For the Evaluation of Pacific Island Athletes, an ECG and Echocardiography Are Highly Recommended

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Abstract: Physical exercise increases the relative risk of sudden cardiac death (SCD) in athletes when compared to a non-sporting population. Pre-participation evaluation (PPE) of athletes is thus of major importance. For Pacific Island athletes, medical guidelines recommend an echocardiography to complement a PPE including personal and family history, a physical examination and a resting twelve-lead electrocardiogram (ECG). Indeed, silent rheumatoid heart diseases found in up to 7.6% of adolescents give rise to severe valve lesions, which are the main causes of SCD in Pacific Island athletes. This short review examines the incidence rate of SCD in Pacific Island athletes and indicates how a questionnaire, physical examination, ECG and echocardiography can prevent it.

Keywords: Melanesian; Polynesian; Black athlete; cardiomyopathy; pre-participation evaluation; athlete screening

1. Introduction

In Pacific Island athletes, the estimated incidence rate of SCD is 3.9/100,000 athletes versus 1–2/100,000 athletes/year in Western countries or 34.2/100,000 athletes in specific American sports and ethnicities like Afro-Caribbean basketball players [1].

The aim of a pre-participation cardiovascular evaluation (PPE) is to detect the CV diseases that have a risk of SCD. As about 80% of these diseases are asymptomatic [2], a resting twelve-lead electrocardiogram (ECG) is recommended [3].

In Pacific Island athletes, echocardiography is also recommended. Indeed, school surveys reported a high prevalence of silent rheumatic heart disease (RHD) reaching a level of 7.6% in asymptomatic children. RHD gives rise to severe valve lesions related to acute rheumatic fever (ARF) and are the major causes of SCD.

This short review will examine the incidence rate of SCD in Pacific Island athletes and how a questionnaire, physical examination, ECG and echocardiography can prevent it.

2. Incidence Rate of Sudden Cardiac Death

In Pacific Islands athletes, SCD was studied only in New Caledonia, an island located in the South Pacific at 1200 km east of Australia and 1500 km from New Zealand [4]. During a 7-year follow up, the incidence rate was estimated to be 3.9 cases of SCD per 100,000 athletes, age range 15–20 years, and concerned a majority of Melanesian athletes who are genetically Black people (Table 1). These values are 2–3 fold higher than those in western countries but remain far fewer than the 34 cases of SCD/100,000 athletes found in Afro-Caribbean basketball players [1].
Table 1. Sudden cardiac death (SCD) in athletes and non-athletes registered between 2012 and 2014 in the New Caledonian population 10–40 age group: Poly = Polynesian, Mel = Melanesian, HCM = hypertrophic cardiomyopathy, WPW = Wolff–Parkinson–White, RHD = rheumatic heart disease, UR = un resuscitated after electric shock, * resuscitation after an SC arrest and an electric shock, ** estimation.

| Subjects | Category | n | SCD | Age | Sex | Sports | Ethnicity | Cause |
|----------|----------|---|-----|-----|-----|--------|-----------|-------|
| Athletes (A) | Elite and Interregional | 362 | 1 | 18 | F | Shot put | Polynesian | Prolonged QT suspicion |
| | Elite school of sports | 431 | 0 | M | | | | |
| | Other registered athletes | 42,655 | 1 | 17 | M | Badminton | Métis | Ventricular rhythm issue * |
| | | | 1 | 18 | M | Football | Melanesian | HCM |
| | Not registered athletes ** | 7800 | 3 | 16 | M | Basketball | Melanesian | Ventricular rhythm issue, UR |
| | | | 15 | M | Badminton | Unknown | Unknown, UR |
| | | | 20 | M | Golf | Polynesian | Unknown |
| | Army ** | 1000 | 1 | 18 | M | Running | Melanesian | Ventricular rhythm issue, possible HCM previous inverted T waves |
| Total | | 53,041 | 7 | | | | |

Non Athletes (B)

| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

Total 18.3/100,000/year 58,267 32 - - - - -

(A)+(B) Total 11.7/100,000/year 111,308 39 - - - - -

3. Differences between Countries

In Germany, the incidence rate was 0.1 to 0.2 cases of SCD/100,000 athletes [5], vs. 0.3 to 0.6 SCD/100,000 athletes in the USA [6], vs. 1/100,000 in France [7], 1.2/100,000 in Denmark [8], 2.1/100,000 in the Veneto region of Italy [9], and 3.9/100,000 in New Caledonia (Table 2) [4].

