

Sports and Athlete's Heart

Relevant Guidelines

ESC 2020 Guidelines on sports cardiology

2020 ESC Guidelines on sports cardiology and exercise in patients with cardiovascular disease. *Eur Heart J.* 2020

Relevant Scientific Statements and Position Papers

ESC Working Groups 2020 Statement on Athletes with CAGD

Recommendations for participation in competitive sport in adolescent and adult athletes with Congenital Heart Disease (CHD): position statement of the Sports Cardiology & Exercise Section of the European Association of Preventive Cardiology (EAPC), the European Society of Cardiology (ESC) Working Group on Adult Congenital Heart Disease and the Sports Cardiology, Physical Activity and Prevention Working Group of the Association for European Paediatric and Congenital Cardiology (AEPC). *Eur Heart J.* 2020.

AHA 2015 Statement on Eligibility for Competitive Athletes

Eligibility and Disqualification Recommendations for Competitive Athletes With Cardiovascular Abnormalities: Preamble, Principles, and General Considerations: A Scientific Statement From the American Heart Association and American College of Cardiology. *Circulation.* 2015;132:e256-261

International Experts Group 2017 Statement on ECG in Athletes

International Recommendations for Electrocardiographic Interpretation in Athletes. *J Am Coll Cardiol.* 2017;69:1057-1075.

European Association of Preventive Cardiology of the ESC 2026 Statement on ECG in Athletes

Abnormal electrocardiogram findings in athletes. *Eur Heart J.* 2026;47:152-169

European Association of Preventive Cardiology of the ESC and ACC 2026 Statement on Masters Athletes

Masters athletes with abnormal cardiovascular findings: a clinical consensus statement of the European Association of Preventive Cardiology of the ESC and the American College of Cardiology. *Eur Heart J.* 2026;47:2541-2560.

AHA 2026 Statement for the Care of Athletes

Clinical Considerations for the Care of the Tactical Athlete With Cardiovascular Abnormalities: A Scientific Statement From the American College of Cardiology and the American Heart Association. *Circulation.* 2026;154:e524-e572.

SPORTS AND ATHLETE'S HEART

Definitions

Characteristics of exercise and indices of intensity are presented in Table 1 and Figure 1. The definition of an athlete is imprecise, but athlete can be defined as someone who engages in routine vigorous training (e.g., >150 minutes per week) and is skilled in exercises, sports, or games requiring physical strength, agility, or stamina.¹ Athletic training is associated with a spectrum of morphologic and functional cardiac adaptations known as the “athlete’s heart”.²⁻⁵

Sports and Cardiac Health

Physical activity is beneficial for most cardiac conditions, and exercise has a beneficial effect on several risk factors for atherosclerosis.⁴ Indices of exercise intensity are presented in Table 2. In most situations, however, a U curve phenomenon exists. Longstanding endurance exercise may modestly increase the risk of **coronary atherosclerosis** but with a more benign composition of calcified atherosclerotic plaques.^{6,7} Atherosclerotic coronary heart disease is the leading cause of deaths attributable to CVD and accounts for almost 45% of all cases in athletes.⁸ However, there is strong evidence that elite and amateur athletes live longer than the general population.⁸ Long-term *vigorous exercise* predisposes to **AF** in active athletes,^{9,10} but *light to moderate physical activities*, particularly leisure-time activity and walking, are associated with significantly lower AF incidence in older adults.¹¹ There is an inverse relationship between cardiorespiratory fitness and cardiovascular complications or incident AF, including in patients with established AF.¹²⁻¹⁴ **Performance-enhancing drugs** may have an adverse effect on the cardiovascular system by means of directly altering the myocardium, vasculature, and metabolism.¹⁵

Recommendations for exercise and sports in apparently healthy individuals or individuals with risk factors for cardiac disease are presented in Tables 3-7. Recommendations for patients with specific disease entities are presented in relevant Chapters. An algorithm for cardiovascular assessment of potentially increased risk individuals is proposed in Figure 2.

Exercise-induced Cardiac Remodelling

Isotonic exercise, ie endurance exercise with activities such as long-distance running, cycling, and swimming, results in sustained elevations in cardiac output, with normal or reduced peripheral vascular resistance. It represents primarily a volume challenge for the heart that affects all 4 chambers.^{16,17} **Isometric exercise**, ie strength training, results in increased peripheral vascular resistance and normal or only slightly elevated cardiac output.

