Hypertension in special populations: athletes

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Main issues to discuss:

- Relationship between blood pressure values and physical activity
- Clinical approach to athletes with high blood pressure
- Relationship between sport, high blood pressure and cardiovascular risk
Hypertension in athletes: epidemiology

...the overall prevalence of high blood pressure in athletes is approximately 50% lower than in the general population...

Fagard RH, Cardiol Clin 2007

...so hypertension, though it may rarely be present in the young athlete, can occur frequently in the older sportsman!
Dynamic exercise reduces blood pressure

- Meta-analysis of 72 trials (3936 participants)
- Significant net reduction of resting and daytime ambulatory blood pressure (3.0/2.4 mmHg and 3.3/3.5 mmHg, respectively)
- Reduction of blood pressure was more pronounced in the hypertensive patients (6.9/4.9 mmHg) than in the others (1.9/1.6 mmHg)

Cornelissen VA, and Fagard RH, Hypertension 2005
Hypertension in athletes: clinical approach
1) Establish BP levels

- 410 football players at the annual preventive check (age 16 ± 4 years)
- 41 athletes out of 410 (10%) were detected as having elevated systolic BP or diastolic BP in the first measurement.
- 18 athletes out of 410 (4.4%) had BP above the accepted normal levels after two or more BP measurements
- Only 2 athletes had elevated 24h-ABPM values!

Kouidi E et al, Am J Hypert 1999

Be careful (as usual) in diagnosing hypertension before starting treatments / restrain the activity of an athlete!
Establishing BP levels in young athletes or in power sports (boxing, wrestling, weight lifting) athletes is not so simple...

- Children and adolescents
  - Age-adjusted tables base upon gender and height percentile
- Power sport athletes
  - Measurement of forearm circumference
- Appropriately sized cuff
  - Good luck finding one...

Fig 4. Determination of proper cuff size: step 2. The cuff bladder should cover 80% to 100% of the circumference of the arm.
2) Identify secondary causes of hypertension

As usual, but paying particular attention to:

- oral contraceptive pills (commonly taken by female athletes)
- caffeine, decongestants
- herbs and dietary supplements used to increase energy or control weight (often contain “natural” substances such as guarana, mahuang, and ephedra, which are stimulants)
- cocaine
- anabolic steroids
- growth hormone
- erythropoietine
- over-the-counter medications, including nonsteroidal anti-inflammatory drugs (NSAIDs)
Performance-enhancing drugs: androgenic-anabolic steroids

- synthetic derivatives of the male hormone testosterone
- increase strength of 5-20% and body weight (mainly lean mass) of 2-5 kg → used by body-builders, weight lifters; no effect on endurance performance
- Cardiovascular effects:
  - ↑ blood haemoglobin concentrations (↑ Epo)
  - ↑ blood pressure
  - ↓ HDL-cholesterol levels
  - Uncertain effect on cardiac structure and function
  - prothrombotic effect
  - ↑ atherosclerosis
  - Increased risk for CV events
  - Effects underestimated because of the relatively low doses administered in studies, lower than doses used by illicit steroid users

Hartgens, F and Kuipers H Sports Medicine 2004
Performance-enhancing drugs: GH and Epo

- **Growth hormone**
  - Increase muscle mass & decrease fat mass
  - **Cardiovascular effects:**
    - hypertension
    - cardiac disease
    - diabetes mellitus

- **Erythropoietin**
  - Stimulates red blood cells production, ↑blood viscosity
  - Increases oxygen carrying capacity
  - **Cardiovascular effects:**
    - hypertension
    - CV events
Performance-enhancing drugs: stimulants

- **Amphetamines**
  - Delay fatigue, enhance alertness, speed, power, endurance, concentration
  - Cardiovascular effects:
    - hypertension
    - angina
    - cerebral hemorrhage
    - arrhythmias

- **Ephedrine and pseudoephedrine**
  - OTC products (cold and allergy remedies)
  - Cardiovascular effects: *similar to amphetamines in high doses*

- **Caffeine**
  - Shortened reaction time, improved concentration, diuresis
  - Glycogen sparing leading to delayed fatigue
  - Cardiovascular effects:
    - cardiac damage
    - arrhythmias: combination with other stimulants may be fatal
Performance-enhancing drugs: illicit substances

- **Cocaine**
  - Minimal performance enhancing effect
  - Heightened arousal and increased alertness with low doses
  - Over confidence leading to increased risk of injury
  - Cardiovascular effects:
    - hypertension
    - miocardial ischemia
    - CV events
    - arrhythmias
2) Evaluate global cardiovascular risk

- Associate risk factors
- Target organ damage
- Accompanying clinical conditions

As usual!

