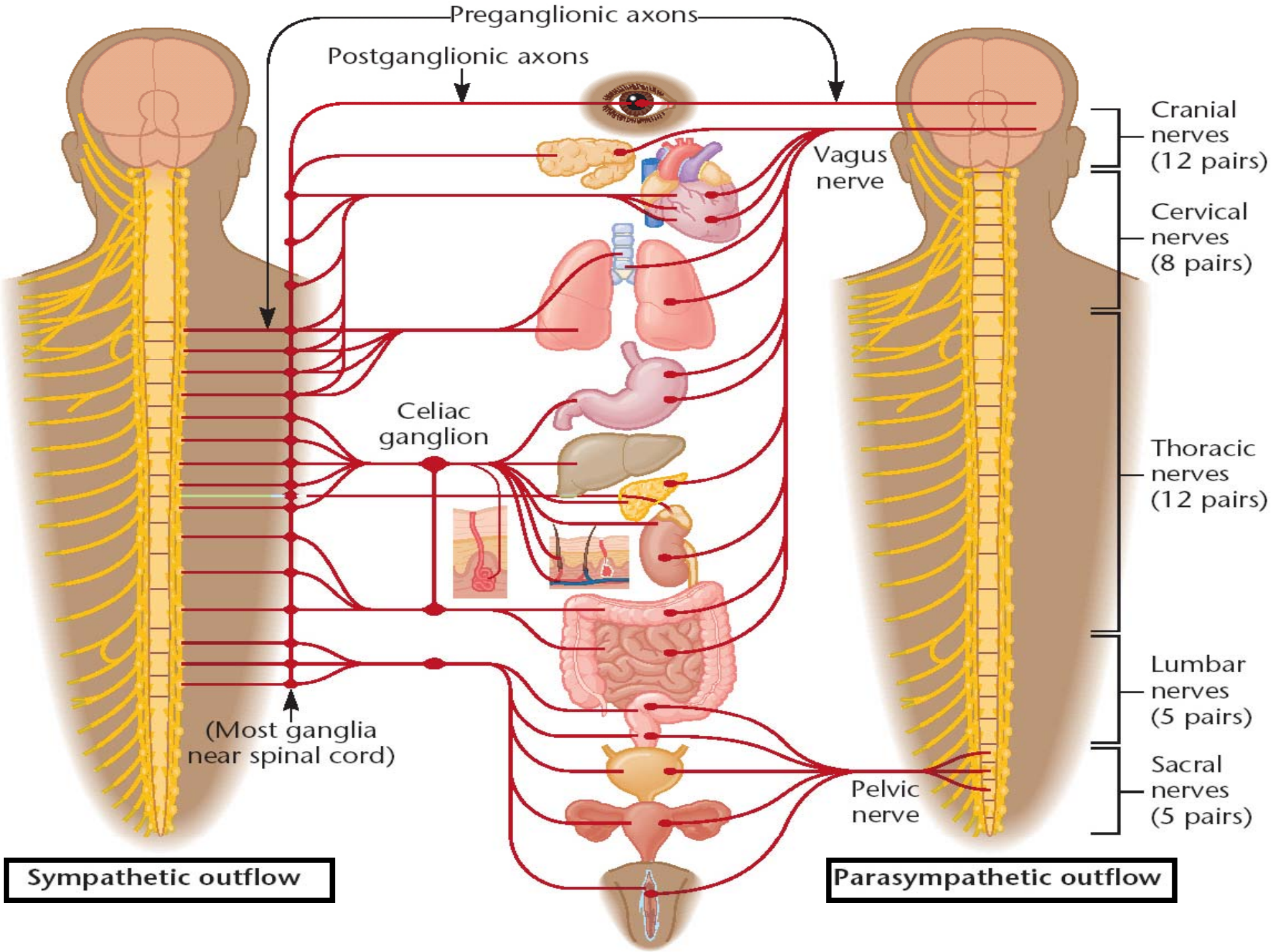
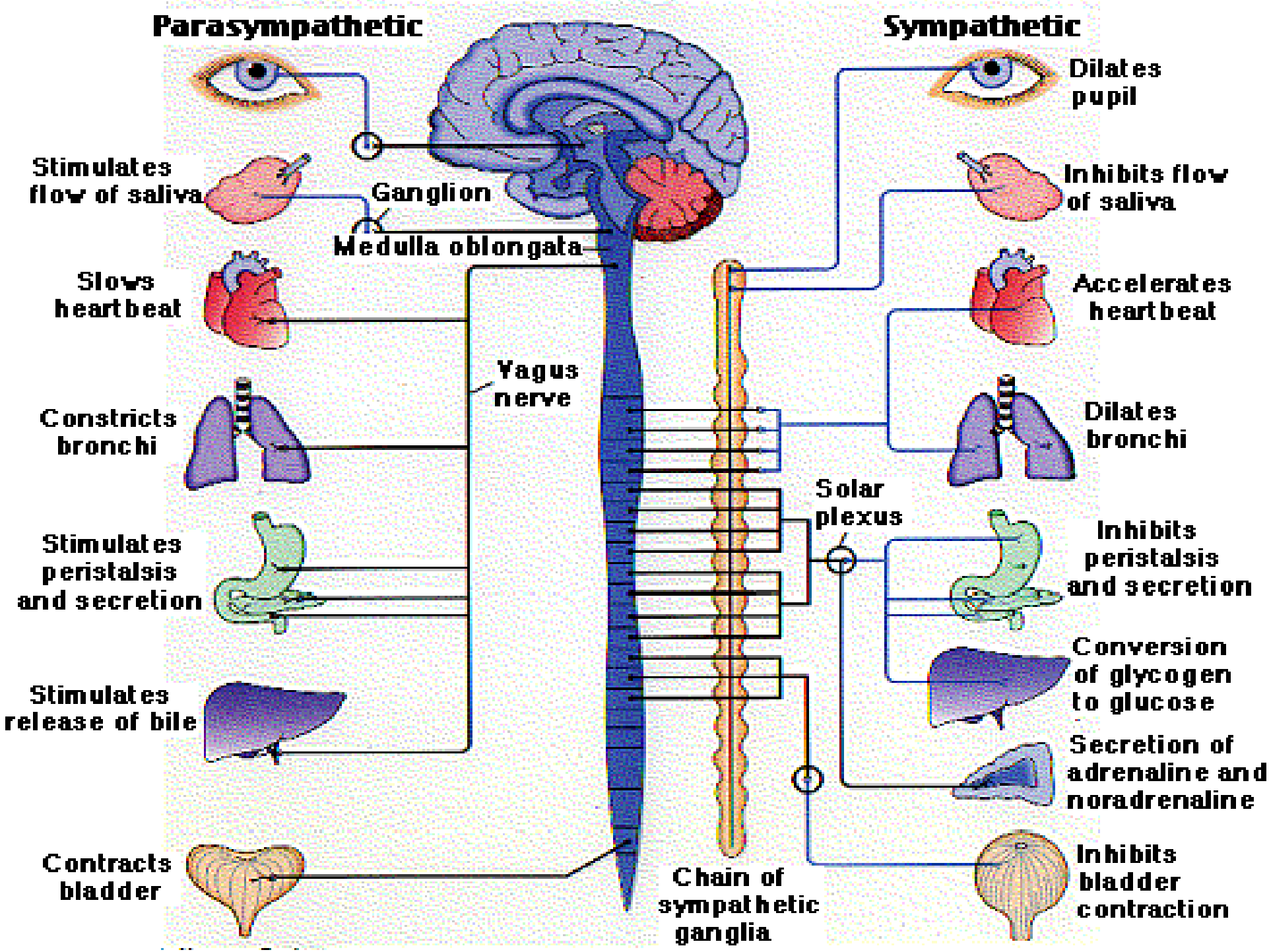
Exercise Training

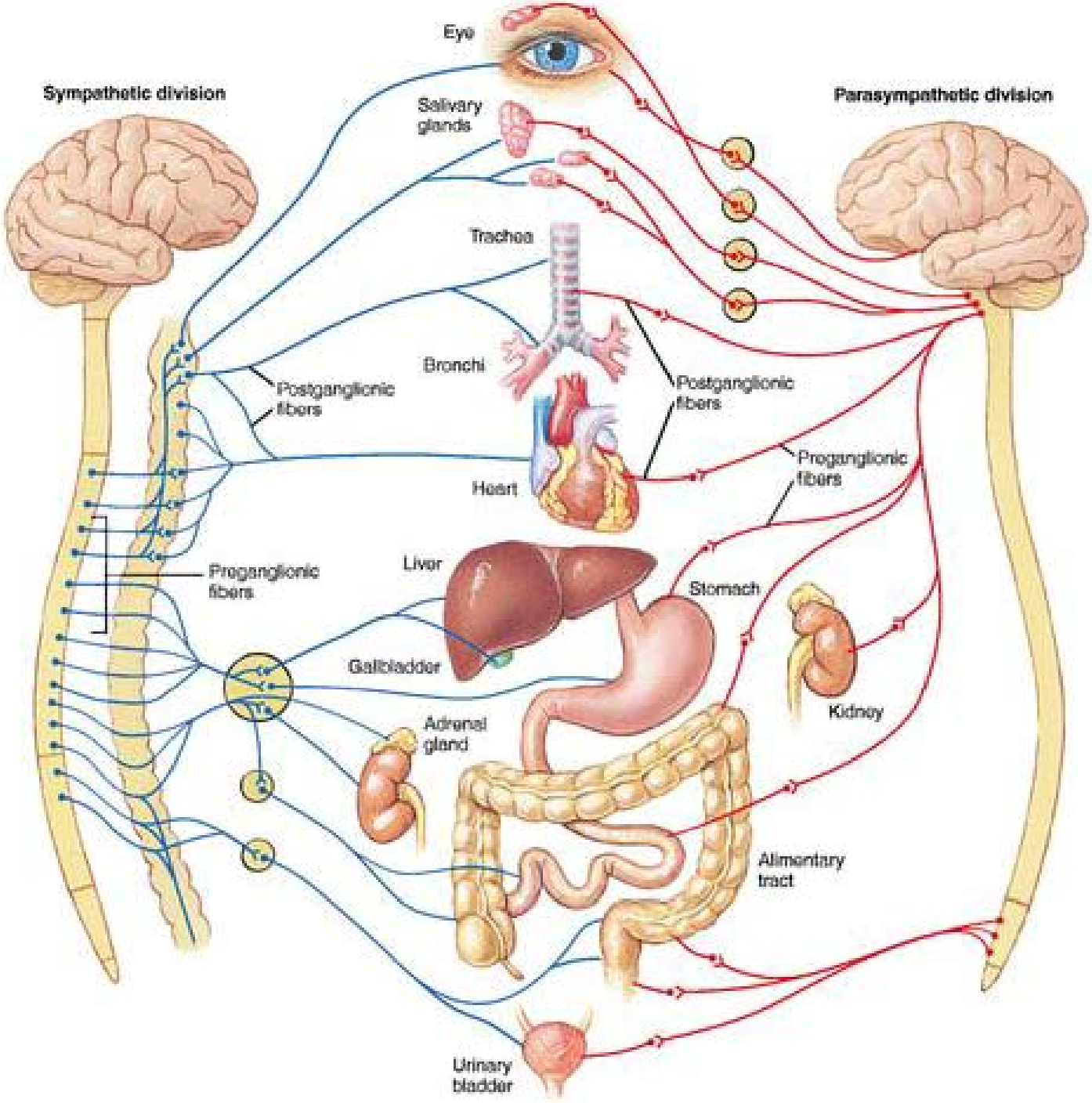
- Exercise training induces many physiological changes that make a conditioned individual more efficient and better able to deliver and use the oxigen and nutrients and resist fatigue.
- The conditioning effect also offers some protection against cardiovascular mortality and enhances ability to perform activities af daily living.

