HYPERTENSION IN ELITE ATHLETES

NEW INSIGHTS INTO AN OLD PROBLEM

– Written by Jelena Suzic Lazic, Serbia and Victoria Watt, Qatar

The high physiological and psychological demands of elite sport and the lifestyle habits of many sportspeople make athletes with hypertension and other cardiovascular disorders a 'specific' population in terms of prevention, diagnosis, treatment and prognosis.

Hypertension is a usually asymptomatic but serious condition that, if untreated, may lead to a series of pathologic changes – particularly in the cardiovascular system. It is a well-established risk factor for cardiovascular disease and – if present during early adulthood – confers an increased risk of coronary heart disease (CHD) and other cardiovascular disorders (including stroke) in later life[1]. Almost 80% of adolescents with elevated blood pressure (BP) will develop chronic hypertension[1]. Hypertension, even in athletes, is associated with a higher risk of CHD, which is the major cause of sudden cardiac death in athletes over 35 years of age.

THE LINK BETWEEN SPORT AND HYPERTENSION

Essential hypertension is the most prevalent cause of high blood pressure in athletes (older than 10 years of age). It is probably a consequence of a complex interplay between genetic determinants and specific behavioural characteristics. However, there are contradictory data on the association between elevated blood pressure in athletes and a positive family history of hypertension[2,3]. There are a number of other factors which may increase the risk of hypertension in elite athletes: dietary habits (high salt intake through processed food), beverages rich in salt (for faster rehydration), energy drinks, the overuse of dietary supplements, prohibited substances (stimulants, androgenic steroids, growth hormone), the frequent use of non-steroid anti-inflammatory drugs (NSAIDs) to treat sports-related injuries, oral contraceptive pills, as well as fatigue, poor sleep and psychological stress associated with the high demands of competitive sport[2-8].

Besides the above-mentioned factors, recent studies indicate that participation in certain sports may be associated with an increased risk of developing hypertension. A higher prevalence of prehypertension and hypertension has been reported among American football players at collegiate and NFL level, when compared to age-matched athletes and healthy men from the general US population respectively[6,7]. Moreover, the reported increase in BP during the season, with higher prevalence of hypertension (and prehypertension) post-season compared to pre-season, again in American football, has raised even more concern[3]. The greatest inter-seasonal variations in BP were observed in linemen, who also demonstrated the highest weight

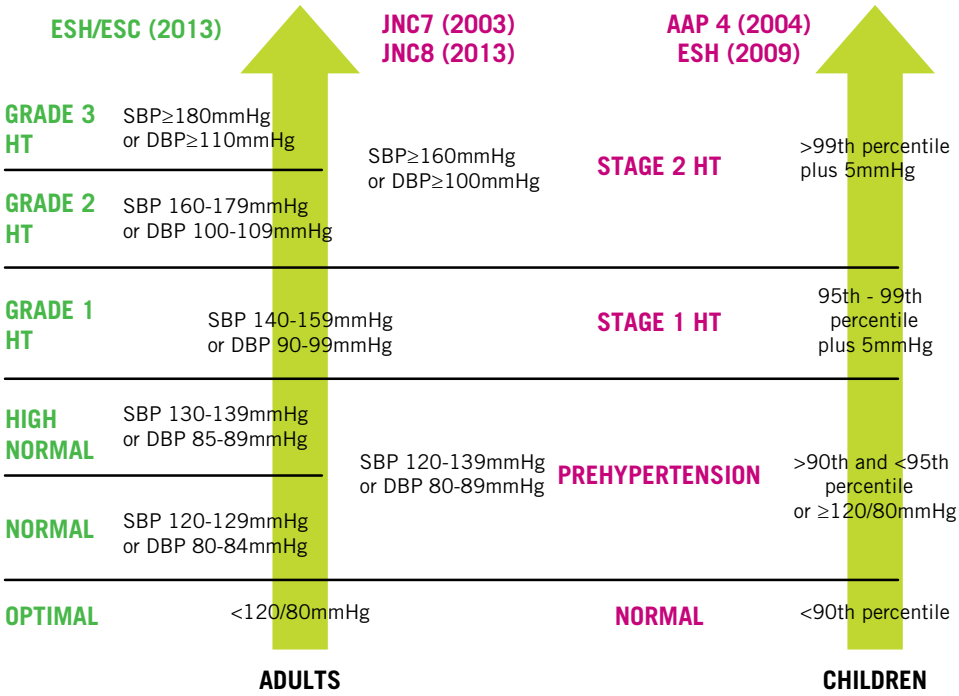

Figure 1: Blood pressure classification in adult and paediatric populations: a summary of current guidelines. ESH=European Society of Hypertension, ESC=European Society of Cardiology, JNC=report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure, AAP=American Academy of Pediatrics, HT=hypertension, SBP=systolic blood pressure, DBP=diastolic blood pressure.

