CLINICAL REVIEW

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Physical Activity and Arterial Hypertension

Körperliche Aktivität und Arterielle Hypertonie

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Summary

› **Arterial hypertension** is the most important modifiable cardiovascular risk factor for all-cause morbidity and mortality worldwide. It is associated with an increased risk of cardiovascular diseases (CVD) and cognitive impairment. In this regard, accumulating evidence points to beneficial effects of intensified blood pressure lowering by implementation of protective lifestyle patterns (e.g. physical activity, diet) or pharmacotherapy. The aim of this clinical review is to summarize the role of physical activity and/or exercise in prevention and treatment of arterial hypertension.

› **Epidemiology, prospective observational studies, and randomized controlled trials** have shown positive effects of physical activity on blood pressure levels in patients with hypertension and in patients with high-normal and normal blood pressure. Thus, physical activity can prevent or slow down micro- and macrovascular end-organ damage.

› **Physical activity** should be recommended for prevention and treatment of all hypertension grades, but most patients with hypertension will concomitantly require drug treatment (depending on hypertension grade and individual cardiovascular risk profile).

› **Currently,** increasing attention is directed to the role of personalized exercise prescriptions for prevention and treatment of arterial hypertension and for addressing cardiometabolic risk.

KEY WORDS:
Exercise, Prevention, Lifestyle, Cardiovascular Risk Factor, Cardiovascular Diseases

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Diagnosis, Classification and Prevalence of Arterial Hypertension

Arterial hypertension is the most important modifiable risk factor for all-cause morbidity and mortality worldwide and is associated with an increased risk of cardiovascular diseases (CVD). Additionally, arterial hypertension is the most important modifiable risk factor for dementia and vascular impairment (16).

According to the 2018 ESC/ESH guidelines, arterial hypertension is defined (Table 1), based on the presence of reproducibly measured resting blood pressure (BP) values in the practice/hospital, as a systolic blood pressure ≥140 mmHg and/or a diastolic blood pressure ≥90 mmHg (24). Alternatively, arterial hypertension can be diagnosed by self-monitoring of BP at home (systolic ≥135 mmHg and/or diastolic ≥85 mmHg) or long-term BP measurement (systolic ≥130 mmHg and/or diastolic ≥80 mmHg). In the U.S.A., lower limit values apply for arterial hypertension. In 2017, for example, the U.S. guidelines reduced the threshold values for diagnosing hypertension to ≥130 mmHg systolic and/or ≥80 mmHg diastolic (measurement in practice/hospital).

The global prevalence of hypertension has increased dramatically in recent decades. In the period from 1990 to 2019, for example, the number of people aged 30 to 79 with arterial hypertension almost doubled from approximately 650 million to around 1.3 billion. Alarmingly, current projections predict a further increase in the global number of patients with hypertension to up to 1.5 billion by 2025 (24). Even in athletes, hypertension is highly prevalent and one of the most common findings during screening (13).

The aim of antihypertensive therapy is to normalize BP values with the goal of preventing or

slowing down micro- and macrovascular end-organ damage. The prognostic benefit of antihypertensive therapy with regard to this aspect has been demonstrated in several randomized, controlled trials. In this regard, accumulating evidence promotes the beneficial effect of intensive BP treatment (16).

In 2015, the Systolic Blood Pressure Intervention Trial (SPRINT), which compared the benefit of treatment of systolic BP to a target of less than 120 mm Hg with treatment to a target of less than 140 mm Hg, demonstrated lower rates of major cardiovascular events and deaths from any cause following intensive treatment (25). The following SPRINT-MIND study has shown that intensive BP treatment significantly reduced the risk of mild cognitive impairment, but not of dementia. Furthermore, a sub-study of the SPRINT-MIND study has shown positive effects of intensive BP treatment on brain outcomes (smaller increases in WMH (White Matter Hyperintensities), reduced brain volume loss) (14).