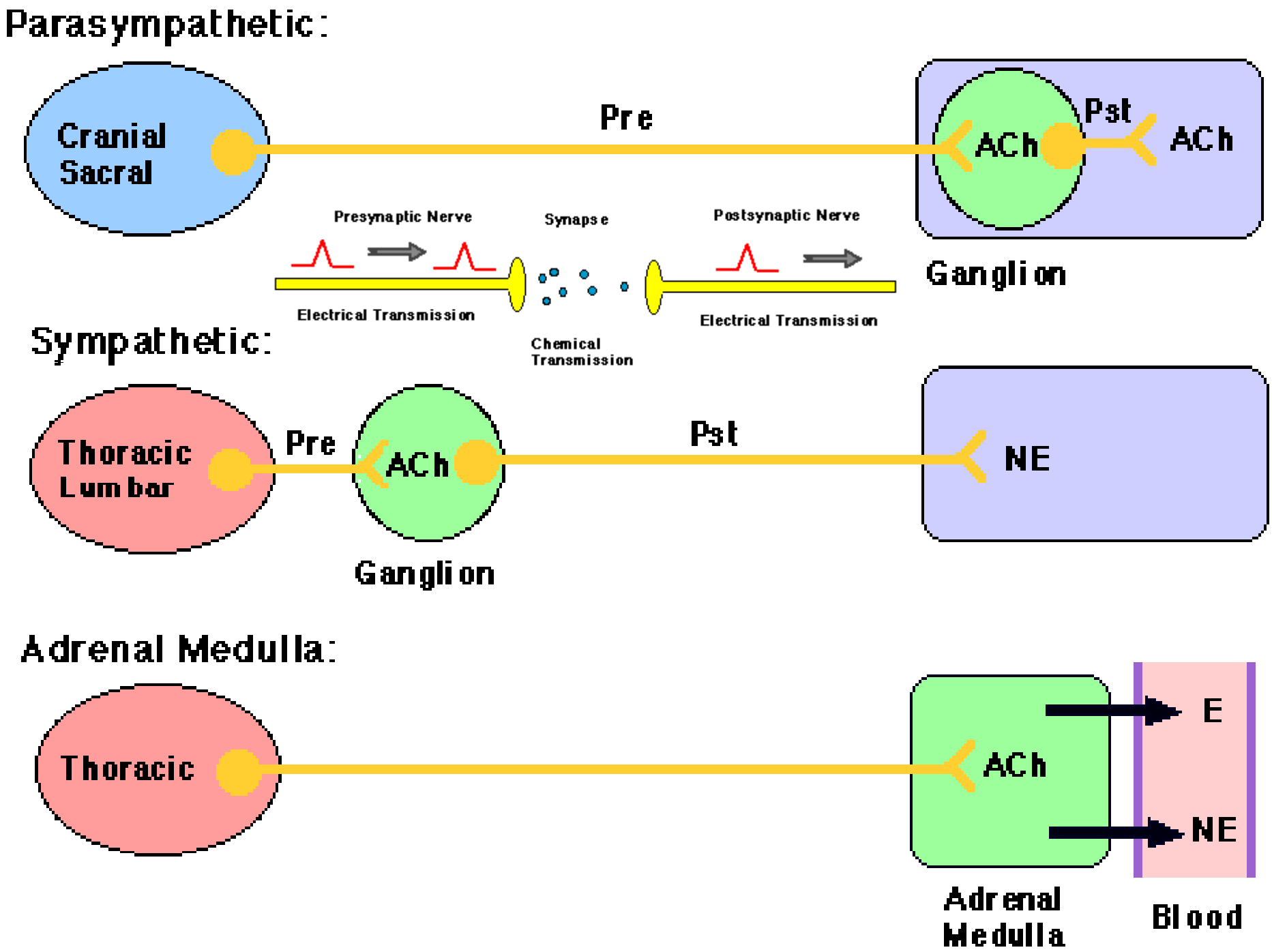
The Autonomic Nervous System

- The Autonomic Nervous System is an important tool that the central system uses to mantain the organismic homeostasis at rest and during challenges imposed by acute changes in physiological states such as physical exercise
- The physiological effects of ANS depend on both a)the change in the activities of autonomic nerves and their release of neurotransmitters and b)the responsiveness of the peripheral tissues to this neurochemical stimulus


Preganglionic axons
Postganglionic axons
Vagus nerve
Celiac ganglion
(Most ganglia near spinal cord)
Pelvic nerve
Cranial nerves (12 pairs)
Cervical nerves (8 pairs)
Thoracic nerves (12 pairs)
Lumbar nerves (5 pairs)
Sacral nerves (5 pairs)
Sympathetic outflow
Parasympathetic outflow


Parasympathetic
Sympathetic
Dilates pupil
Stimulates flow of saliva
Ganglion
Medulla oblongata
Inhibits flow of saliva
Slows heartbeat
Accelerates heartbeat
Vagus nerve
Constricts bronchi
Dilates bronchi
Solar plexus
Stimulates peristalsis and secretion
Inhibits peristalsis and secretion
Conversion of glycogen to glucose
Stimulates release of bile
Secretion of adrenaline and noradrenaline
Contracts bladder
Chain of sympathetic ganglia
Inhibits bladder contraction


Eye
Sympathetic division
Parasympathetic division
Salivary glands
Trachea
Bronchi
Postganglionic fibers
Postganglionic fibers
Preganglionic fibers
Heart
Preganglionic fibers
Liver
Stomach
Gallbladder
Kidney
Adrenal gland
Alimentary tract
Urinary bladder


Parasympathetic:
Cranial
Sacral
Pre
ACh
Pst
ACh
Ganglion
Presynaptic Nerve
Synapse
Postsynaptic Nerve
Electrical Transmission
Chemical
Transmission
Electrical Transmission
Sympathetic:
Thoracic
Lumbar
Pre
ACh
Pst
NE
Ganglion
Adrenal Medulla:
Thoracic
ACh
E
NE
Adrenal
Medulla
Blood

The Sympathetic is the "Fight or Flight" Branch of the ANS

1. Emergency situations, where the body needs a sudden burst of energy, are handled by the sympathetic system
2. The sympathetic system increases cardiac output and pulmonary ventilation, routes blood to the muscles, raises blood glucose and slows down digestion, kidney filtration and other functions not needed during emergencies
3. Whole sympathetic system tends to "go off" together
4. In a controlled environment the sympathetic system is not required for life, but it is essential for any stressful situation

The Parasympathetic is the "Rest and Digest" Branch of the ANS

1. The parasympathetic system promotes normal maintenance of the body- acquiring building blocks and energy from food and getting rid of the wastes
2. It promotes secretions and mobility of different parts of the digestive tract.
3. Also involved in urination, defecation.
4. Does not "go off" together; activities initiated when appropriate
5. The vagus nerve (cranial number 10) is the chief parasympathetic nerve
6. Other cranial parasympathetic nerves are: III (oculomotor), VII (facial) and IX (glossopharyngeal

The Hypothalamus Has Central Control of the ANS

- The hypothalamus is involved in the coordination of ANS responses,
- One section of the hypothalamus seems to control many of the "fight or flight" responses; another section favors "rest and digest" activities

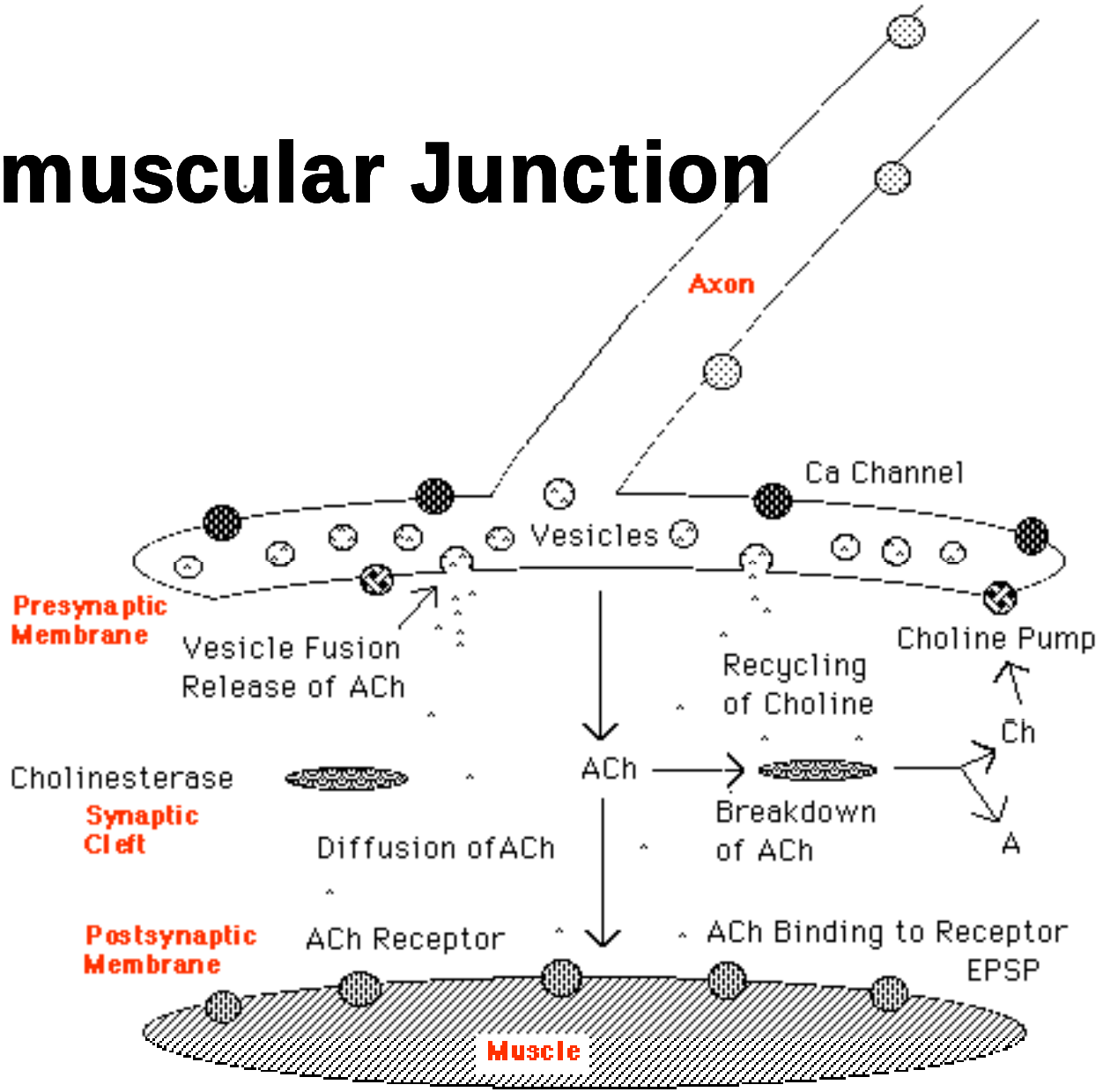
The Adrenal Medulla is an Extension of the Sympathetic Nervous System

1. The adrenal medulla behaves like a combined autonomic ganglion and postsynaptic sympathetic nerve (see diagram above)
2. Releases both norepinephrine and epinephrine in emergency situations
    1. Releases a mixture of epinephrine (E = 80%) and norepinephrine (NE = 20%)
    2. Epinephrine = adrenaline
3. This action is under control of the hypothalamus

Comparison of the Actions if the Sympathetic & Parasympathetic Systems

- Usually (but not always) both sympathetic and parasympathetic nerves go to an organ and have opposite effects
- You can predict about 90% of the sympathetic and parasympathetic responses using the 2 phrases: "Fight or Flight" and "Rest and Digest".
- Special cases:
  - Occasionally the 2 systems work together: in sexual intercourse the parasympathetic promotes erection and the sympathetic produces ejaculation
  - Eye: the sympathetic response is dilation and relaxation of the ciliary muscle for far vision (parasympathetic does the opposite)
  - Urination: the parasympathetic system relaxes the sphincter muscle and promotes contraction of muscles of the bladder wall -> urination (sympathetic blocks urination)
  - Defecation: the parasympathetic system causes relaxation of the anal sphincter and stimulates colon and rectum to contract -> defecation (sympathetic blocks defecation)

Neuromuscular Junction



Chronic Cardiac Adaptation to Exercise

Morphological

- Myocardial
- Vascular

Functional

- Neural

Dynamic and static exertion

Dynamic or isotonic activity: physical exertion characterized by rhytmic,repetitive movements of large muscle groups

Isometric or static activity: physical exertion characterized by sustained muscle contraction against a fixed load or resistance with non change in length of the involved muscle group or joint motion

Risposte cardiovascolari all'esercizio dinamico e statico

ESERCIZIO DINAMICO	ESERCIZIO STATICO
– aumento FC proporzionale alle richieste metaboliche	– minore incremento della FC
– aumento modesto/nullo PA media	– marcato aumento PA media
– prevalente vasodilatazione	– prevalente vasocostrizione
– facilitato ritorno venoso	– ostacolato ritorno venoso
– aumento consumo miocardico O_2	– aumento consumo miocardico O_2
– aumento proporzionale gettata sistolica e portata cardiaca	– aumento "inadeguato" gettata sistolica e portata cardiaca
LAVORO DI VOLUME DEL CUORE	*LAVORO DI PRESSIONE DEL CUORE*


What about resistance training?

