12 Specific Cardiovascular Diseases and Competitive Sports Participation: Arterial Hypertension

Stefano Caselli and Josef Niebauer

Learning Objectives

1. Recognize the definition of arterial hypertension and its classification.
2. Recognize risk factors of arterial hypertension and realize that blood pressure levels have to be within the normal range, regardless if one is an athlete or not—no exceptions.
3. Understand the safety even of competitive sports if blood pressure values are well controlled.
4. Understand the importance of target organ damage and associated clinical condition when making the decision regarding eligibility for competitive sports.
5. Appreciate that if indicated athletes have to be treated non-medically or medically just like any other patient, but that some drugs cannot be given because they are on the list of prohibited drugs, i.e. because of doping.
6. Recognize the beneficial effects of exercise training in everybody with arterial hypertension.

12.1 Introduction

Arterial hypertension is defined by the 2018 European Society of Cardiology Guidelines, as office systolic blood pressure (BP) values >140 mmHg and/or diastolic blood pressure values >90 mmHg [1]. These cut-off values are based on evidence from multiple randomized controlled trials having shown that treatment of patients with higher values is beneficial and outweighs potential side effects of this

S. Caselli
Cardiovascular Center Zurich, Hirslanden Klinik im Park, Zurich, Switzerland

J. Niebauer (✉)
University Institute of Sports Medicine, Prevention and Rehabilitation, Paracelsus Medical University, Salzburg, Austria
e-mail: j.niebauer@salk.at

A. Pressler, J. Niebauer (eds.), *Textbook of Sports and Exercise Cardiology*,
https://doi.org/10.1007/978-3-030-35374-2_12

treatment [1]. The same cut-off values are used in younger, middle-aged, and older people. Fewer data are available in children and adolescents; however, specific guidelines for the classification of blood pressure in boys and girls <16 years, have been published in 2016 by the European Society of Hypertension [2].

Due to the high prevalence of arterial hypertension in the general population, this condition is also one of the most common cardiovascular abnormalities reported in the setting of pre-participation screening of large athletic populations [3–5]. The common clinical scenarios in this context may include the middle-aged individual with cardiovascular risk factors including arterial hypertension, still aiming to participate in competitive sports; the middle-aged or even older individual with cardiovascular risk factors who aims to improve her/his cardiovascular risk profile by starting physical activity programs; the young individual with high blood pressure who engages in sport but follows an "unhealthy" diet and lifestyle.

Sport participation per se should not be considered as a risky undertaking, and as a matter of fact the ESC guidelines for cardiovascular disease prevention suggest at least 150 min of mild to moderate exercise activity per week [6]. However, hypertension as one of the most important cardiovascular risk factors may induce structural changes in target organs (Table 12.1) such as the kidneys, retina, brain and the heart that may be associated with increased morbidity and mortality in the long term. Arterial hypertension is also a risk factor for the occurrence of atherosclerotic plaques in peripheral vessels and in the coronary arteries [7, 8]. Furthermore, an acute increase in BP during effort may trigger atherosclerotic plaque rupture leading to acute myocardial infarction or cerebrovascular events [9–11].

A few other minor abnormalities have also been described in athletes with arterial hypertension. These athletes may achieve lower exercise performance on bicycle exercise and show lower cardiovascular fitness with an average 15% reduction in maximal oxygen consumption compared to non-hypertensive individuals [12]. Additionally, a study on vascular function in hypertensive athletes hypothesized that an early and subclinical vascular dysfunction (impaired reduction of peripheral vascular resistances) could be responsible for increased arterial stiffness and prevalence of elevated BP at effort, and this may be advocated to explain the reduced performance [13].

Table 12.1 Signs of subclinical target organ damage and associated clinical conditions that may be helpful for risk stratification and sport eligibility in athletes with hypertension

Target organ damage	Associated clinical conditions
LV hypertrophy induced by hypertension	Atrial fibrillation
LV diastolic dysfunction	Ischemic heart disease
Ultrasound evidence of arterial wall thickening or plaques	Heart Failure
Hypertensive eye fundus	Peripheral vascular disease
Increase in serum creatinine (men 1.3–1.5 mg/dl; women 1.2–1.4 mg/dl)	Renal impairment, proteinuria
Microalbuminuria	Advanced retinopathy

In order to address the proper management of athletes with arterial hypertension, the Sports Cardiology Section of the European Association of Preventive Cardiology updated in 2018 the specific recommendations for participation in leisure-time and competitive sports [14]. This document, together with other important recent evidence, will be discussed in this chapter.

