Harvard step test
Letunov´s test

- tests of fitness and response of the cardiovascular system to physical activity

Evaluation of cardiac efficiency

Evaluation of systolic function:

- ejection fraction evaluates the functional performance ventricle contraction

EF = 100 x (EDV - ESV) / EDV

normal value: 55 – 80%

Evaluation of diastolic function:

- ventricular compliance
- filling rate
- blood flow through the valvular orifice

Evaluation of cardiac efficiency

Cardiac index:

= minute cardiac output related to body surface (m^2) - more precisely characterizes tissue perfusion

Normal value: 2.6 – 4.2 $l/min/m^2$

< 2.5 $l/min/m^2$ - LV failure with hypoperfusion of tissues

< 1.8 $l/min/m^2$ - shock

Shock index:

heart rate/systolic BP (< 1)

Circulation failure → ↓ blood pressure, tendency to maintain tissue perfusion by ↑ TF → shock index > 1

Cardiac reserve

- The ability of the heart to increase cardiac output (5 - 7 times).
- It is an evidence of circulatory efficiency.
- Limits individual's physical performance (with intact motoric apparatus)

Coronary flow reserve:

= the maximum increase in blood flow through the coronary arteries above the normal resting volume

Athletic heart syndrome

- Develops as adaptation of the heart muscle to the load (increased volume and increased pressure - static-dynamic physical activity - cycling, rowing).
- The cardiomyocytes grow proportionally in length and width.
- The athletic heart has a great contractility and a large heart cavity:

  - resting SV: 80-100 ml,
  - SV at load: 160-200 ml load

  → resting bradycardia, moderate increase of heart rate during physical exercise
- Differentiation from hypertrophic cardiomyopathy!
- Thickness of the left ventricle wall maximally 13 mm!

	Sportsman		Pathological hypertrophy	
	Endurance load	Force load	Hypertrophic cardiomyopathy	Hypertension
LV diameter	> 55 mm	> 45 mm	< 45 mm	> 45 mm
LV wall thickness	< 13 mm	< 13 mm	> 15 mm	< 15 mm
left atrium	< 45 mm	< 45 mm	enlarged	enlarged
regression without training	within 3 months	within 3 months	no	no
LV filling	↑	normal	↓	↓
aerobic endurance	↑	normal	↓	↓