Table 1

1. *Before BP measurement, subjects should refrain from physical activity, caffeine for 30 minutes and smoking for 1 hour.*
2. *The athlete should sit in a quiet room (with the back supported on a chair) at least 3 (but preferably 5) minutes before measurement.*
3. *The measurement should be taken by sphygmomanometer (if available) with appropriately sized cuff (the bladder should encircle at least 80% of upper arm circumference), placed at the heart level.*
4. *During the first visit, the measurement should be performed on both arms. If BP differs, the arm with the higher BP level should be taken into account.*
5. *At least two measurements (three measurements in children) should be made (1 or 2 minutes apart). In case of arrhythmia and/or significant differences between measurements (more than 5 mmHg) additional readings should be taken (until two readings are close) and the average value of BP should be reported.*
6. *For a definite diagnosis of hypertension, elevated blood pressure needs to be detected at least twice, with a minimum of 1 to 2 weeks between measurements.*
7. *If systolic and diastolic BP falls into different BP categories, the higher category should be chosen.*

Table 1: Recommendations for reliable assessment of blood pressure.

gain, implying a potential influence of weight gain on BP elevation[3]. This emerging evidence supports a link between obesity and hypertension and these studies emphasise the need to focus on preventive measures in American football and other sports where weight gain is encouraged as desirable to enhance performance[3,9].

The training regime may also have a role in BP elevation. Busy training and competition schedules, strenuous, exhausting exercise and inadequate recovery practices could also be contributing factors in the development of elevated BP. Long-term, low-to-moderate intensity resistance training may decrease the resting BP level in a similar manner to dynamic exercise. However, a strenuous static training regimen may induce an unfavourable BP profile.

EVALUATION OF BLOOD PRESSURE

Part of the pre-participation screening of athletes includes an assessment of the athlete's BP and, if necessary, further diagnostic evaluation. This enables appropriate risk stratification, treatment and advice regarding fitness to participate in sporting activity[8].

The normative values of blood pressure are different for the paediatric and adult populations. In adult athletes hypertension is defined as systolic blood pressure ≥140mmHg and/or diastolic BP ≥ 90mmHg[4,10-12]. In young athletes (up to 18 years of age) hypertension is defined as a blood pressure level greater than or equal to the 95th percentile for gender, age and height, which can be evaluated by using BP tables[13,14]. There are some variations in the current European and American guidelines in classification of blood pressure levels, but only in terms of BP classes below the threshold for hypertension in adults[10-14]. The current guidelines for children and adults are summarised in Figure 1. Accurate recording of an athlete's BP is essential as blood pressure levels can vary significantly if the procedure is not appropriately performed. In order to ensure reliable assessment of blood pressure, specific recommendations should be followed (Table 1)[4,8,12].

DETECTION OF WHITE-COAT AND MASKED HYPERTENSION – THE IMPORTANCE OF 24-HOUR AMBULATORY BLOOD PRESSURE MONITORING

It is already known that office blood pressure measurement often overestimates the true BP level. This phenomenon, sometimes referred to as white-coat hypertension (WCH) is more common among young subjects and has been attributed to the anxiety associated with visiting a healthcare professional. The prognostic significance of WCH is uncertain and it is not known if subjects with WCH are comparable to their normotensive counterparts. Current recommendations are that, for individuals with WCH, regular follow-up and repeated out-of-office BP measurements should be performed[12].

Under some circumstances, office blood pressure can be lower than usual, and some patients with hypertension might not be recognised during routine screening. This is known as masked hypertension or isolated ambulatory hypertension. The prognosis of individuals with masked hypertension is worse than that of the normotensive population, with an incidence of cardiovascular events similar to that seen in the sustained hypertensive population[8,12].