In summary, in patients ≤65 years of age, if tolerated, the target systolic BP should be set at 120-130 mmHg, and in patients ≥65 years target systolic pressure values of ≤140 mmHg should be recommended.

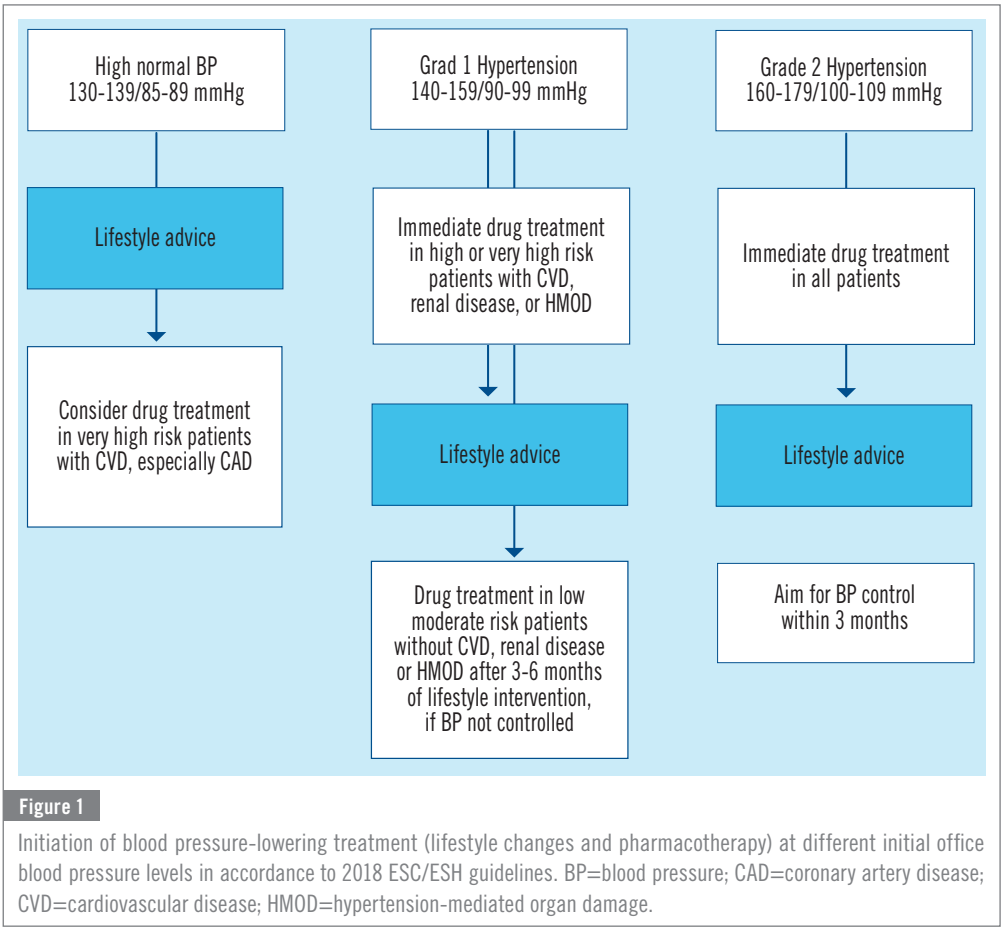

Figure 1

Initiation of blood pressure-lowering treatment (lifestyle changes and pharmacotherapy) at different initial office blood pressure levels in accordance to 2018 ESC/ESH guidelines. BP=blood pressure; CAD=coronary artery disease; CVD=cardiovascular disease; HMOD=hypertension-mediated organ damage.

Physical (In-)Activity and Exercise

Physical inactivity is associated with low cardiorespiratory fitness, hypertension, coronary artery disease (CAD), heart failure, insulin resistance, type 2 diabetes mellitus, dyslipidemia, stroke, dementia, and other chronic diseases (22).

Current guidelines (e.g. Wold Health Organization; WHO) recommend a minimum of 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity aerobic activity and strength training per week. According to a global analysis, 30% of the world's population do not meet these recommendations (7). Additionally, the COVID-19 pandemic has aggravated this situation (2).

