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Athletes with Systemic Hypertension

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Epidemiology

Blood pressure increases with age. Systolic blood pressure continues to increase throughout adult life, related to progressive arterial stiffening, whereas diastolic blood pressure plateaus in the sixth decade of life and decreases thereafter [1]. Blood pressure is lower in women than in men below the age of about 50, rises more steeply in women around menopause, and becomes higher in women than in men thereafter.

In recent epidemiologic studies, hypertension is defined as systolic blood pressure greater than or equal to 140 mm Hg or diastolic blood pressure greater than or equal to 90 mm Hg, or being on antihypertensive treatment. The prevalence of hypertension in the population amounts to about 25% and is expected to increase to up to about 29% in 2025 [2].

When broken down by age and gender, the prevalence is approximately 15%, 30%, and 55% in men aged 18 to 39, 40 to 59, and 60 and older, respectively, and about 5%, 30%, and 65% in women in these age groups. The prevalence of isolated systolic hypertension is very low before the age of 50, but increases sharply thereafter. These epidemiologic data indicate that hypertension may already be present in the young athlete, although rarely, but occurs more frequently in the older sportsman.

Unless blood pressure is measured, hypertension may remain undetected because it usually causes no symptoms. However, about 25% of patients who have hypertension by conventional measurements have a normal blood pressure on 24-hour ambulatory monitoring or on home blood pressure measurements; this phenomenon is the so-called ''white-coat'' or isolated clinic hypertension [3,4]. Young athletes with clinic hypertension often have normal blood pressure on ambulatory monitoring [5]. On the other hand, patients may have masked or isolated ambulatory hypertension, which is characterized by a normal blood pressure in the office and an elevated blood pressure out of the office [6].

Hypertension as a cardiovascular risk factor

Hypertension is associated with an increased incidence of all-cause and cardiovascular mortality, sudden death, stroke, coronary heart disease, heart failure, atrial fibrillation, peripheral arterial disease, and renal insufficiency. In the population at large, the relationship between cardiovascular complications and blood pressure is linear [7]. The prognosis of white-coat hypertension is better than that of sustained ambulatory hypertension, and studies suggest that it is even similar to that of persons with true normal blood pressure, whereas patients who have masked hypertension appear to have a worse outcome than true normotensives [3,4,6,8–10].

Despite conclusive evidence that antihypertensive therapy reduces the complications of hypertension [1,11], only about one half of all patients who have hypertension are under treatment and only a fraction of these have normal blood pressure [12,13]. Systolic blood pressure appears to be more difficult to control than diastolic blood pressure, particularly in older patients.

Classification of hypertension

The classification of hypertension is based on multiple conventional blood pressure measurements taken on separate occasions, in the sitting

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position, by use of a mercury sphygmomanometer or another calibrated device. Table 1 summarizes the definitions and classification of blood pressure levels, according to the European Society of Hypertension – European Society of Cardiology guidelines for the management of arterial hypertension [1,14]. The universally accepted blood pressure threshold for hypertension is 140/90 mm Hg.

Twenty-four hour ambulatory blood pressure monitoring should be considered in cases of suspected white-coat hypertension, considerable variability of office blood pressure, marked discrepancy between blood pressure measured in the office and at home, and in subjects with high office blood pressure and low global cardiovascular risk. The threshold for the definition of hypertension is 130/80 mm Hg for 24-hour blood pressure. The threshold for daytime ambulatory blood pressure and the self-measured blood pressure at home is 135/85 mm Hg. Patients above the threshold for conventional blood pressure and below the threshold for the out-of-office pressure are considered to have white-coat or isolated office hypertension and the reverse is true for masked or isolated ambulatory hypertension [1,15].

Approximately 95% of patients who have hypertension have essential or primary hypertension, which results from an interaction between genetic factors and lifestyle/environmental factors that include being overweight, high salt intake, excessive alcohol consumption, and physical inactivity. The main causes of secondary hypertension involve renovascular, renal, and adrenal abnormalities [1].

The role of ergogenic aids in increasing blood pressure should be considered in the hypertensive sportsman or athlete. Athletes may abuse prohibited substances such as anabolic steroids, erythropoietin, stimulants, and so forth. The uncontrolled use of these agents has been associated with numerous side effects, including hypertension. Also, the use of nonsteroidal anti-inflammatory drugs should be specifically considered because these compounds may increase blood pressure and are commonly used in the athletic setting [16].

