Hypertrophic Cardiomyopathy

General Considerations

Hypertrophic cardiomyopathy, although a relatively uncommon cardiac malformation (~0.1% to 0.2% of the general population) (1), is of great importance because it is probably the most common cause of unexpected sudden cardiac death in young people, including competitive athletes (2–12). Indeed, sudden death in hypertrophic cardiomyopathy usually occurs in the absence of previous symptoms (2–7,10–12).

Hypertrophic cardiomyopathy is a primary cardiac disease in which the most consistent diagnostic feature demonstrated by echocardiography is an asymmetrically hypertrophied and nondilated left ventricle in the absence of another cardiac or systemic disease associated with left ventricular hypertrophy (13). The clinical and morphologic expression and natural history is recognized to be particularly diverse and heterogeneous (14–21). The familial form of the disease (22) is genetically heterogeneous and has been attributed to several genetic defects involving contractile proteins troponin T and alpha-tropomyosin and a number of missense mutations of the beta-myosin heavy-chain gene (23–26).

Hypertrophic cardiomyopathy is generally regarded to be present when the maximal diastolic left ventricular wall thickness, as defined by echocardiography, is ≥15 mm in an adult (or the equivalent, relative to body surface area, in children). However, it is also recognized that some affected patients with hypertrophic cardiomyopathy have wall thicknesses <15 mm (21,22), whereas a subgroup of highly trained male athletes without cardiovascular disease (i.e., athlete’s heart with physiologic hypertrophy) may show wall thicknesses that exceed normal limits (i.e., >12 mm, ranging up to 16 mm) (27). Therefore, left ventricular wall thicknesses of 13 to 14 mm may place an individual athlete in an inconclusive diagnostic “gray zone” (28). Such a circumstance may not easily permit a definitive distinction of hypertrophic cardiomyopathy from the physiologic “athlete’s heart,” in which left ventricular hypertrophy is not truly pathologic (28). In such instances, additional data, including identification of other echocardiographic or clinical features most consistent with either hypertrophic cardiomyopathy or “athlete’s heart” (29,30), should be sought to resolve this sometimes difficult differential diagnosis.

It should be emphasized that there is also considerable risk to the well-being of the athlete associated with the overdiagnosis of hypertrophic cardiomyopathy in borderline cases because this diagnosis may be based solely on the echocardiographic assessment of left ventricular wall thickness and often in only a single segment of the ventricle. Therefore, the recommendations of this Task Force are predicated on the presumption that the clinical diagnosis of hypertrophic cardiomyopathy in a given athlete has been judged to be highly probable or definite.

In hypertrophic cardiomyopathy, the pattern and extent of left ventricular hypertrophy is diverse, but a greater magnitude and extent of wall thickening appear to convey less favorable clinical consequences (9,31,32). We also recognize that the phenotypic expression of hypertrophic cardiomyopathy (i.e., unexplained left ventricular wall thickening) may be incompletely expressed in young patients who are in the age range of many competitive athletes (i.e., <18 years old), and in some instances full morphologic manifestation of the disease may not be clearly evident until young adulthood (33).
Evaluation. For the purpose of diagnosis and evaluation, an asymptomatic athlete with hypertrophic cardiomyopathy may be assessed reliably by noninvasive testing utilizing, in particular, clinical examination and history, echocardiography, a 12-lead and 24-h Holter ambulatory electrocardiogram (ECG). Cardiac catheterization is not usually required for diagnostic purposes. The demonstration of unexplained left ventricular hypertrophy by two-dimensional echocardiography represents the sine qua non of clinical diagnosis (13,14,16). Recent identification of gene or disease loci responsible for hypertrophic cardiomyopathy raises the possibility of DNA diagnosis, by virtue of genetic testing for the known molecular abnormalities (23–26). Such testing may achieve a practical application in those individuals for whom a precise clinical diagnosis of hypertrophic cardiomyopathy is uncertain for a variety of reasons, including young people (and athletes) in whom there is not yet a definitive morphologic expression of the disease identified by echocardiography (26).

Assessment of risk. The present recommendations are based largely on both published data and clinical experiences but also on a “common sense” approach to the art of medical practice. The relative risk for sudden death by virtue of participating in competitive athletics with hypertrophic cardiomyopathy is largely unknown, and some athletes may tolerate extreme athletic life-styles with extraordinary levels of systematic training without incurring either sudden cardiac death or disease progression (34). At present, insufficient data are available that support particular invasive or noninvasive approaches for definitively stratifying risk for sudden death in individual youthful patients with hypertrophic cardiomyopathy (35). Indeed, the magnitude of risk for sudden death is undoubtedly determined by multiple factors, including the nature and intensity of the athletic training and competitive situations, as well as particular features of the individual patient's cardiomyopathic disease state (10). The latter include potential trigger mechanisms (paroxysmal atrial fibrillation, ventricular arrhythmia, accelerated or impaired atrioventricular conduction and myocardial ischemia) (3,6,7,10,35) in addition to the extent of myocardial disarray (7), which presumably represents the substrate for electrical instability (10).