<table>
<thead>
<tr>
<th>Blood pressure (mmHg)</th>
<th>Other risk factors, OD or Disease</th>
<th>Normal SBP 120–129 or DBP 80–84</th>
<th>High normal SBP 130–139 or DBP 85–89</th>
<th>Grade 1 HT SBP 140–159 or DBP 90–99</th>
<th>Grade 2 HT SBP 160–179 or DBP 100–109</th>
<th>Grade 3 HT SBP ≥180 or DBP ≥110</th>
</tr>
</thead>
<tbody>
<tr>
<td>No other risk factors</td>
<td>Average risk</td>
<td>Average risk</td>
<td>Low added risk</td>
<td>Moderate added risk</td>
<td>High added risk</td>
<td></td>
</tr>
<tr>
<td>1–2 risk factors</td>
<td>Low added risk</td>
<td>Low added risk</td>
<td>Moderate added risk</td>
<td>Moderate added risk</td>
<td>Very high added risk</td>
<td></td>
</tr>
<tr>
<td>3 or more risk factors, MS, OD or Diabetes</td>
<td>Moderate added risk</td>
<td>High added risk</td>
<td>High added risk</td>
<td>High added risk</td>
<td>Very high added risk</td>
<td></td>
</tr>
<tr>
<td>Established CV or renal disease</td>
<td>Very high added risk</td>
<td>Very high added risk</td>
<td>Very high added risk</td>
<td>Very high added risk</td>
<td>Very high added risk</td>
<td></td>
</tr>
</tbody>
</table>

Mancia G et al., J Hypertens 2007
Which diagnostic procedures are indicated in athletes with hypertension?

As usual:
• medical history and physical examination
• Routine blood exams
• ECG

Mancia G et al., ESC/ESC Guidelines on Hypertension, J Hypertens 2007

Plus:
• echocardiography
• exercise testing

Pelliccia A et al. Recommendations for competitive sports participation in athletes with cardiovascular disease, ESC consensus document, Eur Heart J 2005
Indications for exercise testing depends on the patient’s risk profile

<table>
<thead>
<tr>
<th>Demands of exercise (static or dynamic)</th>
<th>Risk category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light (＜40% of max)</td>
<td>No</td>
</tr>
<tr>
<td>Moderate (40%–59% of max)</td>
<td>No</td>
</tr>
<tr>
<td>High (≥60% of max)</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Critical issues:

- Athletes are a population with a low probability of coronary heart disease and high prevalence of left ventricular hypertrophy → most positive tests on electrocardiography are falsely positive!
- Exaggerated blood pressure response to exercise → Inconclusive evidence about its role. However, subjects with an excessive rise of blood pressure during exercise are more prone to develop hypertension and should be followed up more closely.
Sports eligibility depends on the patient’s risk profile

<table>
<thead>
<tr>
<th>Level of risk</th>
<th>Criteria for eligibility</th>
<th>Recommendations</th>
<th>Follow up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low added risk</td>
<td>Well controlled BP</td>
<td>All sports</td>
<td>Yearly</td>
</tr>
<tr>
<td>Moderate added risk</td>
<td>Well controlled BP and risk factors</td>
<td>All sports, with the exclusion of high static / high dynamic sports (boxing, canoeing, cycling, triathlon, decathlon, speed skating)</td>
<td>Yearly</td>
</tr>
<tr>
<td>High added risk</td>
<td>Well controlled BP and risk factors</td>
<td>All sports, with the exclusion of high static sports (all above plus rock climbing, waterskiing, weight lifting, windsurfing, body building, wrestling, downhill skiing, snowboarding)</td>
<td>Yearly</td>
</tr>
<tr>
<td>Very high added risk</td>
<td>Well controlled BP and risk factors, no associated clinical conditions</td>
<td>Only low-moderate dynamic / low static sports (bowling, cricket, golf, riflery, table tennis, tennis, volleyball, baseball)</td>
<td>Yearly</td>
</tr>
</tbody>
</table>