Table 1
Definitions and classification of clinic blood pressure levels (mm Hg)

Category	Systolic		Diastolic
Optimal	<120	and/or	<80
Normal	120–129	and/or	80–84
High normal	130–139	and/or	85–89
Grade 1 hypertension	140–159	and/or	90–99
Grade 2 hypertension	160–179	and/or	100–109
Grade 3 hypertension	≥180	and/or	≥110
Isolated systolic hypertension	≥140	and/or	<90

Isolated systolic hypertension can also be graded (grades 1, 2, 3) according to systolic blood pressure values in the ranges indicated, provided diastolic values are less than 90 mm Hg.

Assessment of the severity of hypertension and risk stratification

The severity of hypertension depends not only on the blood pressure level (see Table 1) but also on the presence of other cardiovascular risk factors, target organ damage, and cardiovascular and renal complications. Table 2 summarizes the classification based on the overall cardiovascular risk [1,14]. The terms low, moderate, high, and very high added risk, in comparison with healthy normotensives without risk factors, are calibrated to indicate an approximate absolute 10-year risk of cardiovascular disease of less than 15%, 15% to 20%, 20% to 30% and greater than 30%, respectively, according to the Framingham criteria, or an approximate absolute risk of fatal cardiovascular disease of less than 4%, 4% to 5%, 6% to 8% and more than 8%, according to the European SCORE system [17].

The risk stratification is based on the accumulated number of selected risk factors, the presence of target organ damage, or cardiovascular or renal disease, as outlined in Table 2. With regard to left ventricular hypertrophy, it should be noted that sports activity itself may induce hypertrophy; the extent and distribution of hypertrophy and assessment of diastolic left ventricular function may help to distinguish between hypertensive heart disease and athlete's heart [18–21]. Athlete's heart typically shows normal diastolic filling and relaxation, and is considered a physiologic adaptation to training, in contrast to the hypertrophy secondary to hypertension. Hypertensive patients usually have concentric left ventricular hypertrophy (but eccentric hypertrophy has also been described) [22]; whether or not hypertension in an athlete will accentuate the development and extent of left ventricular hypertrophy, or whether athletic conditioning in a hypertensive patient will worsen the left ventricular hypertrophy, is not known.

The importance of the risk stratification is that hypertensive patients at high or very high added risk should be treated promptly with

Table 2
Stratification of cardiovascular risk in four categories

Other risk factors, target organ damage, or disease	Blood pressure (mm Hg)				
	Normal (SBP 120–129 or DBP 80–84)	High normal (SBP 130–139 or DBP 85–89)	Grade 1 HT (SBP 140–159 or DBP 90–99)	Grade 2 HT (SBP 160–179 or DBP 100–109)	Grade 3 HT (SBP≥180 or DBP≥110)
No other risk factors[a]	Average risk	Average risk	Low added risk	Moderate added risk	High added risk
1–2 risk factors[a]	Low added risk	Low added risk	Moderate added risk	Moderate added risk	Very high added risk
3 or more risk factors[a], TOD[b], MS or diabetes	Moderate added risk	High added risk	High added risk	High added risk	Very high added risk
Established CV or renal disease[c]	Very high added risk	Very high added risk	Very high added risk	Very high added risk	Very high added risk

Low, moderate, high and very high added risk indicate an approximate 10-year risk of fatal or nonfatal cardiovascular disease of less than 15%, 15% to 20%, 20% to 30%, and higher than 30%, respectively; or a risk of fatal cardiovascular disease of less than 4%, 4% to 5%, 5% to 8%, and higher than 8%, according to SCORE charts.

Abbreviations: CV, cardiovascular; DBP, diastolic blood pressure; HT, hypertension; SBP, systolic blood pressure; MS, metabolic syndrome; TOD, target organ damage.

[a] Risk factors used for stratification are blood pressure level; levels of pulse pressure (in the elderly); gender and age (men > 55 years; women > 65 years); smoking; dyslipidemia (total cholesterol > 190 mg/dL or low-density lipoprotein cholesterol > 115 mg/dL, or high-density lipoprotein cholesterol < 40 mg/dL in men and < 46 mg/dL in women, or triglycerides > 150 mg/dL); abdominal obesity (men ≥ 102 cm; women ≥ 88 cm); first-degree family history of premature cardiovascular disease (men < 55 years; women < 65 years); fasting plasma glucose (102–125 mg/dL); abnormal glucose tolerance test.