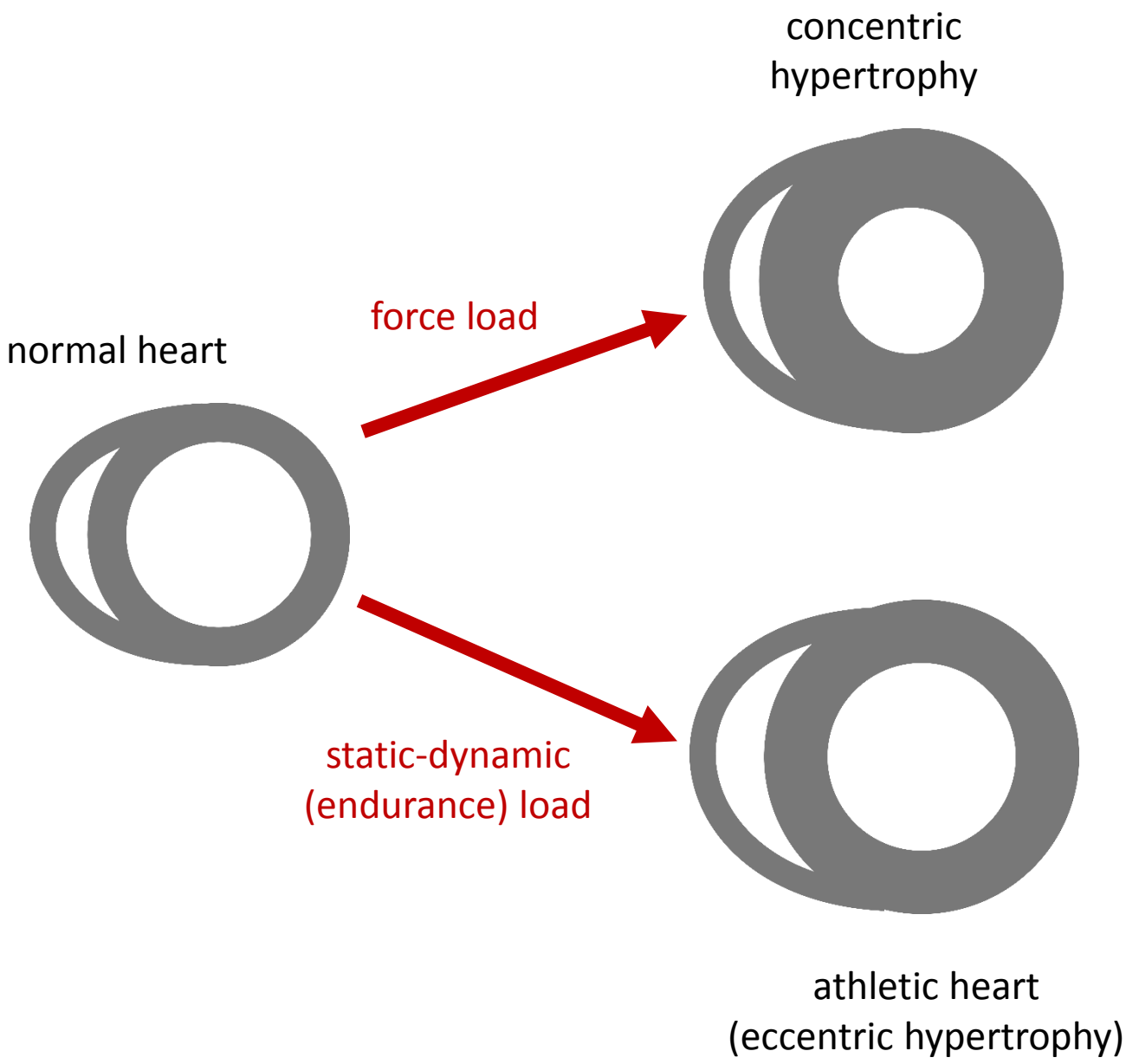
Concentric hypertrophy of the heart

- risk in static training (weight-lifting)
- myocardial pressure load prevails (most of the muscles are in contraction – compression of the capillaries, LV works against high pressure)
- → maladaptation - increase of sarcomere number, thickening of the walls, but reduction of the volume of the heart cavities, reduction of compliance of heart walls
- risks: thickening of cardiomyocytes increases the diffusion pathway for oxygen and nutrients → higher sensitivity to ischemia and generation of arrhythmias, the balance between signals of intracellular cascades controlling apoptosis also changes → degradative processes, dilatation and failure of affected ventricle

- **Eccentric hypertrophy:**
  - occurs when the ventricle is loaded with increased volume, cardiomyocytes increase their length

- **Reactive hypertrophy:**
  - compensates dysfunctional scarring parts of the myocardium

- **Simple myocardium dilatation:**
  - adaptive reaction to a sudden situation (the heart has no time to develop hypertrophy), e.g. massive pulmonary embolism, infusion therapy of the patient, rupture of the papillary muscle


concentric
hypertrophy
force load
normal heart
static-dynamic
(endurance) load
athletic heart
(eccentric hypertrophy)

Disturbances of mechanical functions of the heart ventricles

- Systolic and diastolic disorders are often combined
- Clinical symptoms mostly identical
- The main symptoms of failure of mechanical function of the ventricle:
  - reduced cardiac output
  - blood stasis before the failing ventricle

Systolic disorders

- Reduced contraction ability
- The main causes: ischemia, disorders of cardiomyocyte metabolism, inflammation, cardiomyopathy
- EF < 40% - ventricular failure
- EF < 20% - life threatening
- clinical symptoms: ↓ systolic blood pressure → reaction of aortic baroreceptors → activation of sympathetic NS → ↑ heart rate, activation of renin-angiotensin-aldosterone system, ADH → ↑ blood volume → ↑ residual ventricular volume → dilatation, vicious circle ending with failure of the ventricle
- treatment: beta blockers, ACE inhibitors, diuretics