Acute static exercise and the blood pressure response

Acute static exercise increase both Systolic and Diastolic pressure……

….. due to the Valsalva maneuver,pressor reflexs from tendoms stretching and compression of arteries by contracting muscles…..

……the intraabdominal pressure is simultaneusly increased and this is immediatly trasmitted to the cerebrospinal fluid through the intervetebral foramina:the transmural pressure across cerebral vessels is reduced and protects the cerebral vessels from acute damage.

Chintanadilok.J,Lowenthal.DT Exercise and Sport Cardiology 2003

Acute static exercise and the blood pressure response

During heavy weightlifting with Valsalva maneuver,
The pressor reflexs is extremely exaggerated but
may be dramatically reduced when the exercise is performed
with an open glottis or slow exalation

With Valsalva	Without Valsalva
311/284 mmHg	198/175 mmHg

Chintanadilok.J,Lowenthal.DT Exercise and Sport cardiology 2003

Resistance Exercise in Individuals with and without Cardiovascular Disease

Benefits,rationale,safety and prescription

An advisory from the committee on exercise rehabilitation and prevention,Council on Clinical Cardiology,American Heart Association

Position paper endorsed by ACSM

Circulation 2000;101:828

Comparison of effects of aerobic training with strength training on health and fitness variables

Variable	Aerobic ex.	Resistance ex.
Bone mineral density	↑↑	↑↑
Body composition		
% Fat	↓↓	↓
LBM	-	↑↑
Strength	-	↑↑↑
Basal insulin levels	↓	↓
Insulin sensivity	↑↑	↑↑
HDL	↑-	↑ -
LDL	↓-	↓ -
Blood pressure	⬇	⬇
VO2 max	↑↑	↑-
Basal metabolism	↑	↑↑

Circuit weight training in borderline hypertensive subjects

Subjects : 26 males with BL hypertension (140/90 - 160/95 mmHg)
Exercise program: 9 weeks partecipation in circuit weight training

Results	Pre	Post
♥ Upper and lower body strength		+ 12,5% and + 53% *
♥ Lean body mass	64 Kg	65,4 Kg = 2,2% *
♥ Treadmill VO2 max	40,9 ml x Kg x min	44,1 ml x Kg x min = + 7,8% *
♥ Arm ergometry VO2 max	1,9 L x min -1	2,3 L x min -1 = +21,1% *
♥ Diastolic blood pressure	95,8 mmHg	91,3 mmHg *
♥ Sistolic blood pressure		no difference

* p<0,05

Circuit weigth training does not exacerbate resting or exercise blood pressure and may have beneficial effects

Med Sci Sports Exerc 01-Jun 1987; 19(3):246-52

Chronic Cardiac Adaptation to Exercise

Morphological

Myocardial hypertrophy

Coronaries

Chronic Cardiac Adaptation to Exercise

Morphological

Myocardial hypertrophy

- *Concentric*
- *Eccentric*

Hypertrophy-Hyperplasia

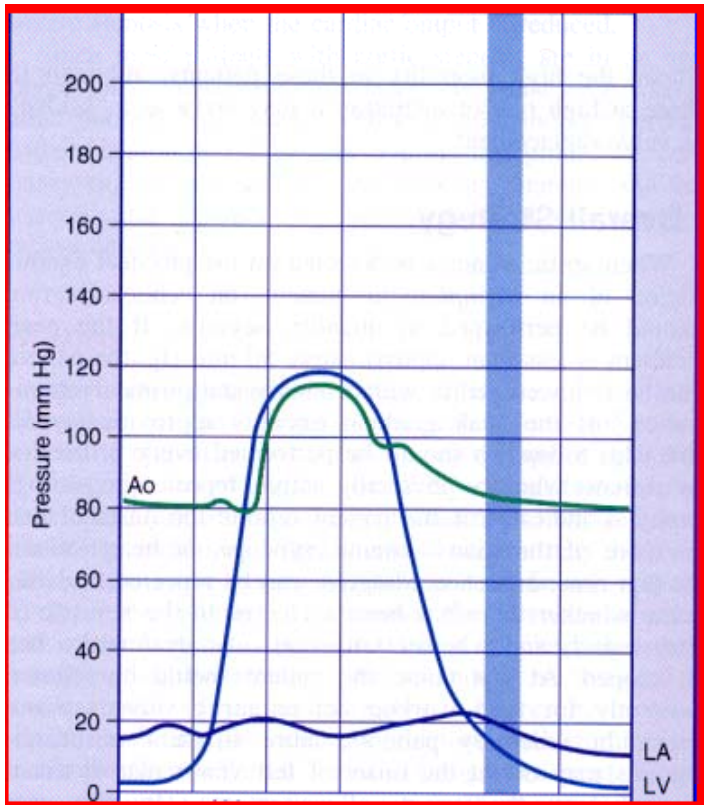
- Hyperplasia constitutes an increase in the number of cells in an organ or tissue, which may then have increased volume.
- Hypertrophy refers to an increase in the size of cells and, with such change, an increase in the size of the organ

Myocardial Hypertrophy

- Due to physical stimuli
  - *volume overload*
  - *pressure overload*
- Due to hormonal chemical stimuli

