Recomendaciones para el ejercicio físico en deportistas con cardiopatías familiares (segunda parte)

Aridane Cárdenes León[1,2], José Juan García Salvador[1], Marta López Pérez[1], Clara Azucena Quintana Casanova[3], Eduardo Caballero Dorta[1]

[1]Servicio de Cardiología. Hospital Universitario de Gran Canaria Dr. Negrín. Las Palmas de Gran Canaria. [2]Centro Cardiológico Cardiavant. Las Palmas de Gran Canaria. [3]Unidad de Medicina del Deporte. Hospital Perpetuo Socorro. Las Palmas de Gran Canaria.

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Summary

The safety of physical activity and sports in patients with inherited heart disease is not well established. The recommendations on physical exercise in these patients are usually quite restrictive without clear evidence for this, despite the fact that sport has shown important cardiovascular benefits. Participation in sports in adults with inherited heart disease is considered a relatively little known territory and many clinicians find it difficult to advise their patients. The development of current medicine has meant a significant improvement in the study of inherited heart diseases, as well as in their early diagnosis and treatment. In addition, genetic studies have assumed a fundamental aspect in the follow-up of these heart diseases, guiding more appropriately the therapeutic attitude that we must follow. Until recently, patients with such heart disease have been frequently disqualified from competitive sports, and in many cases, complete cessation of physical activity, including recreational sport, is recommended. However, current recommendations are less restrictive, insisting on individualizing the different cases depending on the type of pathology, the type of physical activity performed, whether they present the disease or are only carriers of causal genetic mutations, etc. Current research focuses primarily on the safety of physical activity in patients with inherited heart disease and the fear that the practice of competitive physical activity can significantly increase the risk of adverse events, especially arrhythmic events and sudden death. In this review, we analyzed numerous studies and clinical practice guidelines, in order to establish the recommendations of physical activity, as well as their restrictions depending on the different types of inherited heart disease.

Key words:
Sport cardiology. Inherited heart disease. Sporting activity. Cardiomyopathies. Channelopathies.

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Resumen

La seguridad de la actividad física y deportiva en pacientes con cardiopatías familiares aún no está bien establecida. Las recomendaciones sobre el ejercicio físico en estos pacientes suele ser bastante restrictiva sin que haya clara evidencia para ello, a pesar de que el deporte haya demostrado importantes beneficios cardiovasculares. La participación en deportes en los adultos con cardiopatías familiares se considera un territorio relativamente poco conocido y muchos clínicos se encuentran con dificultades en el asesoramiento a sus pacientes. El desarrollo de la medicina actual ha supuesto una mejoría significativa en el estudio de las cardiopatías familiares, así como en su diagnóstico precoz y tratamiento. Asimismo, los estudios genéticos han supuestos un pilar fundamental en el seguimiento de estas cardiopatías, guiando de manera más adecuada la actitud terapéutica que debemos seguir. Hasta hace poco tiempo, los pacientes que presentan dichas cardiopatías han sido descalificados de manera frecuente de los deportes competitivos y en muchas ocasiones, se recomienda el cese completo de la actividad física, incluido el deporte tipo recreacional. Sin embargo, las recomendaciones actuales son menos restrictivas, insistiendo en individualizar los diferentes casos en función del tipo de patología, del tipo de actividad física realizada, si éstos presentan la enfermedad o son únicamente portadores de mutaciones genéticas causales, etc. Las investigaciones actuales se centran fundamentalmente en la seguridad de la actividad física en pacientes con cardiopatías familiares, y el temor a que la práctica de actividad física a nivel competitivo pueda aumentar significativamente el riesgo de eventos adversos, especialmente de eventos arrítmicos y muerte súbita. En esta revisión, analizamos numerosos estudios y las guías de práctica clínica, con el fin de establecer las recomendaciones de actividad física, así como sus restricciones en función de los diferentes tipos de cardiopatías familiares.

Palabras clave:
Cardiología deportiva. Cardiopatías familiares. Actividad deportiva. Miocardiopatías. Canalopatías.