It is essential therefore, that the diagnosis of hypertension is confirmed with ambulatory BP monitoring and/or additional out-of-office measurements. For 24-hour ambulatory BP monitoring, the threshold for diagnosis of hypertension is 130/80mmHg (135/85mmHg for day-time) in adult athletes[12]. In the paediatric population, the cut off value for hypertension obtained by 24-hour ambulatory BP monitoring is the 95th percentile for gender and height (or age) and appropriate tables have recently been published by the American Heart Association[15].

ISOLATED SYSTOLIC HYPERTENSION IN THE YOUNG

Isolated systolic hypertension is sometimes seen in the younger population. At present, there are no data to support an adverse outcome in this group, or indeed to support medical intervention. It is thought that isolated systolic hypertension in youth is due to high amplification of the central pressure wave (hence 'spurious' hypertension), whereas in people over 60 years of age, stiffening of the aorta is the key factor in the development of this condition. The central aortic pressure waveform can now be measured non-invasively, and this may be a useful tool to separate cases of spurious from true systemic hypertension – and thereby avoid unecessary treatment[16].

DIAGNOSTIC EVALUATION OF HYPERTENSIVE ATHLETES

Athletes with confirmed hypertension should undergo a full diagnostic evaluation. A summary of useful investigations can be found in the clinical pathway for hypertension in athletes (Appendix 1). This includes a complete personal and family history and physical examination. Screening and investigation for secondary causes of hypertension, end organ damage (cardiac, renal, ophthalmological sequelae) and an assessment of lifestyle factors should also be done. Personal and family history, physical examination and electrocardiogram are already a part of pre-participation screening of athletes in Europe[5]. However, the history should be taken in more detail to facilitate the plan for future lifestyle intervention. It is important to document all regular and occasional medications used by the athlete, supplements (dietary and otherwise) and any recreational drugs, as these may be implicated in the aetiology of elevated BP. A thorough cardiac assessment is essential

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for hypertensive athletes, including echocardiography and exercise testing (ideally cardiopulmonary exercise testing). Echocardiography is effective in detecting hypertension-associated changes in the heart, and can provide valuable information about aetiology, target organ damage and the response to medical intervention[10,12]. This is of particular importance in athletes with sustained hypertension[4,5,8].

Abdominal (renal) ultrasound, microalbuminuria and quantitative proteinuria testing should be performed, particularly in children - where 90% of secondary hypertension is attributed to renal or renovascular disease. Additional tests, including 24-hour electrocardiogram monitoring, retinal examination, carotid ultrasound, and evaluation of sleep disorders (in obese athletes), may provide further information in athletes with symptoms such as dyspnoea, chest discomfort and palpitations[8]. In any athlete with hypertension, it is essential to exclude a secondary cause, to identify any target organ damage and to obtain the necessary information for risk stratification and treatment.

Athletes with hypertension – the importance of echocardiography

As already mentioned, echocardiography is mandatory for elite athletes with sustained hypertension. It is important to distinguish training-related adaptive changes (athlete's heart) from the pathological changes seen with established hypertension. Children with signs of a possible 'athlete's heart' should be evaluated and followed by a paediatric cardiologist[9].

In physiological conditions the heart undergoes serial morphologic and functional adaptive changes to prolonged, regular exercise training. This physiologic cardiac remodelling affects mostly the left ventricle (LV) with an increased cavity size, wall thickness and mass. In hypertension, two major maladaptive changes in the left ventricle are commonly seen: left ventricular hypertrophy (increased LV mass) and diastolic dysfunction.

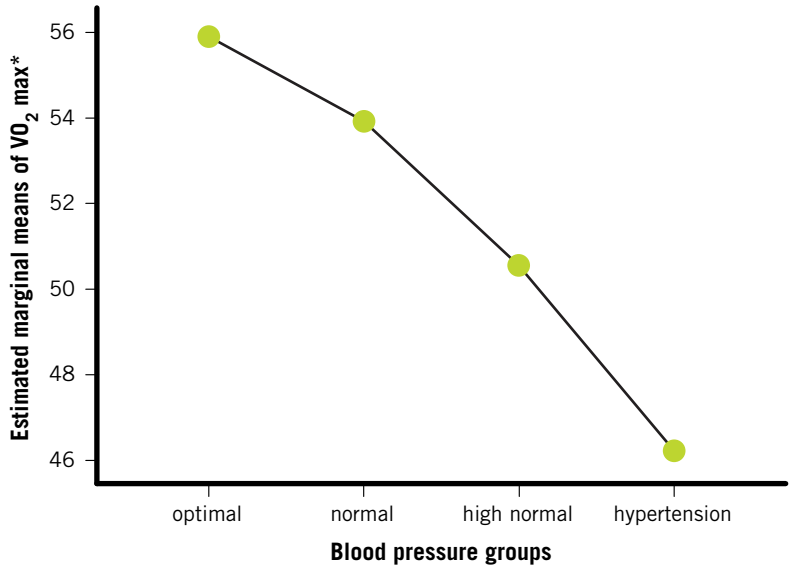


Figure 2: Maximal oxygen consumption (adjusted for age and body fat) in 89 elite male soccer players according to the level of blood pressure (unpublished data).