We recognize that all patients or athletes with hypertrophic cardiomyopathy are undoubtedly not at the same risk for sudden cardiac death (3,4,10,34–38). However, the differentiation of subgroups of young patients with differing risks has proved challenging and, unfortunately, at present remains unresolved. Although electrophysiologic testing with programmed electrical stimulation has provided some measure of predictability with regard to outcome in high risk patients with coronary artery disease (39), it is not necessarily valid to make inferences from those data to patients with a diverse and heterogeneous disease such as hypertrophic cardiomyopathy (6,7,14,15,40), or in particular to the highly selected subset of trained athletes with this disease who have experienced extraordinary life-styles without previous cardiovascular symptoms or evidence of ventricular arrhythmia (34). Indeed, in a disease such as hypertrophic cardiomyopathy in which there is a propensity for potentially lethal arrhythmias in some individuals, the stress of athletic training and competition as well as associated alterations in blood volume, hydration and electrolytes that may occur make any extrapolation from assessment of risk in nonathletes with hypertrophic cardiomyopathy directly to highly trained competitive athletes with this condition very tenuous.

Electrophysiologic testing with programmed electrical stimulation has been applied in highly selected populations of high risk patients with hypertrophic cardiomyopathy (who were not athletes) with symptoms of impaired consciousness or ventricular arrhythmias, or both, in an effort to identify subgroups at increased risk for sudden cardiac death on the basis of inducibility of ventricular arrhythmias (polymorphic or monomorphic ventricular tachycardia or ventricular fibrillation) (41–47). However, in patients with hypertrophic cardiomyopathy, the predictive accuracy of inducible, sustained ventricular arrhythmias for sudden death is low and not predictive of clinical outcome; aggressive stimulation protocols induce sustained ventricular arrhythmias in the majority of high risk patients as well as in many patients who appear to be at low risk (41,45,46,48). Conversely, stimulation protocols judged to be less aggressive generate a low inducibility rate even in patients who are known to be at increased risk (43). Therefore, because of its relatively low predictive accuracy, programmed electrical stimulation does not at present permit definitive clinical decisions to be made in individual athletes with hypertrophic cardiomyopathy regarding prediction of outcome or design of treatment strategy (48).

The fact that we are not able at present to stratify risk for athletes with hypertrophic cardiomyopathy is reflected in the present recommendations for athletic eligibility that are both conservative and similar for most athletes with hypertrophic cardiomyopathy. Current investigatory efforts are directed at improving risk stratification assessment in hypertrophic cardiomyopathy. We anticipate that future investigatory work in molecular genetics and electrophysiology and in the evaluation of vascular responses will more accurately define variables of hemodynamic and electrical instability and permit more reliable identification of those athletes with this disease who are at particular risk for sudden cardiac death.

Recommendations

1. Athletes with the unequivocal diagnosis of hypertrophic cardiomyopathy should not participate in most competitive sports, with the possible exception of those of low intensity (class IA [see Table 1 in Classification of Sports]). This recommendation includes those athletes with or without symptoms or left ventricular outflow obstruction.

2. In recognition of the observation that the risk for sudden cardiac death may be reduced in older patients with hypertrophic cardiomyopathy (3,4,10,35), we alternatively suggest that individual judgment in assessing eligibility may be utilized in selected older athletes (>30 years old) for whom each of the following clinical features (judged or established to be unfavorable or potential risk factors for sudden death) are absent: a) ventricular tachycardia (sustained or nonsustained) on ambulatory ECG (37,38); b) family history of sudden death due to hypertrophic cardiomyopathy, particularly if occurring at <40
years of age (2,6,7,15,25); c) history of syncope or other clinically relevant episodes of impaired consciousness (36,49); d) severe hemodynamic abnormalities, including a dynamic left ventricular outflow tract gradient (≥50 mm Hg) (50–52); e) exercise-induced hypotension (53); f) moderate to severe mitral regurgitation, enlarged left atrium (≥50 mm) or paroxysmal atrial fibrillation (54); and g) evidence of abnormal myocardial perfusion.

These recommendations are not altered if medical or surgical treatment is undertaken in an individual athlete (6,7).