Table 2. Incidence rate of sudden cardiac death related to exercise in different countries: comparison between male and female, White and Black athletes, and sports.

| Authors | Country | Studied Period | Age Years | Category | Total Million | Incidence Rate /100,000 |
|---------|---------|----------------|-----------|----------|---------------|-------------------------|
| Chatard et al., 2019 [4] | New Caledonia | 2011–2017 | 10–40 | Elite athletes Melanesian+Polynesian+Wallisian+White | 3.9 | |
| | | 2012–2014 | 10–40 | Registered and non-registered athletes Melanesian+Polynesian+Wallisian+White | 0.11 | 11.7 |
| | | | | Black + White | 1.9 | 2.3 |
| | | | | Black | 0.3 | 5.7 |
| | | | | White | 1.6 | 1.7 |
| | | | | Black male | 7.7 | |
| | | | | Basketball | 8.8 | |
| | | | | Male | 14.3 | |
| | | | | Female | | |
| | | | | Division I | 0.8 | 34.3 |
| | | | | Division I Black male | 32 | |
| | | | | Swimming | - | 4.3 |
| | | | | Football | - | 2.6 |
| | | | | Cross country | - | 2.4 |
| Harmon et al., 2011 [1] | USA | 2004–2008 | 15–24 | | | |
| Maron et al., 2016 [6] | USA | 1980–2011 | 8–39 | White + Nonwhite | >80 | 0.6 |
| Toresdahl et al., 2014 [10] | USA | 2009–2011 | College | Black + White | 4.1 | 1.1 |
| Roberts et al., 2013 [11] | Minnesota | 1993–2012 | 12–19 | High school athletes | 1.7 | 0.2 |
Table 2. Cont.

| Authors               | Country     | Studied Period | Age Years | Category | Total Million | Incidence Rate /100,000 |
|-----------------------|-------------|----------------|-----------|-----------|---------------|------------------------|
| Landry et al., 2017 [12] | Canada      | 2009–2014      | 12–45     |           | 18.5          | 0.8                    |
| Holst et al., 2010 [8]   | Denmark     | 2000–2006      | 12–35     | White     | 1.6           | 1.2                    |
| Marijon et al., 2011 [7] | France      | 2005–2010      | 10–35     | White     | 13.4          | 1.0                    |
| Bohm et al., 2016 [5]    | Germany     | 2012–2014      | 10–79     |           |               | 0.1–0.2                |
| Corrado et al., 1998 [13] | Italy       | 1979–2004      | 12–35     | White     | 36.1          | 2.1                    |
| Steinvil et al., 2011 [14] | Israel     | 1985–2009      | 10–40     |           |               | 2.6                    |

4. Differences between Sex, Ethnicity and Sports

In Pacific Islanders, the incidence rate according to sex was seven times higher for males than for females [4]. For males, football is the most practiced sport, followed by volleyball, martial arts and rugby. For females, the most important sport is volleyball. These sports represent more than 50% of all sports practiced. They are mainly anaerobic and known to serve as a trigger for ventricular arrhythmias on underlying, predominantly silent, rheumatic heart disease. A specific aerobic sport called Va’a, namely sea canoeing, is widely practiced in Polynesia.

Pacific Island athletes [4], Afro-Caribbean [15], Asian [16], West-Asian [17] and South of Far East athletes [18] have heart specificities when compared to Caucasians.

Football, running, swimming gymnastics, rugby and tennis were also reported to have a higher incidence of SCD than other less popular sports [6].

5. Causes of Sudden Cardiac Death

In 842 athletes, Maron et al. [6] found that SCD was mainly due to hypertrophic cardiomyopathy (HCM) plus indeterminate left ventricular hypertrophy (LVH) considered as possible HCM (45%), 3.5-fold more common among males than among females, as well as anomalous coronary artery (33% of females vs. 17% of males), arrhythmogenic cardiomyopathy (ACM) (13% of females vs. 4% of males) and myocarditis (6%).

In Pacific Island Athletes, the main causes of SCD are severe valve lesions of rheumatoid origin identified in 25% of athletes [4].

6. Prevention of Sudden Cardiac Death

Cardiovascular prevention has a marked place in PPE for competitive sports. Specific attention is given to males and to communities such as Melanesians, Polynesians or Afro-Caribbean groups [4,6].