However, it can be difficult to distinguish adaptive from maladaptive left ventricular hypertrophy (LVH). The previous idea that concentric LVH is usually maladaptive and eccentric LVH adaptive has been abandoned[8]. We have recently reported only eccentric LVH in hypertensive athletes[2]. Therefore, the applicability of LVH assessment in the risk stratification of hypertensive athletes is questionable[2]. Although we found preserved diastolic function in all athletes, there was a certain degree of diastolic modulation among those with elevated blood pressure, which could be seen as early manifestation of hypertensive heart disease. It seems that the evaluation of diastolic function would provide better insight into the cause (physiological or pathological) of LVH.

Accordingly, two-dimensional echo-cardiography with tissue Doppler imaging (to assess LV diastolic function) can be useful when evaluating athletes with elevated blood pressure and their further risk stratification[2,8].

TREATMENT

Lifestyle modification

This is the first and the most important step in the prevention and treatment of hypertension. A summary of available medical interventions can be found in the clinical pathway for hypertension in athletes (Appendix 1). Non-pharmacological intervention should be started promptly with the aim to accomplish BP goals within a few months among athletes with stage 1 and 2 hypertension without other risk factors (at low-to-moderate added risk). Of course, all athletes, regardless of the blood pressure level should be encouraged to make lifestyle modifications such as healthy balanced dietary choices, weight management, smoking cessation and rational use of dietary supplements and NSAIDs. Although these are usually regarded as modifiable risk factors, some lifestyle changes could be challenging in the environment of elite sport.

Restriction of sodium intake, high consumption of fruits, vegetables and low-fat dairy products and other dietary changes have been shown to be effective in reducing BP. Evidence confirms that weight loss may reduce BP level in overweight individuals, but inappropriate weight loss strategies may affect athletic performance. The loss of fat with simultaneous preservation of lean (muscle) mass is an ideal scenario, but can be difficult to accomplish. An individualised approach should be promoted that takes into account the athlete's general health and dietary habits, as well as the specific aspects of their sport, training regimen and time of the season. Supervision by

experienced dieticians is ideal to minimise potential risks to health and performance and to accomplish the target BP level. In addition, the promotion of a high body mass in certain sports should be discouraged, especially in young athletes[9].

Recent studies have reported overuse of dietary supplements and a high prevalence of NSAID use in elite athletes (about 25%)[18]. Even though the athlete may consider the use of these substances beneficial, it is rarely rational and evidence-based, so should not be encouraged. Many of the dietary supplements used by athletes have little, if any, evidence to demonstrate health or performance benefits. Despite this, they still enjoy great popularity among athletes[18]. In addition, it has been demonstrated that the role of anti-inflammatory treatment is questionable for certain conditions (such as chronic tendinopathy)[19]. Furthermore, the concurrent use of 2 or more NSAIDs at the same time, by 20% athletes, shows that education of athletes and sports physicians about rational and effective NSAID use would be valuable[18]. In summary, a comprehensive and individualised approach to lifestyle modification, information, education and support for the athlete and team are central to the management of the hypertensive athlete.

Pharmacotherapy

After several months, if lifestyle changes are not successful in normalising BP in athletes at high risk, pharmacotherapy should be started. However, it is not mandatory for patients at low risk[5]. Sports cardiologists should follow current guidelines for management of hypertension for the general population and individualise the choice of drug and target dose[8,9]. Among recommended classes of antihypertensive therapy, the first-line options for athletes of all ages are: calcium antagonists, angiotensin-converting enzyme (ACE) inhibitors and angiotensin receptor blockers (ARB)[8]. They have been proven to be efficient, safe and without an adverse influence on exercise haemodynamics or exercise capacity.

