ARISTOTLE UNIVERSITY OF THESSALONIKI, GREECE
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EXERCISE IN HYPERTENSION

EFFECTIVENESS OR DANGEROUS?

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Factors Influencing Blood Pressure

- Blood Pressure = Cardiac Output x Systemic Vascular Resistance

Factors Influencing BP

- HR
- SNS/PNS
- Vasoconstriction/vasodilation
- Fluid volume
  - Renin-angiotensin
  - Aldosterone
  - ADH

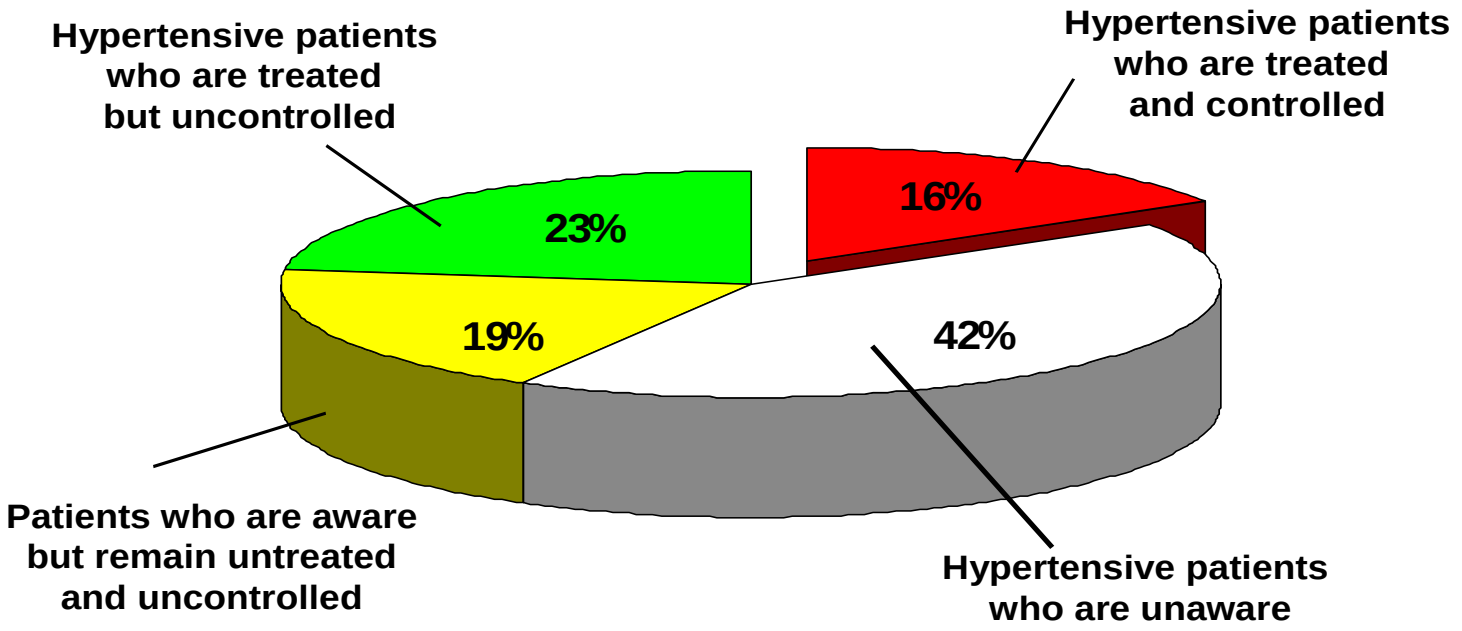
Hypertension
Definition

- **Hypertension is sustained elevation of BP**
  - **Systolic blood pressure ≥ 140 mm Hg**
  - **Diastolic blood pressure ≥ 90 mm Hg**

HYPERTENSION

The Challenge

22% of Canadian adults 18 to 70 years of age have hypertension



Source : Joffres et al. (1997) Am. J. Hypertension 10: 1097-1102

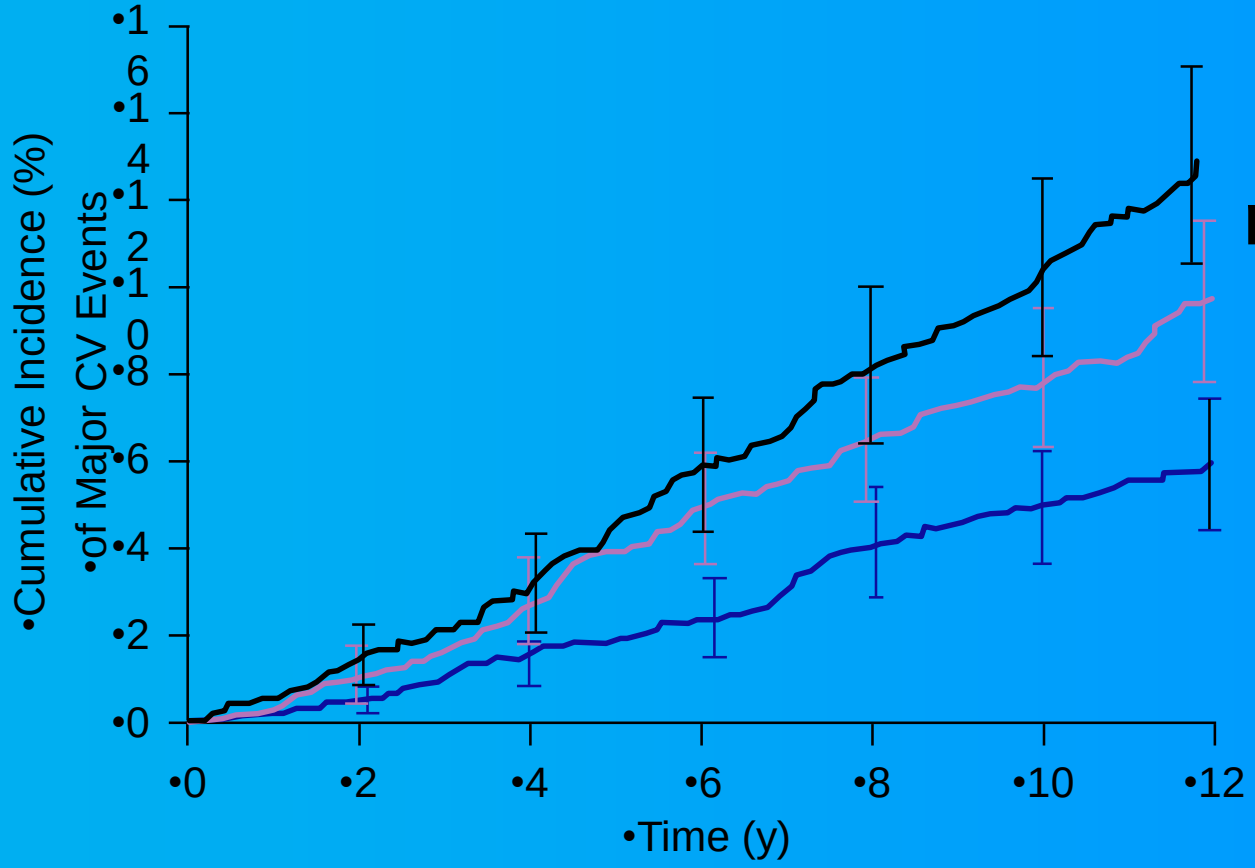
Epidemiology of arterial hypertension

- **Arterial hypertension is one of the most prevalent cardiovascular diseases.**
- **Arterial hypertension affects 20-50 % of adults in developed countries.**
- **Frequency of arterial hypertension suddenly increases after 50 years of life (>50% of this population).**
- **Worldwide, hypertension affects over 970 milion persons.**

Definition and classification of blood pressure levels (mmHg)

Category	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 syst. hypertension	≥140	and	<90

Impact of High-Normal BP on Risk of Major CV Events* in Men



•High-normal BP

•Normal BP

•Optimal BP

- * Defined as death due to CV disease; recognized myocardial infarction (MI), stroke, or congestive heart failure (CHF).
- Adapted from Vasan RS. *N Engl J Med.* 2001;345:1291-1297.