Correspondence: Aridane Cárdenes León
E-mail: aricardenes@gmail.com

Other genetic aortic diseases

As is well known today, high-intensity sports practice is associated with certain haemodynamic alterations, leading to increased aortic wall tension, thereby progressively increasing its dimensions. It has frequently been described that competitive athletes could have slightly larger aortic diameters, particularly with regard to the sinuses of Valsalva, than the general population. However, in recent literature, such as Boraita *et al*.[25], it is considered that significant aortic dilation is rarely due to a normal and physiological adaptation to high intensity training. We should therefore rule out a concomitant aortic pathology that may be exacerbated by continued physical activity. For this reason, different imaging techniques (transthoracic echocardiogram, computed tomography, cardiac magnetic resonance, etc.) should be used to make a proper study of the aorta and to rule out an underlying aortic pathology. Likewise, it is important to consider conducting a genetic study on those patients with aortic pathology, particularly at early ages, and also on those patients with a family history of aortic dilation, acute aortic syndrome (aortic dissection, aortic rupture, etc.), thoracic aortic aneurysm syndrome, etc.

For the aortic root study, it is recommended to make these measurements on the echocardiogram from inner edge to inner edge at the sinuses of Valsalva during the systole. Likewise, it is recommended to make measurements at different levels: ring, sinotubular junction, ascending aorta, etc. Moreover, other imaging techniques such as cardiac MR and CT will give greater spatial resolution and permit a more appropriate study of the thoracic and abdominal aorta. It is important to progressively analyse the increase in the aortic dimensions in relation to any prior checks made in previous years.

Typically, isolated measurements of the aortic diameters were used to make the diagnosis and monitoring of these pathologies. However, today, the criteria most commonly used to diagnose aortic pathology are the "Z-scores"[26] which include a number of variables such as body mass index, gender and age. In this way, it would be said that the aorta presents a slight, moderate or severe dilation depending on whether the Z-score is between 2-3, 3.1-4 or >4 respectively. However, it is recommended that any athlete with a marked aortic dilation (Z-score >2), should be assessed by doctors with experience in the field of aortic pathology in athletes.

Some years ago, the recommendations were quite restrictive in relation to competitive sports participation, restricting any athlete with "unequivocal aortic enlargement", defined as an aortic diameter >40 mm (or >2 standard deviations in children or young people, Z score >2) to participation in class IA competitive sports only. However, the American guidelines published in 2015[9] are less restrictive in the recommendation for sports activity for these patients:

- Today, athletes with aortic dimensions above the normal ranges (Z scores of 2 to 2.5 or aortic diameters of 40-41 mm in tall sportsmen or 36-38 mm in tall sportswomen, and with no signs that are compatible with Marfan syndrome, Loeyz-Dietz syndrome or familial thoracic aneurysm syndrome, should undergo echocardiographic or MR monitoring every 6-12 months, depending on aortic size and stability of measurements (Class I; level of Evidence C).
- Athletes with aortic dimensions above the normal ranges (Z scores of 2 to 2.5 or aortic diameters of 40-41 mm in tall sportsmen or 36-38 mm in tall sportswomen, and with no signs that are compatible with Marfan syndrome, Loeyz-Dietz syndrome, familial thoracic aneurysm syndrome, or bicuspid aortic valve, can participate in all competitive sports provided that a genetic study of gene FBN1 and other related genes has excluded a genetic aortic disease (Class IIb; level of evidence C).
- Athletes with aortic dimensions above the normal ranges (Z scores of 2 to 2.5 or aortic diameters of 40-41 mm in tall sportsmen or 35-37 mm in tall sportswomen, and with no signs that are compatible with Marfan syndrome, Loeyz-Dietz syndrome or familial thoracic aneurysm syndrome, should avoid intensive weight training (Class IIb; level of evidence C).
- Likewise, athletes with familial or non-familial thoracic aortic aneurysms or carriers of a known mutation related to thoracic aortic aneurysm syndrome must undergo echocardiographic monitoring (or CT or MR depending on the diagnosis) every 6-12 months to assess the progression of the aortic dilation or other vascular branches.
- It is reasonable for athletes with familial or non-familial thoracic aortic aneurysms or carriers of a known mutation related to thoracic aortic aneurysm syndrome to participate in class IA sports if they do not have ≥1 of the following characteristics (Class IIa; level of evidence C): aortic root dilation (Z score > 2, 40 mm or > 2 SD for children and adolescents under 15 years), moderate-severe mitral insufficiency, family history of aortic dissection, cerebrovascular disease and/or branch vessel aneurysm or dissection.
- It is reasonable for athletes with Loeys-Dietz syndrome or vascular Ehler-Danlos syndrome to participate in class IA sports if they have none of the following characteristics (class IIa; level of evidence C): aortic enlargement (score>2), dissection or branch vessel enlargement, moderate to severe mitral insufficiency and/or extracardiac involvement that may represent a risk.
- It is reasonable for athletes who have had surgery for aortic dissection or aneurysms and with no post-operational evidence of enlargement or dissection, to participate in class IA sports that do not include the risk of bodily collision (class IIa; level of evidence C).
- Athletes with Loeys-Dietz syndrome, Ehler-Danlos syndrome, familial or non-familial thoracic aneurysms or any other related disorder, should not participate in any competitive sports involving intense physical exertion or the potential for bodily collision (Class III; level of evidence C).