12.2 Prevalence

- Prevalence of arterial hypertension in the general population varies between countries.
- In Italy, a national cross-sectional study in 493 individuals aged 18–35 reported elevated BP values in 11% of young adults [15].
- In economically developed countries, the burden of hypertension in young adults has been reported as 14% and 21% in men aged 20–29 and 30–39, respectively and as 6% and 10% in women in the same age groups [16].
- The largest study on hypertension in athletes was recently published in Italy [3]. According to the ESC classification, optimal BP was found in 47%, normal BP in 38%, high-normal in 12% and a definite diagnosis of hypertension was made in 3%.
- Athletes with hypertension were in the large majority males (87%), and no differences were identified related to the sport discipline.
- Risk factors for hypertension were identified in family hypertension history and larger body size. Specifically, athletes with larger body size had also higher percentage of body fat, suggesting that overweight could be a determinant of hypertension.

12.3 Diagnosis

All athletes with a diagnosis of hypertension or suspected hypertension should undergo a complete cardiac evaluation including clinical history, physical examination, resting ECG, echocardiography and exercise testing [14]. Additional testing such as ambulatory BP measurements, specific laboratory tests or radiologic evaluation are not routinely performed and are warranted only in selected cases [1].

12.3.1 Medical History

Regarding clinical history, specific attention should be directed to the use of energy drinks, supplements (such as vitamins and minerals; see also Chap. 28) and herbal remedies, which are commonly used by athletes and are frequently not reported. Anti-inflammatory drugs including steroidal or non-steroidal agents are as well commonly used by athletes to reduce pain after injuries that are more frequent in contact sports such as boxing, soccer, rugby or American football.

Secondary hypertension may account for up to 8% of hypertension in young athletes and therefore should be always suspected and searched for [3, 17]. The **red flags** to suspect secondary hypertension are:

- age at onset younger than 40 years
- resistant hypertension at presentation
- absence of additional risk factors
- severe hypertension
- sudden increase in blood pressure
- obstructive sleep apnea syndrome.

Furthermore, the following combinations of symptoms should raise the suspicion of suffering from rare but clinically significant secondary causes of hypertension:

- anxiety, sweating, flushing, headache and paroxysmal hypertension may suggest *pheochromocytoma*
- palpitations, changes in body weight or fatigue may be indicative of *thyroid dysfunction*
- weight gain, fatigue, muscle weakness, hirsutism, skin atrophy and striae rubrae may be symptoms and signs of *Cushing's syndrome*
- fatigue, constipation, polyuria and muscle weakness may be caused by *primary hyperaldosteronism*
- abdominal bruits on physical examination are characteristic for *renal artery stenosis* [17].

12.3.2 Blood Pressure Measurement

According to the ESC guidelines the office BP measurement should be performed according to specific requirements [1]:

1. Patient should be seated comfortably in a quiet environment for 5 min before beginning BP pressure measurements.
2. 2 or 3 BP measurements should be recorded 1 or 2 min apart and additional measurements only if the first two readings differ by more than 10 mmHg. BP is recorded as the average of the last two blood pressure readings.
3. Additional measurements may have to be performed if BP values vary largely (e.g. due to arrhythmias).
4. Use correct size of cuff according to arm's circumference.
5. The cuff should be positioned at the level of the heart with the back and arm supported to avoid muscle contraction.
6. When using auscultatory methods use phase 1 and 5 (sudden reduction and disappearance) of Korotkoff sounds to identify systolic blood pressure and diastolic blood pressure respectively (see also Chap. 7).
7. During first visit, measure BP in both arms.