Arterial Hypertension as a risk factor

- **Hypertension is a highly prevalent risk factor for cardiovascular disease**

- **Hypertension plays a major etiologic role in the development of cerebrovascular disease, ischemic heart disease, cardiac and renal failure**

Assessment of global cardiovascular risk in arterial hypertension

- **Grades of hypertension**

- **Total cardiovascular risk (coexistence different risk factors, organ damage, concomitant diseases)**

Stratification of total CV risk

- **Four categories :**

- **- Low**
- **- Moderate**
- **- High**
- **- Very high**

refer to 10 year risk of fatal or non-fatal CV event

Diagnostic evaluation in arterial hypertension

- **Establishing BP values**
- **Identyfying secondary causes of AH**
- **Searching for :**
- **-other risk factors**
- **-subclinical organ damage**
- **-concomitant diseases**
- **-accompanying CV and renal complications**

Diagnostic procedures in arterial hypertension

- **repeated BP measurements**
- **family and clinical history**
- **physical examination**
- **laboratory and instrumental investigation**

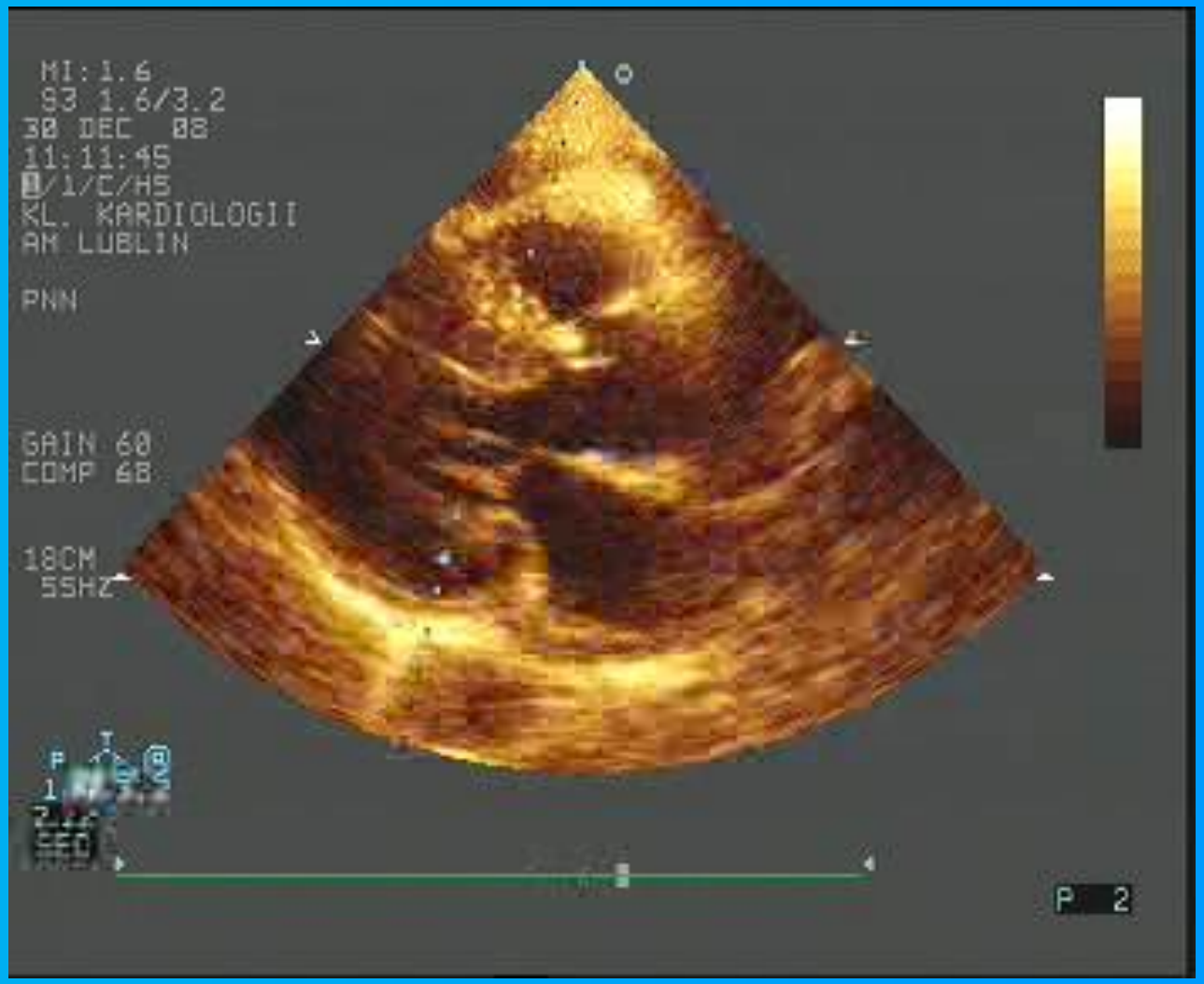
Laboratory and instrumental investigation- routine tests

- Fasting plasma glucose
- Serum total cholesterol, LDL-cholesterol, HDL-cholesterol
- Fasting serum triglycerides
- Serum potassium
- Serum uric acid
- Serum creatinine
- Estimated creatinine clearance
- Haemoglobin and haematocrit
- Urinalysis
- Electrocardiogram

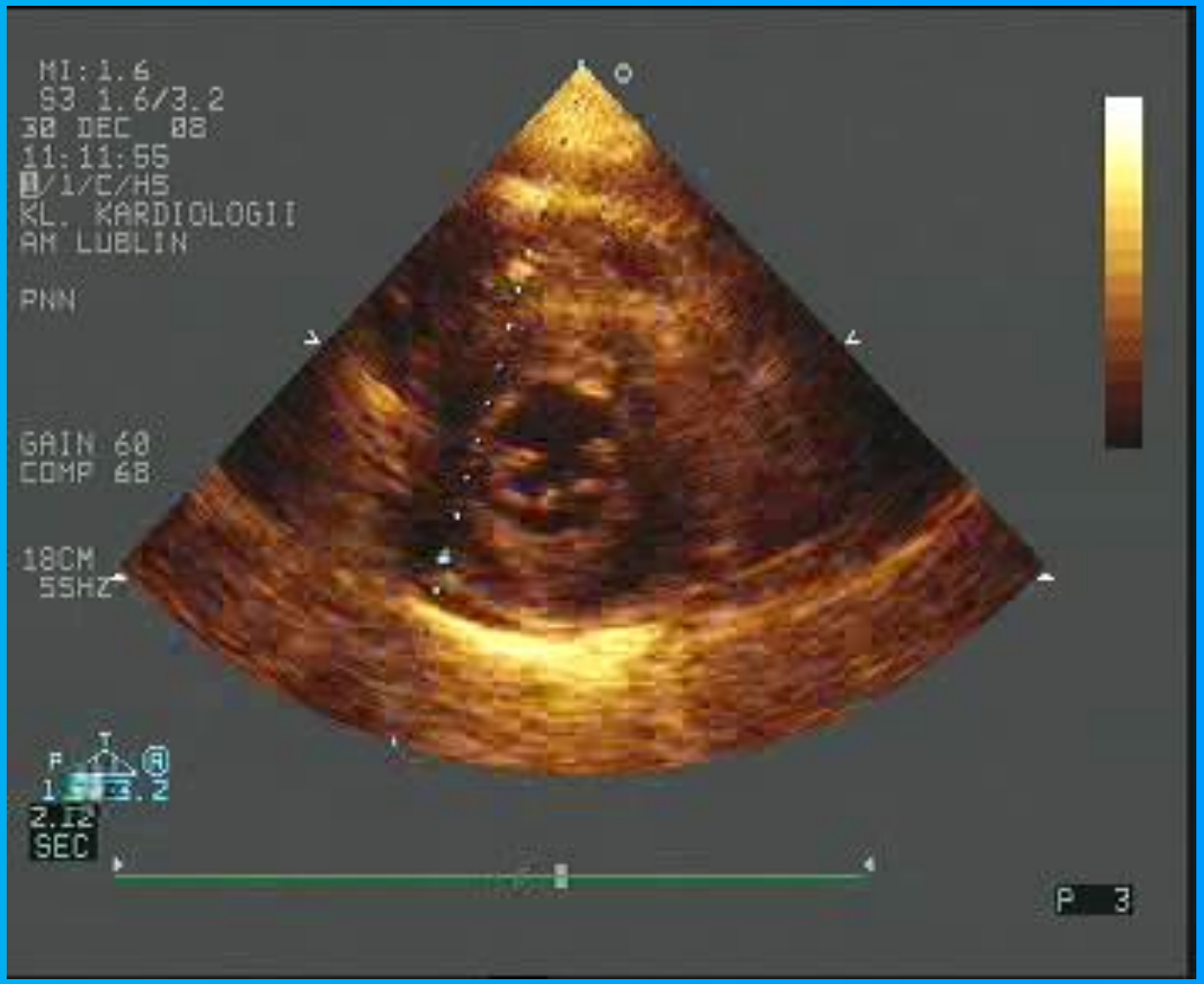
Laboratory and instrumental investigation