Scientific committees recommend a PPE program that encompasses family and personal history, physical examination and a systematic resting twelve-lead electrocardiogram (ECG) for competitive sports in subjects between 12 and 35 years. This ECG must be repeated every 2–3 years [19].

For Pacific Island athletes, both ECG and echocardiography are recommended. Indeed, in the PPE of athletes, including systematic ECG screening, up to 3.9% of cardiovascular abnormalities were found [4]. In school surveys using systematic echocardiographic screening, a high prevalence of RDH has been found ranging from 2.9 to 7.6% in asymptomatic school children, Melanesians and Polynesians across the developing countries Fiji, New Caledonia and New Zealand [20].

7. Questionnaire and Physical Examination

7.1. Medical History Questionnaires

For Pacific Islanders, specific attention is given to their history of ARF, an autoimmune disease that follows throat infection or reinfection with the bacterium Group A Streptococcus [21]. It is estimated that 60% of all those contracting ARF will develop RHD. Although
RHD has almost disappeared from industrialized and wealthy countries, it remains the most frequent heart disease in children worldwide. The questionnaire addresses family history, and the present and past complaints of the personal history. The short questionnaire of the AHA [22] of 14 items is recommended.

7.2. Family History

Family history focuses on (i) known RHD, valvular lesions, valve replacement surgery (ii) premature/unexpected SCD in at least one first degree relative before the age of 50, and (iii) inherited cardiac diseases like CM, Marfan syndrome, short or long QT syndrome, and severe arrhythmias. Any family history of SCD before the age of 35 years necessitates a cardiological referral to determine what further diagnostic testing is to be conducted because of the prevalent genetic transmission of HCM, long QT, ACM, Marfan Syndrome and related vascular disorders including familial bicuspid aortic valve.

7.3. Personal History

Personal history focuses on previous ARF during childhood, repeated throat infections, iterative joint pain and on five determinant symptoms related to exercise: (i) syncope or near syncope, (ii) exertional chest pain, (iii) shortness of breath, (iv) palpitation, and (v) abnormal dyspnea or fatigue. The questionnaire also assesses previously known severe cardiovascular diseases. It assesses less severe cardiovascular diseases like cardiac murmur, arterial hypertension, smoking habits, recent infection, prescribed medication and results of previous systematic echocardiography.

7.4. Physical Examination

The physical examination focuses on abnormal cardiac area auscultation related to RHD such as heart murmur diastolic or systolic >2/6, fixed by respiration and reinforced after exercise, systolic click, irregular heart rhythm, and/or asymmetric artery pulses especially between the arms and legs (aorta coarctation), bilateral brachial blood pressure, musculoskeletal and ocular features suggestive of Marfan syndrome.

8. Standard Twelve-Lead Resting ECG

In Pacific Island athletes, the 2018 International Recommendations [23] are applicable: increased vagal tone and cardiac dimensions with bradycardia, first degree atrio-ventricular block, large QRS voltage, incomplete right bundle branch block [18]. Early repolarization is present in about 50% of Pacific athletes, as in Afro-Caribbean athletes. Most of the TWIs located in the V2 to V4 leads are not associated with any CV disease [21].

In Pacific Island athletes, the uncommon ECG changes requiring further cardiac investigations are presented in Table 3.

| Table 3. Twelve-lead ECG criteria requiring further cardiac investigations in Pacific Island athletes [4]. |
|-----------------------------------------------|
| **Heart Frequency** | **Bradycardia < 30 bpm or Pauses ≥ 3 s** |
| **P wave** | In I and II amplitude > 2.5 mm and/or duration > 120 ms *  
In V1–V2, >1 mm in depth, >40 ms in duration *  
Atrial fibrillation, flutter, supraventricular tachycardia |
| **PR interval** | PR < 120 ms and delta wave at the beginning of QRS  
and sometimes inverted T waves = WPW.  
Atrio-ventricular block 1° ≥ 400 ms  
Mobitz II, 2° block without Wenckebach phenomenon.  
3° complete AV block |
| **Q wave** | Q/R ratio 25% or > 40 ms duration in 2 or more leads  
except III and aVR |
Table 3. Cont.