According to 2018 ESC guidelines blood pressure is classified [1]:

	Systolic		Diastolic
Optimal	<120	and	<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	<90

In case of high or borderline office BP measurements or when a white coat hypertension or masked hypertension is suspected, home BP measurements with a well compiled diary of values, and/or ambulatory BP measurement could be considered for further evaluation. In the athletic population, ambulatory BP measurement is preferred, since it provides objective measurements also during the night and gives information about dipping. Home blood pressure measurements are useful for monitoring over longer time periods. However, information on self-measurements may not be precise and some athletes may provide false values fearing the potential consequences of high blood pressure on sport eligibility.

12.3.3 Blood Pressure Response During Exercise Testing

- Resting and exercise ECG should be performed in all individuals
- During ergometry BP needs to be documented. This may be more easily obtained during bicycle ergometry because the arm is more stable; during treadmill testing at higher velocities reliable measurements are more difficult to achieve [18].
- During maximal exercise, systolic BP increases by approximately 70 mmHg while diastolic BP usually remains unchanged.
- In a large cohort of Olympic athletes, the upper reference value (95th percentile) for systolic BP has been reported as 220 mmHg in males and 200 mmHg in females, and for diastolic BP 85 mmHg in male and 80 mmHg in female athletes [18, 19].
- These values were even exceeded in another large cohort of adolescent, professional and master athletes undergoing standardized exercise testing on bicycle ergometers. Only athletes fulfilling both subjective and objective criteria of complete exhaustion were selected for this study, and the upper normative value of systolic BP in male endurance athletes was 247 mmHg, whereas diastolic BP did also not change relevantly [20].

An exaggerated BP response to exercise testing may predict incident hypertension: In athletes with high blood pressure response (HBPR) to exercise, over 7-year

follow-up no cardiac events occurred. However, the subsequent incidence of hypertension was higher in the HBPR group (13.5%) compared to controls (3.5%; p = 0.009). Baseline BP and HBPR were the strongest predictors of incident hypertension, being 3.6 times higher in these conditions compared to those with normal BP response during exercise [19]. Moreover, in a recent study on well-trained triathletes, HBPR was found to be associated with the presence of myocardial fibrosis detected by cardiac magnetic resonance imaging, but these preliminary observations require further evaluation in larger cohorts before definite conclusions on these potential deleterious effects are allowed [21].

- Overall, HBPR to exercise should not automatically raise concerns in terms of sport participation and should not be the reason for medical treatment. Nonetheless, these individuals should enter a periodical follow-up program.

12.3.4 Echocardiography

Echocardiography is particularly important to detect potential target organ damage. It has to be kept in mind, however, that left ventricular (LV) hypertrophy may both represent a physiologic cardiovascular adaptation to exercise or a pathological response to hypertension [12, 18]. Generally speaking, hypertrophy induced by hypertension can be suspected when the degree of hypertrophy is out of proportion in relation to the specific sport discipline.

- LV hypertrophy is defined as LV mass index >95 g/m^2 in women or >115 g/m^2 in men
- Geometry is described using the relative wall thickness (RWT = (interventricular septum + posterior wall)/(end-diastolic diameter)). The pattern of LV hypertrophy is defined concentric when associated with an RWT > 0.42 (see also Chap. 4).
- Diastolic dysfunction may be suspected by a trans-mitral E/A ratio <1 or by an e′ septal velocity on Tissue Doppler Imaging (TDI) <8 cm/s.
- Global longitudinal strain has been reported as an additional tool to detect subclinical left ventricular impairment and may help to identify athletes with pathological LV hypertrophy due to hypertension [22].

12.3.5 Further Evaluation

Further evaluation should be performed in order to rule out target organ damage. An ankle-brachial index <0.9 may suggest peripheral artery disease; carotid sonography may help identifying wall thickening or plaques; eye fundoscopy may reveal hypertensive retinopathy; lab tests are useful to detect impaired renal function through microalbuminuria, increased creatinine or reduced eGFR [1].

12.4 Management

Athletes should be treated according to the specific ESC guidelines. Management strategy is based on risk profile, specific risk scores, and presence or absence of target organ damage (Fig. 12.1).