- **Echocardiogram**
- **Carotid ultrasound**
- **Quantitative proteinuria**
- **Fundoscopy**
- **Glucose tolerance test (if fasting plasma glucose >5.6 mmol/L (100 mg/dL)**
- **Home and 24 h ambulatory BP monitoring**

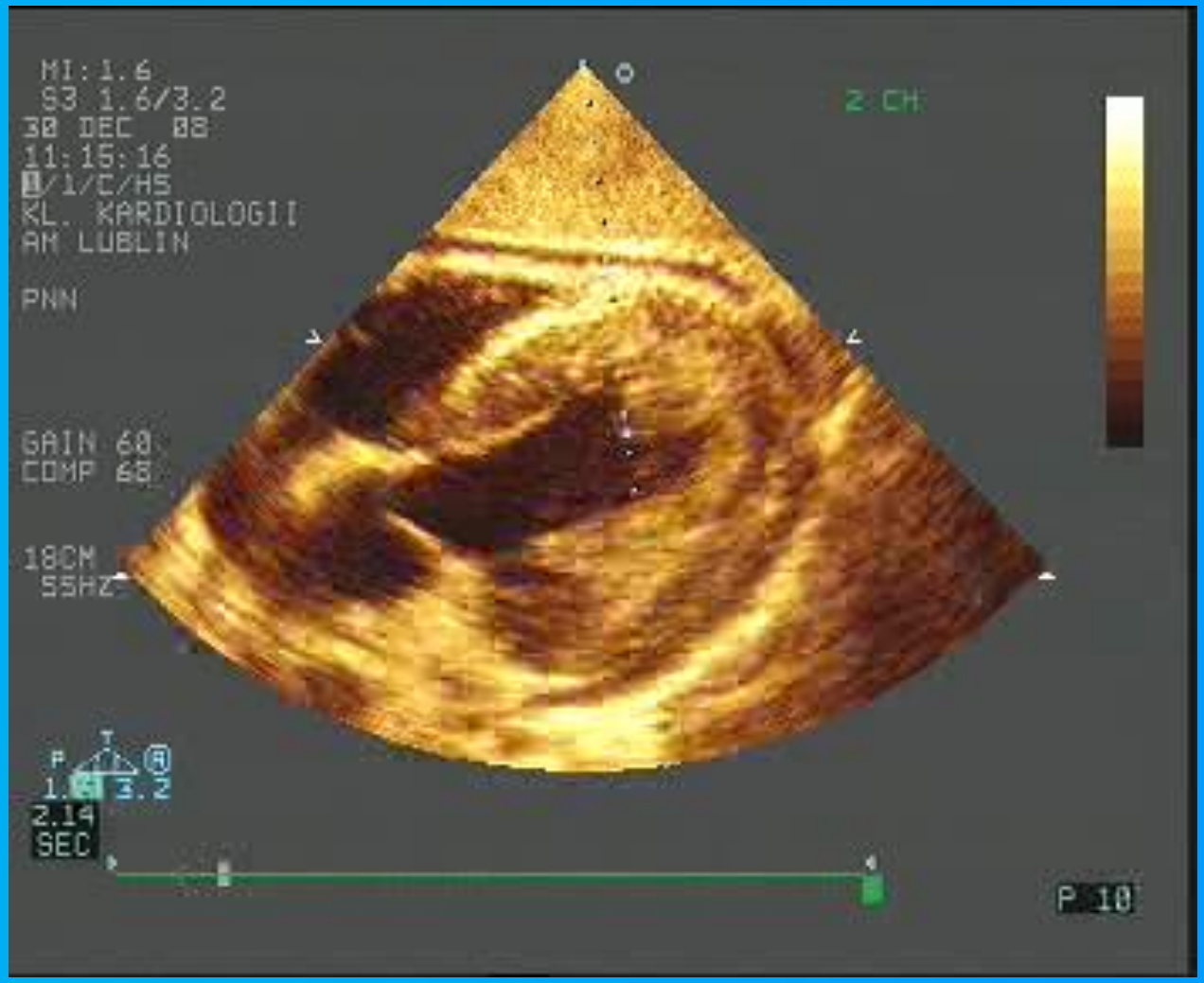
Left ventricular hypertrophy, parasternal long axis view



Left ventricular hypertrophy, parasternal short axis view



Left ventricular hypertrophy, subcostal view



Extended laboratory and instrumental investigation

- **Search for cerebral, cardiac, renal, vascular damage, for secondary hypertension:**
- **measurement of renin, aldosteron,corticosteroids,catecholamines in plasma and/or urine**
- **arteriographies, CT, MRI**

Aim of antihypertensive therapy

- **The primary goal of treatment is to achieve maximum reduction in the long-term total risk of CV disease**
- **For this reason lowering BP therapy (at least < 140/90 mm Hg) and treatment of all reversible risk factors are indicated**
- **In diabetes and in high and very high risk patients BP target should be at least < 130/80 mmHg**

Risk Stratification and Treatment

Blood Pressure Stages (mm Hg)	Risk Group A No Risk Factors No TOD/CCD	Risk Group B ≥ One Risk Factor other than DM No TOD/CCD	Risk Group C TOD/CCD and/or DM
High-Normal (130-139/ 85-89)	Lifestyle modifications	Lifestyle modifications	**Drug therapy**
Stage 1 (140-159/ 90-99)	Lifestyle modifications (up to 12 months)	Lifestyle modifications (up to 6 mos)	**Drug therapy**
Stages 2 and 3 (≥ 160/ ≥100)	**Drug therapy**	**Drug therapy**	**Drug therapy**

Adapted from JNC VI; TOD = Target organ damage CCD = Clinical cardiovascular disease

Choice of the antihypertensive drugs

- **Five major classes of these drugs are suitable for initiation and maintenance of treatment, alone or in combination :**
- **thiazide diuretics**
- **calcium antagonists (CA)**
- **ACE-inhibitors (ACEI)**
- **angiotensin receptor blockers (ARB)**
- **beta-blockers (BB)**

Lifestyle changes

- smoking cessation
- weight reduction
- reduction of excessive alkohol intake
- physical exercise
- reduction of salt intake
- increase in fruit and vegetables intake
- decrease in saturated and total fat intake

PHYSICAL INACTIVITY AND LOW FITNESS LEVELS ARE ASSOCIATED WITH:

- **HIGHER BLOOD PRESSURE LEVELS**

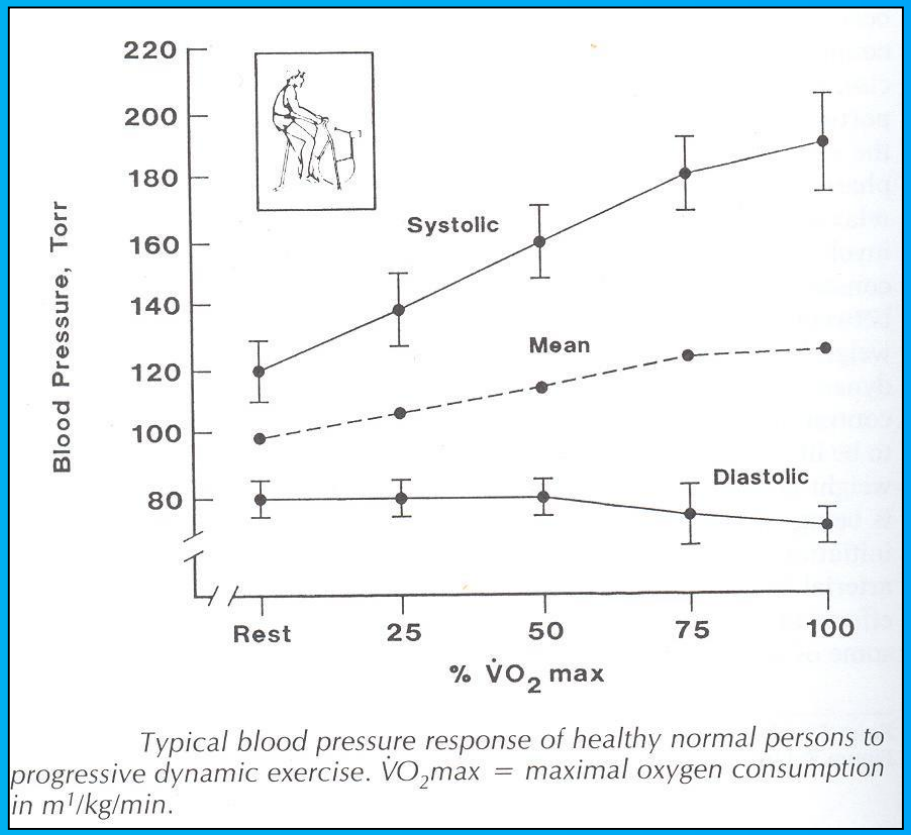
- **INCREASED INCIDENCE OF HYPERTENSION IN MEN**

USA National Institutes of Health, 1997

REGULAR AEROBIC EXERCISE IS AN IMPORTANT PART OF AN INITIAL LIFESTYLE MODIFICATION FOR PATIENTS WITH ESSENTIAL HYPERTENSION

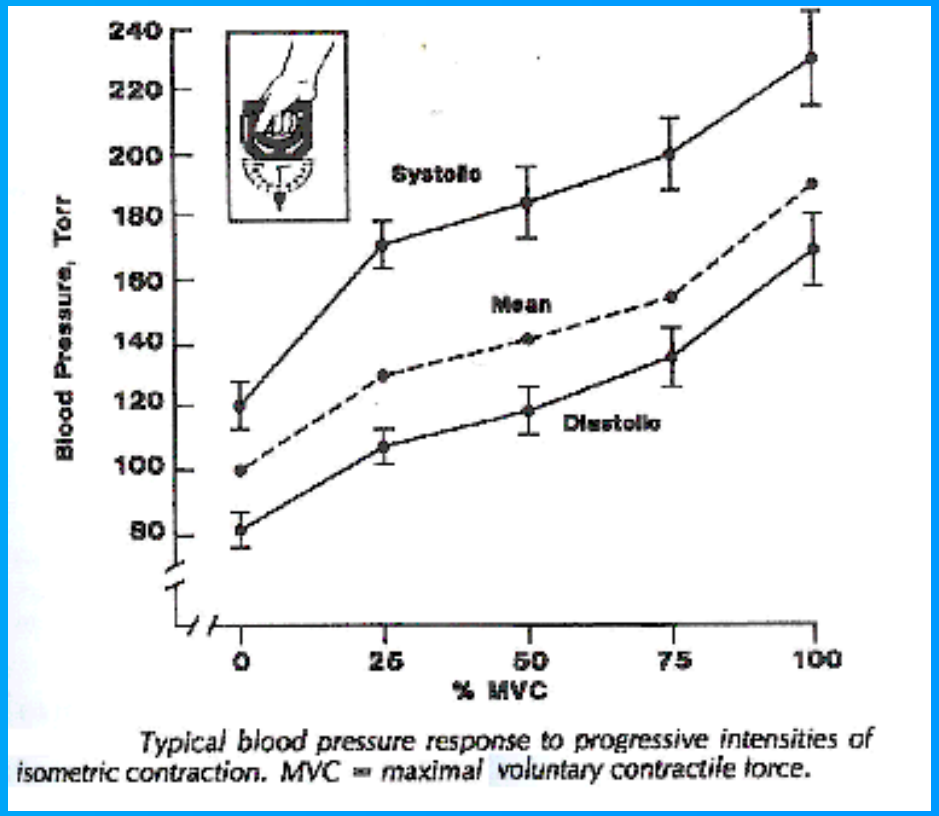
W.H.O. 1999

BLOOD PRESSURE RESPONSE TO EXERCISE IN NORMOTENSIVES



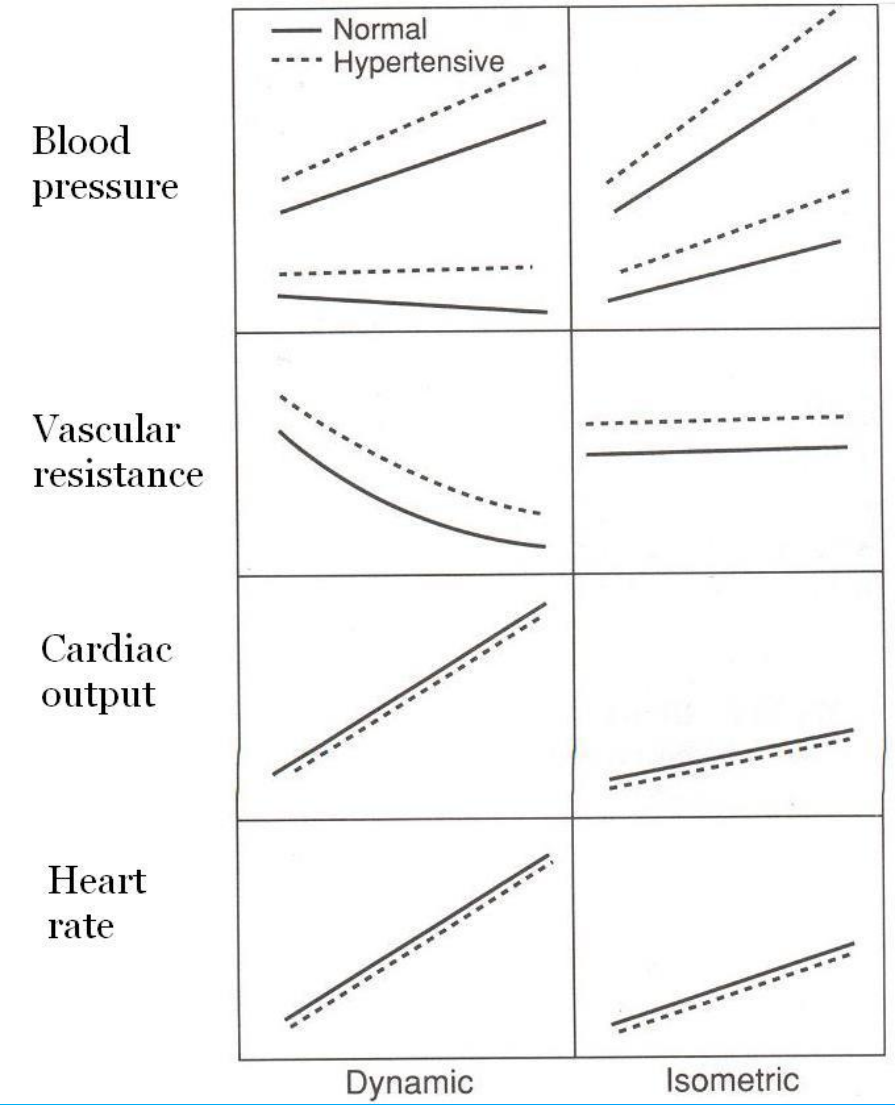
Typical blood pressure response of healthy normal persons to progressive dynamic exercise. $\dot{V}O_2$max = maximal oxygen consumption in m^1/kg/min.