[b] Target organ damage includes hypertension-induced left ventricular hypertrophy; ultrasound evidence of arterial wall thickening or atherosclerotic plaque; slight increase in plasma creatinine (men 1.3–1.5 mg/dL; women 1.2–1.4 mg/dL); estimated glomerular filtration rate < 60 mL/min/1.73 m^2); presence of microalbuminuria; carotid-femoral pulse wave velocity > 12 m/s; ankle/brachial blood pressure ratio < 0.9.

[c] Diseases include cerebrovascular disease (stroke; transient ischemic attack); ischemic heart disease (myocardial infarction, angina, coronary revascularisation); heart failure; peripheral vascular disease; renal disease (diabetic nephropathy; renal impairment; proteinuria); advanced retinopathy (hemorrhages; exudates; papiledema).

antihypertensive drugs, whereas patients at low or moderate added risk are only treated when hypertension persists despite lifestyle measures. An alternative way to estimate risk in those who are not at high or very high added risk according to Table 2 is to use the European SCORE system [17].

Assessment of the risk associated with exercise

Exercise-related sudden death at a younger age is mainly attributed to hypertrophic cardiomyopathy, anomalies of the coronary arteries, or arrhythmogenic right ventricular dysplasia [21,23–25], and is unlikely to be related to hypertension. On the other hand, coronary heart disease has been identified in approximately 75% of victims of exercise-related sudden death above the age of 35 [26]. Whether or not high blood pressure is a cause of exercise-related sudden death on its own is not known, but hypertension is certainly a major risk factor for the development of coronary artery disease. In addition, hypertension-induced left ventricular hypertrophy may cause life-threatening ventricular arrhythmias [27]. It is likely that the risk associated with exercise can be derived from the overall risk stratification (see Table 2). Therefore, the general approach to the hypertensive patient should also apply to the exercising patient.

Diagnostic evaluation

Diagnostic procedures are aimed at

Establishing blood pressure levels
Identifying secondary causes of hypertension
Evaluating the overall cardiovascular risk by searching for other risk factors, target organ damage and concomitant diseases, or accompanying clinical conditions [1,14].

Diagnostic procedures comprise a thorough individual and family history; physical examination, including repeated blood pressure measurements according to established recommendations; and laboratory and instrumental investigations, of which some should be considered part of the routine approach in all subjects with high blood pressure, some are recommended, and some are indicated only when suggested by the core examinations.

Routine tests include hemoglobin and hematocrit; serum potassium, creatinine and uric acid; estimated glomerular filtration rate; fasting plasma glucose; serum total, low-density and high-density lipoprotein cholesterol, and triglycerides; urine analysis complemented by microalbuminuria dipstick test and sediment examination; and standard electrocardiography. In addition, in the competitive athlete with hypertension, echocardiography and exercise testing with electrocardiography and blood pressure monitoring are indicated as routine tests [28,29].

Recommended tests include echocardiography; carotid ultrasound; pulse wave velocity measurement; ankle-brachial blood pressure ratio index; fundoscopy; quantitative proteinuria (if dipstick test positive); or glucose tolerance test (if fasting plasma glucose > 100 mg/dL); and home and 24-hour blood pressure monitoring. Extended evaluation may be necessary, based on the findings from these investigations [1,14].

The indication for exercise testing depends on the patient's risk profile and on the amateur/leisure-time sports characteristics (Table 3) [29,30]. In patients who have hypertension and are about to engage in intense (although amateur) exercise training (ie, intensity ≥60% of maximum), a medically supervised peak or symptom-limited exercise test with electrocardiography (or cardiopulmonary testing) and blood pressure monitoring is warranted. In asymptomatic men or women with low or moderate added risk (see Table 2) who engage in low-to-moderate leisure-time physical activity (ie, intensity <60% of maximum), further testing beyond the routine evaluation is generally not needed. Asymptomatic patients with high or very high added risk may benefit from exercise testing before engaging in moderate-intensity exercise (ie, 40%–60% of maximum). Patients who have exertional dyspnea, chest discomfort, or palpitations need further examination, which includes exercise testing, echocardiography, Holter monitoring, or combinations thereof.

Table 3
Indications for exercise testing for sports participation in patients who have hypertension

	Risk category	
Demands of exercise (static or dynamic)	Low or moderate	High or very high[a]
Light (<40% of max)	No	No
Moderate (40%–59% of max)	No	Yes
High (≥60% of max)	Yes	Yes

[a] In case of an associated clinical condition, the recommendations for the specific condition should be observed.