Channelopathies

Channelopathies are those genetic disorders caused by mutations in the genes of the different ion channels, causing various alterations

in their structure and function[27]. They are characterised by generally occurring in a structurally normal heart, and are responsible for most hereditary arrhythmias and a high percentage of sudden cardiac deaths that are not associated with structural cardiopathy. This term includes a number of pathologies, primarily Brugada syndrome, long and short QT and polymorphic ventricular tachycardia. These channelopathies have a number of characteristics in common:

- Phenotypic heterogeneity: The mutations in the same gene may give rise to different diseases and symptoms. For example, the mutations in the sodium channel may give rise to diseases such as long QT syndrome, Brugada syndrome, etc.
- Genetic heterogeneity: The mutations in different genes may give rise to the same disease. For example, the long QT syndrome may be caused by mutations in genes that encode different potassium channels or, on some occasions, affect the sodium channels.
- Clinical heterogeneity: Family members who carry the same mutation may have different phenotypes which, in the Brugada syndrome for example, range from normal electrocardiograms (ECG) to ST elevation and ventricular arrhythmias leading to sudden death.

According to recommendations of the American guidelines, a comprehensive study should be made of each particular case, differentiating between a symptomatic athlete and an athlete with concealed channelopathy, being aware of the difference between both terms. A symptomatic athlete is considered to be an individual who has suffered at least one adverse event (malignant arrhythmias, syncope, sudden death, etc.) that is related or probably related to a channelopathy. However the term "concealed channelopathy" is used to refer to a genotype-positive/phenotype-negative athlete. In other words, the athlete is a carrier or a specific mutation related to a channelopathy, and yet is completely asymptomatic, exhibiting no baseline electrocardiographic alterations or during exercise stress testing (ventricular arrhythmias etc.).

Described below are the principal channelopathies existing today.

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Long QT syndrome

This channelopathy has a prevalence of 1 in 2,000-3,000 persons[28], predominantly affecting young people or adolescents. It is characterized by prolonged ventricular repolarization with a QT interval prolongation, T-wave alteration, etc. These patients typically present potentially lethal arrhythmic events, predominantly in the context of polymorphic ventricular tachycardia or in torsade de pointes. There are different types of long QT syndrome, classified by the type of causal mutations as well as the activity triggering the arrhythmic events. For example, type 1 long QT syndrome, which is the most common, is the one that primarily needs to be ruled out in athletes, given the fact that the appearance of arrhythmias in this group is associated with physical exercise, frequently swimming. Type 2 LQTS arrhythmias are generally triggered by intense emotions or abrupt auditory stimuli (although the presence of arrhythmic events has also been described in these cases while sleeping with no excitation)[29], while type 3 LQTS is related to rest or sleep.

It is recommended to measure the QT interval at electrocardiogram leads II and V5. Given the fact that this interval varies in relation to heart rate, this should be corrected according to the patient's heart rate (QTc corrected). Given the fact that a significant proportion of athletes exhibit a tendency to bradycardia, if the QT interval duration is not corrected (through the Bazzet formula), then we would be faced with a high percentage of prolonged QT intervals that would be over-estimated and impossible to assess.