MacDougall JD et al, J Appl Physiol 1992



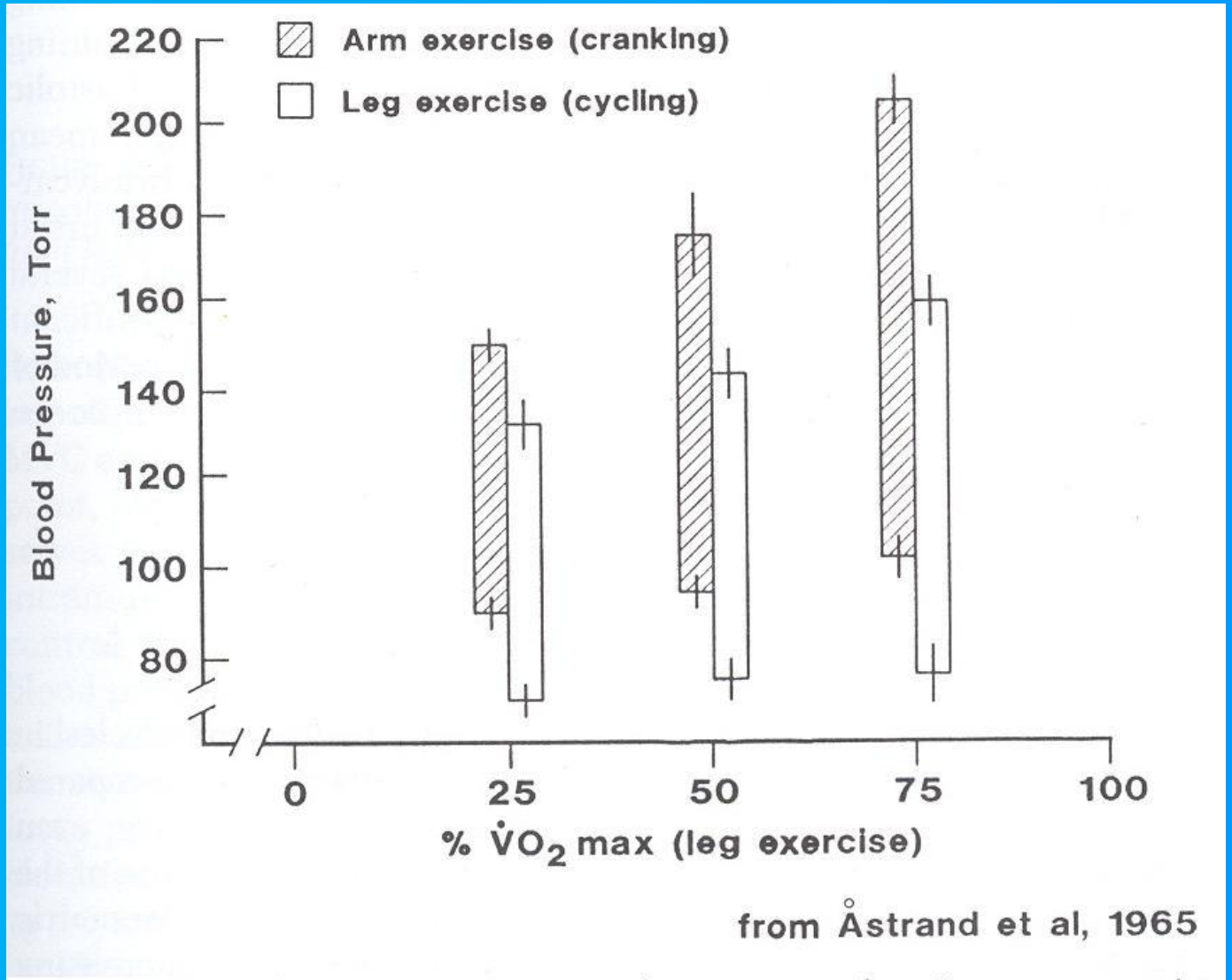
Typical blood pressure response to progressive intensities of isometric contraction. MVC = maximal voluntary contractile force.

BLOOD PRESSURE RESPONSE TO EXERCISE IN HYPERTENSIVE PATIENTS

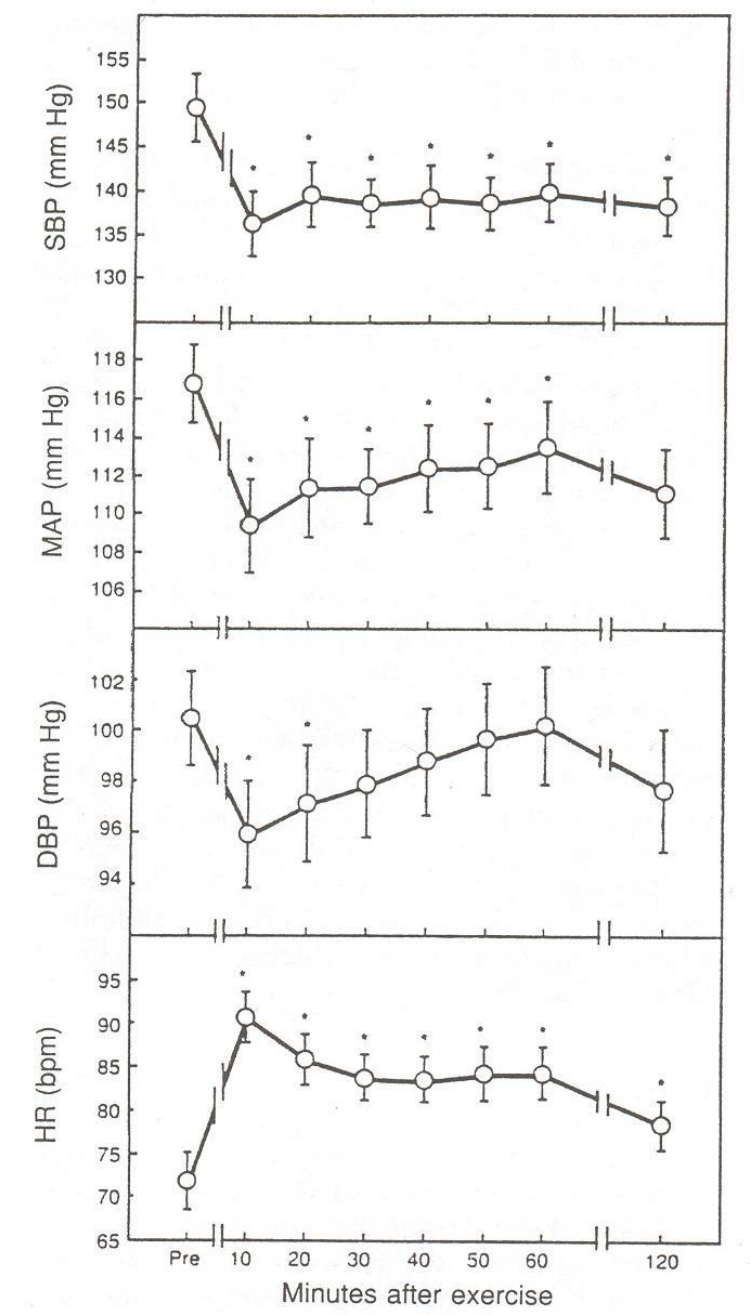


BLOOD PRESSURE RESPONSE TO ISOMETRIC HANDGRIP AND TREADMILL EXERCISE IN NORMAL AND HYPERTENSIVE YOUNG ADULTS

	Isometric Handgrip	Treadmill Exercise	
	50% of maximum	50%	100%
Normal	<180/120	≤180/80	<220/80
Mild Hypertension	180-190/120-130	180-190/80-90	210-220/80-90
Moderate Hypertension	>190/130	>190/90	>220/90



Blood pressure response of persons performing arm exercise and leg exercise at the same absolute power output ($\dot{V}O_2$).



Postexercise hypotension

Ambuladory blood pressure recordings during and after a single bout of exercise training in hypertensive subjects. Note continuous decline in systolic (SBP), diastolic (DPB), and mean (MAP) after exercise.

Rueckert P. et al, Am. J. Hypertens 1993

MECHANISMS OF THE HYPOTENSIVE EFFECT OF EXERCISE

- TRANSIENT DECREASE IN STROKE VOLUME
- PERIPHERAL VASODILATION
- SUBSTANTIAL REDUCTION IN MUSCLES
- SYMPATHETIC NERVE ACTIVITY (?)

