandar, Mujtaba & Thompson, 2015).

The percentage of abnormal ECG in this study of 8.5% is slightly lower compared to Bohm P. et al. (2013), which is 12%. This is due to their usage of the Seattle criteria 2013 as a point of reference. However, our number is higher compared to the Malaysian University athletes (2.6%), which used the International Criteria 2017 as their guideline (Lim, Mokhtar & Jaffar, 2017). Lim et al. (2017) reported three athletes with abnormal ECG; ventricular pre-excitation, atrial tachyarrhythmias and multiple premature ventricular complexes (PVCs).

The most common abnormal ECG seen in this study was abnormal T wave inversion (4%), short PR interval (2.9%), and prolonged QTc (0.6%). Abnormal T wave inversion is seen in this study (4%) was lower compared with Indian endurance athletes (16%). However, the prevalence is slightly higher compared to European footballers (2.3%) (Bessem, de Bruijn & Nieuwland, 2009; Malhotra et al., 2015). Nevertheless, abnormal T wave inversions were not seen during the PPE of Malaysia University athletes (Lim, Mokhtar & Jaffar, 2017). All 7 Sabah footballers with abnormal T wave inversion were referred for further cardiac assessment. Out of 7, 4 had physiological left ventricular hypertrophy by echocardiography assessment, while the rest had normal structural heart. Abnormal T wave inversion is an important finding for early detection of cardiomyopathy. However, this finding could be normal for African athletes or an athlete less than 16 years old (Pelliccia et al., 2008).

Footballers (2.9%) with short PR intervals less than 120 milliseconds were similar to Malaysian University athletes (2.7%). However, this was not seen in the American, Dutch, and Indian athletes (Bohm et al., 2013; Bessem, de Bruijn & Nieuwland, 2009; Corrado et al., 2006; Crouse et al., 2009; Lim, Mokhtar & Jaffar, 2017; Malhotra et al., 2015). Nonetheless, the short PR interval is a common ECG finding in athletes due to the impulse generated close to AV nodes outside of SA nodes (Drezner et al., 2013). Out of 5, 3 of the footballers did not have wide QRS complex and delta wave. After further evaluation by the cardiologist, one of the athletes were diagnosed as Wolf Parkinson White syndrome. According to International criteria 2017, an isolated short PR interval is normal in an athlete and not warranted for further investigation (Drezner et al., 2017). Nevertheless, he was stratified under low risk and was declared fit to play as he did not show any ECG changes of ventricular arrhythmias during strenuous exercise stress test nor has any symptoms of cardiac disease during training or at rest. The prevalence of ventricular preexcitation is thought to be 0.1-0.45% in the general population, and at least 1% cause of sudden death in athletes (Rao et al., 2013). However, the exact prevalence in Malaysia is not known. Ventricular pre-excitation is a result of an accessory pathway which bypasses the AV node, which results in shortening of the PR interval and widening of the QRS (Rao et al., 2013). As a result of this, it predisposes athletes to ventricular arrhythmias such as supraventricular tachycardia, ventricular tachycardia and the most dreadful, ventricular fibrillation during high-intensity activity Further cardiology assessment is needed to stratify athlete into low risk or high risk (Drezner et al., 2017). High-risk WPW and some low-risk WPW athlete who participate in high-intensity sports will be subjected to electrophysiology study for further assessment (Drezner et al., 2017).

The criteria for diagnosing a prolonged QTc Syndrome for males in the International criteria 2017 are QTc \geq 470 ms (Drezner et al., 2017). Prolonged QTc is an important finding in ECG as it could be a hallmark ECG of congenital Long QT syndrome, a lethal conduction abnormality of the heart that predisposes a person to ventricular arrhythmias and can cause SCD during sporting activity (Drezner et al., 2017; Schwartz et al., 2009). The prevalence of Long QTc Syndrome is 1 in every 20000 population (Drezner et al., 2017; Schwartz et al., 2009). However, Schwartz et al. (2009) estimated that the number could be higher given the subpopulation of so-called 'normal QT intervals' or 'concealed' LQTS. In our research, there was one footballer (0.6%) diagnosed as prolonged QTc with normal electrolytes and the absence of family history of SCD. He has sinus bradycardia with a resting heart rate of 44 beats per minute and QTc of 580ms. According to the International criteria 2017, the ideal heart rate to measure QTc is 60 to 90 beats per minute using Bazett's

formula, preferably performed manually in lead II or V5 using the teach-the-tangent method (Drezner et al., 2017). The footballer was referred to a cardiologist for further cardiac assessment. His echocardiography showed a normal structural heart, and he was able to complete the exercise stress test of up to stage 6 using Bruce protocol without any chest discomfort nor any cardiac arrhythmias during the test. He was declared fit to play.

Although the footballers screened were not detected to have any cardiac illness necessitating termination of training, it is strongly recommended that all athletes engaging in competitive sport should undergo a comprehensive screening. Our retrospective study creates a limitation as we did not assess the long-term outcomes in athletes with marked ECG abnormalities. This abnormality could represent an early subtle pathological heart disease. Moreover, in our retrospective study, we could not reassess the ECG changes compared to a prospective study. Our footballer with prolonged QTc might have a normal range of QTc if we perform light exercise to increase the heart rate to 60 – 90 beats per minute according to international criteria 2017 (Drezner et al., 2017). Other than that, it would be better to perform a correlation study with an echocardiography study for all athletes as it can reflect the actual finding of ECG onto the anatomical changes of the heart structure. This could demonstrate the physiological and anatomical adaptation with their electro-conductive manifestations. However, as to our best knowledge, this is possibly the first such research done in Sabah, Malaysia. Future research from other clubs in Malaysia, especially among other football teams, may give a better understanding and add to the knowledge of interpreting ECGs in athletes, as well as formulating a specific guideline for preparticipation evaluation among Malaysian athletes.

Conclusion

Most of the ECG changes being seen in Sabah footballers were the result of physiological adaptation of the heart towards systematic exercise training. The number of abnormal ECG is comparatively lower than many international studies as the current guideline for ECG interpretation using the International criteria 2017 has improved ECG interpretation accuracy. None of the footballers screened in this research was detected to have serious cardiac disease. This denotes the importance of preparticipation health screening prior to competitive sports.

Conflict of Interest

We declare that there is no conflict of interest in this study

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