In general, long-QT is when the corrected QT (QTc) is >460 ms in minors under 15 years, >470 ms in adult women and >450 ms in adult men[30]. Today, the Schartz criteria are used (Table 1) to make the definitive diagnosis of long QT syndrome which, in addition to the prolongation of the QTc, also considers other clinical criteria such as family history, history of syncopes or sudden death, etc.

Therefore, this type of channelopathy should be suspected primarily in young people exhibiting syncopal episodes in relation to different stimuli such as exercise, intense emotion, swimming or abrupt auditory stimuli.

Since the start of the beta blocker treatment, the prognosis for this pathology has changed drastically[31], with a drop in overall mortality from 73% to less than 10%, particularly for those cases with a prior history of syncope. However, the administration of beta blockers is not recommended for patients with type 3 LQTS (it may even be contraindicated), given the fact that the arrhythmic events, as already observed, appear during sleep in the context of exaggerated sinus bradycardia. These drugs therefore promote the appearance of malignant arrhythmias.

Table 1. Schartz Criteria for the definitive diagnosis of Long-QT syndrome.

ECG Findings	**Points**
QTc (Bazett formula)	
• ≥ 480 ms	3
• 460-470 ms	2
• 450 ms (in males)	1
VT at *torsade de pointes*	2
Alternating T-wave	1
Coved T-waves in at least 3 leads	1
HR low for age	0.5
Medical records	**Points**
Syncope	
• With stress	2
• Without stress	1
Congenital deafness	0.5
Family history	**Points**
Relative with a diagnosis of congenital long-QT	1
Sudden death in a close relative under the age of 30	0.5

Low diagnostic probability ≤1 point
Intermediate probability 2-3 points
High probability ≥4 points

Nowadays, it is recommended that all patients with long-QT syndrome (except type 3), symptomatic or not, receive beta blocker treatment and avoid drugs that prolong repolarization. For those patients with long-QT syndrome and with a high risk of sudden death (documented ventricular tachycardia, family history of sudden death, excessively prolonged QTc of around 500 ms. etc.), ICD implantation should be considered. Likewise, athletes with a prolonged baseline QTc interval are advised to undergo a maximum stress test, endeavouring to analyse the shortening of the QTc with exercise at maximum rates, which would make this pathology more benign.

The 36th Bethesda Conference and the European Society of Cardiology of 2005 were extremely restrictive, recommending the disqualification of individuals with LQTS from all competitive sports, with the exception of low intensity sports (IA). However, there were discrepancies between the recommendations established by these two entities for the participation of genotype positive-phenotype negative athletes in sports activity; the ESC recommends complete discontinuation of competitive sports, while the Bethesda conference would permit participation in high level sports activity (except swimming for patients with type 1 LQTS). Today, numerous studies have established that the said guidelines are fairly restrictive and should be revised, given the low arrhythmic event rate of athletes with these channelopathies, when following appropriate guidelines.

According to the American guidelines[9] and the most recent recommendations, competitive sport participation may be considered for previously symptomatic patients or with electrocardiographic expression of LQTS, provided that they take appropriate precautionary measures and receive suitable treatment and that they have been totally asymptomatic for at least 3 months (class IIb, level of evidence C). For individuals with an ICD implant, the specific guidelines for performing sports with an ICD should be followed.

Likewise, if a patient has LQTS and has been previously symptomatic or electrocardiographically manifests LQTS (QTc > 470 ms in males or > 480 in females), competitive sports participation may be considered provided that the athlete is receiving suitable treatment and appropriate precautionary measures are taken, and that the said athlete has been asymptomatic on treatment for at least 3 months, except competitive swimming for those athletes with type 1 LQTS (class IIb, level of evidence C).