Since physical activity and/or exercise is associated with a myriad of health benefits, the high prevalence of physical inactivity is a clear call for action. Physical activity is a low-cost intervention in primary and secondary prevention for numerous non-communicable diseases (e.g. cardiovascular diseases, hypertension, metabolic diseases, cancer, dementia) (22).

Often the terms "physical activity" and "exercise" are used synonymously. "Physical activity"' is defined as any muscle-induced bodily movement that increases energy expenditure above ≈1.0/1.5 metabolic equivalent of task (MET, 1 MET=1 kcal (4184 kJ) × kg-1 ×h-1) while "physical exercise" is a specific, planned, and structured intervention/regimen (4).

Physical Activity and Exercise in Prevention and Treatment of Hypertension

Lifestyle factors (e.g. physical activity, exercise, nutrition) are basic components in the prevention and therapy of arterial hypertension (class IA recommendation in the 2018 ESC/ESH guideline for the management of arterial hypertension) (24).

Lifestyle interventions and/or advice should be part of treatment in all hypertension grades, but most patients with hypertension will also require drug treatment. Drug treatment should be initiated depending on hypertension grade (immediate drug treatment in all patients suffering from grade 2 and grade 3 hypertension) and cardiovascular risk profile (immediate drug treatment in patients with very high risk and grade 1 hypertension) (figure 1). In patients with grade 2 and grade 3 hypertension initiation of drug treatment should be recommended before starting physical exercise.

Initial drug therapy should consider a dual combination of angiotensin-converting enzyme inhibitor or angiotensin receptor blocker with calcium channel blocker or diuretic (optimal single pill). However, diuretics (and in some sport disciplines ß-blockers) are not allowed for athletes (doping list) (figure 2)

Regular physical activity, as part of an active lifestyle, can reduce systolic BP by 5-9 mmHg (12). Results from randomized controlled trials demonstrate that a 12-week endurance training can reduce systolic BP by 6 mmHg (5). A meta-analysis of 54 randomized controlled trials reports that regular aerobic exercise can decrease BP levels (8-10 mmHg) in previously sedentary adults (23). A narrative review of 27 randomized controlled trials in patients with hypertension showed that regular aerobic activity reduces BP by a mean of 11/5 mmHg (3). In summary, the current totality of ›