Diastolic disorders

- Diastolic function depends on:
  - venous return
  - compliance of the walls of the heart ventricle
  - heart rate
  - compliance of the pericardium
- reduced wall compliance - the most common cause of diastolic failure (hypertrophic wall, ↓ ventricular volume)
- other causes: pericarditis, cardiac tamponade (insufficient ventricular relaxation)
- EF can be normal! (↓ chamber filling, absolute cardiac output value ↓)

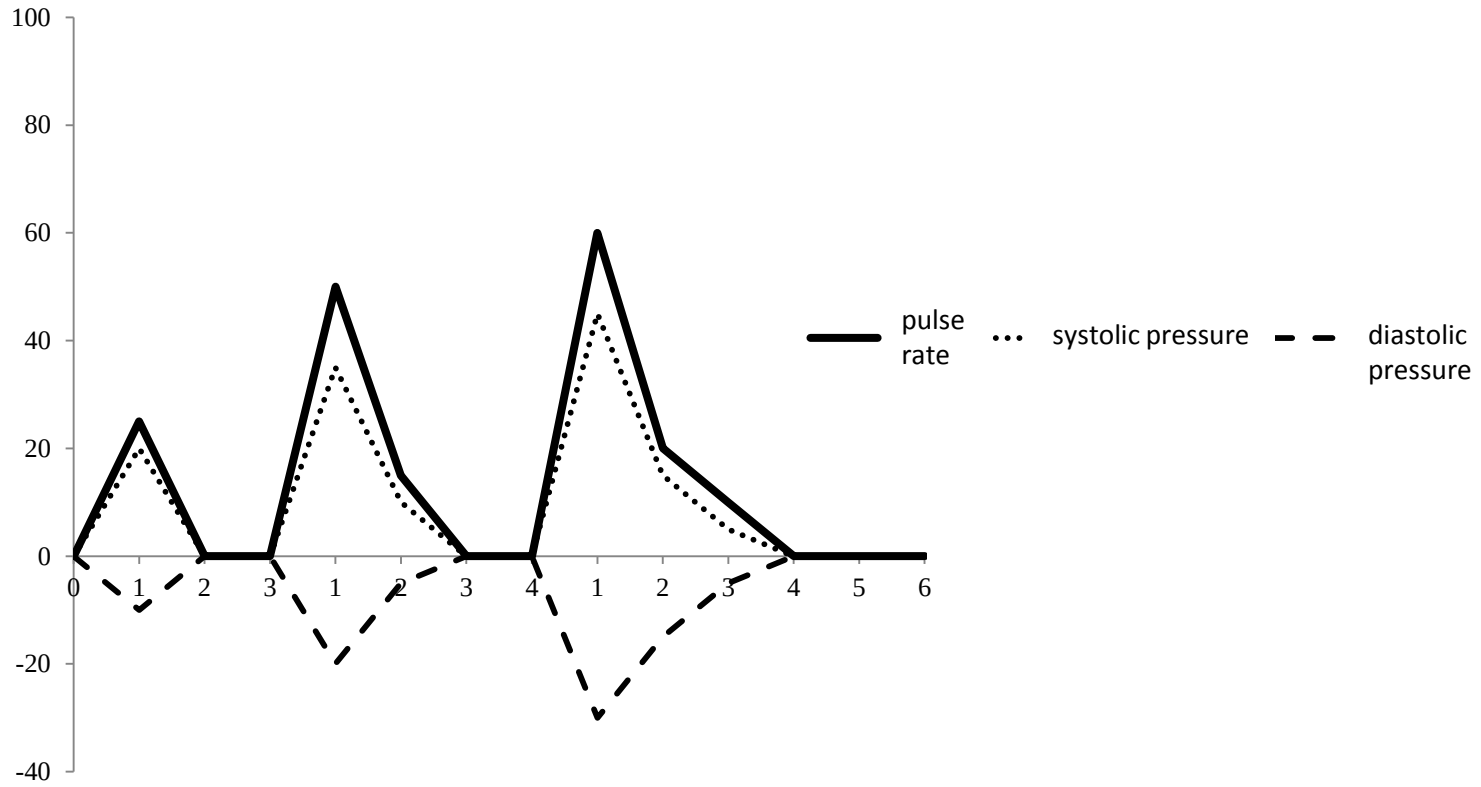
Harvard step test

- examination of functional circulatory efficiency
- evaluation of changes of pulse rates after standardized exertion and of the speed of its return to the initial values
- Index of fitness = duration of exercise in seconds x 100/sum of pulses in 3 measured intervals