Short QT syndrome

This is a rare pathology that could predispose to the appearance of lethal arrhythmias, predominantly ventricular fibrillation[32]. Short QT is characterised by a persistent QTc<300 ms, predominantly associated with peaked, symmetrical T-waves. However, the finding of a short QTc interval on the surface electrocardiogram is not sufficient to refer to the presence of this syndrome, or the predisposition to lethal arrhythmias. This pathology should be suspected when, in addition to these electrocardiographic alterations, the patient exhibits palpitations, auricular fibrillation or syncopal symptoms, as well as a family history of sudden cardiac death. At present, only three causal mutations are known. It is therefore classified into three different types, depending on the mutation. An electrophysiological study is often recommended in order to induce arrhythmic events. Today, ICD implantation is the treatment of choice for the prevention of sudden death in high-risk patients. Although few studies have been made, quinidine could be used as a drug companion to prevent auricular fibrillation or recurrent ventricular tachycardias in patients with SQTS[33].

According to current guidelines, as is the case for athletes with long QT syndrome, competitive sport could be considered for previously symptomatic patients or with electrocardiographic expression of SQTS, provided that the precautionary measures indicated above are taken, that suitable treatment is received and that they have been totally asymptomatic for at least 3 months (class IIb, level of evidence C).

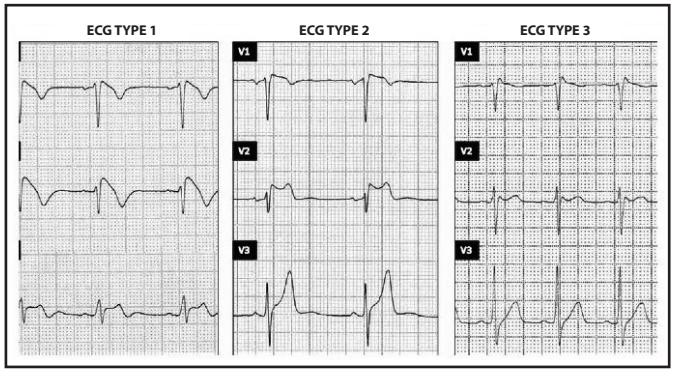
Brugada syndrome

This syndrome is characterised by a typical electrocardiographic pattern in the right precordial leads (V1-V3) often associated with right bundle branch block morphology and a predisposition to exhibit ventricular arrhythmias and sudden death.

Brugada syndrome is far more frequent in males (up to 75% of cases), with a mean age at diagnosis of around 40 years[34]. In general, the most frequent symptoms for these patients are syncope or sudden death in the context of polymorphic ventricular tachycardia or ventricular fibrillation, which most frequently occur during sleep or rest[35]. Today, the most frequent triggering events for this pathology are fever, heatstroke, certain drugs, etc. so that particular care should be taken in the event of any of these circumstances. For this reason, it is essential to establish early treatment for hyperthermia in febrile conditions and to avoid heat stroke during exercise. Likewise, particular care should be taken with the drugs triggering Brugada syndrome (anti-arrhythmic drugs, anti-depressants, etc.) in patients with this pathology. The complete list of these drugs can be consulted at www.brugadadrugs.org.

It has a global prevalence of 5 per 10,000 inhabitants, being more frequent in certain regions such as Southeast Asia. It is estimated that around 5-8% of the global cases of sudden death and 20% of sudden death without structural heart disease are due to this syndrome. In half the cases, the patients have a family history of this syndrome or of sudden death, however it is not unusual to come across sporadic cases. At present, when the diagnosis is made after syncope symptoms in a patient with a family history or following resuscitation from sudden death, management is more evident and the implantation of an ICD would be recommended. However, the treatment of asymptomatic sufferers, that is with a genotype positive-phenotype negative, is controversial. Today, an electrophysiological study with programmed electrical stimulation is recommended in order to identify those patients with the greatest risk of suffering arrhythmic events. However, there is evidence that the mere presence of a type 1 electrocardiographic pattern, even when other clinical criteria are not met, can be associated with death in long-term monitoring. It is thus necessary to consider at-risk patients as those with a type 1 electrocardiographic pattern. However, the management

Figure 1. Classification of the different electrocardiographic patterns established for the Brugada syndrome.



of asymptomatic patients has not yet been definitively established; this therefore requires exhaustive and prolonged monitoring in order to establish a specific therapeutic approach.

Three electrocardiographic patterns have been established for the Brugada syndrome (Figure 1):

Type 1: consisting in a coved ST segment elevation of ≥2 mm, followed by a negative T-wave, in more than one right precordial lead (V1-V3).