Secondary hypertension of renal origin (particularly polycystic kidney): avoid “collision” sports that could lead to kidney damage.
Treatment: non pharmacological therapy

Compared with the general population, athletes and other physically active patients are often more motivated to comply with nonpharmacologic interventions:

• Reduce processed foods (rich in sodium) intake (common in the diets of adolescents)
• Increase rich in potassium food intake (endurance athletes may tend to be hypokalemic)
• Weight loss
• Abstinence from drugs (es. FANS) or illicit substances
No real compelling indications, but consider that:

• Some antihypertensive drugs are considered doping substances and are banned by many sports associations

• Some antihypertensive drugs have negative effect on exercise performance
Pharmacological therapy: diuretics

- **Used as doping substances:** YES
  - Rapid weight loss: useful in boxing, wrestling, judo
  - Excretion or dilution of illegal substances
- **Adverse effects on sport performance:** YES
  - 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 long-term treatment;
  - (Loop >>> thyazide diuretics) Hypovolemia, orthostatic hypotension, electrolyte imbalance (loss of potassium, magnesium)
  - Muscle cramps, arrhythmias, and rhabdomyolysis in patients who are exercising intensely or competing in warm weather
- **Indications:**
  - NO in elite athletes who are required to undergo drug testing
  - 2nd choice and low dosage in physically active patients with hypertension (association with potassium-sparing diuretics?) and salt-sensitive hypertensive athletes (i.e. blacks)
Pharmacological therapy: β-blockers

- **Used as doping substances:** YES
  - Anti-tremor, anxiolytic effect
  - Precision sports: shooters, ski jumpers, archery, diving

- **Adverse effects on sport performance:** YES
  - Non cardioselective >>> cardioselective β-blockers
  - ↓ inotropism and heart rate
  - ↑ systemic vascular resistance (especially muscle and skin), ↓ cardiac output
  - ↓ maximum oxygen uptake,
  - ↓ lipolysis and glycogenolysis → hypoglycemia may occur after intense exercise
  - Perception of greater exertion during exercise
  - Possible bronchospasm

- **Indications:**
  - NO in elite athletes of precision sports
  - Only if there is an underlying condition (e.g., coronary artery disease)
  - Combined alpha-beta blocker may be the best choice (less impairment of muscle blood flow and maximum oxygen uptake)
Pharmacological therapy: RAS blockers

• Used as doping substances: **NO**
• **Adverse effects on sport performance:** **NO**
  – \( \downarrow \) systemic vascular resistance
  – \( \uparrow \) cardiac output
  – No major effects on energy metabolism
  – no impairment of maximum oxygen uptake
• **Indications:**
  – First choice
  – NO in female athletes in reproductive age
Pharmacological therapy: DHP calcium-channel blockers

- **Used as doping substances:** NO
- **Adverse effects on sport performance:** NO
  - No major effects on energy metabolism, no impairment of maximum oxygen uptake, no deleterious effects on training or competition
  - Potential competitive “steal” of muscle blood flow (because of vasodilatation) and earlier onset of the lactate threshold
- **Indications:**
  - First choice, especially in black athletes
Main issues to discuss:

• Relationship between blood pressure values and physical activity
• Clinical approach to athletes with high blood pressure
• Relationship between physical exercise, high blood pressure and cardiovascular risk
CV disease in athletes: epidemiology

...the number of athletes who die of cardiovascular or related causes each year in the U.S. is probably less than 300, compared with the large number of athletes participating in a broad spectrum of organized sports (about 10 to 15 million) of all ages in the U.S...