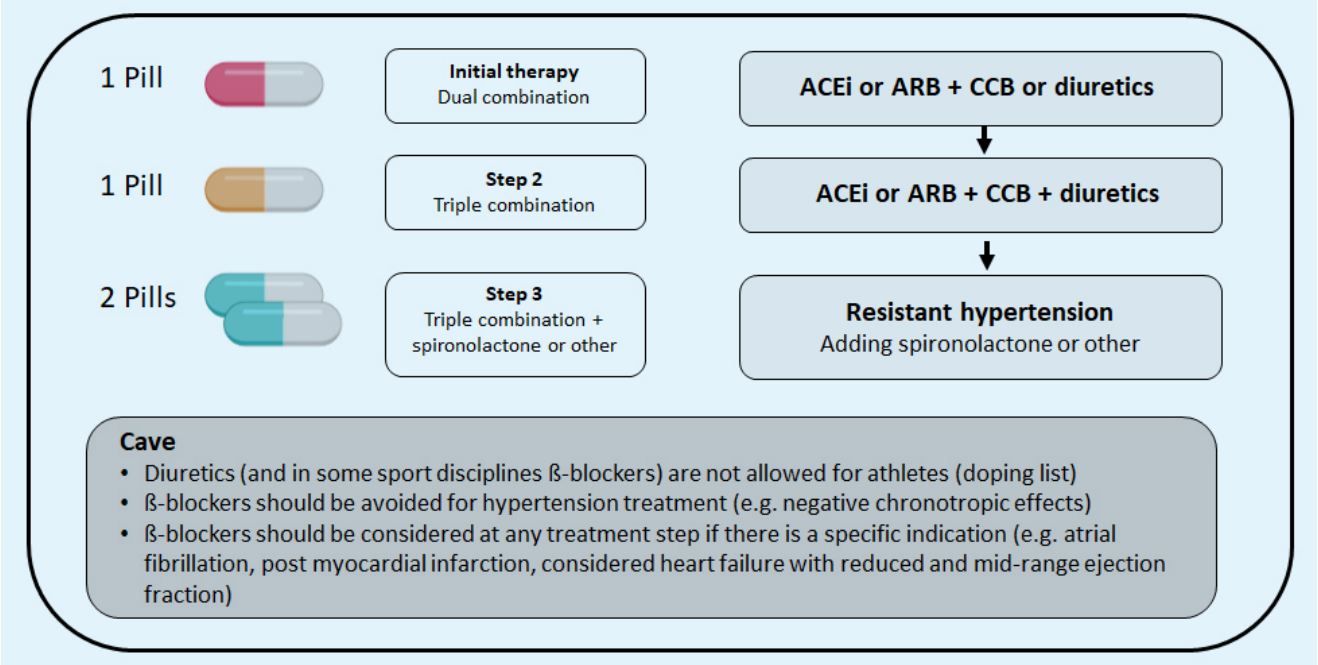

Figure 2

Drug treatment strategy for uncomplicated hypertension and specific aspects for athletes. ACEi=angiotensin-converting enzyme inhibitor; ARB=angiotensin receptor blocker; CCB=calcium channel blocker.

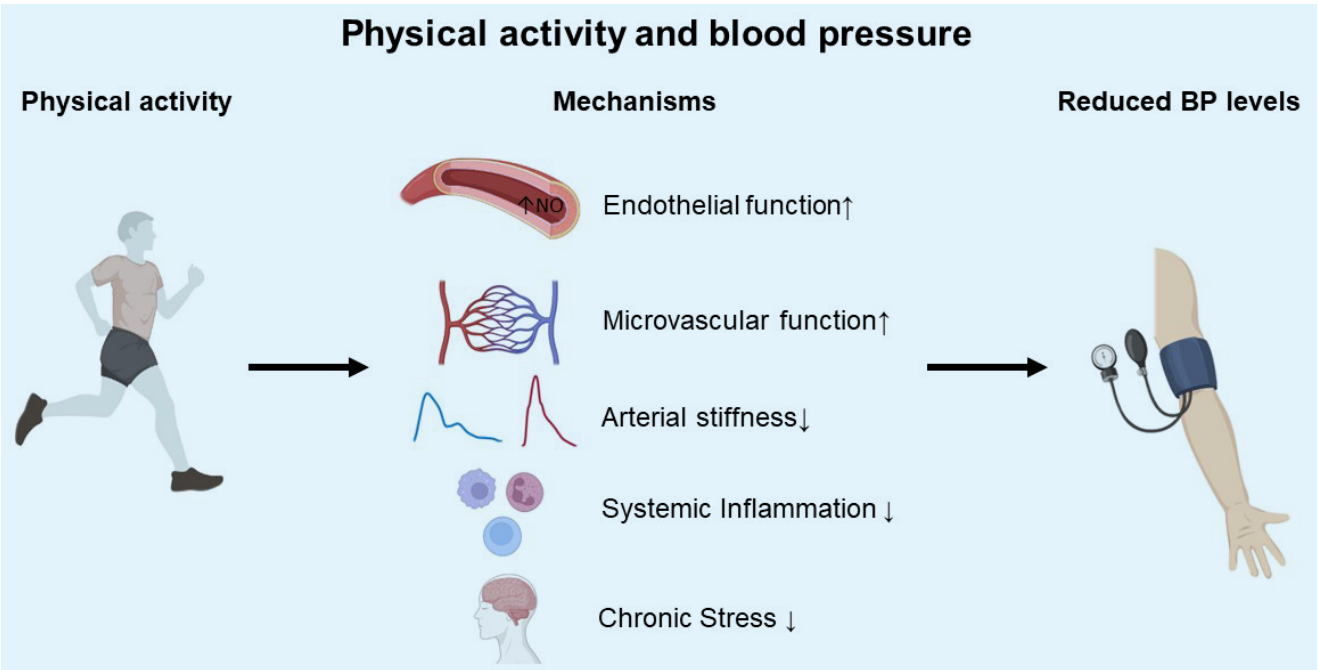

Figure 3

Mechanisms of physical activity on blood pressure levels (created with biorender).