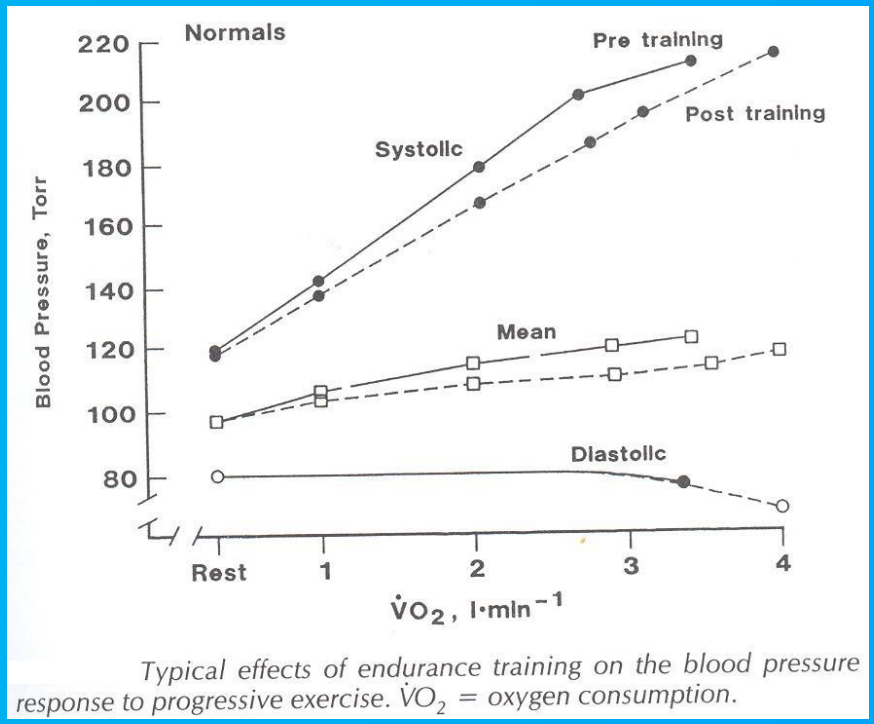
EFFECTS OF EXERCISE TRAINING

- REDUCES THE MAGNITUDE OF RISE IN BP IN PERSONS AT INCREASED RISK FOR DEVOLOPING HYPERTENSION

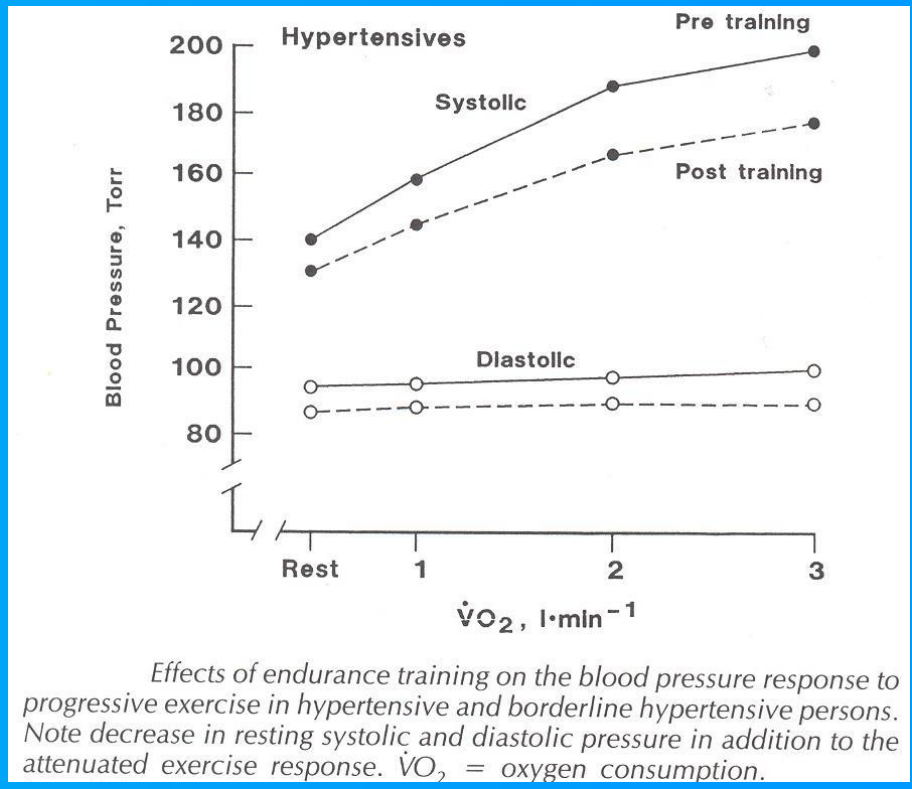
- ELICIT AN AVERAGE REDUCTION OF ABOUT 10mmHg IN BOTH SYSTOLIC AND DIASTOLIC BP (STAGE I/II HYPERTENSION)

META-ANALYSIS OF EXERCISE TRAINING STUDIES IN HYPERTENSION

	All	Control	Mild Hypertension	Substained Hypertension
Δ SBP (mm Hg)	-8	-5	-13	-19
Δ DBP (mm Hg)	-5	-3	-8	-11



Typical effects of endurance training on the blood pressure response to progressive exercise. $\dot{V}O_2$ = oxygen consumption.



Effects of endurance training on the blood pressure response to progressive exercise in hypertensive and borderline hypertensive persons. Note decrease in resting systolic and diastolic pressure in addition to the attenuated exercise response. $\dot{V}O_2$ = oxygen consumption.

MECHANISMS OF POSTTRAINING DECREASES IN BP IN HYPERTENSIVES

A. **DIRECT**

- **Reduce cardiac output**
- **Decrease sympathetic activity (reduce vascular a-adrenergic-receptors responsiveness?)**
- **Reduce total peripheral vascular resistance (improve endothelial function, enhance shear stress, increase production of NO etc.)**
- **Increase large artery compliance**
- **Increase arterial and cardiopulmonary Baroreflex sensitivity**
- **Reduce plasma volume (alteration in renal function)**
- **Ameliorate hyperinsulinemia**

THE EFFECTS OF EXERCISE TRAINING ON REVERSAL OF LVH IN HYPERTENSIVES

Exercise training appears to have substantial benefits for hypertensives in terms of regression of their pathological LVH

Koren MJ et al, Ann Intern Med 1991

REDUCTION IN CV DISEASE RISK WITH EXERCISE TRAINING IN HYPERTENSIVES

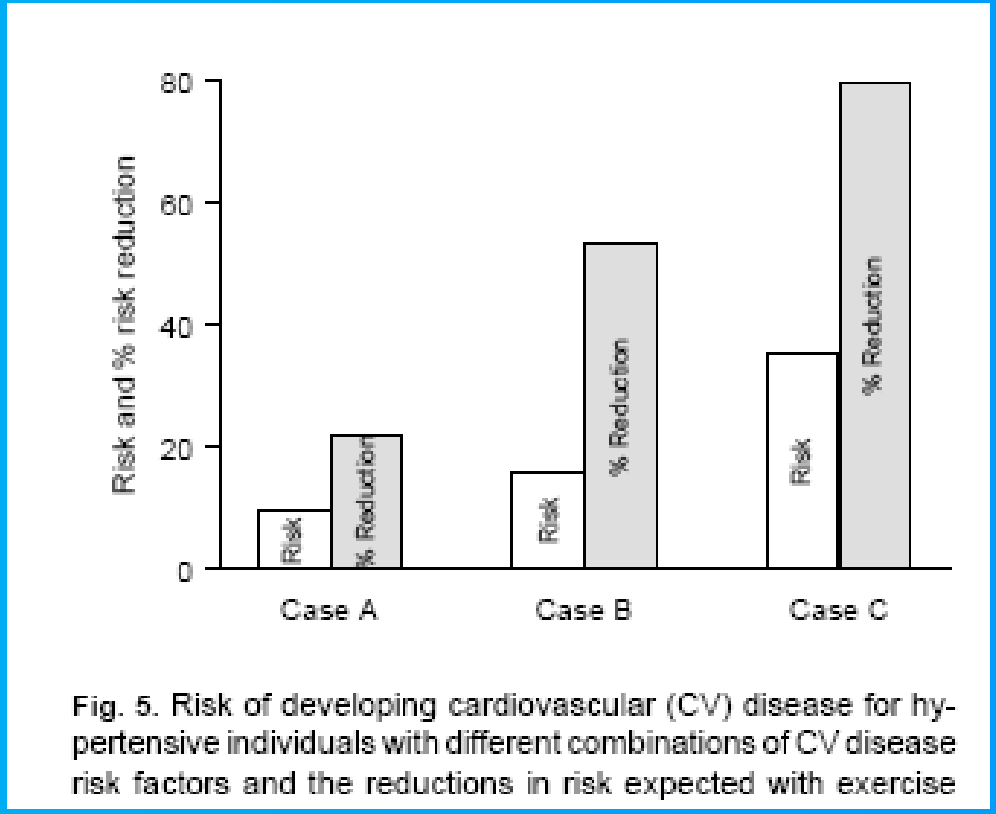


Fig. 5. Risk of developing cardiovascular (CV) disease for hypertensive individuals with different combinations of CV disease risk factors and the reductions in risk expected with exercise