Factors promoting Cardiac hypertrophy

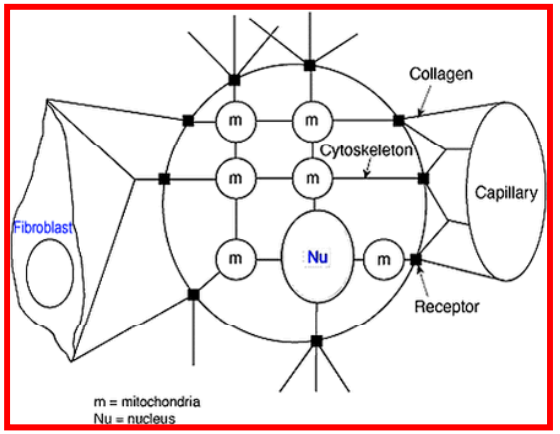
Mechanical Force



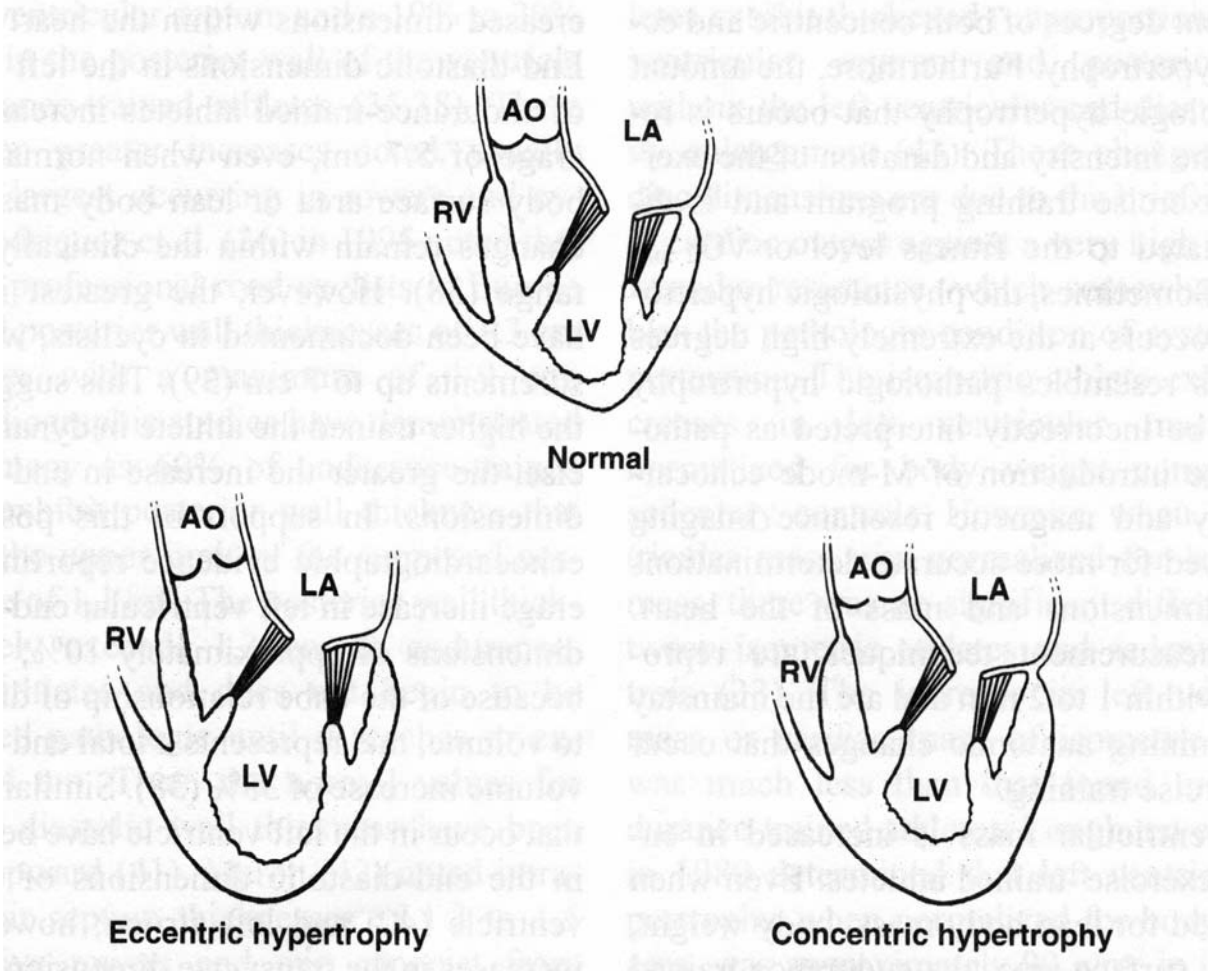
LaPlace Formulation for Wall Stress

$$S \cong \frac{P \times r^2}{h}$$

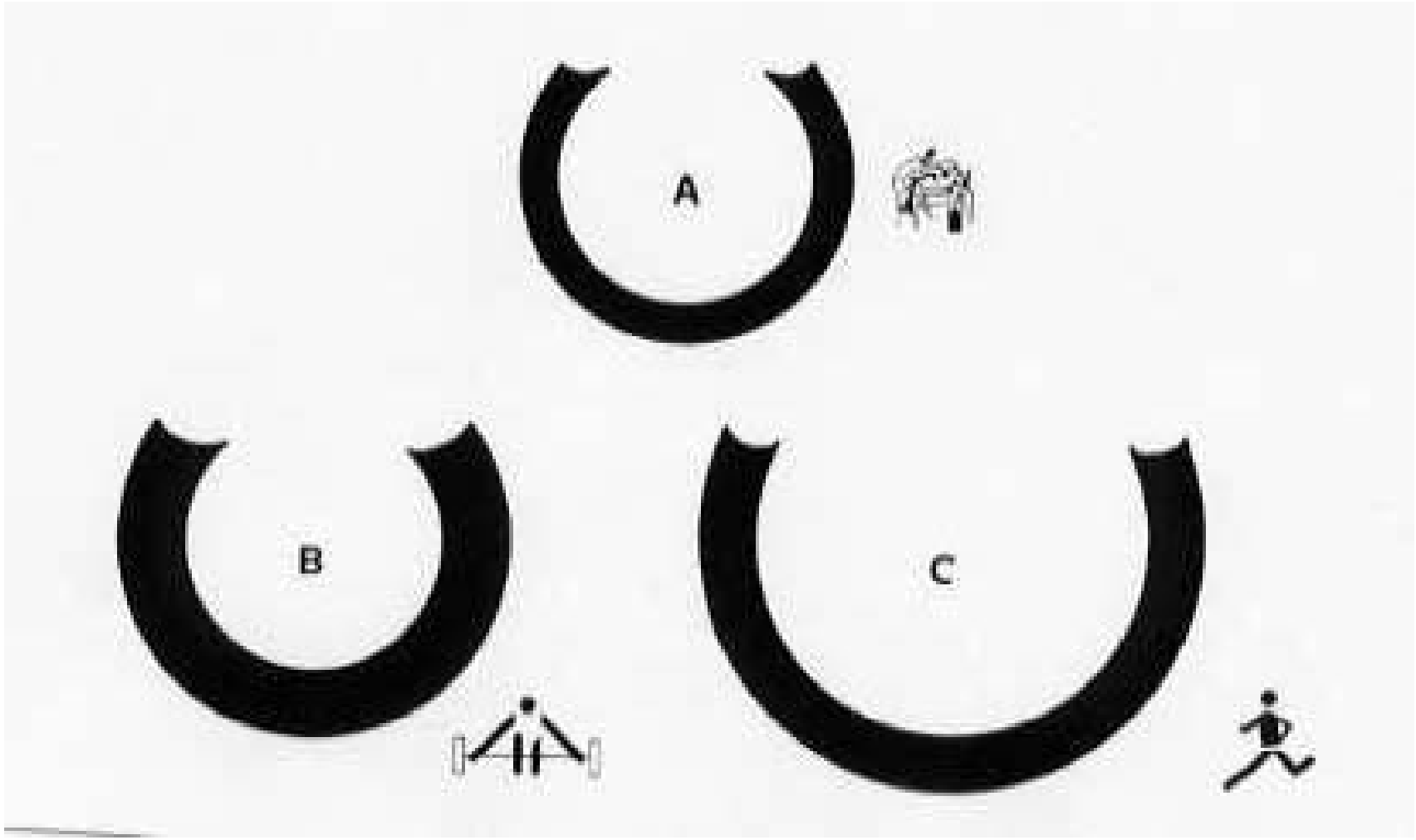
S = wall stress
P = ventricular systolic pressure
r = ventricular radius
h = ventricular wall thickness



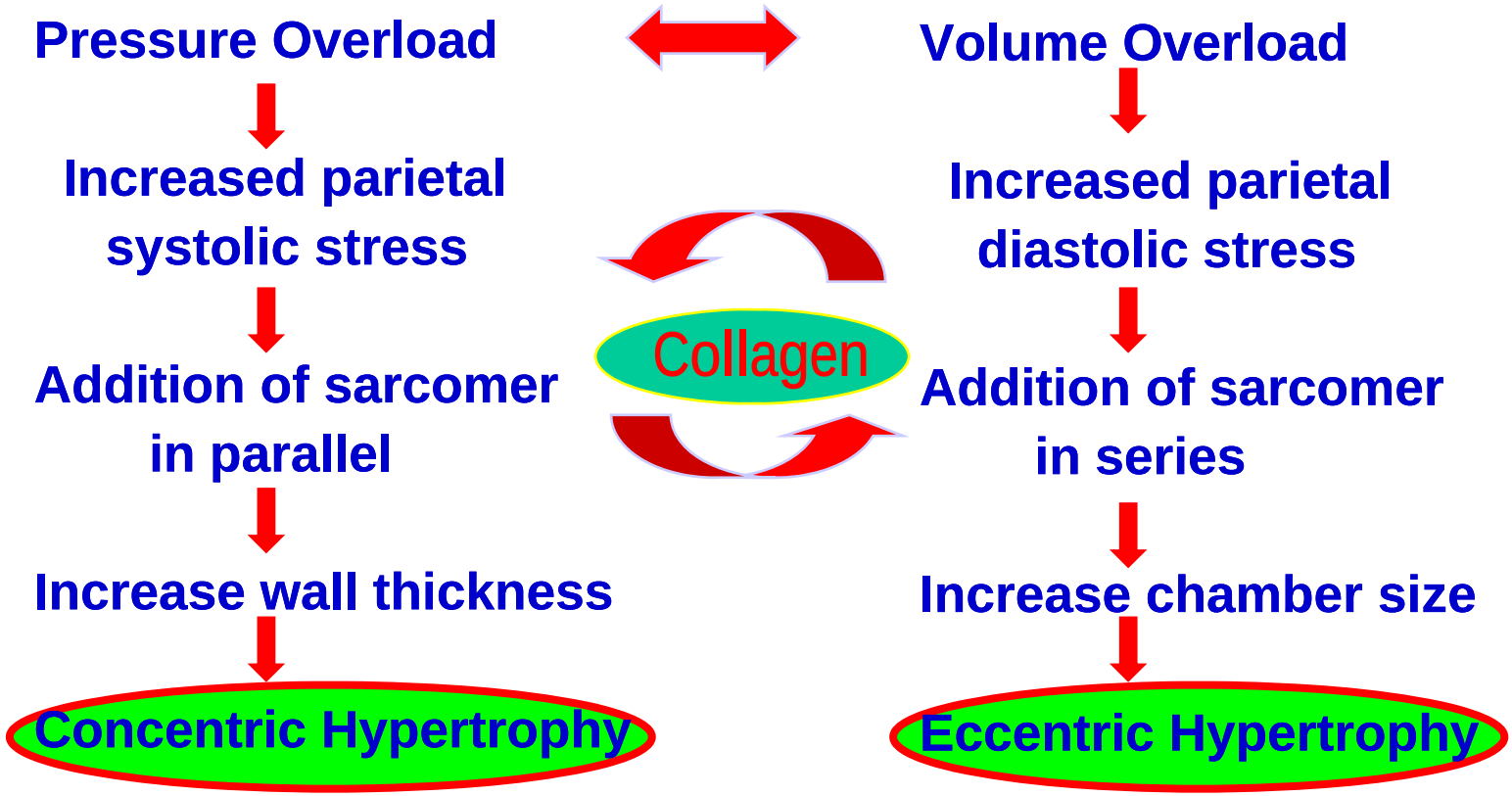
Adaptation of the Heart to Exercise Training



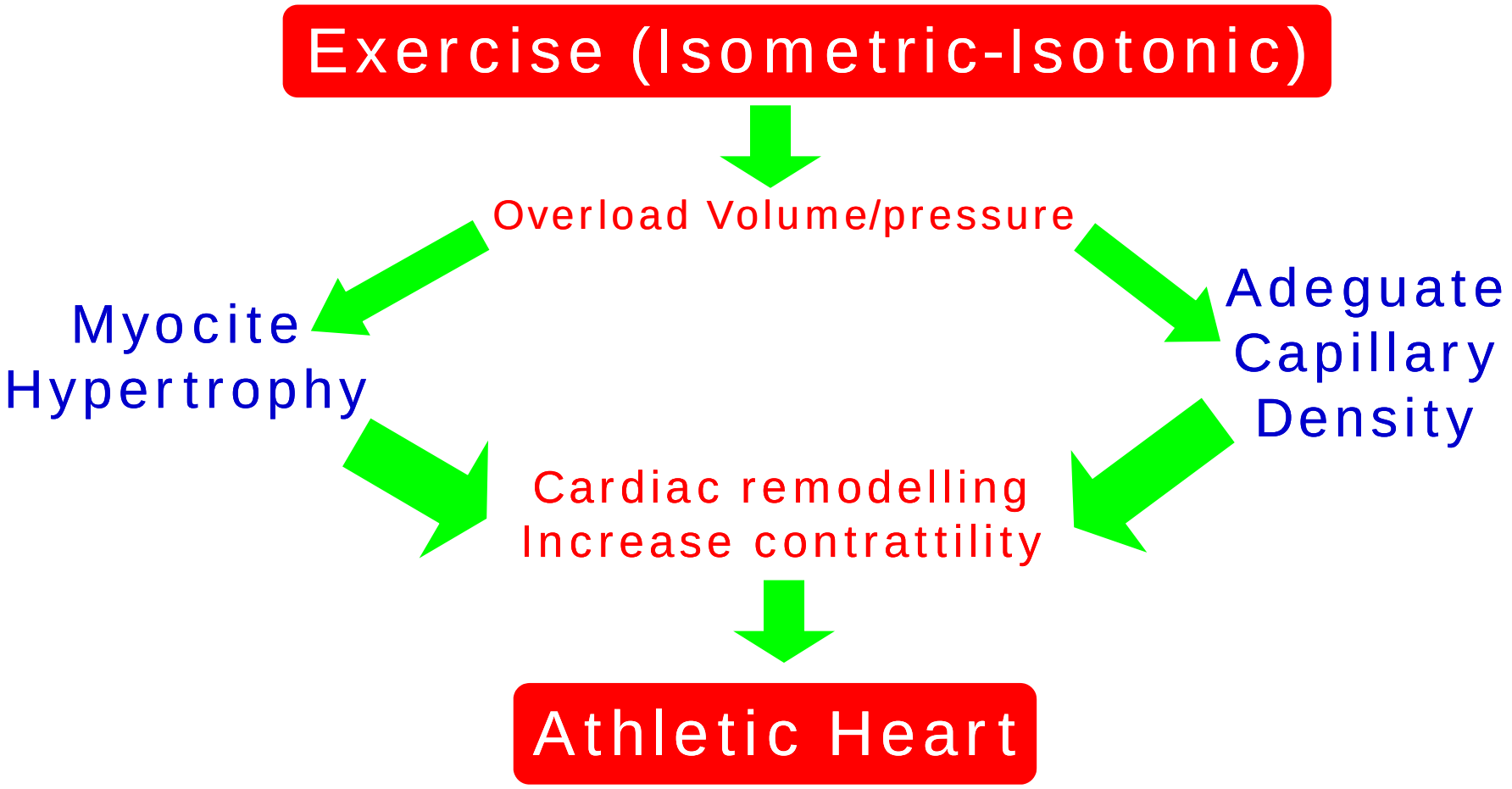
Adaptation of the Heart to Exercise Training