evidence suggests a dose-response mechanism with strongest effect on BP by exercise sessions lasting 40-60 minutes performed at least three times a week.

In that regard, it is worth noting that the effects of physical activity on BP are greater in hypertensive patients than in normotensive individuals.

Mode of Exercise in Hypertension Treatment

Important variables related to exercise and training are the type of exercise (e.g., endurance, resistance, coordinative), training intensity, training volume (temporal extent of the respective training units), and training frequency (number of training units per week).

Regarding the type of exercise, a recent meta-analysis demonstrated that aerobic endurance training in hypertensive patients and isometric strength training in normotensive BP have the largest effect sizes (9). Low-intensity exercise showed no to minimal effects as did high-intensity exercise, while moderate-intensity exercise resulted in the maximal effects on arterial BP.

The 2018 ESC/ESH guideline on the management of arterial hypertension recommends 5-7 units of moderate en-

Table 1

Classification of blood pressure according 2018 ESC/ESH guidelines.

	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

durance training (walking, jogging, cycling, swimming) with a duration of more than 30 minutes per unit (24). However, we recommend, especially for untrained individuals, an increased exercise frequency rather than an increased exercise volume per session (e.g. 6x/week 10 minutes instead of 2x/week 30 minutes).

In this context, exercise intensities should be optimally based on individual performance analysis (e.g. spiroergometry, lactate testing) and should include a thoughtful consideration of patient specific aspects (e.g. gender, age, comorbidities, medication).

During exercise, it is advisable to maintain systolic blood pressure ≤220 mmHg and/or diastolic blood pressure ≤105 mmHg (1). In patients with low or moderate cardiovascular risk, high-intensity exercise with short systolic blood pressure peaks ≥240 mmHg can be performed (15).

Personalized Exercise Prescription

In summary, guidelines and recently published literature recommend a personalized exercise prescription for the prevention and therapy of arterial hypertension (9). Personalized prevention and therapy should be adjusted to the needs and comorbidities (e.g. cycling and swimming training instead of jogging in overweight individuals) of the individual and should involve a shared decision-making process between physician and patient taking into account individual exercise preferences. Particularly in the case of seniors, the risk of injury and falls should also be taken into account (e.g., in the case of an increased risk of falls, recommendation of endurance training on a bicycle ergometer as well as coordinative-motor training to improve balance skills and reduce the risk of falls). Furthermore, an individual performance analysis to determine the individual dose (optimal training heart rate), also in relation to blood pressure values under stress, can be useful.

In addition, all patients should be advised to implement physical activity into their daily routine (e.g. use of a bicycle or a walk for short distances and/or for commuting, use of stairs instead of an elevator, daily goal of at least 10,000 steps).

Other non-pharmacological prevention and treatment approaches include weight reduction, the adaptation of protective dietary patterns, e.g. lower in sodium and higher in potassium, alcohol restriction, and nicotine abstinence (table 2).