This increase in peripheral vascular resistance causes transient but potentially marked systolic hypertension and LV afterload.¹⁶

LV hypertrophy and dilatation in isotonic and hypertrophy in isometric exercise. Mild reductions of LVEF might be seen although there is evidence that both systolic and diastolic LV function may improve with exercise.

RV dilatation and increased free wall thickness have been seen in athletes with isotonic exercise or isometric exercise. Electrocardiographic RV hypertrophy does not indicate underlying pathology.^{18 19} In black athletes, training-related RV enlargement may even mimic ARVC.¹⁸ Intensive, endurance exercise of increased duration (ie marathon runners) has also been reported to result in transient RV dysfunction that is usually reversible, although septal fibrosis was seen in athletes with intensive training for prolonged periods.²⁰ In athletes with normal cardiac function at rest, echocardiographic and CMR measures of RV function performed during exercise may reveal RV contractile dysfunction among athletes with RV arrhythmias, and may assist risk-stratification.²⁰ However, permanent RV damage in elite endurance Caucasian athletes with lifelong high training volumes has not been documented.²¹

Aortic root may be slightly dilated (1.6 mm compared to controls), but marked aortic root dilatation represents a pathological process and not a physiological adaptation to exercise.²²

Slightly larger **left atrium** has also been detected in trained athletes. Intensive and long-lasting endurance exercise such as a full distance Marathon, results in high cardiovascular strain whose clinical relevance especially for middle-aged and older athletes is unclear and remains a matter of controversy.²³

Resting **bradycardia** ($HR \leq 40$ bpm) and **pauses** of 2 to 3 s are present in a significant proportion of endurance athletes and are well tolerated. Both fitness and genetic variation contribute to sinus node function in endurance athletes.²⁴

Arrhythmias in Athletes

Syncope and sudden cardiac death in athletes are discussed in the relevant Chapters. Other arrhythmias in athletes (SVT, AF, VT) are discussed in the relevant chapters. Common cardiovascular conditions associated with sudden death in athletes are presented in Table 8.

Interpretation of the ECG in Athletes

Differentiation between adaptive and pathological ECG changes in athletes is not always easy. The most recent recommendations have been published by EHRA,²⁵ an international

group of experts who have updated the Seattle criteria,²⁶ and the European Association of Preventive Cardiology of the ESC.²⁷

ECG patterns seen in athletes are presented in Tables 9-12. There has been evidence, that isolated QRS voltage criteria (Sokolow-Lyon) for RV hypertrophy may be a non-pathologic, adaptive change, whereas left or right axis deviation, and left or right atrial enlargement may be considered minor training-unrelated abnormalities as indicated in Table 2.²⁸ African athletes display a large proportion of ECG abnormalities, including an increase in R/S-wave voltage, ST-segment elevation, and inverted or diffusely flat T waves.^{29 30}

Points for differentiating between adaptive changes and truly pathologic findings are:

1. Sinus bradycardia is normal.³¹ Only heart rates <30 bpm and pauses ≥3 sec during wake suggest SSS. First and second degree Type 1 (Wenckebach) blocks are benign and usually resolve with hyperventilation or exercise. However, anti-Ro/SSA-antibody testing is now part of the diagnostic work-up of athletes with isolated AVB, also including non-advanced forms such as marked PR-interval prolongation >400 ms and diurnal second-degree Mobitz-1 AVB.²⁷
2. Isolated axis deviation does not indicate further investigation, unless there is a history of pulmonary disease or systemic hypertension.
3. LV hypertrophy needs further evaluation only in the presence of family history of sudden cardiac death, or non-voltage ECG criteria suggesting pathological ECG hypertrophy.
4. Q waves >3mm in depth and/or >40 ms duration in any lead except aVR, III, and V1, suggest HOCM. Standard criteria for MI in athletes should also be considered in those >40 years of age.
5. Inferolateral early repolarization patterns may be seen in young athletes and is a dynamic phenomenon caused by exercise.³² Two types predominate: an elevated ST-segment with upward concavity and positive T-wave is seen in Caucasians, and an elevated ST-segment with upward convexity and negative T-wave in African-Caribbean athletes (Figures 4-8). The combination of J-point elevation and T wave inversion is not considered an abnormal finding among both Caucasian or Afro Caribbean athletes. Conversely, ST-segment elevation without J-point elevation preceding anterior T wave inversion may reflect cardiomyopathy.³³ Pathological early repolarization patterns are discussed in Genetic Channelopathies.
6. Up to 25% of athletes of African/Afro-Caribbean descent (black athletes) and 5% of white athletes also have T wave inversion of unclear clinical significance.³⁴ Repolarization abnormalities are more common among West and Middle African, than East and North Africans athletes.³⁵ T wave inversion seen in leads aVR, III and V1 and in V1-V4 when preceded by domed ST segments in asymptomatic Afro-Caribbean athletes is considered physiological.²⁹ It has to be differentiated from pathological T wave inversion that is associated with cardiac pathology in up to 45% of other athletes as detected by CMR.³⁶ HCM