A major problem with exercise testing in a population with a low probability of coronary heart disease and in subjects with left ventricular hypertrophy is that most positive tests on electrocardiography are falsely positive. Stress myocardial scintigraphy or echocardiography, and, ultimately, coronaroangiography, may be indicated in cases of doubt. Evidence is inconclusive that blood pressure response to exercise, in addition to blood pressure at rest, should play a role in the recommendations for exercise [31]; however, subjects with an excessive rise of blood pressure during exercise are more prone to develop hypertension and should be followed up more closely [29]. Finally, physicians should be aware that high blood pressure may impair exercise tolerance [32].

Effects of exercise on blood pressure

Dynamic exercise

Blood pressure increases during acute dynamic exercise in proportion to the intensity of the effort [32]. During long-term, steady-state exercise, blood pressure tends to decrease after an initial increase of short duration. The increase is greater for systolic than for diastolic blood pressure, which increases only slightly or even remains unchanged. For the same oxygen consumption, the rise is more pronounced in older subjects and when exercise is performed with smaller versus larger muscle groups. The exercise is usually followed by postexercise hypotension, which may last for several hours and is generally more pronounced and of longer duration in patients who have hypertension than in normotensive subjects [30].

Cross-sectional and longitudinal epidemiologic studies indicate that physical inactivity and low fitness levels are associated with higher blood pressure levels and increased incidence of hypertension in the population [33]. Meta-analyses of randomized, controlled intervention studies concluded that regular dynamic endurance training at moderate intensity significantly reduces blood pressure [34–36].

A recent meta-analysis involved 72 trials and 105 study groups [36]. After weighting for the number of participants, training was responsible for a significant net reduction of resting and daytime ambulatory blood pressure (3.0/2.4 mm Hg and 3.3/3.5 mm Hg, respectively). The reduction of resting blood pressure was more pronounced in the 30 hypertensive study groups (−6.9/−4.9) than in the others (−1.9/−1.6). Evidence was not convincing that the degree of reduction in blood pressure was related to the intensity of exercise training, when this ranged between about 40% and 80% of maximal aerobic power [34]. Systemic vascular resistance decreased by 7.1%, plasma norepinephrine by 29%, and plasma renin activity by 20%. Body weight decreased by 1.2 kg, waist circumference by 2.8 cm, percent body fat by 1.4%, and the homeostatic model assessment (HOMA) index of insulin resistance by 0.31 units; high-density lipoprotein cholesterol increased by 0.032 mg/dL. Therefore, aerobic endurance training decreases blood pressure through a reduction of vascular resistance, in which the sympathetic nervous system and the renin-angiotensin system appear to be involved, and favorably affects concomitant cardiovascular risk factors.

Static exercise

Blood pressure increases during acute static exercise and the increase is more pronounced than with dynamic exercise, particularly with heavy static exercise at an intensity of more than 40% to 50% of maximal voluntary contraction. In a recent meta-analysis of randomized controlled trials, ''resistance'' training at moderate intensity was found to decrease blood pressure by 3.5/3.2 mmHg [37]. The meta-analysis included nine studies designed to increase muscular strength and power or endurance, and all but one study involved dynamic, rather than purely static, exercise. In fact, few sports are characterized by purely static efforts. However, only three trials in the meta-analysis reported on patients who had hypertension.

Recommendations

General recommendations

Athletes with hypertension should be treated according to the general guidelines for the management of hypertension [1,14]. Appropriate nonpharmacologic measures should be considered in all patients (ie, moderate salt restriction, increase in fruit and vegetable intake, decrease in saturated and total fat intake, limitation of alcohol consumption to no more than 20 to 30 g ethanol/d for men and no more than 10 to 20 g ethanol/d for women, smoking cessation, and control of body weight). Antihypertensive drug therapy should be started promptly in patients at high or very high added risk for cardiovascular complications (see Table 2). In patients at low or moderate added risk, drug treatment is only initiated when hypertension persists after several weeks (moderate added risk) or months (low added risk) despite appropriate lifestyle changes. The goal of antihypertensive therapy is to reduce blood pressure to at least below 140/90 mm Hg, and to lower values if tolerated, in all hypertensive patients, and to below 130/80 mm Hg in diabetics and other high- or very high-risk conditions.

Current evidence indicates that patients who have white-coat hypertension do not have to be treated with antihypertensive drugs, unless they are at high or very high risk (see Table 2), but regular follow-up and nonpharmacologic measures are recommended [1,14]. Also, subjects with normal blood pressure at rest but exaggerated blood pressure response to exercise should be followed up more closely.