Preventive Sports Medicine Examination

Before resuming or starting a new exercise regimen, a sports medical check-up by a physician is highly recommended,

Table 2

Influence of different lifestyle factors on blood pressure levels (12)

INTERVENTION	SYSTOLIC BP REDUCTION (MMHG)	DIASTOLIC BP REDUCTION (MMHG)
Physical Activity	5-9	2-3
Weight loss (per kg, from 3kg)	1-2	1
Mediterranean diet	4	2-3
Moderate sodium consumption (3-5 g/d)	7	4-5
Alcohol restriction	4-7	3-5

especially if cardiovascular risk factors are present. This should identify risk factors and enable the safe practice of physical activity and exercise through personalized recommendations, adapted to the individual situation. In patients with (i) arterial hypertension grade III, (ii) planned high intensity exercise and (iii) individuals with high cardiovascular risk an examination by a sports cardiologist is recommended. In addition to a medical history and examination as well as a resting ECG and echocardiography, the basis for this is also provided by an exercise test (e.g., spiroergometry) as part of the screening examination. One special focus in sports medicine examination should be exercise-induced hypertension.

Exercise-Induced Hypertension

Exercise-induced hypertension is defined as elevated systolic BP > 190mm Hg for females and >210 mmHg for males (or >200/100 mmHg at 100 Watt) during exercise and is associated with cardiovascular events and mortality independent of office BP (10, 18). The underlying mechanisms of hypertensive exercise response are still unknown. Potential mechanisms are increased arterial stiffness, endothelial dysfunction, metabolic impairment, and resulting reduced peripheral relaxation.

The role of exercise-induced hypertension on myocardial adaptations has been less investigated in athletes. In that regard, one hypothesis is that a transient, repetitive pressure/volume overload may cause myocardial fibrosis with resulting atrial fibrillation (8).

Additionally, exercise-induced hypertension is associated with masked hypertension (17). The masked hypertension is defined as a normal BP in the clinic (<140/90 mmHg), ›