A rational choice of pharmacotherapy for athletes excludes the use of drugs that could impair performance (exercise capacity) and those that are prohibited by the World Anti-Doping Agency (WADA). It is of the utmost importance that, when considering a medication for an athlete, the current WADA prohibited and monitored lists are consulted. Changes to these lists are made on an annual basis, for example telmisartan (an ARB) has recently been added to the monitored list for a potential performance enhancing effect in endurance athletes. Diuretics are banned in all sports and beta blockers in particular sports[20]. Furthermore, both classes of drugs can attenuate exercise capacity (maximal oxygen consumption) and so should be avoided in athletes. However, if these drugs are the only therapeutic option available to normalise BP, athletes should apply to their national or international federation for a Therapeutic Use Exemption certificate.

Competitive sports in athletes with hypertension

Hypertension is one of the major risk factors for CHD, which is the leading cause of sudden cardiac death in athletes above 35 years of age[4,8]. Therefore the risk stratification in athletes with hypertension is based not only on BP but also on the presence of other risk factors, target organ damage and associated clinical conditions (cardiovascular or renal complications). The risk can be graded as: low, moderate, high and very high added 10-year risk for fatal or non-fatal CVD[5,8]. The assessment of risk factor profile is important for decisions regarding the treatment strategy and sports participation of hypertensive athletes.

Hypertension is not just a risk factor but a serious disorder which can – through various mechanisms – lead to underperformance in athletes

The current recommendations for management and sports participation of adult athletes with hypertension and other cardiovascular disease have been addressed in consensus documents published by the American College of Cardiology – 36th Bethesda Conference[4] and European Society of Cardiology[5,8]. Guidelines for sports participation of hypertensive children were published by the American Academy of Paediatrics in 2010[9].

Today, it is clear that both endurance (dynamic) and strength (static) exercises lower blood pressure but the safety of high levels of exercise in hypertensive patients is still debated. It seems that strenuous dynamic activity has a more favourable BP profile than strenuous static exercise[4,5,8]. Aiming to facilitate the decision on sports participation of athletes with cardiovascular disorders, Mitchell et al. classified sports according to the intensity level of dynamic (A-B-C) and static type of exercise (I-II-III)[17].

The first condition for sports participation (of both children and adults) is well-controlled BP. In athletes at low risk (stage 1 HT without risk factors or concomitant heart disease), there are no restrictions for sports participation[4,9]. In adult athletes with moderate risk (e.g. stage 2 HT without risk factors or stage 1 HT with 1 to 2 risk factors) sports with a high static and dynamic component should be restricted (IIIC by Mitchell's classification: boxing, cycling, rowing, canoeing, speed skating and triathlon)[4,17]. On the other hand, in young athletes with stage 2 HT (in the absence of target organ damage) sports with a high static component (class IIIA-C) should be restricted[9,17]. Athletes from the high added risk category should not perform any sport with a high static component (IIIA-C) and those with a very high risk are advised to participate in only low static and low to moderate dynamic sports (IA-B)[5,8].

Hypertension and performance

Although there are conflicting data on whether elevated BP impairs exercise capacity, we recently reported that in elite male athletes, the maximal oxygen consumption gradually decreases across BP groups[2]. This is also illustrated in the sample of 89 male soccer players (unpublished data, Figure 2). Accordingly, hypertension is not just a risk factor but a serious disorder which can – through various mechanisms – lead to underperformance in athletes, especially in sports where dynamic-type components are predominant and higher maximal oxygen consumption is essential for better performance (for example soccer, cycling, rowing).