Hagberg J et al, Sports Med, 2000

MECHANISMS OF POSTTRAINING DECREASES IN BP IN HYPERTENSIVES

B. INDIRECT

- **Effects on other lifestyle modifying factors**
- **Increase in aerobic capacity**

EXERCISE PRESCRIPTION GUIDELINES FOR HYPERTENSIVE PATIENTS

- PATIENT SELECTION AND EVALUATION
- EXERCISE TESTING AND MONITORING
- EXERCISE MODE

CONTRAINDICATIONS TO EXERCISE TRAINING IN HYPERTENSIVES

A. **SIGNS OR SYMPTOMS AT REST:**
   - **Uncontrolled resting BP (systolic >180; diastolic >110)**
   - **End-organ damage (retinal or renal changes or severe LVH)**
   - **Unstable angina, cerebral ischemia, uncompensated CHF**

CONTRAINDICATIONS TO EXERCISE TRAINING IN HYPERTENSIVES

A. **SIGNS OR SYMPTOMS DURING EXERCISE:**
   - **Hypertensive responses (systolic >225; diastolic >110)**
   - **Exercise-induced angina or cerebral ischemia**
   - **Adverse side effects of antihypertensive medications**

POTENTIAL MAIN EFFECTS OF MAJOR ANTIHYPERTENSIVE AGENTS ON EXERCISE AND SPORTS PARTICIPATION

- **DIURETICS** → hypovolemia, orthostatic hypotension, hypokalemia
- **B-BLOCKERS** → ↓$VO_{2\ max}$ (↓CO, muscle flow), ↓substrate mobilization, fatigue, bronchospasm
- **CALCIUM CHANNEL BLOCKERS** → $VO_{2\ max}$ preserved, competitive "steal" of topic muscle blood flow
- **ACE INHIBITORS** → no impairment

LIPPINCOTT
WILLIAMS & WILKINS

EUROPEAN
SOCIETY OF
CARDIOLOGY

Position Paper

ESC Study Group of Sports Cardiology Recommendations for participation in leisure-time physical activities and competitive sports for patients with hypertension

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European Journal of Cardiovascular Prevention and Rehabilitation 2005, 12:326–331

	Clinic Blood Pressure (mmHg)		
Other risk factors and disease history	Grade 1 SBP 140–159 or DBP 90–99	Grade 2 SBP 160–179 or DBP 100–109	Grade 3 SBP ≥ 180 or DBP ≥ 110
No other risk factors[a]	Low added risk	Moderate added risk	High added risk
1–2 risk factors[a]	Moderate added risk	Moderate added risk	Very high added risk
Three or more risk factors[a] or TOD[b] or diabetes	High added risk	High added risk	Very high added risk
Associated clinical conditions[c]	Very high added risk	Very high added risk	Very high added risk

TOD, target organ damage; SBP, systolic blood pressure; DBP, diastolic blood pressure; Low, moderate, high and very high added risk indicate an approximate 10-year risk of fatal and nonfatal cardiovascular disease of <15%, 15–20%; 20–30% and >30%, or of fatal cardiovascular disease of <4%, 4–5%, 5–8% and >8%. [a]Risk factors used for stratification: blood pressure level (grades 1–3); gender and age (men >55 years; women >65 years); smoking; dyslipidaemia (total cholesterol >250 mg/dL or LDL-cholesterol >155 mg/dL or HDL-cholesterol <40 mg/dL in men and <48 mg/dL in women); abdominal obesity (men ≥ 102 cm; women ≥ 88 cm); first degree family history of premature cardiovascular disease (men <55 years; women <65 years). [b]Target organ damage: hypertension-induced left ventricular hypertrophy; ultrasound evidence of arterial wall thickening or atherosclerotic plaque; slight increase in serum creatinine (men 1.3–1.5 mg/dL; women 1.2–1.4 mg/dL); presence of micro-albuminuria. [c]Associated clinical conditions: cerebrovascular disease; ischaemic heart disease; heart failure; peripheral vascular disease; renal impairment; proteinuria; advanced retinopathy (haemorrhages, exsudates, papiloedema).

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

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

White coat hypertension detected during screening of male adolescent athletes.

Eighteen clinically hypertensive cases (4.4%) were detected and evaluated with a 24-h ABPM. Sixteen of them were defined as having "white coat hypertension" because they were detected to have normal daytime and nocturnal BP.

Kouidi Am J Hypertens 1999

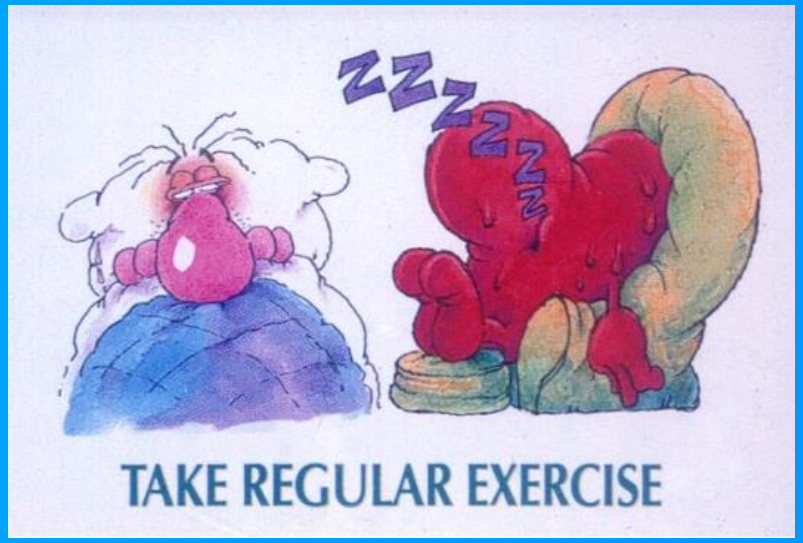
DOPING AND HYPERTENSION IN ATHLETES

The role of blood pressure-increasing ergogenic aids should be considered in the hypertensive sportsman or athlete. Athletes may be taking large doses of prohibited substances such as anabolic steroids, erythropoietin, stimulants, etc

Deligiannis A. Osterr J Sports Med 2002

IS “NO PAIN, NO GAIN” PASSE?

Adults who exercised at least 1 h/wk had approximately half the coronary heart disease risk of those who were sedentary.



Lee IM et al, JAMA, 2001

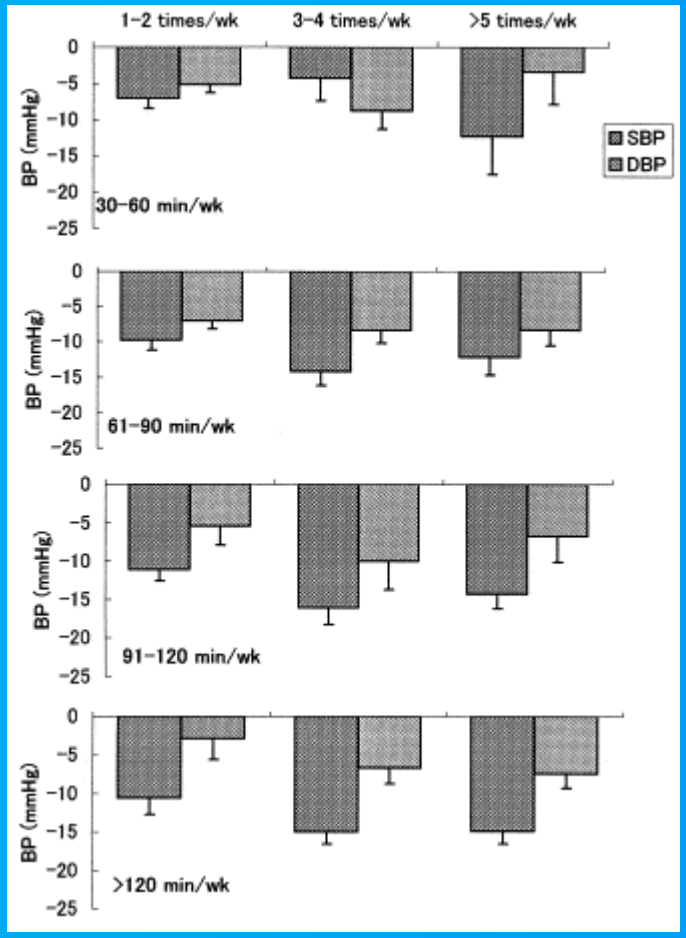
Changes in resting blood pressure with exercise training of different exercise intensities