Low, moderate, high, and very high risk correspond to absolute 10-year-risk of cardiovascular mortality of <1%, 1–4%, 5–10% and >10% respectively, according to the European score system as defined by the 2016 ESC prevention guidelines. Athletes with grade 1 hypertension and low risk profile could be treated with non-pharmacological measures:

Other RFs, asymptomatic OD, or disease	Blood pressure (mmHg)			
	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 RF		Low risk	Moderate risk	High risk
1–2 RF	Low risk	Moderate risk	Moderate to high risk	High risk
≥3 RF	Low to moderate risk	Moderate to high risk	High risk	High risk
OD, CKD Stage 3, or diabetes	Moderate to high risk	High risk	High risk	High to very high risk
CVD, CKD stage ≥4, or diabetes with OD/RFs	Very high risk	Very high risk	Very high risk	Very high risk

Fig. 12.1 Stratification of total cardiovascular risk to quantify prognosis in patients with hypertension [14]. RF: blood pressure (high normal BP; Grades 1–3); gender, age (men > 55 years; women > 65 years); smoking; dyslipidaemia (total cholesterol > 190 mg/dL and/or LDL > 115 mg/dL and/or HDL < 40 mg/dL in men and <46 mg/dL in women); fasting plasma glucose 102–125 mg/dL; abnormal glucose tolerance test; body mass index >30 kg/m^2; abdominal obesity (men > 102 cm; women > 88 cm); First degree family history of premature cardiovascular disease (men < 55 years; women < 65 years). OD: hypertension-induced LV hypertrophy; carotid wall thickening or plaque; carotid-femoral pulse wave velocity >10 m/s; ankle-brachial index <0.9; CKD with eGFR 30–60 mL/min/1.73 m^2; presence of micro-albuminuria. Established cardiovascular or renal disease: cerebrovascular disease; coronary heart disease; heart failure; symptomatic peripheral artery disease; CKD: eGFR < 30 mL/min/1.73 m^2; proteinuria; and advanced retinopathy (haemorrhages; exudates; papilloedema). *CKD* chronic kidney disease, *CVD* cardiovascular disease, *DBP* diastolic blood pressure, *HT* hypertension, *OD* organ damage, *RF* risk factor, *SBP* systolic blood pressure

- salt restriction
- weight reduction
- alcohol restriction
- increased consumption of vegetables and fruits
- smoking cessation
- discontinuation of supplements, ergogenic and/or anti-inflammatory drugs
- aerobic exercise training

In most cases these measures are effective to control blood pressure. In case blood pressure remains elevated or in individuals with grade 2 hypertension or in those with higher risk profile, a pharmacological treatment should be taken into consideration. In any case, a periodical re-evaluation should be performed.

- The goal of antihypertensive therapy is to reduce blood pressure <140/90 and <140/85 mmHg in diabetic patients [14].

12.4.1 Pharmacologic Treatment

Choice of drugs has to be in keeping with the world anti-doping association regulation (www.wada-ama.org). First-choice treatment in athletes is an angiotensin converting enzyme inhibitor or an angiotensin II receptor blocker, since they do not affect exercise capacity and are not on the doping list. These are contraindicated, however, in female athletes because of potential adverse fatal neonatal effects. Alternatively, calcium channel blockers (nifedipine type) are a preferred choice. In case more than one drug is needed, combination drugs should be considered as they may improve compliance [14]. Beta blockers are usually not recommended due to their negative impact on aerobic exercise performance. Also, endurance athletes often present with significant bradycardia that may be further accentuated by this class of drugs. Beta blockers are also prohibited drugs in some specific sport disciplines in which the control of tremor is seeked such as archery and shooting. Diuretics should not be used; they are on the list of prohibited drugs since they may mask performance enhancing drugs. In selected cases, when a specific drug is considered mandatory to treat the athlete, a Therapeutic Use Exemption (TUE) can be requested at the national/international anti-doping associations.

12.5 Recommendations

- In competitive athletes, normal BP values similar to the general population have to be present or have to be attained, i.e. <140/90 and <140/85 mmHg in diabetic subjects. In case of higher values, temporary restriction may be advised, with possible exception for skill disciplines [14].
- Once blood pressure is well controlled, recommendations for appropriate sport disciplines are dependent upon the presence of target organ damage and associated clinical conditions (Fig. 12.2 and Table 12.2).