| Heart Frequency | Bradycardia < 30 bpm or Pauses ≥ 3 s |
|-----------------|-------------------------------------|
| QRS complex     | Delta wave                           |
|                 | LBBB > 120 ms,                       |
|                 | RBBB > 120 ms *                      |
|                 | Any QRS > 140 ms                     |
|                 | Left and right axis deviation < −30° > 120° * |
|                 | R wave in V1 > 7 mm *                |
|                 | R/S > 1 in V1–V2 *, R/S <1 in V5–V6 * |
|                 | Brugada Type 1                       |
|                 | Epsilon wave                         |

| ST segment      | Depression > 0.5 mm in 2 or more contiguous leads |
|                 | Depression > 1 mm in any lead                   |

| Inverted T wave | ≥1 mm in depth in 2 or more contiguous leads |
|                 | Before puberty in any lead except III, VR, V1, V2, V3 |
|                 | Post puberty and adult in any lead except III, VR, V1 |
|                 | Except V2, if IRBBB                               |
|                 | Except V2, V3 and V4 in Black athletes            |

| QTc             | >470 ms in male, >480 ms in female |
|                 | <340 ms in any athlete               |

| Ventricular premature beat | ≥2 premature ventricular beats per 10 s tracing |
|                          | Doubletts, triplets and non-sustained ventricular tachycardia |

ECG: electrocardiogram, IRBBB: incomplete right bundle-branch block, LBBB: left bundle-branch block, QTC: corrected QT duration (Bazet formula), WPW: Wolff–Parkinson–White. * If isolated, asymptomatic and no family or personal history with no need for further investigation, if in association with 2 or more * criteria, further investigation is required [23].

9. Echocardiography and Other Investigations

In the case of Pacific Island athletes, the World Heart Foundation 2012 criteria [24] for echocardiographic diagnosis of definite or borderline RHD are applied. RHD predominantly affects the left-sided cardiac valves, >95% of mitral lesions mainly regurgitations, 1/3 being associated with aortic lesions causing regurgitation, stenosis, or mixed hemodynamic effects. Very few aortic lesions occur on their own [20].

In 2281 Pacific Island adolescents, a 4-fold increase in the incidence of the RDH was found in the 9 to 16 age group (1 to 4%). Most of them were silent. A systematic echocardiography screening was thus recommended for children aged 9–10 and for adolescent Pacific Island athletes (16 ± 1 year). For master athletes, echocardiography should also be recommended at least once between the age of 30 and 40 [20].

Other investigations, like stress ECG are of major importance for detecting disappearance or worsening of resting arrhythmias and ECG abnormalities like T wave inversion. It must be pointed out that in some low-income Pacific Islands these investigations, although highly recommended, cannot always be performed either for economic reasons or the lack of sports cardiologists or specialized medical facilities.

10. Results of Sports Pre-Participation Evaluation

In Pacific Island athletes, Chatard et al. [4] found 0.8% of athletes at risk of an SCD with a cardio-vascular disease contraindicating competitive sport and 3.9% presented a CV disease that needed a regular medical follow up. The major observation was the high prevalence (1.5%) of silent valve diseases of rheumatoid origin almost four times higher than those reported in athletes of Western and Middle Eastern countries (Table 4).
Table 4. Number of cardiac diseases found after athlete screening in 13 studies. M: male, Cat: athlete category, CI: contra-indication to sports, MC: myocardopathy, LVH: left ventricular hypertrophy, WPW: Wolff–Parkinson–White, QT: long QTc, VA: ventricular arrhythmia, AHT: arterial hypertension, Val: valvulopathy, IAC: inter-atrial communication, Brug: Brugada.