Table II. Summary of the effects of exercise training intensity on systolic and diastolic blood pressure (BP) in patients with hypertension

	Training intensity	
	<70% $\dot{V}O_{2max}$	>70% $\dot{V}O_{2max}$
Systolic BP		
Average weighted reduction (mm Hg)[a]	11.1	7.6
% Groups reducing[b]	79	75
Total sample size[c]	684	388
Diastolic BP		
Average weighted reduction (mm Hg)[a]	7.6	6.7
% Groups reducing[b]	81	81
Total sample size[c]	784	317

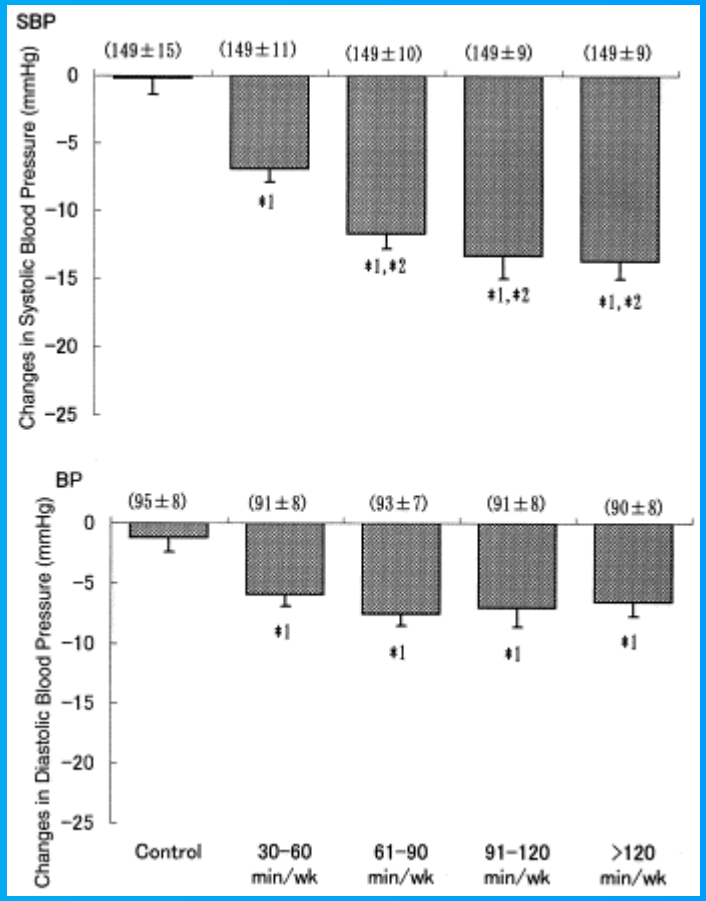
Hagberg J et al, Sports Med, 2000

Changes in resting blood pressure with exercise training of different exercise frequency



Ishikawa-Takata K, et al AJH 2003

Changes in resting blood pressure with exercise training of different exercise duration



Ishikawa-Takata K, et al AJH 2003

Changes in resting blood pressure with exercise training of different exercise training length

Table III. Summary of the effects of exercise training length on systolic and diastolic blood pressure (BP) in patients with hypertension

	Training length (weeks)		
	1-10	11-20	20+
Systolic BP			
Average weighted reduction (mm Hg)[a]	9.8	10.9	11.1
% Groups reducing[b]	67	78	75
Total sample size[c]	299	773	212
Diastolic BP			
Average weighted reduction (mm Hg)[a]	8.4	7.9	9.1
% Groups reducing[b]	90	78	86
Total sample size[c]	229	818	214

Hagberg J et al, Sports Med, 2000

Effects of age

Table I. Summary of the effects of age on systolic and diastolic blood pressure (BP) changes during exercise training in patients with hypertension

	Age of participants (years)		
	21-40	41-60	60+
Systolic BP			
Average weighted reduction (mm Hg)[a]	8.7	11.7	7.6
% Groups reducing[b]	44	85	60
Total sample size[c]	205	902	164
Diastolic BP			
Average weighted reduction (mm Hg)[a]	10.4	7.8	8.8
% Groups reducing[b]	86	82	75
Total sample size[c]	179	1014	55

Hagberg J et al, Sports Med, 2000

Effects of ethnicity

Table IV. Summary of the effects of ethnicity on systolic and diastolic blood pressure (BP) changes with exercise training in patients with hypertension

	Ethnic group	
	Caucasians	Asian/Pacific Islanders
Systolic BP		
Average weighted reduction (mm Hg)[a]	8.0	11.7
% Groups reducing[b]	65	91
Total sample size[c]	554	337
Diastolic BP		
Average weighted reduction (mm Hg)[a]	6.8	6.7
% Groups reducing[b]	75	85
Total sample size[c]	515	310

Hagberg J et al, Sports Med, 2000

Role of genetics in blood pressure reduction resulting from exercise training

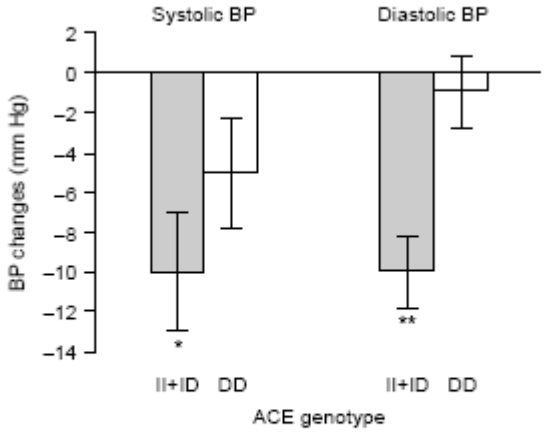


Fig. 1. Changes in systolic and diastolic blood pressure (BP) in men with hypertension during endurance exercise training as a function of ACE genotype. * indicates change with exercise training different between genotype groups at $p = 0.16$; ** indicates change at $p < 0.005$.

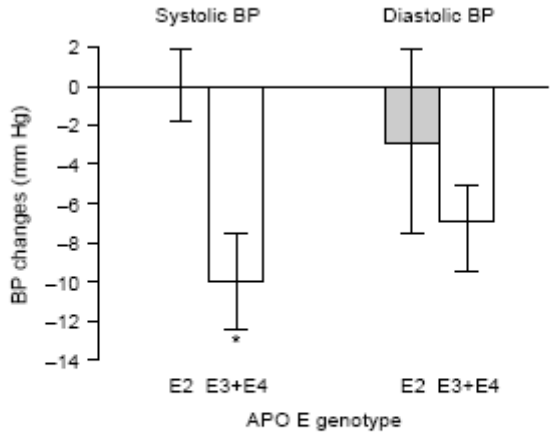


Fig. 2. Changes in systolic and diastolic blood pressure (BP) in men with hypertension during endurance exercise training as a function of APO E genotype. * indicates change with exercise training different between genotype groups at $p < 0.05$.

Staessen JA et al, J Hypertens, 1999

THE IMPORTAN FACTOR IS TO DESIGN A PROGRAM FOR THE INDIVIDUAL TO PROVIDE THE PROPER AMOUNT OF PHYSICAL ACTIVITY TO ATTAIN MAXIMAL BENEFIT AT THE LOWEST RISK

ACSM POSITION STAND

- **Frequency: 3-5 d.wk-1 – Duration: 20-60min**
- **The potential benefits of regular exercise performed more frequently and for a longer duration by a low intensity**
  (40-50% of $VO_{2\,max}$ or 55-65% of HR_{max})
- **An optimum program of training include exercises that improve aerobic capacity, muscular strength and endurance, and flexibility**
- **An appropriate warm-up and cool-down period is recommended**

‘Exercise training, this oldest of physical therapies remains extremely difficult to evaluate. This is at least partly because our modern system of funding trials is firmly in favor of commercial patentable treatments’

Andrew Coats, 2000