36th Bethesda Conference: Eligibility Recommendations for Competitive Athletes With Cardiovascular Abnormalities, JACC 2005
### Table 1. Causes of Sudden Death in 387 Young Athletes*

<table>
<thead>
<tr>
<th>Cause</th>
<th>No. of Athletes</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertrophic cardiomyopathy</td>
<td>102</td>
<td>26.4</td>
</tr>
<tr>
<td>Commotio cordis</td>
<td>77</td>
<td>19.9</td>
</tr>
<tr>
<td>Coronary artery anomalies</td>
<td>53</td>
<td>13.7</td>
</tr>
<tr>
<td>Left ventricular hypertrophy of indeterminate causation†</td>
<td>29</td>
<td>7.5</td>
</tr>
<tr>
<td>Myocarditis</td>
<td>20</td>
<td>5.2</td>
</tr>
<tr>
<td>Ruptured aortic aneurysm (Marfan syndrome)</td>
<td>12</td>
<td>3.1</td>
</tr>
<tr>
<td>Arrhythmogenic right ventricular cardiomyopathy</td>
<td>11</td>
<td>2.8</td>
</tr>
<tr>
<td>Tunneled (bridged) coronary artery‡</td>
<td>11</td>
<td>2.8</td>
</tr>
<tr>
<td>Aortic valve stenosis</td>
<td>10</td>
<td>2.6</td>
</tr>
<tr>
<td>Atherosclerotic coronary artery disease</td>
<td>10</td>
<td>2.6</td>
</tr>
<tr>
<td>Dilated cardiomyopathy</td>
<td>9</td>
<td>2.3</td>
</tr>
<tr>
<td>Myxomatous mitral valve degeneration</td>
<td>9</td>
<td>2.3</td>
</tr>
<tr>
<td>Asthma (or other pulmonary condition)</td>
<td>8</td>
<td>2.1</td>
</tr>
<tr>
<td>Heat stroke</td>
<td>6</td>
<td>1.6</td>
</tr>
<tr>
<td>Drug abuse</td>
<td>4</td>
<td>1.0</td>
</tr>
<tr>
<td>Other cardiovascular cause</td>
<td>4</td>
<td>1.0</td>
</tr>
<tr>
<td>Long QT syndrome§</td>
<td>3</td>
<td>0.8</td>
</tr>
<tr>
<td>Cardiac sarcoidosis</td>
<td>3</td>
<td>0.8</td>
</tr>
<tr>
<td>Trauma causing structural cardiac injury</td>
<td>3</td>
<td>0.8</td>
</tr>
<tr>
<td>Ruptured cerebral artery</td>
<td>3</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Most causes are congenital or idiopathic diseases

Hypertension itself is not associated with sudden death

Dynamic exercise reduces CV risk

- 22,197 men (3,184 previously diagnosed with hypertension, 3,257 with elevated clinic BP but no history of HT, 15,726 normotensives), mean follow-up 10 years
- Cardiorespiratory fitness assessed by maximal exercise testing

Church TS et al, Am J Cardiol 2001
Effects of dynamic exercise on CV risk is explained not only by amelioration of traditional risk factors

- Differences in risk factors explain about 59% of the relative cardiovascular risk reduction associated with exercise
- At least 40% of the risk reduction associated with exercise cannot be explained by established or emerging risk factors

Mora S et al, Circulation 2007
Regular aerobic exercise augments endothelium-dependent vasorelaxation in hypertensive subjects

Higashi Y et al. Circulation 1999
...but what happens when athletes become older?
Ischemic heart disease in former athletes

2049 male athletes who had represented Finland in international competitions during 1920 to 1965, and 1403 controls

In-hospital care from all causes was extracted from the national hospital discharge registry for the period 1970 through 1990

The RR for hospitalization for ischemic heart disease, adjusted for age and occupational group, was:

- lower in endurance (long-distance running, cross-country skiing) and mixed (soccer, ice-hockey, basketball) sports groups as compared with controls (p<.001)
- increased among power sports (boxing, wrestling, weight lifting) athletes (p<.001)
Aging, endothelial dysfunction and aerobic physical exercise

Taddei S et al. Circulation 2000
Conclusions

• Incidence of hypertension is low in athletes, but it can be more frequent with advancing age

• It is important to exclude the intake of substances which can increase blood pressure values (and CV risk!!)

• Diagnostic procedures must include echocardiography and exercise testing

• Sport activity can be permitted depending on the presence of well controlled blood pressure values and low CV risk

• Although compelling indications do not exist, preferred pharmacological treatment should be based on RAS-blockers and/or calcium antagonists

• While endurance sports reduce CV events, power sports increase the risk of coronary artery disease