Type 2: this is also characterised by an ST segment elevation ≥2 mm in right precordial leads, but followed by a positive or biphasic T-wave, that results in a saddle-back configuration.

Type 3: any of the above two morphologies, but with an ST elevation of ≤1 mm.

At present, type 1 is the only diagnostic pattern accepted by the European Society of Cardiology[36]. Likewise, this pattern may be spontaneously evident in a baseline ECG or induced by a provocative drug challenge test with a sodium channel blocker (ajmaline or flecainide). However, in order to establish the definitive diagnosis, in addition to the electrocardiographic alterations, the patient must also present at least one of the clinical criteria (Table 2).

We should emphasise the fact that it is relatively frequent to find an incomplete right bundle branch block in high performance athletes; therefore both morphologies should not be confused. Likewise, the importance of the correct placement of the electrodes on the athlete (particularly for precordial leads V1 and V2 in the 4th right and left intercostal spaces respectively) has frequently been emphasised. This is because, if these are placed too high, then they can frequently simulate a Brugada pattern morphology, particularly for individuals with a greater body surface area[37].

According to current guidelines, competitive sport could be considered for previously symptomatic patients or with electrocardiographic expression of Brugada, provided that appropriate precautionary measures are taken (avoid triggering drugs, hyperthermia, dehydration, etc.), that suitable treatment is received and that patients have been totally asymptomatic for at least 3 months (class IIb, level of evidence C). For individuals with an ICD implant, the specific guidelines for performing sports with an ICD should be followed[34].

Table 2. Clinical criteria for the definitive diagnosis of Brugada syndrome.

ECG Findings
Elevation of the ST segment 2 mm with a coved slope in more than one precordial lead (V1-V3) either spontaneously or following provocation with a sodium blocker.
And one of the following:
Documented ventricular arrhythmia: a) Ventricular fibrillation b) Polymorphic ventricular tachycardia c) Ventricular arrhythmias induced following programmed electrical stimulation
Family history: a) Sudden deaths in individuals aged under 45 years b) Characteristic ECG in relatives
Symptoms related to arrhythmias: a) Syncope b) Nocturnal agonal respiration

Moreover, other possible causes of the ECG alteration should be ruled out.

Account should be taken of the fact that, nowadays, a routine genetic study is practically in place for those individuals suspected of having some type of channelopathy. Therefore, for most patients, an early, reliable diagnosis is made, even for those with a negative phenotype. Asymptomatic genotype positive-phenotype negative patients with Brugada Syndrome are permitted to participate in any competitive sport, provided that the recommended precautionary measures are taken into account (class IIa, level of evidence C).

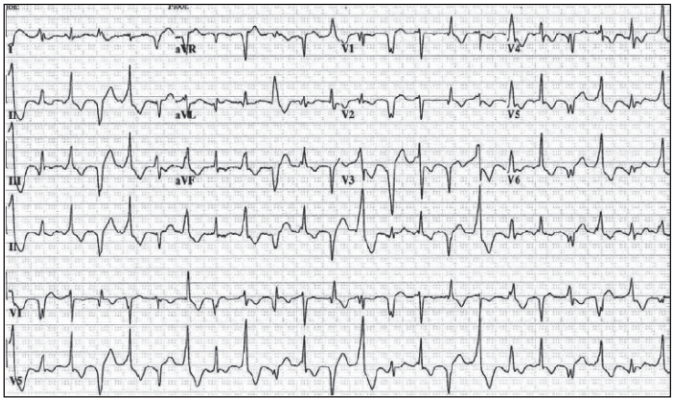
Catecholaminergic ventricular tachycardia

Catecholaminergic polymorphic ventricular tachycardia (CPVT) is a hereditary channelopathy (being the most common mutation located in the ryanodine receptor gene)[38] characterised by the appearance of syncopes or sudden death triggered during exercise or intense emotions in individuals without structural cardiopathy. Generally, the underlying cause of these adverse events is the appearance of potentially lethal arrhythmias, consisting in rapid episodes of bidirectional or polymorphic ventricular tachycardia (Figure 2).