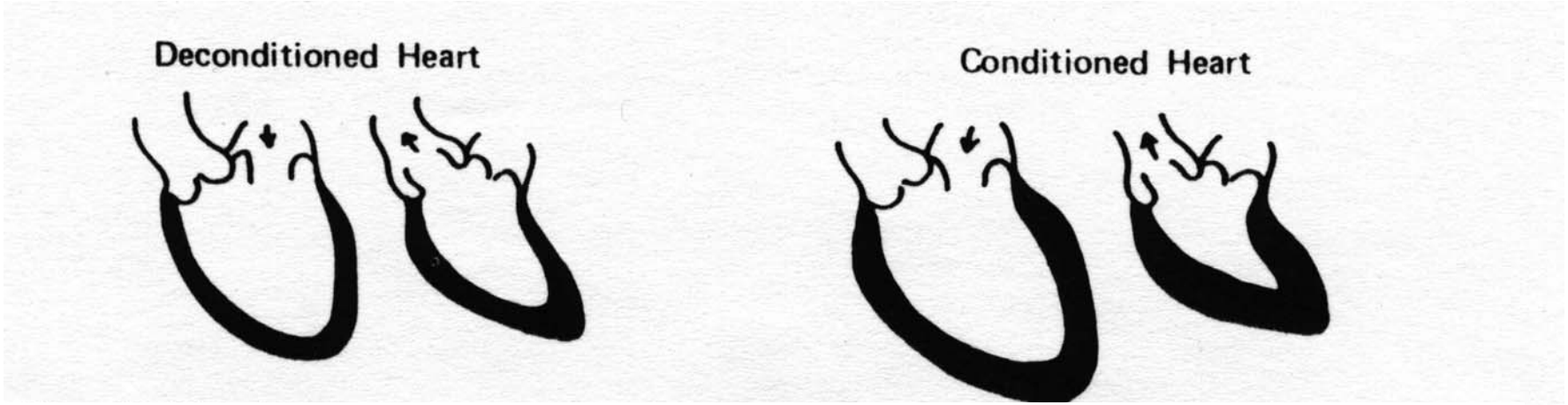
Development of Myocardial Hypertrophy



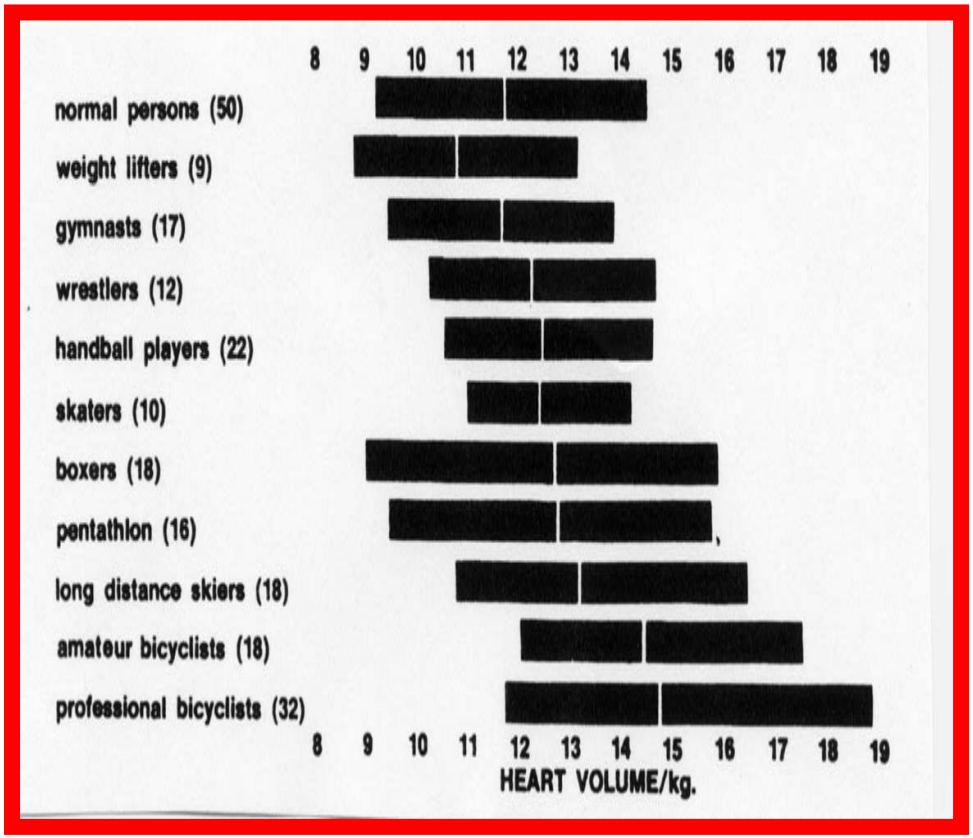
Effects of exercise on cardiac structure and function



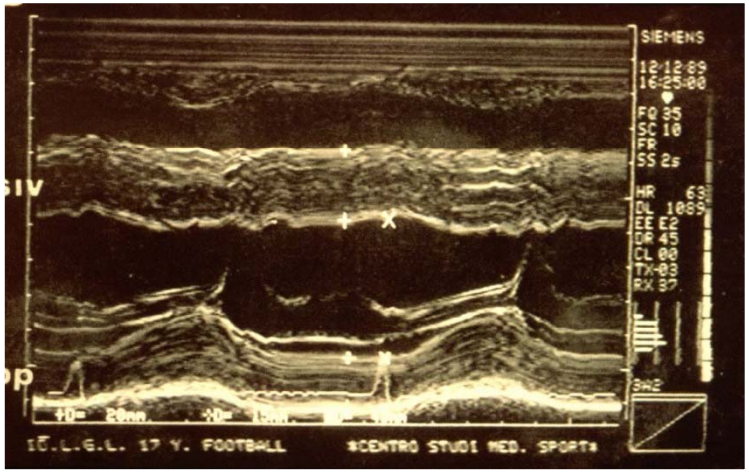
Effects of Training on Left Ventricle

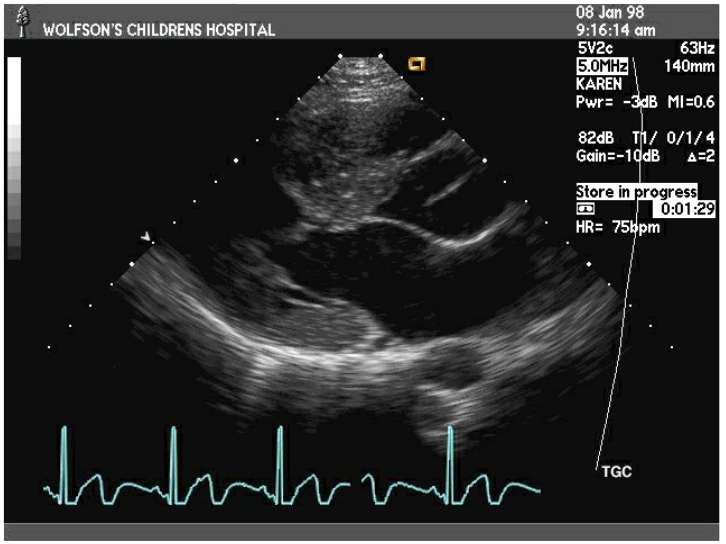


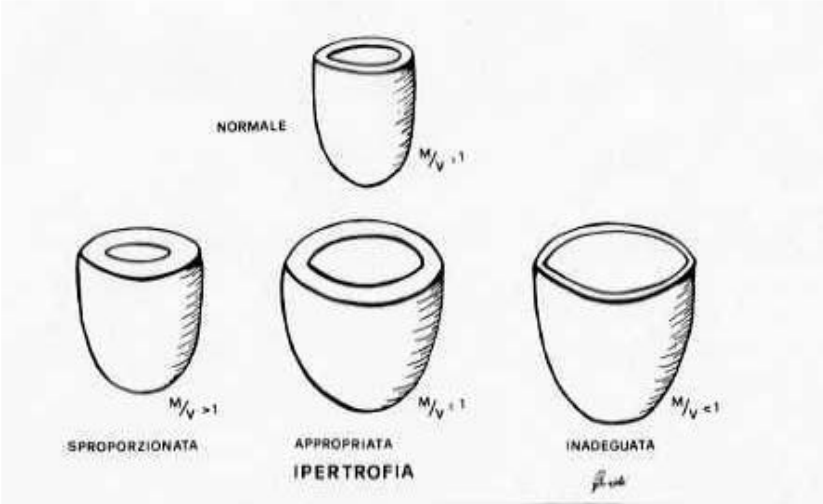

DIADORA
TOYOTA


8 9 10 11 12 13 14 15 16 17 18 19
normal persons (50)
weight lifters (9)
gymnasts (17)
wrestlers (12)
handball players (22)
skaters (10)
boxers (18)
pentathlon (16)
long distance skiers (18)
amateur bicyclists (18)
professional bicyclists (32)
8 9 10 11 12 13 14 15 16 17 18 19
HEART VOLUME/kg.