| Studies                        | n  | M% | Cat | Ethny | Age  | CI  | MC  | LVH | WPW | QT  | VA  | AHT | Val | IAC | Brug |
|-------------------------------|----|----|-----|-------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| Corrado et al., 1998 [13]     | 33,735 | 85 | A   | Ita   | 19   | 621 | 34  | 6   | •  | 44  | 37  | 121 | 168 | 133 |
| Fuller et al., 1997 [25]      | 5615 | 60 | HS  | Ca ?  | 13–19 | 22  | 0   | 3   | *  | 1   | 0   | 15  | 20  | 43  | 0   | 0   |
| Basavarajaiah et al., 2008 [15] | 3500 | 75 | E   | 98% Ca | 20.5 | 15  | 0   | 53° | 6  | 9   | 0   | 0   | 9   | 2   | 0   |
| Papadakis et al., 2011 [26]   | 2745 | 100 | A   | 66% Ca 33% Ba | 14–35 | 12 | 4   | 112° | 4  | 3   | 0   | 22  | 5   | 5   | 1   |
| Chatard et al., 2019 [4]      | 2281 | 69 | E   | 31% Mel 29% Poly 21% Cau 20% Met | 10–40 | 18 | 8   | -   | 6  | 5   | 8   | 6   | 35  | 8   | 0   |
| Price et al., 2014 [27]       | 2017 | 71 | S   | 34% Ca 31% Ba | 14–18 | 5  | 1   | 1   | •  | 4   | 1   | 0   | 3   | 0   | 0   |
| Magalski et al., 2008 [28]    | 1959 | 100 | EF  | 67% Ba 31% Ca | 23 | 0 | 0   | 6   | •  | 0   | 0   | 0   | ?   | 0   | 0   | 0   |
| Hevia et al., 2012 [29]       | 1220 | 96 | S   | Ca ? | 23  | 2  | 2   | 8   | •  | 4   | 0   | 4   | 0   | 0   | 0   | 0   |
| Wilson et al., 2012 [17]      | 1220 | 100 | AP  | 66% Wa 25% Ba | 22.6 | 7 | 4   | 13° | •  | 2   | 1   | 1   | 10  | 2   | 1   | 0   |
| Wilson et al., 2008 [30]      | 1074 | 100 | J   | Ca ? | 15.8 | 9 | 1   | 0   | 4  | 3   | 1   | ?   | ?   | ?   | ?   | 0   |
| Menafoglio et al., 2013 [31]  | 1070 | 75 | A   | 98% Ca | 19.7 | 4  | 0   | 0   | 3  | 1   | 0   | 1   | 5   | 0   | 0   | 0   |
| Mayer et al., 2012 [32]       | 733  | 57 | ES  | Ca ? | 12.3 | 4 | 1   | 0   | 3  | 0   | 0   | 0   | 0   | 10  | 3   | 0   |
| Baggish et al., 2010 [33]     | 508  | 61 | S   | 68% Ca 10% Ba | 19 | 3  | 2   | 2° | •  | 0   | 0   | 0   | 0   | 7   | 0   | 0   |
| Total                         | 57,677 | - | -  | -   | -   | 722 | 57  | 204 | 81 | 60  | 150 | 227 | 252 | -   | -   |

Mean percentage: 82 - - 19.4 1.0 0.35 0.14 0.10 0.26 0.40 0.43 - -

A: amateur, AP: amateur and professional, E: elite, ES, elite school of sports, EF: elite football players, HS: high school, J: junior, S: student athletes. Ba: Black, Ca: Caucasian, Ita: Italian, Wa: West-asian, Arabic. Left ventricular thickness: ° ≥11 mm, † ≥12 mm, • ≥13 mm.

Another observation concerning the Pacific Islanders was their high HCM prevalence (2.6/1000 athletes). Only 50% were symptomatic, while all had an abnormal ECG confirming the value of an ECG examination [18,34].

In Pacific Island athletes, the HCM prevalence was close to the 3.2/1000 athletes found by Wilson et al. [17]. In these two studies, Black athletes, Melanesian and Afro-Caribbean athletes, were highly represented.

Wolff–Parkinson–White, inter-auricular or ventricular communications, long QT syndrome, ventricular arrhythmia and high blood pressure were the other most prevalent abnormalities found, confirming previous PPE studies (Table 4).

In the future, there is clearly a need for follow up and research in professional/high level athletes, undergoing structural treatment of rheumatic heart disease. Eligibility can be given as soon as the follow up of the valve repair, valvuloplasty or valve replacement is successfully performed, confirmed by echocardiography and stress ECG.

11. Conclusions

In Pacific Island athletes, there is a significant risk of SCD, especially in male adolescents, young adults and Black athletes. Most instances of SCD are due to silent arrhythmogenic cardiovascular diseases.

A systematic twelve-lead ECG would save lives. Indeed, Melanesians, of Black origin, presented with frequent TWIs in V2–V4 similar to those described in Afro-Caribbean athletes. Most of the other TWIs were associated with cardiomyopathies.

The high prevalence of RHD also confirms the importance of including a systematic echocardiography in PPE for Pacific Island athletes whatever their age.

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