The mean age for the commencement of symptoms is in childhood, between 7 to 12 years, although cases of late diagnosis of patients aged over 40 years have been reported. The diagnosis is generally delayed by 2 years, from the first syncope, which is generally labelled as vasovagal, neurally mediated syncope, etc. Furthermore, this diagnosis should also be considered for swimming-related syncopes.

It is considered to be one of the most aggressive and lethal channelopathies; it is estimated that around 30% of affected, untreated individuals experience at least one sudden death[38] and at least 80% exhibit at least one syncopal event. Unfortunately, on occasions, sudden death may be the first manifestation of the disease. We therefore need to be pay particular attention to those athletes with a family history or with suspicion of this pathology.

Figure 2. Electrocardiographic record of a patient with CPVT during a cardiac stress test, noting the presence of repeat bidirectional ventricular extrasystoles.



The baseline electrocardiogram does not generally prove useful in the diagnosis of this pathology[39], given the fact that, just like the echocardiogram and other imaging techniques, it does not generally show pathological alterations. For these patients, the exercise stress test is the key diagnostic tool. With this test, the clinician will endeavour to use an intense adrenergic discharge to evoke different malignant arrhythmias (bidirectional tachycardia, polymorphic ventricular tachycardia, etc.) (Figure 2). In the CPVT, these arrhythmic events during exercise generally appear at a threshold heart rate of 100-120 beats per minute, progressively worsening as the work load increases. For this reason, when an athlete is suspected of having this pathology, the cardiac stress test must be made following a protocol, with a gradual and progressive increase in the physical stress load, thereby avoiding sharp increases in the work loads. The diagnostic performance of the Holter monitor is lower than that of the exercise stress test. However, it could prove useful for persons with reduced mobility and small children who are unable to undergo a stress test.

Ventricular arrhythmias may become apparent with the adrenalin test. However, this diagnostic test is controversial, its diagnostic performance is extremely variable (2-50%) and it is only recommended in very specific cases[40]. Finally, we should mention that the genetic study has become a key element in establishing the definitive diagnosis of this channelopathy.

Given the lethality of this pathology and, as is the case for the rest of the familial cardiopathies, the genetic study should be recommended to first degree relatives of an affected individual, particularly if the specific causal mutation is known. Furthermore, a full cardiology study should be made on these relatives, including a baseline electrocardiogram, echocardiogram, cardiac stress test etc.

With regard to the treatment of these channelopathies, beta blockers are essential, given the fact that the channelopathies are generally induced by an important adrenergic discharge[41]. It is of interest to conduct periodical cardiac stress tests on these individuals, aiming to achieve a reproducible induction of the arrhythmia during exercise. This will permit a suitable assessment of the response to treatment as well as the monitoring of the effectiveness of these drugs. When faced with cases of incomplete protection with this medication (persistence of arrhythmias during exertion) then the addition of flecainide to the treatment should be considered[42]. Likewise, beta blockers are also suggested for primary prevention; in other words, those patients who are carriers of pathogenic mutations in CPVT associated genes, despite having a strictly normal cardiac stress test. This is due to the fact that, as mentioned above, on many occasions sudden death may be the first manifestation of this disease. Likewise, for these patients, consideration should be given to the implantation of an ICD in those cases in which episodes of sudden death or potentially lethal arrhythmic events have occurred, despite being under pharmacological treatment or for individuals that cannot take beta blockers. For patients with an ICD, it is recommended to maintain the above mentioned pharmacological treatment, thereby significantly reducing the number of device discharges. Furthermore, sympathetic denervation could be considered for those cases in which patients are refractory to other therapies, although it is not a widely recommended technique today, given its secondary effects, as well as the long-term recurrence of cardiological events.

Finally, we must insist on the importance of strict monitoring and a regular check-up by a cardiologist every 6 months approximately, in order to supervise adherence to treatment (cases of ventricular tachycardia have been described in which patients stopped their beta blocker treatment after just one day), as well as the response to the drugs. In order to recommend the intensity and limits of physical activity, the clinician can be guided by the objectified results of the cardiac stress test conducted in a hospital setting with the appropriate safety measures. Moreover, the use of different cardiac monitoring devices has been proposed in order to provide guidance for participation in sports, controlling that the athlete's heart rate is within the range considered to be safe for physical activity. However, given the risks involved, this is never considered as an alternative to strict monitoring and to suitable medical treatment.