was the commonest pathology (81%) in this series, and echocardiography did not identified pathology in up to 50% of the cases.³⁶ The prevalence of cardiomyopathy in white athletes with T-wave inversion is higher compared with black athletes with T-wave inversion (30% versus 12%).³⁴

7. Anterior T wave inversion confined to leads V1 and V2 may be a normal variant or physiological phenomenon in asymptomatic white individuals without a family history of relevant heart disease.³⁷

8. Incomplete RBBB (QRS<120 ms) is common. However, it should be differentiated from ARVC (Figure 7 and Table 11), and Brugada syndrome (Figure 8). Complete LBBB or RBBB with hemiblock necessitates cardiological work-up including myocardial imaging. ECG of the siblings should be also obtained to exclude genetically determined AV conduction disease.³⁸

9. Suspicion of long QT (> 470 ms in men and > 480 ms in women) or short QT (<340 msec) should lead to evaluation by a specialist. A QTC ≤380 ms may also be a marker of abuse of anabolic androgenic steroids.

10. WPW needs ablation for the elimination of the very low risk of sudden death, particularly since athletes may develop AF. Exclusion of conditions such as Ebstein disease, HCM and glycogen storage cardiomyopathy should be undertaken.

11. Isolated PVCs (1 on a resting ECG(with RVOT or fascicular morphology do not require further investigation.³¹ Investigations are undertaken with more than 1 PVC on a resting ECG.

12. Female athletes exhibit less hypertrophy, dilation, right ventricular remodelling, coronary atherosclerosis, myocardial fibrosis, and sympathetic tone than males, reducing sources for fatal arrhythmias. Nonetheless, in female athletes, a LV wall thickness > 12mm, LVEDD ≥60mm, concentric hypertrophy/ remodelling, and inferior or lateral TWI may represent cardiac pathology, warranting investigation for structural abnormalities.³⁹

Recommendations for management of abnormal ECG findings are provided in Figures 9-13.

Pre-participation Screening and Recommendations for Eligibility and Disqualification

A mandatory national preparticipation screening strategy with routine ECGs is recommended by the European Society of Cardiology,⁴⁰ and the International Olympic Committee,⁴¹ mainly based on the beneficial results of screening observed in the Veneto region of Italy.⁴²

The American Heart Association has expressed reservations about the cost-efficiency and effectiveness of such screening (Tables 13 and 14),⁴³ that has been adopted by the ESC⁴⁰ (Table 15 and Figure 14). Although debatable,⁴⁴ there is evidence in favor of a closer scrutiny,

especially since cardiac symptoms before death are often found.^{36,45-48} A US Interassociation Consensus Statement also favors a pre-participation evaluation of college student-athletes.⁴⁹ Genetic testing is rarely useful, with a low reported yield for pathogenic disease-causing genetic mutations in athletes (10%).³⁴

Recommendations for the indication and interpretation of cardiovascular imaging (including novel techniques such as 3-D echocardiography and speckle tracking-derived LV global longitudinal strain) in athletes have been published by the European Associations of Preventive Cardiology and Cardiovascular Imaging (Figures 15 and 16).⁵⁰ The European Associations of Preventive Cardiology has also published recommendations for participation in competitive sports of athletes with arterial hypertension,⁵¹ coronary artery disease,⁵² and myocarditis and cardiomyopathies.⁵³ A goal of <140/90 mmHg (140/85 mm Hg in diabetics) is recommended in athletes,⁵¹ as opposed to <130/80 mm HG recommended by the ACC/AHA guidelines on hypertension.⁵⁴ Sports according to risk of impact and educational background are presented in Table 16. Risks and Participation Considerations Related to Anticoagulation and Bodily Collision are presented in Table 17.⁵⁵