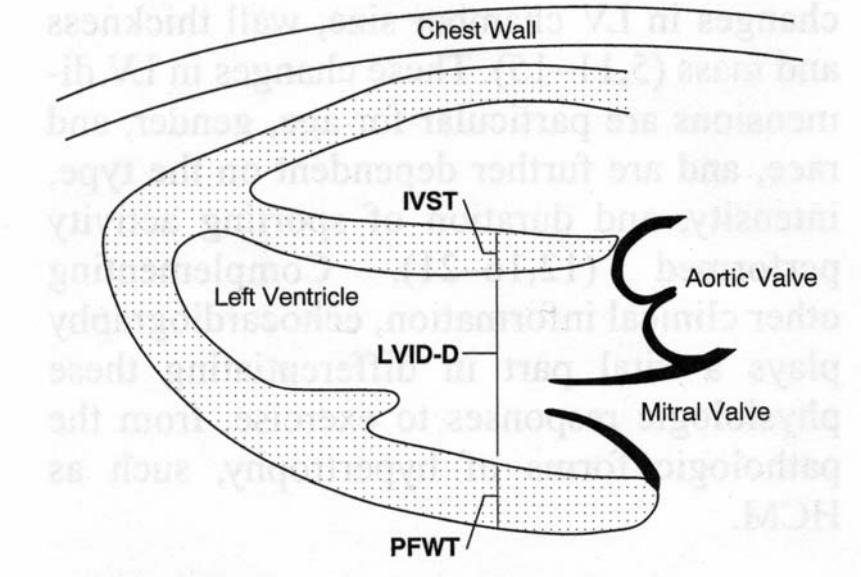
Echo & Left Ventricular Mass

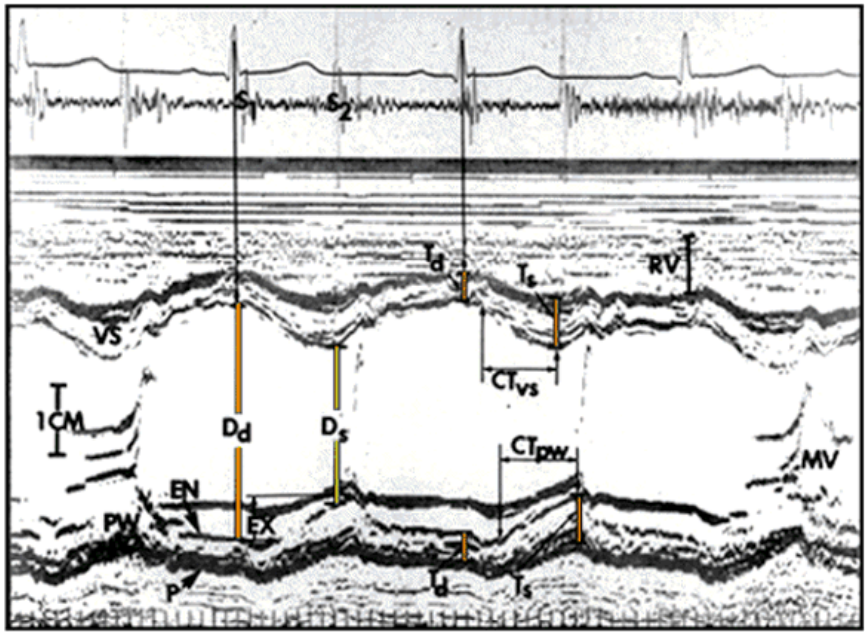






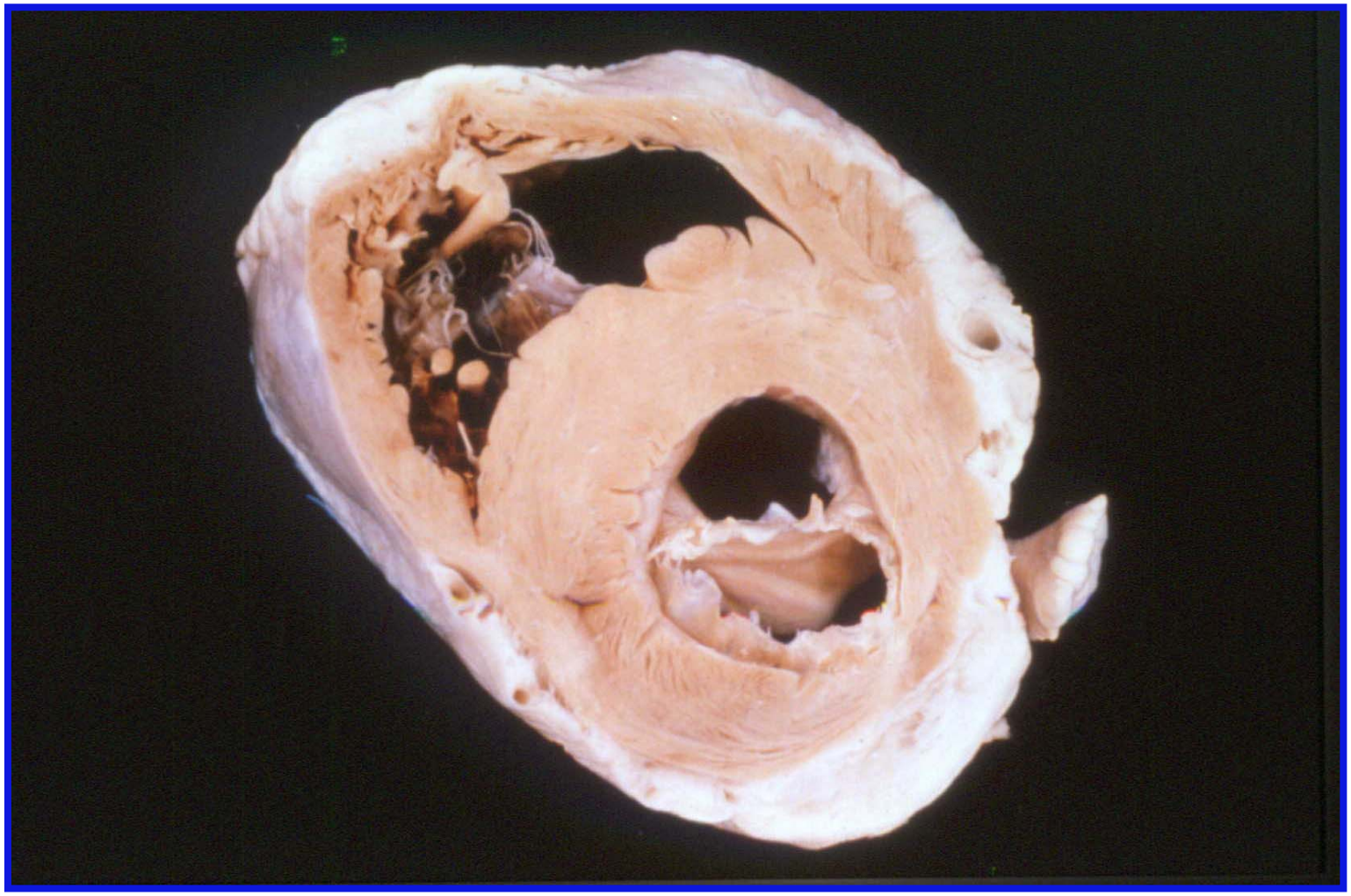
Calculation of LV M



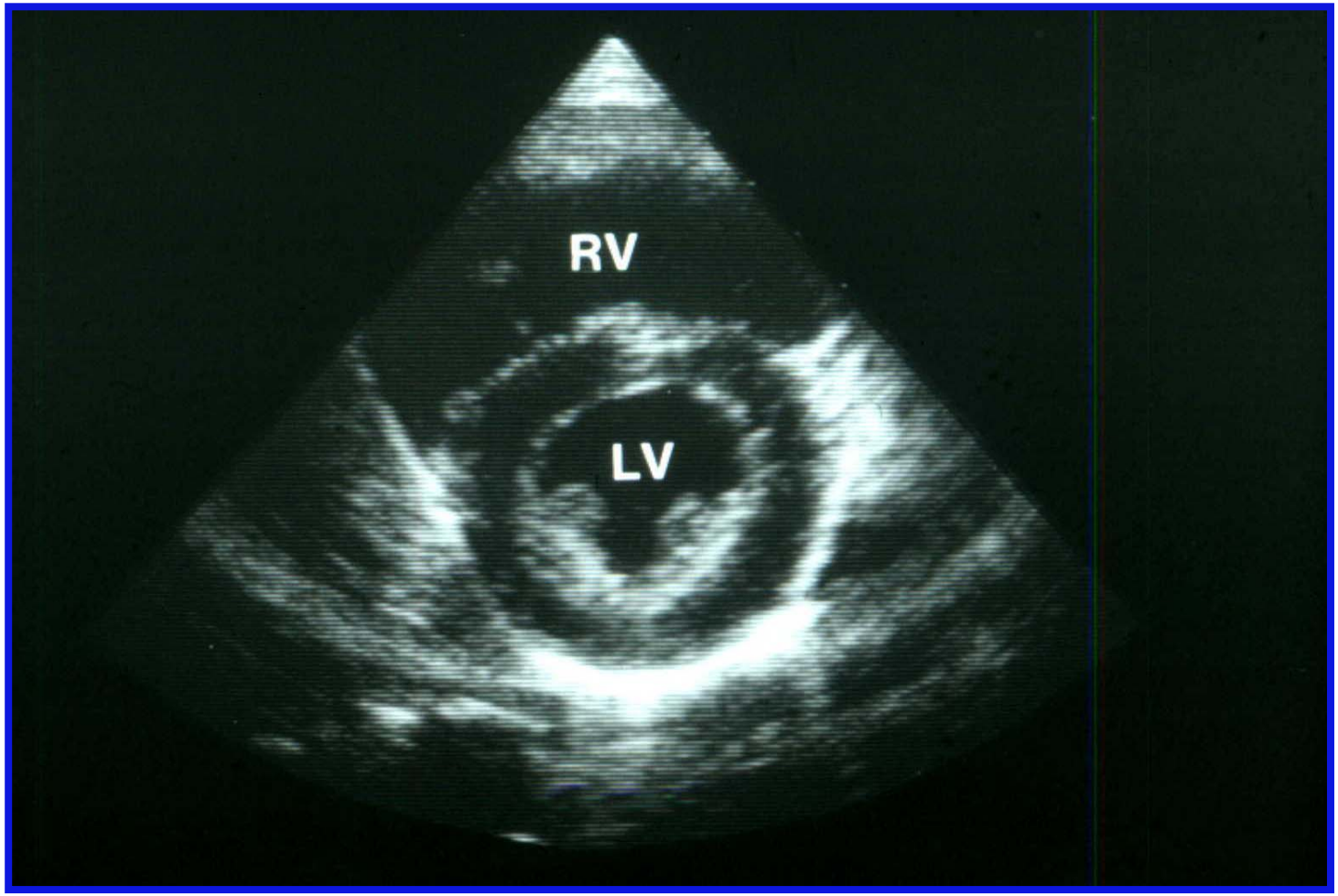


$$LVM(gr) = 0{,}80 \times 1{,}05 \times \left[(IVS + PWT + LVID)^3 - LVID^3 \right]$$

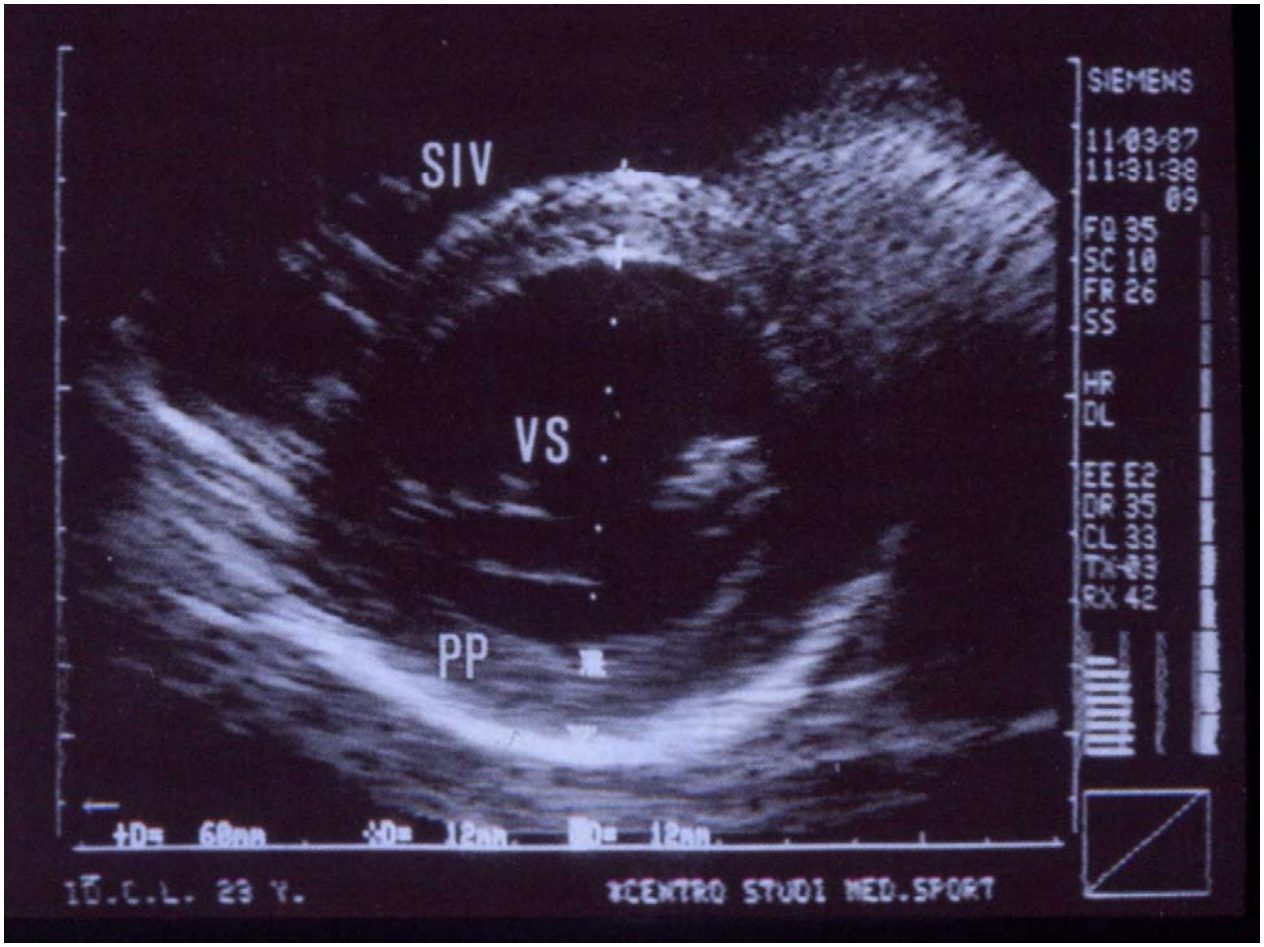
Anatomical Section Through the Short Axis of Left Ventricle