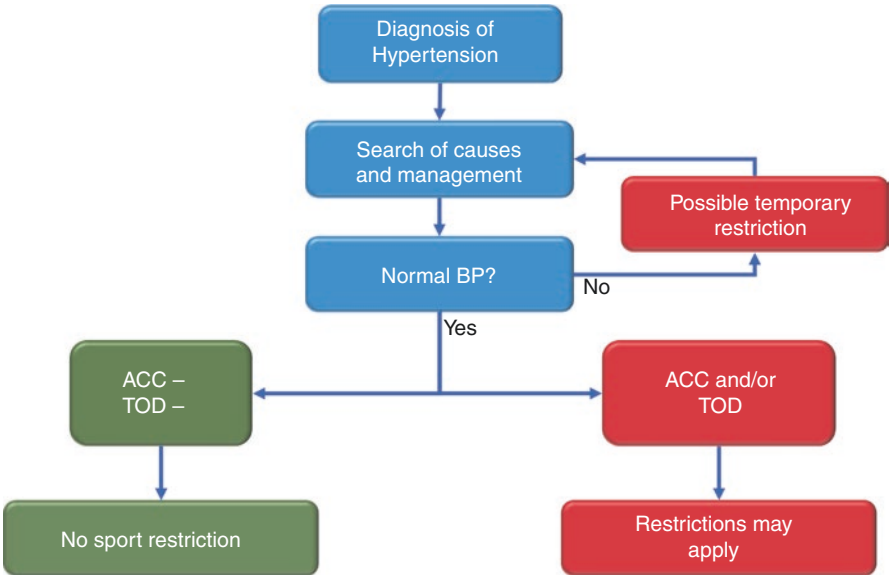

Fig. 12.2 Recommended decision tree for clinical guidance of athletes with arterial hypertension. If blood pressure is well controlled, eligibility is dependent upon the presence of target organ damage and associated clinical conditions. (Modified from [14])

Table 12.2 Criteria for risk stratification in athletes with hypertension (adapted from [14])

Criteria for eligibility	Recommendations	Evaluation	Follow-up
BP well controlled Further RF: none TOD: none ACC: none	All sports	History, PE, ECG, ET; echo[a]	Annually
BP well controlled Further RF: well controlled TOD: none ACC: none	All sports	History, PE, ECG, ET; echo	6–12 months
BP well controlled Further RF: well controlled TOD: present ACC: none	All sports, except power sports known to severely increase BP	History, PE, ECG, ET; echo	6 months
BP well controlled Further RF: well controlled TOD: none or present ACC: present	All sports, except power sports known to severely increase BP[b]	History, PE, ECG, ET; echo	6 months

Individual recommendations need to also consider cardiovascular risk profile, target organ damage (TOD) and associated clinical conditions (ACC)
BP blood pressure, *ET* exercise testing, *PE* physical examination, including BP measurements, *RF* risk factors
[a]Echocardiography according to clinical condition, but once every 1–2 years
[b]Eligibility depending on type and severity of ACC and/or TOD

- Specifically, in the presence of target organ damage, power sport disciplines are not recommended. In the presence of associated clinical conditions (Table 12.2) the sport eligibility should be evaluated according to the severity of these conditions [14].

12.6 Summary

In the general population as well as in athletes the prevalence of arterial hypertension is relatively high, increases with age and is influenced by all negative effects of the Western lifestyle. On the other hand, arterial hypertension is relatively easy to diagnose, and diagnostic procedures are rather inexpensive and lend themselves suitable for screening of athletes of all ages. In case of confirmation of arterial hypertension, in athletes special considerations have to be taken into account regarding the pharmacological treatment. While eligibility for competitive sports may have to be restricted if target organ damage is present, an athlete with well-controlled BP, having no additional risk factor or target organ damage, is eligible for competition in all sports.