Athletes with genetic heart diseases predisposing to SCD are restricted from playing competitive athletics. However, those who return to play after expert risk stratification and tailoring of therapy face a low risk of cardiac events.⁵⁶ Clinical consideration in athletes with known cardiac abnormalities are presented in Tables 18-26.

References

1. Maron BJ, Zipes DP, Kovacs RJ, American Heart Association E, Arrhythmias Committee of Council on Clinical Cardiology CoCDiYCoC, Stroke Nursing CoFG, Translational B, American College of C. Eligibility and Disqualification Recommendations for Competitive Athletes With Cardiovascular Abnormalities: Preamble, Principles, and General Considerations: A Scientific Statement From the American Heart Association and American College of Cardiology. *Circulation*. 2015;132:e256-261. doi: 10.1161/CIR.0000000000000236
2. Baggish AL, al. e. Sports Cardiology. Core Curriculum for Providing Cardiovascular Care to Competitive Athletes and Highly Active People. *J Am Coll Cardiol*. 2017.
3. Budts W, Pieleas GE, Roos-Hesselink JW, Sanz de la Garza M, D'Ascenzi F, Giannakoulas G, Muller J, Oberhoffer R, Ehringer-Schetitska D, Herceg-Cavrak V, et al. Recommendations for participation in competitive sport in adolescent and adult athletes with Congenital Heart Disease (CHD): position statement of the Sports Cardiology & Exercise Section of the European Association of Preventive Cardiology (EAPC), the European Society of Cardiology (ESC) Working Group on Adult Congenital Heart Disease and the Sports Cardiology, Physical Activity and Prevention Working Group of the Association for European Paediatric and Congenital Cardiology (AEPC). *Eur Heart J*. 2020. doi: 10.1093/eurheartj/ehaa501
4. Pelliccia A, Sharma S, Gati S, Back M, Borjesson M, Caselli S, Collet JP, Corrado D, Drezner JA, Halle M, et al. 2020 ESC Guidelines on sports cardiology and exercise in patients with cardiovascular disease. *Eur Heart J*. 2020. doi: 10.1093/eurheartj/ehaa605
5. La Gerche A, al. e. The Athlete's Heart—Challenges and Controversies. *JACC*. 2022.
6. Aengevaeren VL, Mosterd A, Braber TL, Prakken NHJ, Doevendans PA, Grobbee DE, Thompson PD, Eijssvogels TMH, Velthuis BK. Relationship Between Lifelong Exercise Volume and Coronary Atherosclerosis in Athletes. *Circulation*. 2017;136:138-148. doi: 10.1161/CIRCULATIONAHA.117.027834
7. Merghani A, Maestrini V, Rosmini S, Cox AT, Dhutia H, Bastiaenen R, David S, Yeo TJ, Narain R, Malhotra A, et al. Prevalence of Subclinical Coronary Artery Disease in Masters Endurance Athletes With a Low Atherosclerotic Risk Profile. *Circulation*. 2017;136:126-137. doi: 10.1161/CIRCULATIONAHA.116.026964
8. Aengevaeren VL, Mosterd A, Sharma S, Prakken NHJ, Mohlenkamp S, Thompson PD, Velthuis BK, Eijssvogels TMH. Exercise and Coronary Atherosclerosis: Observations, Explanations, Relevance, and Clinical Management. *Circulation*. 2020;141:1338-1350. doi: 10.1161/CIRCULATIONAHA.119.044467
9. Andersen K, Farahmand B, Ahlbom A, Held C, Ljunghall S, Michaelsson K, Sundstrom J. Risk of arrhythmias in 52 755 long-distance cross-country skiers: a cohort study. *Eur Heart J*. 2013;34:3624-3631. doi: 10.1093/eurheartj/eh188
- eht188 [pii]
10. Newman W, Parry-Williams G, Wiles J, Edwards J, Hulbert S, Kipourou K, Papadakis M, Sharma R, O'Driscoll J. Risk of atrial fibrillation in athletes: a systematic review and meta-analysis. *Br J Sports Med*. 2021. doi: 10.1136/bjsports-2021-103994
11. Mozaffarian D, Furberg CD, Psaty BM, Siscovick D. Physical activity and incidence of atrial fibrillation in older adults: the cardiovascular health study. *Circulation*. 2008;118:800-807. doi: 10.1161/CIRCULATIONAHA.108.785626
- CIRCULATIONAHA.108.785626 [pii]
12. Qureshi WT, Alirhayim Z, Blaha MJ, Juraschek SP, Keteyian SJ, Bawner CA, Al-Mallah MH. Cardiorespiratory Fitness and Risk of Incident Atrial Fibrillation: Results From the Henry Ford Exercise Testing (FIT) Project. *Circulation*. 2015;131:1827-1834. doi: 10.1161/CIRCULATIONAHA.114.014833
- CIRCULATIONAHA.114.014833 [pii]
13. Garnvik LE, Malmo V, Janszky I, Ellekjaer H, Wisloff U, Loennechen JP, Nes BM. Physical activity, cardiorespiratory fitness, and cardiovascular outcomes in individuals with atrial fibrillation: the HUNT study. *Eur Heart J*. 2020;41:1467-1475. doi: 10.1093/eurheartj/ehaa032
14. Elliott AD, Linz D, Mishima R, Kadhim K, Gallagher C, Middeldorp ME, Verdicchio CV, Hendriks JML, Lau DH, La Gerche A, et al. Association between physical activity and risk of incident arrhythmias in 402 406 individuals: evidence from the UK Biobank cohort. *Eur Heart J*. 2020;41:1479-1486. doi: 10.1093/eurheartj/ehz897
15. La Gerche A, Brosnan MJ. Cardiovascular Effects of Performance-Enhancing Drugs. *Circulation*. 2017;135:89-99. doi: 10.1161/CIRCULATIONAHA.116.022535
16. Baggish AL, Wood MJ. Athlete's heart and cardiovascular care of the athlete: scientific and clinical update. *Circulation*. 2011;123:2723-2735. doi: 10.1161/CIRCULATIONAHA.110.981571