With the advent of the preclinical genetic diagnosis of hypertrophic cardiomyopathy (26), a small number of youthful family members have been identified as affected on the basis of a DNA diagnosis in the absence of typical morphologic features of their disease. The clinical significance of such findings is uncertain, and at present there is no available evidence to preclude such subjects from competitive athletics in the absence of cardiac symptoms or a family history of sudden cardiac death.

**Mitrval Valve Prolapse**

**General Considerations**

Mitrval valve prolapse is of particular concern to physicians evaluating large numbers of athletes for competition because of its relatively high prevalence in the general population (estimated to be ~5%) (55).

Mitrval valve prolapse is a generally benign disorder, characterized by systolic protrusion of the mitral valve leaflets into the left atrium (as demonstrated by echocardiographic and angiographic studies) (56,57). A midystolic (nonejection) click, with or without a late systolic murmur, is the auscultatory hallmark of this condition (55–60).

In some patients, mitral valve prolapse is associated with palpitations, dizziness, an abnormal 12-lead electrocardiogram and supraventricular or ventricular arrhythmias (55–60); syncope in such patients is often due to orthostatic hypotension associated with low blood volume (61). Mitrval valve prolapse may also be the cause of chronic mitral regurgitation (sometimes associated with bacterial endocarditis) necessitating operative valve repair or replacement, and, on occasion, of cerebrovascular accident or sudden cardiac death (55,62–75).

It has been proposed that it is the morphologic form of mitral valve prolapse in which a structural abnormality of the mitral valve is clearly evident (i.e., leaflet thickening and elongation and myxomatous degeneration) associated with substantial systolic protrusion of the valve into the left atrium that conveys the greatest risk for unfavorable sequelae (63). Relatively mild systolic bowing of the leaflets (particularly when limited to the echocardiographic apical four-chamber view) and associated with a structurally normal mitral valve is a nonspecific finding and probably represents a normal variant or benign form within the broad clinical spectrum of this diverse condition (63).

Available clinical evidence supports a generally favorable prognosis for patients within the disease spectrum of mitral valve prolapse. Although sudden cardiac death has been reported in patients with mitral valve prolapse (5,12,55,65–70,73), such occurrences appear to be rare; furthermore, athletes who die suddenly rarely have myxomatous mitral valve abnormalities at autopsy (55,65–67). To date, ~12 patients documented to have mitral valve prolapse are described in published reports to have died suddenly during exercise (5,12,60,67–69,73), and of these were trained competitive athletes at the time of their death (5,12,69,70,73). Coexistence of mitral valve prolapse and hypertrophic cardiomyopathy in the same patient does not appear to convey a particularly unfavorable prognosis (75).

**Recommendations**

1. Athletes with mitral valve prolapse (having a structurally normal valve manifested by leaflet thickening and elongation) and without any of the following criteria can engage in all competitive sports: a) history of syncope, documented to be arrhythmogenic in origin; b) family history of sudden death associated with mitral valve prolapse; c) repetitive forms of sustained and nonsustained supraventricular tachyarhythmias or complex ventricular arrhythmias, particularly if exaggerated by exercise (see also Task Force 6); d) moderate to marked mitral regurgitation; e) prior embolic event.

2. Athletes with mitral valve prolapse and any of the aforementioned criteria can participate in low intensity competitive sports only (class 1A).

Recommendations related to the hemodynamic burden of mitral regurgitation in athletes with mitral valve prolapse appear in Task Force 2.

**Myocarditis**

**General Considerations**

Myocarditis (usually of viral etiology due to Coxackie B) has been regarded as an uncommon cause of sudden death in young competitive athletes (5,12); in some instances, viral myocarditis may culminate in dilated cardiomyopathy with chronic cardiac dysfunction, presumably as a consequence of viral-mediated immunologic cardiac damage (76). However, the frequency with which myocarditis occurs in young athletes has been a source of controversy due, in large measure, to the often substantial uncertainty regarding the precise criteria for the clinical or even histologic diagnosis of the disease.

Myocarditis is suspected clinically by virtue of fatigue, exertional dyspnea, syncope, palpitations, arrhythmias or acute congestive heart failure in the presence of left ventricular dilation and associated with evidence of ventricular dysfunction (usually segmental wall motion abnormalities) or ST-T changes on the ECG. Morphologic criteria have also been proposed (e.g., the consensus Dallas criteria) (77), which represent useful definitions for more consistent and rigorous pathologic diagnosis of myocarditis. These emphasize that myocarditis is a process characterized by an inflammatory infiltration of the myocardium with necrosis or degeneration of adjacent myocytes, or both, not typical of the ischemic damage characteristically associated with coronary artery disease.