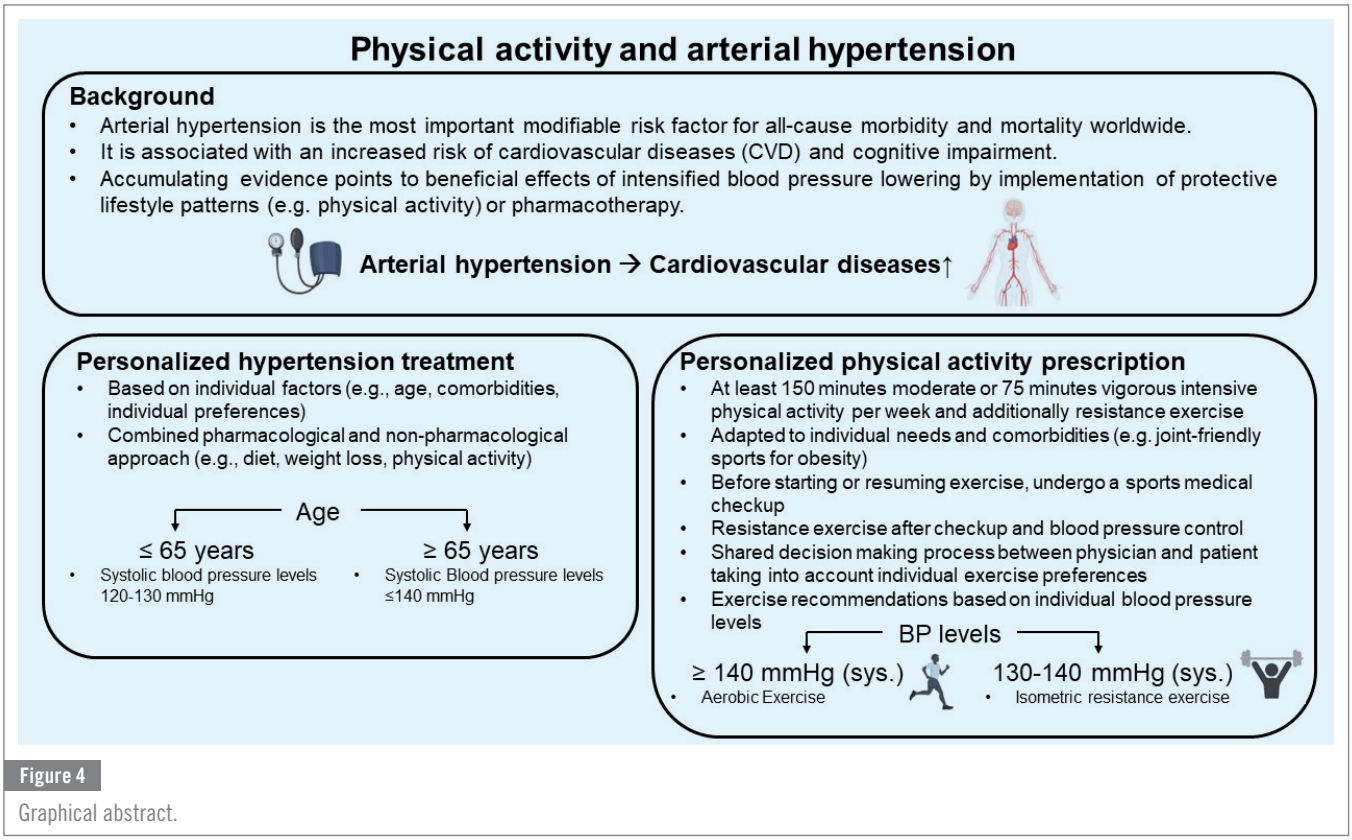

Figure 4

Graphical abstract.

but an elevated BP out of the clinic (ambulatory daytime BP or home BP>135/85 mmHg) causing not diagnosed and resulting increased rates of organ damage and cardiovascular events.

Elevated BP levels are not uncommon in middle-aged marathon runners (11). Moreover, in middle aged athletes the prevalence of masked hypertension is increased (20).

Thus, diagnosis and treatment of exercise-induced hypertension should be recommended. Based on the potential role of elevated angiotensin II, endothelial dysfunction (reduced NO levels), and an increased autonomic nervous system first treatment choice are angiotensin-converting enzyme inhibitors. Furthermore, reduction of exercise intensity and duration are potential approaches.

Mechanisms of Physical Activity Associated Blood Pressure Improvements

The cardiovascular benefits of physical activity are pleiotropic. Physical activity can induce vascular adaptations like increased vascular compliance with concomitantly reduced total peripheral resistance, resulting in reduced blood pressure and cardiac afterload. Additionally, it reduces sympathetic nerve activity, reduces systemic inflammation, and - this way - prevents arterial stiffening. Additionally, physical activity is associated with weight loss, improved glycaemic control, and beneficial changes in lipoprotein metabolism resulting in favourable vascular effects (21).

One central mechanism of physical activity on blood pressure regulation is its effect on endothelial function. Endothelial dysfunction seems to precede arterial hypertension and microvascular diseases, one of the mechanisms being impaired nitric oxide (NO) availability and function. NO is a key mediator of endothelial function, and both animal and human clinical studies have shown the ability of exercise to improve NO-dependent endothelial vasodilation. Via multiple molecular mechanisms, physical activity improves vascular remodelling through endothelial cell regulation and smooth muscle remodelling (6, 19) (figure 3).

Conclusion

Arterial hypertension is the most important modifiable risk factor for cardiovascular diseases and cognitive impairment. In the context of the demographic change, the number of individuals with arterial hypertension will increase worldwide. This opens a huge window of opportunities for preventive measures for reducing the clinical burden of hypertensive complications.

Epidemiology, prospective observational studies, and randomized controlled trials have shown positive effects of physical activity and/or exercise on blood pressure levels in patients with arterial hypertension, high-normal, and individuals with normal blood pressure. Regarding implementation strategies, increasing attention is currently being directed to the role of personalized exercise prescriptions for prevention and treatment of arterial hypertension and for addressing the cardiometabolic risk.

Ideally, physical activity should be part of a healthy, active lifestyle (e.g. weight control and/or weight reduction, alcohol restriction) for prevention of diastolic dysfunction, atrial fibrillation and enlargement of the left atrium.

Conflict of Interest

The authors have no conflict of interest.

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