Clinical Pearls

- Definition of arterial hypertension is the same for athletes and non-athletes and defined by the 2018 European Society of Cardiology Guidelines as office systolic blood pressure values >140 mmHg and/or diastolic blood pressure values >90 mmHg.
- Sport participation per se should not be considered as a risky undertaking, and as a matter of fact, the ESC guidelines for cardiovascular prevention suggest at least 150 min of mild to moderate exercise activity per week.
- All athletes with a diagnosis of hypertension or suspected hypertension should undergo a complete cardiac evaluation including clinical history, physical examination, resting ECG, echocardiography and exercise testing.
- Regarding clinical history, ask for the use of energy drinks, supplements and herbal remedies as well as anti-inflammatory drugs to reduce pain, which are commonly used by athletes, frequently not reported, but may well result in increased blood pressure levels.
- Office blood pressure measurement should be performed according to guidelines [1].
- In the athletic population, ambulatory blood pressure measurement is preferred, since it provides objective measurements also during the night and gives information about dipping.
- During ergometry blood pressure needs to be recorded. This is easier during bicycle ergometry because the arm is more stable.
- In a large cohort of Olympic athletes, the upper reference value (95th percentile) for systolic blood pressure was 220 mmHg in male and 200 mmHg in females, and for diastolic blood pressure 85 mmHg in male and 80 mmHg in female athletes [18].
- Echocardiography is particularly important in hypertensive athletes to detect potential target organ damage.

- Recommendation for choice of competitive sports depends on the actual blood pressure values, target organ damage and associated clinical conditions.
- Athletes, just like any other patients, need to be regularly followed.

Review

Questions

1. Secondary hypertension may account for up to 8% of hypertension in young athletes and therefore should always be searched for. What are the red flags to suspect a secondary hypertension?
2. Both athletes and patients have to reach normal blood pressure values, if needed with the help of medical drugs. In athletes, generally speaking, what are the preferred types of drugs and which ones should usually not be prescribed?
3. Can athletes with well controlled blood pressure values participate in any competitive sport?

Answers

1. Red flags to suspect secondary arterial hypertension are:
   (a) age at onset younger than 40 years
   (b) resistant hypertension at presentation
   (c) absence of additional risk factors
   (d) severe hypertension
   (e) sudden increase in blood pressure
   (f) obstructive sleep apnea syndrome.
2. First-choice treatment is an angiotensin converting enzyme inhibitor or an angiotensin II receptor blocker, which however is contraindicated in female athletes because of potential adverse neonatal effects. Alternatively, calcium channel blockers (nifedipine type) are a preferred choice. Beta blockers are not recommended due to their negative impact on aerobic exercise performance, frequent bradycardia and their presence on the list of prohibited drugs. The latter holds true for diuretics as well.
3. Generally speaking, decision about specific sports has to be made in the light of the individual cardiac risk and absence or presence of end organ damage and associated clinical conditions.

References

1. Williams B, Mancia G, Spiering W, Agabiti Rosei E, Azizi M, Burnier M, et al. 2018 ESC/ESH Guidelines for the management of arterial hypertension. Eur Heart J. 2018;39(33):3021–104.