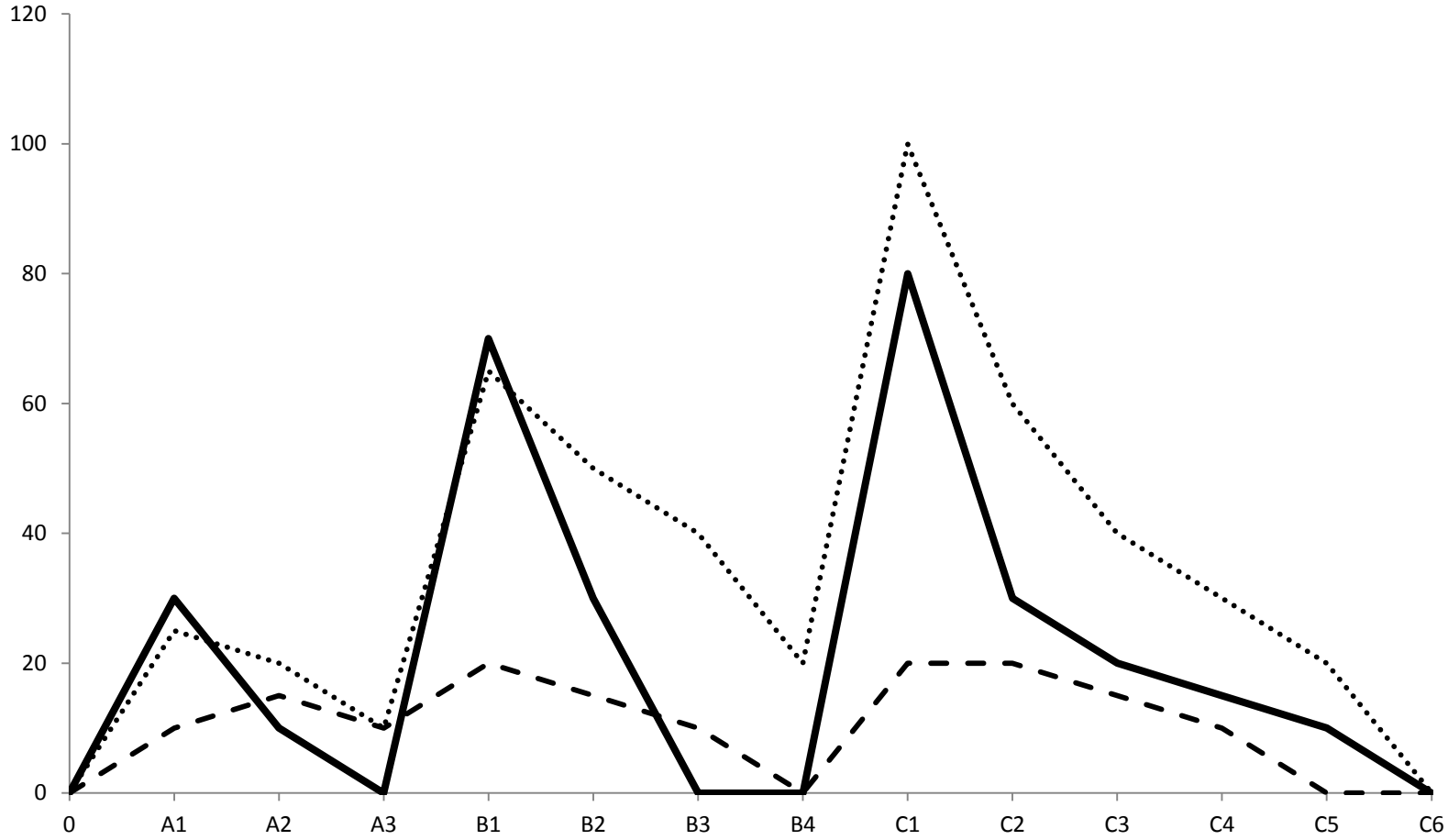
Letunov´s test

- evaluation of pulse rate and blood pressure changes evoked by three different types of exercise
- obtained values are presented graphically
- obtained curves are compared with the basal types of curves described by Letunov