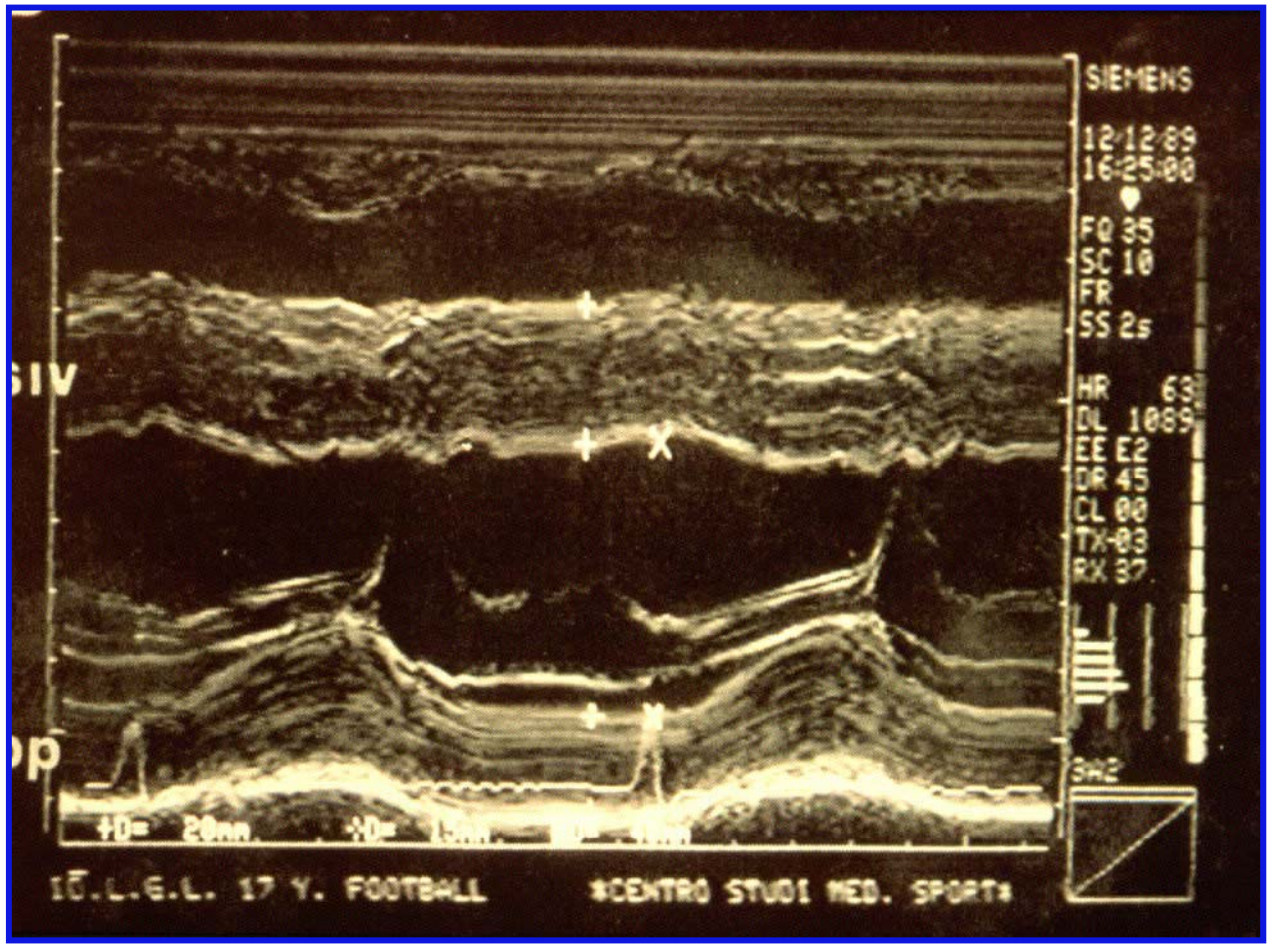
Short Axis View of Left Ventricle in Normal Subject



Short Axis View of L V in Athlete



Pathological Hypertrophy



Athlete's Heart

- Adeguate Hypertrophy
- Normal Systolic Function
- Normal Diastolic Function
- Reversibility

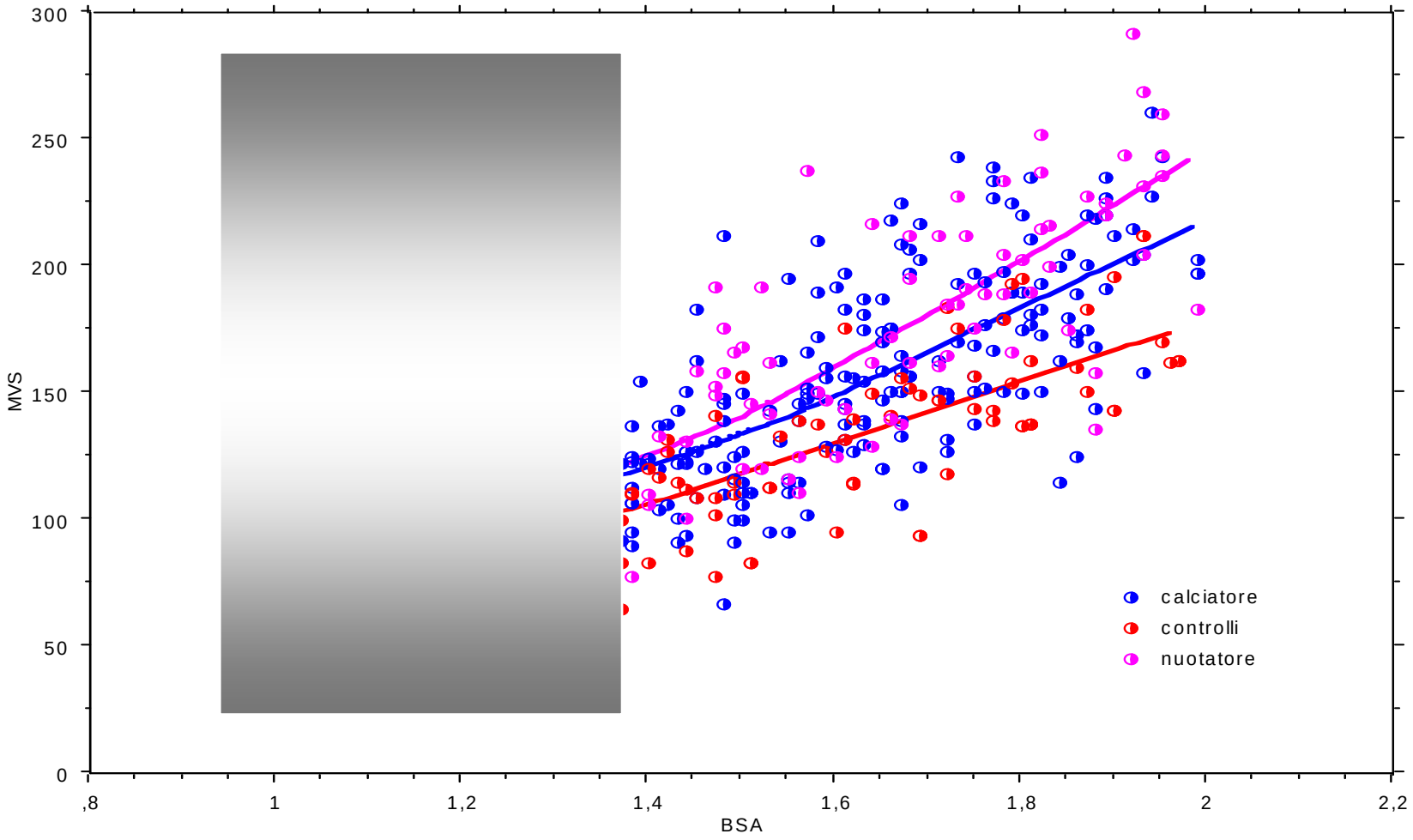
Hypertrophy Modulating Factors

1. Age
2. Gender
3. Type of stimulus
4. Genetic heritage

Conclusions

- Our data suggest that exercise induces a physiological left ventricular hypertrophy in sportive population.
- This hypertrophy becomes evident after sexual maturation was achieved.

MVS - BSA


300
250
200
150
100
50
0
MVS
,8
1
1,2
1,4
1,6
1,8
2
2,2
BSA
calciatore
controlli
nuotatore

Hypertrophy Modulating Factors

Age
Genetic Heritage

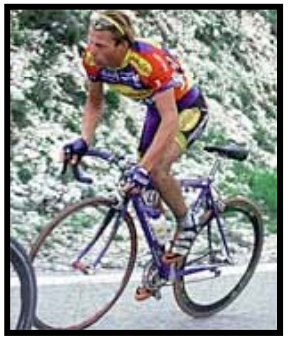
La scelta dello sport è geneticamente determinata?

Hum Genet (2001) 108:230–232
DOI 10.1007/ s004390100466

ORIGINAL INVESTIGATION

David Woods · Michelle Hickman · Yalda Jamshidi
David Brull · Vassilis Vassiliou · Alun Jones
Steve Humphries · Hugh Montgomery

Elite swimmers and the D allele of the ACE I/D polymorphism

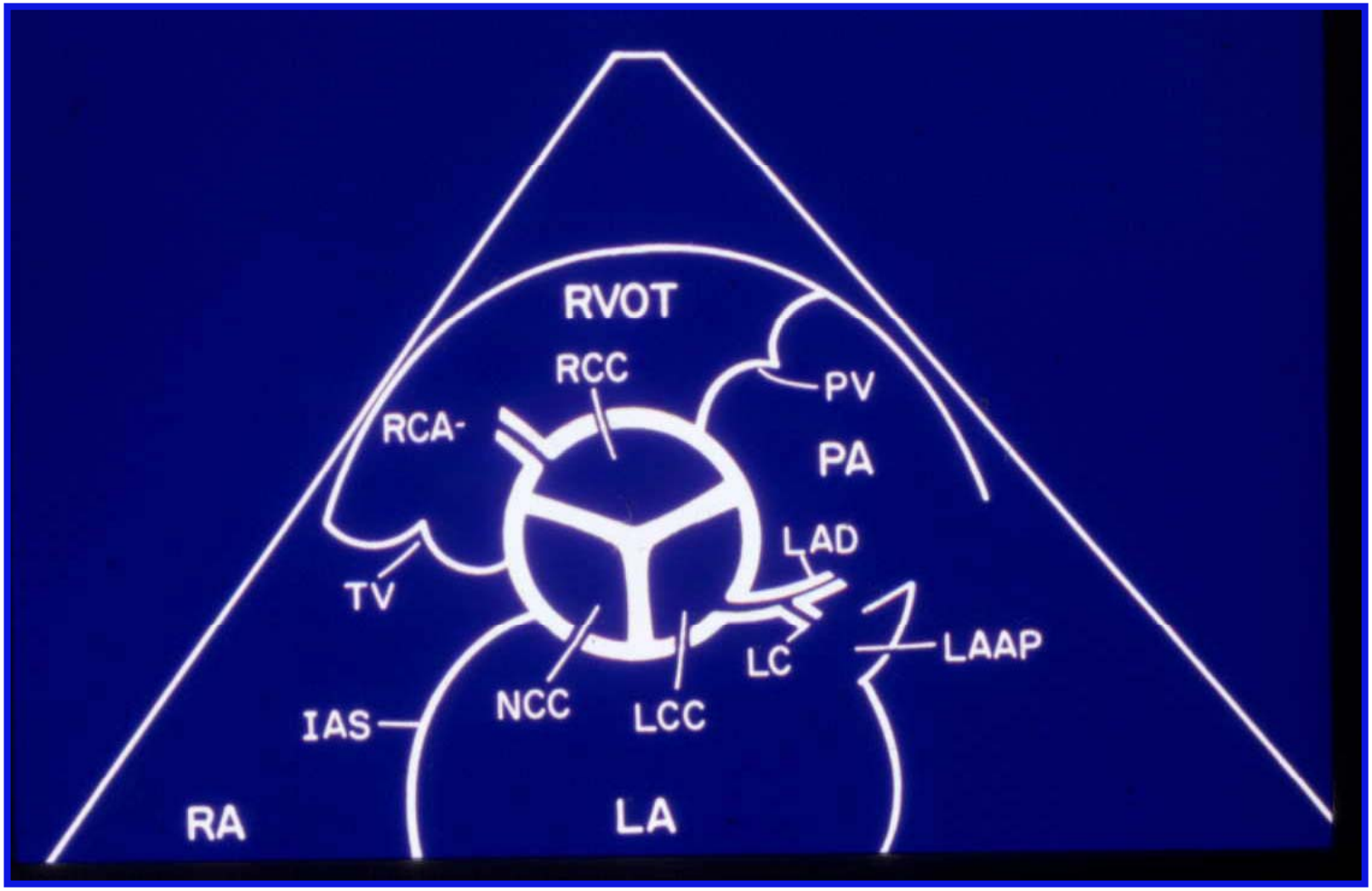


Association of angiotensin-converting enzyme gene I/D polymorphism with change in left ventricular mass in response to physical training