Open questions

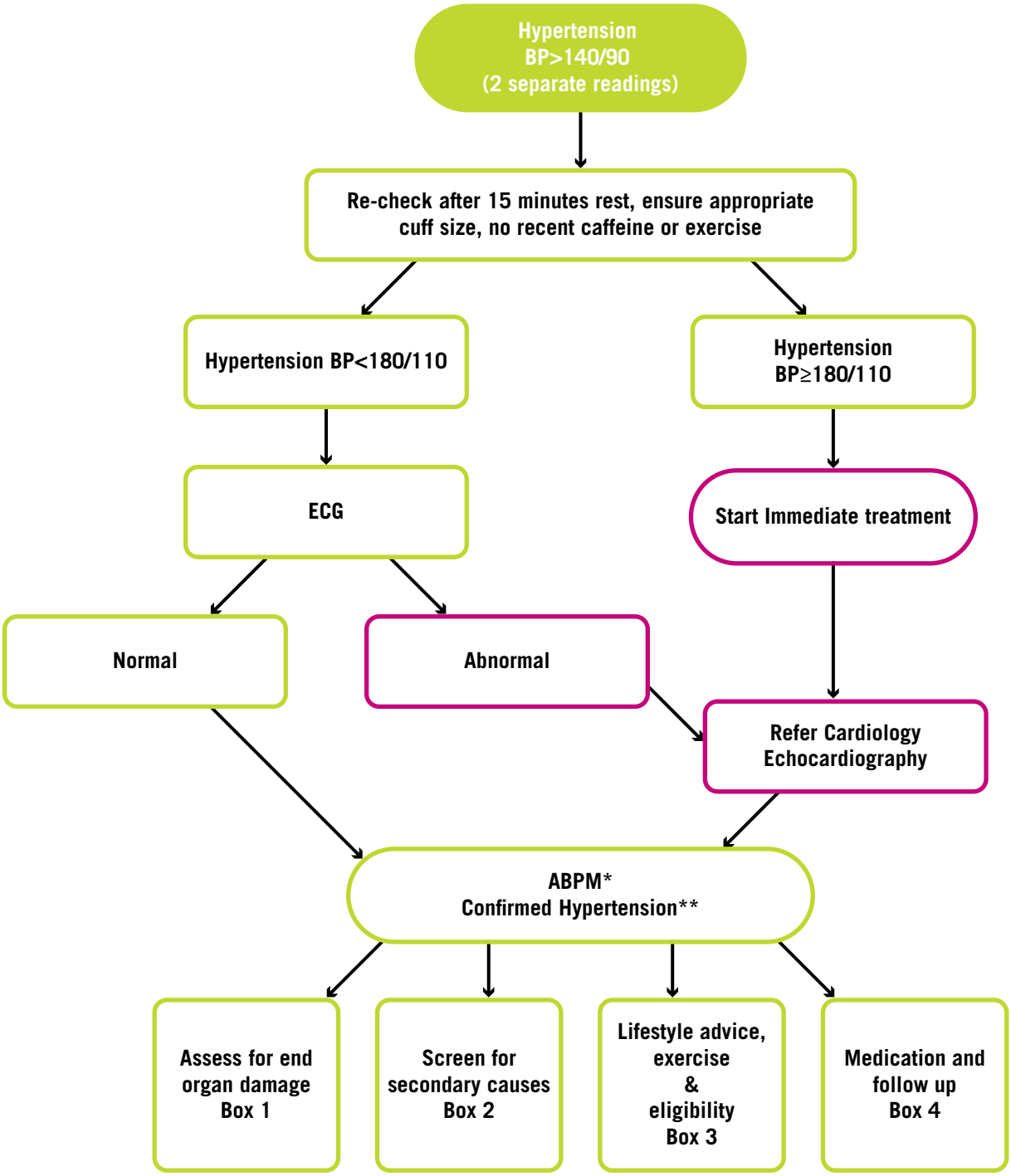
Further studies are necessary to identify subgroups of athletes and sports which may be at increased risk of developing hypertension, in order that more frequent pre-participation screening can be performed in those groups.

By following the current recommendations we note that pharmacologic treatment is not mandatory in athletes with stage 1 hypertension and without added risk factors. In addition, there are certain disagreements between the current European and American guidelines on sports participation of hypertensive athletes. For example, a cyclist with stage 1 hypertension and dyslipidaemia should refrain from his sport, according to ESC sports cardiology study groups' guidelines[5,8] but is eligible for any competitive sport (in the absence of target organ damage), according to 36th Bethesda conference[4]. Future studies are needed to clarify the real short- and long-term risks of competitive sport for the hypertensive athletic population.

Finally, more studies are needed to elucidate whether therapeutic goals for elite athletes should be set to lower BP levels in order to improve performance or diminish potential risks. For now, as for the general population, lowering the BP below the threshold for hypertension is the therapeutic goal in elite athletes.