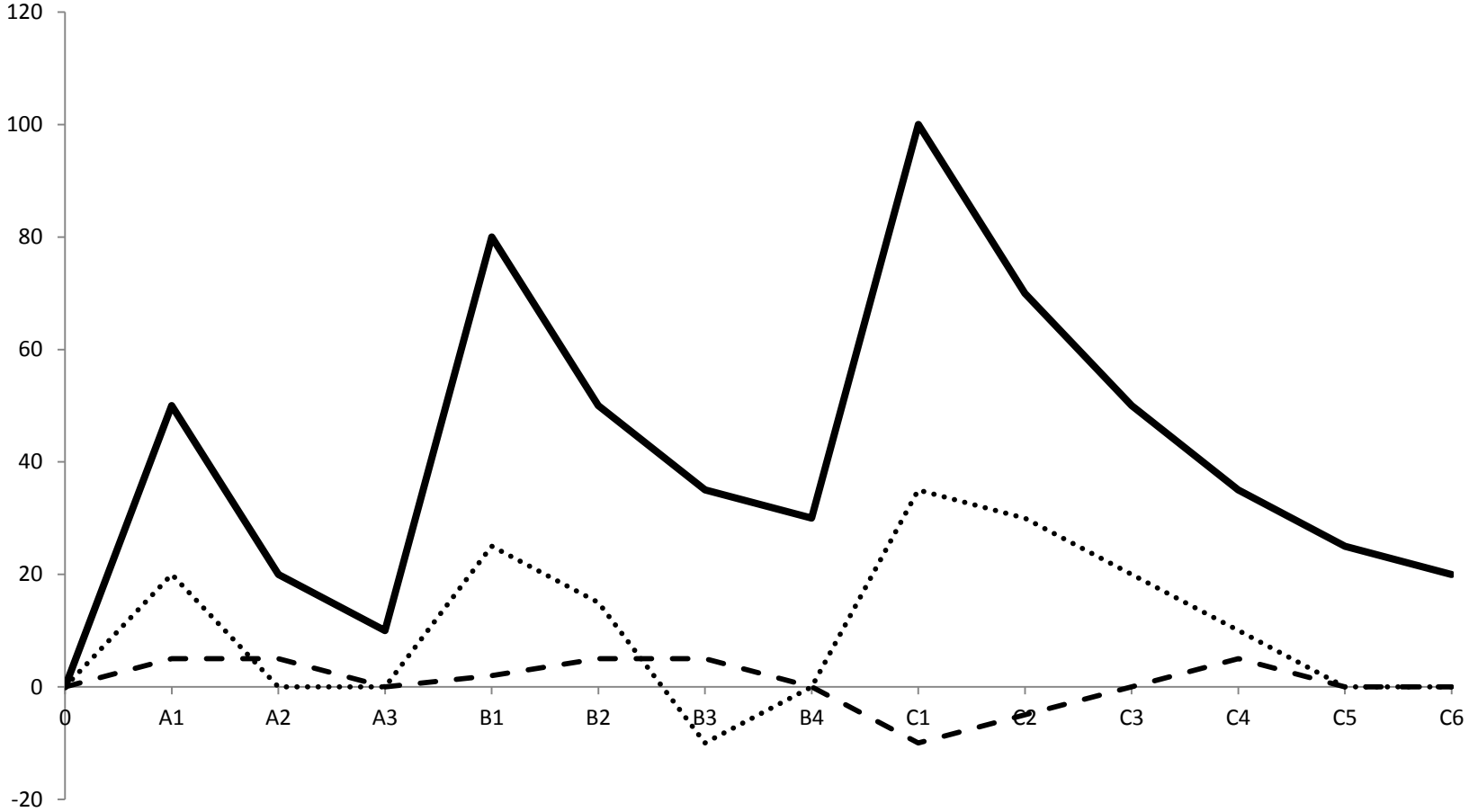
Normotonic reaction: healthy and trained subjects



Hypertonic reaction: in patients with hypertension, it may also predict the tendency to this disease



Hypotonic reaction: high tachycardia with only small changes of both values



Gradual reaction: typical for untrained persons