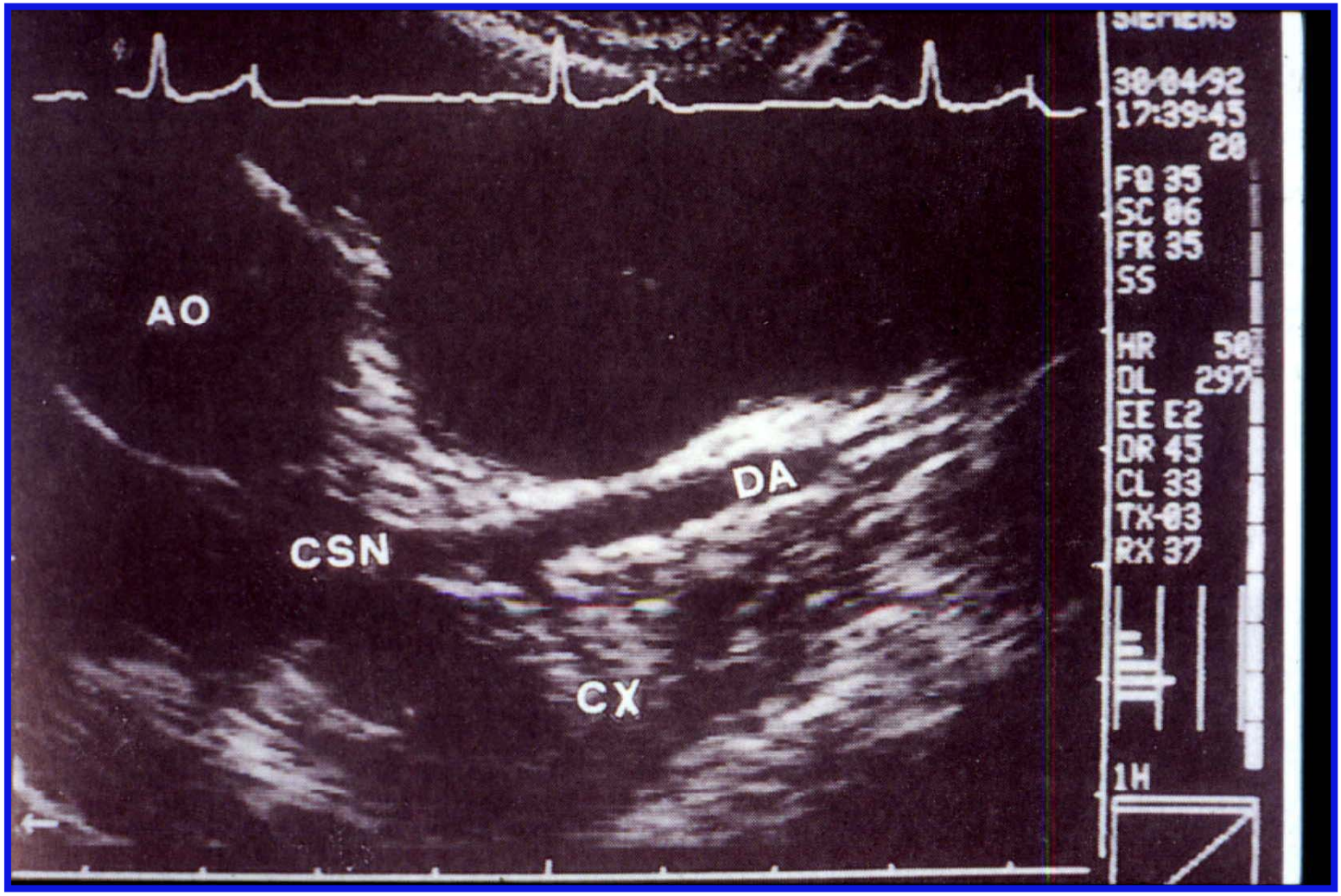
Montgomery H, Clarkson P et al
Circulation 1997, 96: 741-747)

CRMS

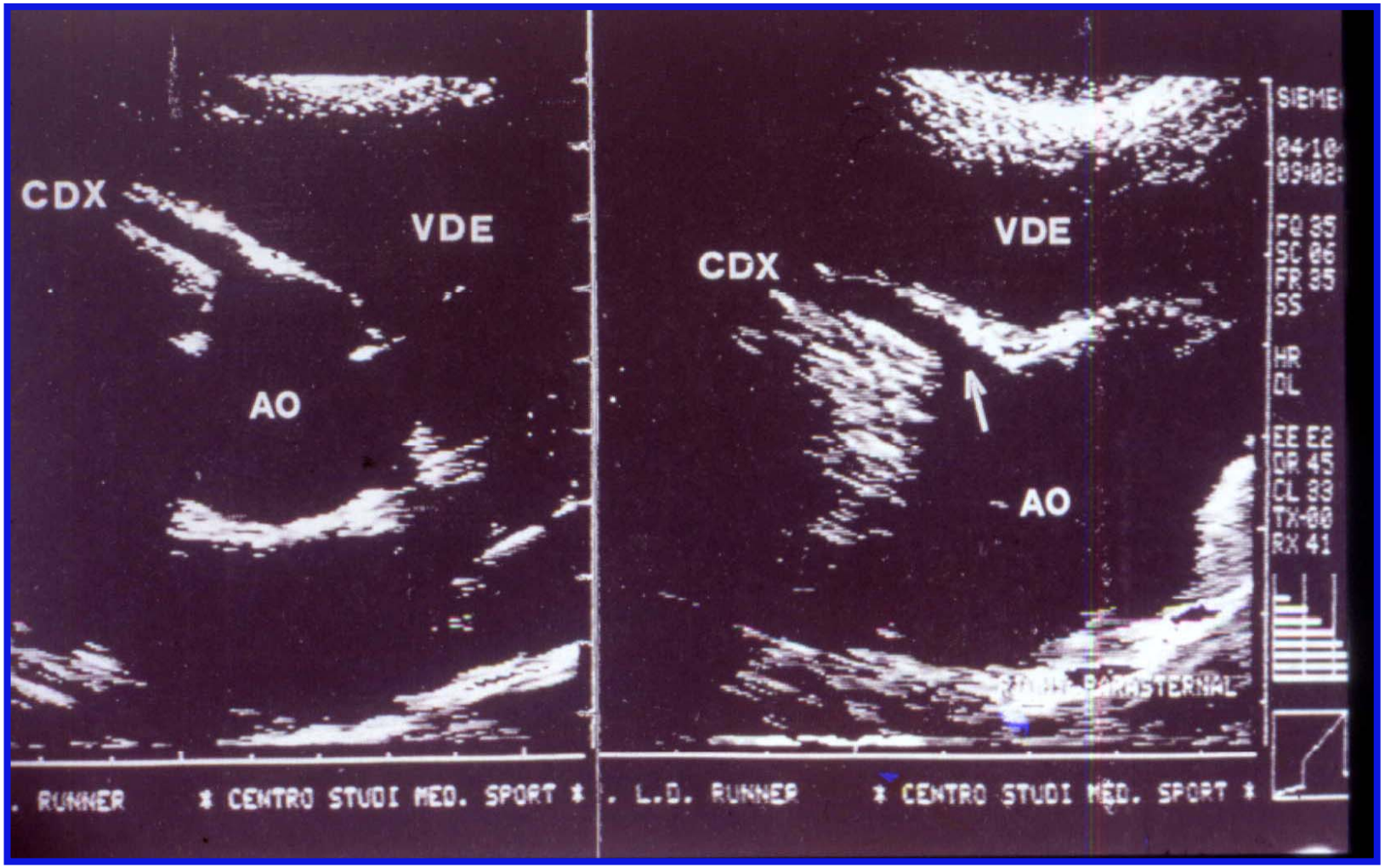
Coronary Arteries



Left Coronary in Athlete



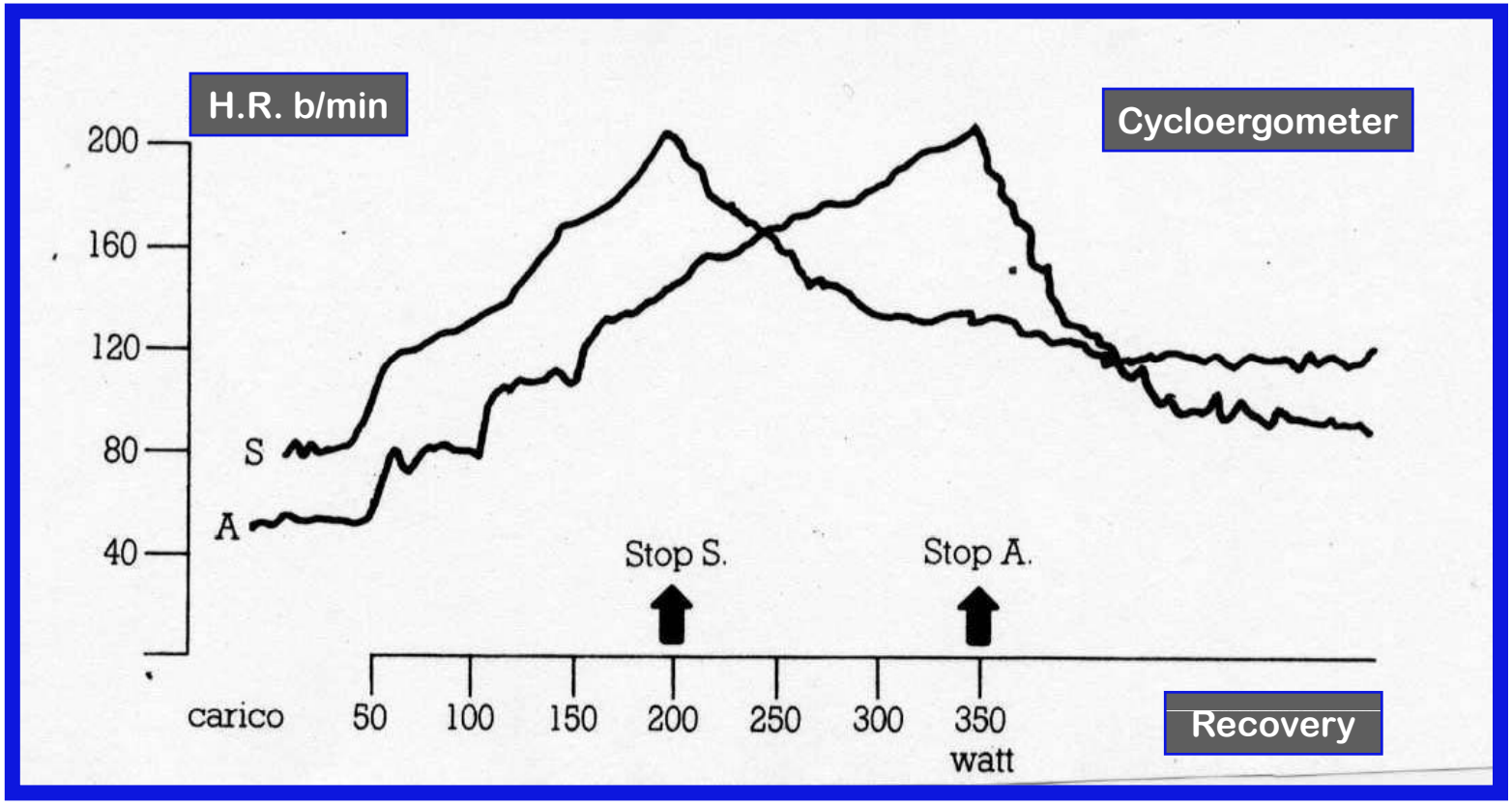
Rigth Coronary in Athlete



Cardiac Adaptation to Exercise
chronic

Functional
Heart Rate

Cardiovascular Response to Acute Exercise in trained subjects




FILA
Nintendo