123/23/2723 [pii]

17. Lawless CE, Asplund C, Asif IM, Courson R, Emery MS, Fuisz A, Kovacs RJ, Lawrence SM, Levine BD, Link MS, et al. Protecting the heart of the American athlete: proceedings of the American College of Cardiology Sports and Exercise Cardiology Think Tank October 18, 2012, Washington, DC. *J Am Coll Cardiol*. 2014;64:2146-2171. doi: 10.1016/j.jacc.2014.08.027
 18. Zaidi A, Ghani S, Sharma R, Oxborough D, Panoulas VF, Sheikh N, Gati S, Papadakis M, Sharma S. Physiological right ventricular adaptation in elite athletes of African and Afro-Caribbean origin. *Circulation*. 2013;127:1783-1792. doi: 10.1161/CIRCULATIONAHA.112.000270
 19. Zaidi A, Ghani S, Sheikh N, Gati S, Bastiaenen R, Madden B, Papadakis M, Raju H, Reed M, Sharma R, et al. Clinical significance of electrocardiographic right ventricular hypertrophy in athletes: comparison with arrhythmogenic right ventricular cardiomyopathy and pulmonary hypertension. *Eur Heart J*. 2013;34:3649-3656. doi: 10.1093/eurheartj/ehs391
 20. La Gerche A, Burns AT, Mooney DJ, Inder WJ, Taylor AJ, Bogaert J, Macisaac AI, Heidebuchel H, Prior DL. Exercise-induced right ventricular dysfunction and structural remodelling in endurance athletes. *Eur Heart J*. 2012;33:998-1006. doi: 10.1093/eurheartj/ehr397
- ehr397 [pii]
21. Bohm P, Schneider G, Linneweber L, Rentzsch A, Kramer N, Abdul-Khaliq H, Kindermann W, Meyer T, Scharhag J. Right and Left Ventricular Function and Mass in Male Elite Master Athletes: A Controlled Contrast-Enhanced Cardiovascular Magnetic Resonance Study. *Circulation*. 2016;133:1927-1935. doi: 10.1161/CIRCULATIONAHA.115.020975
 22. Iskandar A, Thompson PD. A meta-analysis of aortic root size in elite athletes. *Circulation*. 2013;127:791-798. doi: 10.1161/CIRCULATIONAHA.112.000974
 23. Predel HG. Marathon run: cardiovascular adaptation and cardiovascular risk. *Eur Heart J*. 2014;35:3091-3098. doi: 10.1093/eurheartj/ehs502
 24. D'Ambrosio P, De Paepe J, Spencer LW, Ohanian M, Janssens K, Mitchell AM, Flannery MD, Bekhuis Y, Pauwels R, Delpire B, et al. Bradycardia in Athletes: Prevalence, Mechanisms, and Risks. *Circulation*. 2026;153:616-630. doi: 10.1161/CIRCULATIONAHA.125.076170
 25. Mont L, Pelliccia A, Sharma S, Biffi A, Borjesson M, Terradellas JB, Carre F, Guasch E, Heidebuchel H, Gerche A, et al. Pre-participation cardiovascular evaluation for athletic participants to prevent sudden death: Position paper from the EHRA and the EACPR, branches of the ESC. Endorsed by APHRS, HRS, and SOLAECE. *Europace*. 2017;19:139-163. doi: 10.1093/europace/eww243
 26. Sharma S, al. e. International Recommendations for Electrocardiographic Interpretation in Athletes. *J Am Coll Cardiol*. 2017;69:1057-1075. doi: 10.1016/j.jacc.2017.01.015