The present recommendations underscore the heterogeneous nature of myocarditis and the fact that the disease process evolves
through active, healing and healed phases. Unfortunately, there may be little correspondence between these pathologic stages and the timing of sudden cardiac death; therefore, healed (as well as active) myocarditis may constitute a pathologic substrate for cardiac arrhythmias. For these reasons, it is possible that the frequency with which myocarditis is responsible for sudden death in competitive athletes has been underestimated. This would be particularly true if, in addition to those cases in which pathologic examination describes a documented inflammatory cell infiltrate (12,78,79), other cases are included that are consistent with healed myocarditis by virtue of foci of replacement fibrosis in the absence of extramural atherosclerotic coronary artery narrowing (and associated with normal heart weight and cavity size) (80).

It has been proposed that sudden death occurring in healed (as well as active) myocarditis is due to a rhythm disturbance developing in the setting of an unstable left ventricular electrical substrate. Although myocarditis is often infectious in origin, it is worth noting that histologic evidence of the acute and healed phases may also be a consequence of long-term cocaine use (81–85). There is a body of largely anecdotal data suggesting that cocaine abuse is a growing and prevalent problem among segments of the general and athletic population, with the potential to lead to complications such as myocardial damage and dysfunction.

If clinical judgment suggests the presence of myocarditis in an athlete, the possibility of performing an endomyocardial biopsy for the purpose of confirming that diagnosis should be considered. We recognize that an endomyocardial biopsy positive for myocarditis may clarify an otherwise ambiguous clinical profile. Conversely, biopsy is not required when strong clinical evidence of the disease is present.

**Recommendations**

1. Athletes judged as probably having myocarditis should be withdrawn from all competitive sports and undergo a prudent convalescent period of ~6 months after the onset of clinical manifestations. Before the athlete may return to competitive athletic training, an evaluation of cardiac status should be undertaken, including assessment of ventricular function at rest and with exercise (with radionuclide angiography or echocardiography).

2. An athlete should be allowed to return to competition when ventricular function and also cardiac dimensions have returned to normal, and clinically relevant arrhythmias (repetitive forms of ventricular ectopic activity or sustained supraventricular tachycardia) are absent on ambulatory monitoring.

3. Sufficient clinical data are not available to justify a strong recommendation to perform endomyocardial biopsy as a pre-condition for return to athletic competition after the proposed 6-month period of deconditioning. The role of invasive electrophysiologic testing in assessing the eligibility of athletes with myocarditis remains to be defined.

### Pericarditis

Athletes with pericarditis, regardless of etiology, should not participate in competitive sports during the acute episode. Such athletes can return to full activity when there is no longer evidence of active disease by history or physical examination, appropriate blood tests, exercise testing and an ambulatory and 12-lead ECG. In athletes with a history of pericarditis associated with evidence of significant myocardial involvement, recommendations should be based predominantly on the course of the myocarditis. Athletes with chronic pericardial disease that results in constriction should not engage in any competitive sports.

### Other Myocardial Diseases

A number of other uncommon diseases of the right or left ventricle deserve consideration here as potential causes of sudden death in athletes. These include idiopathic dilated cardiomyopathy (76); primary restrictive cardiomyopathies, such as endomyocardial fibrosis with or without eosinophilia (86), and systemic diseases with cardiac involvement, such as sarcoidosis (87).

Arrhythmogenic right ventricular dysplasia has been cited as a frequent cause of sudden death in young people and athletes in the northeastern (Veneto) region of Italy (88,89), although it is apparently less common in other geographic regions, including the United States (12). The definitive diagnosis of this condition is based on demonstration of fibro-fatty replacement of the right ventricular myocardium (88–90). Diagnosis during life, although challenging (90), relies on clinical manifestations of the disease, including ventricular arrhythmias, depolarization and repolarization alterations on the ECG, right ventricular dilation and hypokinesia and familial occurrence of the disease (with or without sudden death) (88–90).

Few data are available with regard to the relative risks of athletic training and competition in athletes with the aforementioned myocardial diseases. Therefore, until more information is available in this regard, athletes with these diseases are advised not to participate in any competitive sports.

### References


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Task Force 4: Systemic Hypertension

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General Considerations

Systemic hypertension is the most common cardiovascular condition observed in competitive athletes. The diagnosis of hypertension is based on the presence of blood pressure persistently at or above certain levels as measured by routine sphygmomanometry on at least three separate occasions (Table 1). In determining the level of competitive athletic activity that a hypertensive person may assume, it is also important to ascertain the degree of hypertension-related target organ damage (1). Although hypertension is associated with an increased risk for sudden death and complex ventricular arrhythmias (2), this disease has not yet been incriminated as a cause of sudden cardiac death in young competitive athletes.