According to current recommendations, an athlete with previously symptomatic CPVT or an asymptomatic CPVT athlete with ventricular contractions in bigeminy, couplets, or NSVT in the cardiac stress test, can only participate in class Ia competitive sports. A CPVT specialist cardiologist must be consulted for any exception (class III, level of evidence C).

In short, for athletes with channelopathies, the main recommendation has traditionally comprised avoiding all types of competitive sports. However, at present, some changes have occurred that make it possible to modify these recommendations. Over the last few years, in the United States, no event has been described related to competitive sport and attributable to channelopathy (provided that suitable precautionary measures were taken). Moreover, there are other registries, such as the North American ICD Sports Registry, that have shown a very low incidence of events for patients with channelopathies participating in competitive sport. All the same, even today, there is insufficient scientific evidence to determine the real risk for a competitive athlete with channelopathy and, therefore, the recommendations have a C level of evidence.

With regard to specific treatment, we need to bear in mind that this must be guided by the severity of the disease and not simply focus on the fact that we are dealing with an athlete. In other words, the implantation of an ICD in a patient with channelopathy would not be recommended simply because the patient is a competitive athlete.

Likewise, athletes with a suspected/diagnosed channelopathy, must be assessed by a cardiologist (arrhythmologist, experts in familial cardiopathies, etc. (class I; level of evidence C).

Moreover, it is recommended that symptomatic athletes with any suspected or diagnosed channelopathy should refrain from all competitive sports until evaluated by a specialist, the correct treatment program has been implemented, and the athlete has been asymptomatic on treatment for 3 months (class I; level of evidence C).

It is reasonable for an asymptomatic athlete with concealed channelopathy (genotype-positive / phenotype-negative) to participate in all competitive sports with appropriate precautionary measures, (class IIa, level of evidence C).

Conclusion

The development of present day medicine has led to a significant improvement in the study of familial cardiopathies, as well as early diagnosis and treatment. Likewise, genetic studies play a key role in the monitoring of these cardiopathies, providing the most appropriate guidance for the best therapeutic approach to be followed. Today it is considered that the advances in genetic studies will have an impact on prognosis and on a deeper knowledge of these diseases. However, on many occasions, genetics places us in a great dilemma when establishing recommendations for sports activities for causal mutation carriers with no phenotypic development of the disease. For this reason, extensive work is being conducted in this area.

We would therefore emphasise the importance of closely monitoring athletes who are carriers of pathogenic mutations with phenotype negative. It is evident that, depending on the penetration and expressiveness of each individual mutation, a percentage of these carriers will develop the familial disease. It is therefore important to develop individualised monitoring protocols in order to detect the appearance of phenotypic manifestations. These protocols are extremely useful in order to prevent these carriers from experiencing adverse events during sports activities.

At present, the permitted level of exercise for patients with familial cardiopathies represents a great challenge for clinicians. On the one hand, strenuous exercise could be harmful and could increase the risk of sudden death and other adverse events. However, the excessive restriction of physical exercise leads to physical inactivity and has an unfavourable impact on health and quality of life. Today, certain fitness programmes have been developed by a number of healthcare centres, directed at promoting safe exercise for patients with familial cardiopathies. These could be made available to different sports disciplines, while also offering the possibility of being easily implemented anywhere.

Therefore, there is a growing trend to be more permissive with these patients. Although current recommendations are progressively less restrictive, there are still restrictions in place in many of these cardiopathies. In order to obtain more reliable and specific findings, there is a need to have more evidence in extensive records of athletes with familial cardiopathies. Moreover, further studies are required in order to help us determine the real role of exercise in the phenotypic development of these diseases, in addition to the risk of sudden death that this entails.

In conclusion, the time has come to pay more attention to familial cardiopathies and to update their management, from the point of view of sporting activities, particularly due to the clear benefits that this can bring, while always acting with caution and basing our work at all times on two fundamental principles: safety and its benefits.

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