 27. Finocchiaro G, Zorzi A, Abela M, Baggish A, Castelletti S, Cavarretta E, Claessen G, Corrado D, Sanz de la Garza M, Gati S, et al. Abnormal electrocardiogram findings in athletes. *Eur Heart J*. 2026;47:152-169. doi: 10.1093/eurheartj/ehaf646
 28. Gati S, Sheikh N, Ghani S, Zaidi A, Wilson M, Raju H, Cox A, Reed M, Papadakis M, Sharma S. Should axis deviation or atrial enlargement be categorised as abnormal in young athletes? The athlete's electrocardiogram: time for re-appraisal of markers of pathology. *Eur Heart J*. 2013;34:3641-3648. doi: 10.1093/eurheartj/ehs390
 29. Sheikh N, Papadakis M, Ghani S, Zaidi A, Gati S, Adami PE, Carre F, Schnell F, Wilson M, Avila P, et al. Comparison of electrocardiographic criteria for the detection of cardiac abnormalities in elite black and white athletes. *Circulation*. 2014;129:1637-1649. doi: 10.1161/CIRCULATIONAHA.113.006179
 30. Di Paolo FM, Schmied C, Zerguini YA, Junge A, Quattrini F, Culasso F, Dvorak J, Pelliccia A. The athlete's heart in adolescent Africans: an electrocardiographic and echocardiographic study. *J Am Coll Cardiol*. 2012;59:1029-1036. doi: 10.1016/j.jacc.2011.12.008
- S0735-1097(11)05356-3 [pii]
31. Eijssvogels TMH, Kim JH, Aengevaeren VL, D'Ascenzi F, Churchill TW, Dineen EH, Sanz-de la Garza M, Gati S, Halasz G, Haugaa K, et al. Masters athletes with abnormal cardiovascular findings: a clinical consensus statement of the European Association of Preventive Cardiology of the ESC and the American College of Cardiology. *Eur Heart J*. 2026;47:2541-2560. doi: 10.1093/eurheartj/ehag040
 32. Noseworthy PA, Weiner R, Kim J, Keelara V, Wang F, Berkstresser B, Wood MJ, Wang TJ, Picard MH, Hutter AM, Jr., et al. Early repolarization pattern in competitive athletes: clinical correlates and the effects of exercise training. *Circ Arrhythm Electrophysiol*. 2011;4:432-440. doi: 10.1161/CIRCEP.111.962852
- CIRCEP.111.962852 [pii]
33. Calore C, Zorzi A, Sheikh N, Nese A, Facci M, Malhotra A, Zaidi A, Schiavon M, Pelliccia A, Sharma S, et al. Electrocardiographic anterior T-wave inversion in athletes of different ethnicities: differential diagnosis between athlete's heart and cardiomyopathy. *Eur Heart J*. 2016;37:2515-2527. doi: 10.1093/eurheartj/ehv591
 34. Sheikh N, Papadakis M, Wilson M, Malhotra A, Adamuz C, Homfray T, Monserrat L, Behr ER, Sharma S. Diagnostic Yield of Genetic Testing in Young Athletes with T-wave Inversion. *Circulation*. 2018. doi: 10.1161/CIRCULATIONAHA.118.034208
 35. Riding NR, Sharma S, McClean G, Adamuz C, Watt V, Wilson MG. Impact of geographical origin upon the electrical and structural manifestations of the black athlete's heart. *Eur Heart J*. 2019;40:50-58. doi: 10.1093/eurheartj/ehy521

