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Review

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

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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. RDH 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 *
	Not registered athletes **	7800	1	18	M	Football	Melanesian	HCM
			3	16 15 20	M M M	Basketball Badminton Golf	Melanesian Unknown Polynesian	Ventricular rhythm issue, Unknown, UR Unknown
	Army **	1000	1	18	M	Running	Melanesian	Ventricular rhythm issue, possible HCM previous inverted T waves
	Total 4.4/100,000/year	53,041	7					
Non Athletes (B)			8	-	-	-	Melanesian	Consequence of RHD
			6	-	-	-	Melanesian	Aneurysms
			5	-	-	-	Melanesian	Massive heart infarction
			2	-	-	-	Melanesian	Pulmonary embolism
			1	-	-	-	Melanesian	Mellitus coma
			10	-	-	-	Melanesian	Unknown
	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
Harmon et al., 2011 [1]	USA	2004–2008	15–24	Black + White Black White Black male Basketball Male Female Division I Division I Black male Swimming Football Cross country	1.9 0.3 1.6 0.8 - - -	2.3 5.7 1.7 7.7 8.8 14.3 2.6 34.3 32 4.3 2.6 2.4
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 cardio-vascular 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 RDH, 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 biscupid 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 RDH such as heart murmur diastolic or systolic >2/6, fixed by respiration and reinforced after exercise, systolic click, irregular heart rhythm, and/or asymetric artery pulses especially beetwen 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 blanch 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 Doubletss, 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: myocardiopathy, LVH: left ventricular hypertrophy, WPW: Wolff–Parkinson–White, QT: long QTc, VA: ventricular arrhythmia, AHT: arterial hypertension, Val: valvulopathy, IAC: interatrial 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	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
Mayer et al., 2012 [32]	733	57	ES	Ca ?	12.3	4	1	0	3	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	1.3	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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