Choice of drugs

Several drug classes can be considered for the initiation of antihypertensive therapy: diuretics; beta-blockers; calcium channel blockers; angiotensin-converting enzyme inhibitors, and angiotensin II receptor blockers [1,14]. However, diuretics and beta-blockers are not recommended for first-line treatment in patients engaged in competitive or high-intensity endurance exercise [32]. Diuretics impair exercise performance and capacity in the first weeks of treatment through a reduction in plasma volume, but exercise tolerance appears to be restored during longer-term treatment; nevertheless, diuretics may cause electrolyte

and fluid disturbances, which are not desirable in the endurance athlete. Beta-blockers reduce maximal aerobic power by 7% on average, as a result of the reduction in maximal heart rate, which is not fully compensated for by increases in maximal stroke volume, peripheral oxygen extraction, or both. Furthermore, the time that submaximal exercise can be sustained is reduced by about 20% by cardioselective beta-blockers and by about 40% by nonselective beta-blockers, most likely as a result of impaired lipolysis [32,38,39]. In addition, diuretics and beta-blockers are on the doping list for some sports in which weight loss or control of tremor are of paramount importance. Diuretics are also banned because they may be used to conceal the use of other doping agents, such as anabolic steroids, by diluting the urine samples. The hypertensive athlete who has to use a diuretic or beta-blocker for therapeutic purposes should follow the International Standard for Therapeutic Use Exceptions of the World Anti-Doping Agency.

Calcium channel blockers and blockers of the renin-angiotensin system are currently the drugs of choice for the hypertensive endurance athlete [32,40], and may be combined in case of insufficient blood pressure control. However, the combination of an angiotensin-converting enzyme inhibitor and an angiotensin II receptor blocker is currently not advocated for the treatment of hypertension because the benefit of the combination for blood pressure control has not been proved. If a third drug is required, a low-dose thiazide-like diuretic, possibly in combination with a potassium-sparing agent, is recommended. Unequivocal evidence that antihypertensive agents would impair performance in ''resistance'' sports does not exist.

Recommendations for leisure-time and competitive sports participation

Recommendations to athletes with hypertension for participation in intense leisure-time and competitive sports are based on the results of the evaluation and on the risk stratification (see Table 2), with the understanding that the general recommendations for the management of hypertension as described earlier are observed, and provided that the clinical condition is stable. Table 4 summarizes recommendations with regard to competitive sports participation [28,29].

The same recommendations may apply to patients who aim to engage in hard or very hard leisure-time sports activities to enhance performance substantially. However, most recreational physical activities are performed at low-to-moderate intensity. Dynamic sports activities are preferred, but also, low-to-moderate resistance training may not be harmful and may even contribute to blood pressure control [37]. In cases of cardiovascular or renal complications, the recommendations are based on the associated clinical conditions. Finally, all patients should be

Table 4
Recommendation for intense leisure-time physical activity and competitive sports participation in athletes who have systemic hypertension (and other risk factors) according to the cardiovascular risk profile

Risk category	Evaluation	Criteria for eligibility	Recommendations	Follow-up
Low added risk	History, PE, ECG, ET, Echo	Well-controlled BP	All sports	Yearly
Moderate added risk	History, PE, ECG, ET, Echo	Well-controlled BP and risk factors	All sports, with exclusion of high-static, high-dynamic sports (III C)	Yearly
High added risk	History, PE, ECG, ET, Echo	Well-controlled BP and risk factors	All sports, with exclusion of high-static sports (III A–C)	Yearly
Very high added risk	History, PE, ECG, ET, Echo	Well-controlled BP and risk factors; no associated clinical conditions	Only low- to moderate-dynamic, low-static sports (I A–B)	6 months

Abbreviations: BP, blood pressure; ECG, 12-lead electrocardiography; Echo, echocardiography at rest; ET, exercise testing; PE, physical examination, including repeated blood pressure measurements according to guidelines.

followed up at regular intervals, depending on the severity of hypertension and the category of risk (see Table 4). In addition, all exercising patients should be advised on exercise-related warning symptoms, such as chest pain or discomfort, abnormal dyspnea, and dizziness or malaise, which would necessitate consulting a qualified physician.

Summary

Hypertension is rare in the young, but its prevalence increases with aging. The overall risk of the hypertensive patient depends not only on blood pressure but also on the presence of other cardiovascular risk factors, target organ damage, and associated clinical conditions. The recommendations for preparticipation screening, sports participation, and follow-up depend on the cardiovascular risk profile of the individual athlete. When antihypertensive treatment is required, calcium channel blockers and blockers of the renin-angiotensin system are currently the drugs of choice.

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