2. Lurbe E, Agabiti-Rosei E, Cruickshank JK, Dominiczak A, Erdine S, Hirth A, et al. 2016 European Society of Hypertension guidelines for the management of high blood pressure in children and adolescents. J Hypertens. 2016;34(10):1887–920.
3. Caselli S, Vaquer Sequi A, Lemme E, Quattrini F, Milan A, D'Ascenzi F, et al. Prevalence and management of systemic hypertension in athletes. Am J Cardiol. 2017;119(10):1616–22.
4. D'Ascenzi F, Caselli S, Alvino F, Digiacinto B, Lemme E, Piepoli M, et al. Cardiovascular risk profile in Olympic athletes: an unexpected and underestimated risk scenario. Br J Sports Med. 2019;53(1):37–42.
5. Karpinos AR, Roumie CL, Nian H, Diamond AB, Rothman RL. High prevalence of hypertension among collegiate football athletes. Circ Cardiovasc Qual Outcomes. 2013;6(6):716–23.
6. Authors/Task Force M, Piepoli MF, Hoes AW, Agewall S, Albus C, Brotons C, et al. 2016 European Guidelines on cardiovascular disease prevention in clinical practice: the Sixth Joint Task Force of the European Society of Cardiology and Other Societies on Cardiovascular Disease Prevention in Clinical Practice (constituted by representatives of 10 societies and by invited experts): developed with the special contribution of the European Association for Cardiovascular Prevention & Rehabilitation (EACPR). Eur J Prev Cardiol. 2016;23(11):NP1–NP96.
7. Mancia G, Fagard R, Narkiewicz K, Redon J, Zanchetti A, Bohm M, et al. 2013 ESH/ESC Guidelines for the management of arterial hypertension: the Task Force for the management of arterial hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). J Hypertens. 2013;31(7):1281–357.
8. Selden MA, Helzberg JH, Waeckerle JF. Early cardiovascular mortality in professional football players: fact or fiction? Am J Med. 2009;122(9):811–4.
9. Laukkanen JA, Jennings JR, Kauhanen J, Makikallio TH, Ronkainen K, Kurl S. Relation of systemic blood pressure to sudden cardiac death. Am J Cardiol. 2012;110(3):378–82.
10. Laukkanen JA, Khan H, Kurl S, Willeit P, Karppi J, Ronkainen K, et al. Left ventricular mass and the risk of sudden cardiac death: a population-based study. J Am Heart Assoc. 2014;3(6):e001285.
11. Laukkanen JA, Willeit P, Kurl S, Makikallio TH, Savonen K, Ronkainen K, et al. Elevated systolic blood pressure during recovery from exercise and the risk of sudden cardiac death. J Hypertens. 2014;32(3):659–66.
12. Mazic S, Suzic Lazic J, Dekleva M, Antic M, Soldatovic I, Djelic M, et al. The impact of elevated blood pressure on exercise capacity in elite athletes. Int J Cardiol. 2015;180:171–7.
13. Kim JH, Sher S, Wang F, Berkstresser B, Shoop JL, Galante A, et al. Impact of American-style football participation on vascular function. Am J Cardiol. 2015;115(2):262–7.
14. Niebauer J, Borjesson M, Carre F, Caselli S, Palatini P, Quattrini F, 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(40):3664–71.
15. Bruno RM, Pucci G, Rosticci M, Guarino L, Guglielmo C, Agabiti Rosei C, et al. Association between lifestyle and systemic arterial hypertension in young adults: a national, survey-based, cross-sectional study. High Blood Press Cardiovasc Prev. 2016;23(1):31–40.
16. Kearney PM, Whelton M, Reynolds K, Muntner P, Whelton PK, He J. Global burden of hypertension: analysis of worldwide data. Lancet. 2005;365(9455):217–23.
17. Rimoldi SF, Scherrer U, Messerli FH. Secondary arterial hypertension: when, who, and how to screen? Eur Heart J. 2014;35(19):1245–54.
18. Caselli S, Vaquer Segui A, Quattrini F, Di Gacinto B, Milan A, Assorgi R, et al. Upper normal values of blood pressure response to exercise in Olympic athletes. Am Heart J. 2016;177:120–8.
19. Caselli S, Serdoz A, Mango F, Lemme E, Vaquer Segui A, Milan A, et al. High blood pressure response to exercise predicts future development of hypertension in young athletes. Eur Heart J. 2019;40(1):62–8.
20. Pressler A, Jahnig A, Halle M, Haller B. Blood pressure response to maximal dynamic exercise testing in an athletic population. J Hypertens. 2018;36(9):1803–9.

21. Tahir E, Starekova J, Muellerleile K, von Stritzky A, Munch J, Avanesov M, et al. Myocardial fibrosis in competitive triathletes detected by contrast-enhanced CMR correlates with exercise-induced hypertension and competition history. JACC Cardiovasc Imaging. 2018;11(9):1260–70.
22. Galderisi M, Lomoriello VS, Santoro A, Esposito R, Olibet M, Raia R, et al. Differences of myocardial systolic deformation and correlates of diastolic function in competitive rowers and young hypertensives: a speckle-tracking echocardiography study. J Am Soc Echocardiogr. 2010;23(11):1190–8.