36. Schnell F, Riding N, O'Hanlon R, Axel Lentz P, Donal E, Kervio G, Matelot D, Leurent G, Doutreleau S, Chevalier L, et al. Recognition and significance of pathological T-wave inversions in athletes. *Circulation*. 2015;131:165-173. doi: 10.1161/CIRCULATIONAHA.114.011038
37. Malhotra A, et al. Anterior T-Wave Inversion in Young White Athletes and Nonathletes: Prevalence and Significance *J Am Coll Cardiol*. 2017;69:1-9. doi: 10.1016/j.jacc.2016.10.044
38. Corrado D, van Tintelen PJ, McKenna WJ, Hauer RNW, Anastakis A, Asimaki A, Basso C, Bauce B, Brunckhorst C, Bucciarelli-Ducci C, et al. Arrhythmogenic right ventricular cardiomyopathy: evaluation of the current diagnostic criteria and differential diagnosis. *Eur Heart J*. 2020;41:1414-1429. doi: 10.1093/eurheartj/ehz669
39. Rajan D, Garcia R, Svane J, Tfelt-Hansen J. Risk of sports-related sudden cardiac death in women. *Eur Heart J*. 2021. doi: 10.1093/eurheartj/ehab833
40. Zeppenfeld K, Tfelt-Hansen J, de Riva M, Winkel BG, Behr ER, Blom NA, Charron P, Corrado D, Dagres N, de Chillou C, et al. 2022 ESC Guidelines for the management of patients with ventricular arrhythmias and the prevention of sudden cardiac death. *Eur Heart J*. 2022. doi: 10.1093/eurheartj/ehac262
41. 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;13:859-875. doi: 10.1097/01.hjr.0000238397.50341.4a
42. Corrado D, Basso C, Pavei A, Michieli P, Schiavon M, Thiene G. Trends in sudden cardiovascular death in young competitive athletes after implementation of a preparticipation screening program. *JAMA*. 2006;296:1593-1601. doi: 10.1001/jama.296.13.1593
43. Maron BJ, Friedman RA, Kligfield P, Levine BD, Viskin S, Chaitman BR, Okin PM, Saul JP, Salberg L, Van Hare GF, et al. Assessment of the 12-lead ECG as a screening test for detection of cardiovascular disease in healthy general populations of young people (12-25 Years of Age): a scientific statement from the American Heart Association and the American College of Cardiology. *Circulation*. 2014;130:1303-1334. doi: 10.1161/CIR.0000000000000025
44. Roberts WO, Stovitz SD. Incidence of sudden cardiac death in Minnesota high school athletes 1993-2012 screened with a standardized pre-participation evaluation. *J Am Coll Cardiol*. 2013;62:1298-1301. doi: 10.1016/j.jacc.2013.05.080
45. Dhutia H, Malhotra A, Gabus V, Merghani A, Finocchiaro G, Millar L, Narain R, Papadakis M, Naci H, Tome M, et al. Cost Implications of Using Different ECG Criteria for Screening Young Athletes in the United Kingdom. *J Am Coll Cardiol*. 2016;68:702-711. doi: 10.1016/j.jacc.2016.05.076
46. Harmon KG, Asif IM, Maleszewski JJ, Owens DS, Prutkin JM, Salerno JC, Zigman ML, Ellenbogen R, Rao AL, Ackerman MJ, et al. Incidence, Cause, and Comparative Frequency of Sudden Cardiac Death in National Collegiate Athletic Association Athletes: A Decade in Review. *Circulation*. 2015;132:10-19. doi: 10.1161/CIRCULATIONAHA.115.015431
47. Price DE, McWilliams A, Asif IM, Martin A, Elliott SD, Dulin M, Drezner JA. Electrocardiography-inclusive screening strategies for detection of cardiovascular abnormalities in high school athletes. *Heart Rhythm*. 2014;11:442-449. doi: 10.1016/j.hrthm.2013.12.002