CONCLUSION

Elite athletes, especially children, are usually regarded as a healthy population. However, the increasing trend towards hypertensive heart disease and evidence of several hypertension-related specific lifestyle habits raise concerns about the added risk of this disorder in athletes. Elevated blood pressure coupled with the physiological and psychological demands of elite sport may contribute to impairment of exercise capacity but also serious health risks. Established hypertension is associated with an elevated long-term risk of developing coronary artery disease, the leading cause of sudden cardiac death in older athletes. It is unequivocal that participation in some sports is associated with a higher prevalence of hypertension. By raising the awareness of hypertension amongst the athletic population, implementing more rigorous BP monitoring and developing preventive strategies and effective athlete-specific treatment interventions, we may make elite sport a healthier and safer environment.



*Use HBPM if ABPM not tolerated/available

**See box below for how to confirm diagnosis with ABPM/HBPM

Appendix 1: The Aspetar clinical pathway for the management of athletes with hypertension. BP=blood pressure, ECG=electrocardiogram, ABPM=ambulatory blood pressure monitoring, HBPM=home blood pressure monitoring.

Box 1: Assess for end organ damage

Cardiac

- *Echocardiography*
- *Assess cardiovascular risk (fasting lipid profile and glucose)*
- *Refer to cardiologist (if not already seen)*
- *Stress ECG*

Renal

- *Urine albumin excretion*
- *Serum electrolytes and creatinine*
- *Estimated glomerular filtration test*

Retina

- *Refer for fundoscopy and ophthalmology assessment*

Box 3: Lifestyle advice, exercise and eligibility

Smoking

- *Cessation*
- *Support groups and literature*

Diet

- *Assess current dietary habits, consider referral to dietician if BMI >25*
- *Avoid excess sugar, fat, cholesterol and salt. Increase fruit, vegetable and grain intake*
- *Beetroot juice 250ml daily (6.4mmol nitrate)*

Exercise

- *Moderate to vigorous physical aerobic activity, for 40 minutes, 3 to 5 days/week and avoid more than 2 hours daily of sedentary activities*
- *Establish realistic goals*

Eligibility criteria (Bethesda guidelines)

- *Athletes with stage I hypertension (140-159/90-99 mmHg), in the absence of end organ damage or concomitant heart disease, are free to compete without restriction but must be followed up to assess the impact of exercise*
- *Athletes with stage 2 hypertension (BP≥160/100 mmHg) should be restricted from high static sports (classes IIIA to IIIC) until hypertension is controlled*

Alcohol

- *Assess current intake and advise appropriately*
- *Support groups and literature*

Box 2: Screen for secondary causes

Drugs

- *Corticosteroids and mineralosteroids*
- *NSAIDs/cyclooxygenase-2 inhibitors*
- *Anabolic steroids*
- *Erythropoeitin*
- *Sympathomimetics*
- *Illicit drugs (cocaine/stimulants)*

Endocrine

- *24-hour urinary & plasma catecholamines/ metanephrines*
- *Plasma renin, aldosterone*
- *Plasma cortisol, aderenocorticotrophin hormone*
- *24-hour urinary cortisol*
- *Thyroid stimulatory hormone, free T3 (thyroxine) and free T4 (triiodothyronine)*
- *Plasma deoxycorticosterone & corticosterone*

Renal

- *Urine microscopy 24-hour collection for protein*
- *Abdominal ultrasound scan*

Renovascular

- *Plasma renin*
- *Doppler studies/MR angiography renal arteries*

Box 4: Medication & Follow Up

Medication

All drugs being taken must be registered with appropriate governing bodies. It is important to check current WADA prohibited and monitored lists.

Calcium channel antagonists

- *Not on WADA prohibited list 2015*

Diuretics

- *WADA list 2015 - may need TUE*
- *May lead to reduction in exercise performance and capacity*
- *Avoid in endurance athletes/training in heat*

ACE inhibitors/ARBs

- *Not on WADA list (telmisaratan)*
- *Can be combined with calcium channel antagonists*
- *Avoid in women of child-bearing age*

Beta blockers

- *WADA list 2015 - may need TUE*
- *May lead to reduction in exercise performance and capacity*

Follow-up

- *Regular BP checks, encourage home monitoring*
- *Combination therapy if needed*
- *Educate and reinforce compliance*
- *Repeat ambulatory monitoring to ensure adequate treatment and avoid overtreatment*

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Jelena Suzic Lazic M.D.

Department of Cardiology

University Clinical Centre 'Dr Dragisa Misovic-Dedinje'

Belgrade, Serbia

Victoria Watt M.D.

Cardiologist

Aspetar – Orthopaedic and Sports Medicine Hospital

Doha, Qatar

Contact: jsuzic@yahoo.com