48. Risgaard B, Winkel BG, Jabbari R, Glinge C, Ingemann-Hansen O, Thomsen JL, Ottesen GL, Haunso S, Holst AG, Tfelt-Hansen J. Sports-related sudden cardiac death in a competitive and a noncompetitive athlete population aged 12 to 49 years: data from an unselected nationwide study in Denmark. *Heart Rhythm*. 2014;11:1673-1681. doi: 10.1016/j.hrthm.2014.05.026
49. Hainline B, Drezner J, Baggish A, Harmon KG, Emery MS, Myerburg RJ, Sanchez E, Molossi S, Parsons JT, Thompson PD. Interassociation consensus statement on cardiovascular care of college student-athletes. *Br J Sports Med*. 2016. doi: 10.1136/bjsports-2016-096323
50. Pelliccia A, Caselli S, Sharma S, Basso C, Bax JJ, Corrado D, D'Andrea A, D'Ascenzi F, Di Paolo FM, Edvardsen T, et al. European Association of Preventive Cardiology (EAPC) and European Association of Cardiovascular Imaging (EACVI) joint position statement: recommendations for the indication and interpretation of cardiovascular imaging in the evaluation of the athlete's heart. *Eur Heart J*. 2017. doi: 10.1093/eurheartj/ehx532
51. Niebauer J, Borjesson M, Carre F, Caselli S, Palatini P, Quattrini F, Serratos L, Adami PE, Biffi A, Pressler A, et al. Recommendations for participation in competitive sports of athletes with arterial hypertension: a position statement from the sports cardiology section of the European Association of Preventive Cardiology (EAPC). *Eur Heart J*. 2018;39:3664-3671. doi: 10.1093/eurheartj/ehy511
52. Borjesson M, Dellborg M, Niebauer J, LaGerche A, Schmied C, Solberg EE, Halle M, Adami E, Biffi A, Carre F, et al. Recommendations for participation in leisure time or competitive sports in athletes-patients with coronary artery disease: a position statement from the Sports Cardiology Section of the European Association of Preventive Cardiology (EAPC). *Eur Heart J*. 2019;40:13-18. doi: 10.1093/eurheartj/ehy408
53. Pelliccia A, Solberg EE, Papadakis M, Adami PE, Biffi A, Caselli S, La Gerche A, Niebauer J, Pressler A, Schmied CM, et al. Recommendations for participation in competitive and leisure time sport in athletes with cardiomyopathies, myocarditis, and pericarditis: position statement of the Sport Cardiology Section of the European Association of Preventive Cardiology (EAPC). *Eur Heart J*. 2019;40:19-33. doi: 10.1093/eurheartj/ehy730
54. Whelton PK, Carey RM, Aronow WS, Casey DE, Jr., Collins KJ, Dennison Himmelfarb C, DePalma SM, Gidding S, Jamerson KA, Jones DW, et al. 2017

- ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *J Am Coll Cardiol*. 2017. doi: 10.1016/j.jacc.2017.11.006
55. Writing Committee M, Dineen EH, Haigney MC, Levine BD, Ackerman MJ, Baggish AL, Batts TC, Braverman AC, Chung EH, Cole GJ, et al. Clinical Considerations for the Care of the Tactical Athlete With Cardiovascular Abnormalities: A Scientific Statement From the American College of Cardiology and the American Heart Association. *Circulation*. 2026;154:e524-e572. doi: 10.1161/CIR.0000000000001476
 56. Martinez KA, Bos JM, Baggish AL, Phelan DM, Tobert KE, Newman DB, Scherer E, Petek BJ, Ackerman MJ, Martinez MW. Return-to-Play for Elite Athletes With Genetic Heart Diseases Predisposing to Sudden Cardiac Death. *J Am Coll Cardiol*. 2023;82:661-670. doi: 10.1016/j.jacc.2023.05.059