Fitness Cardiocircolatorio
Fitness Cardorespiratorio

- Quanto la funzionalità cardiorespiratoria condiziona/determina la capacità di svolgere attività fisica.
  - Potenza aerobica
  - Resistenza aerobica

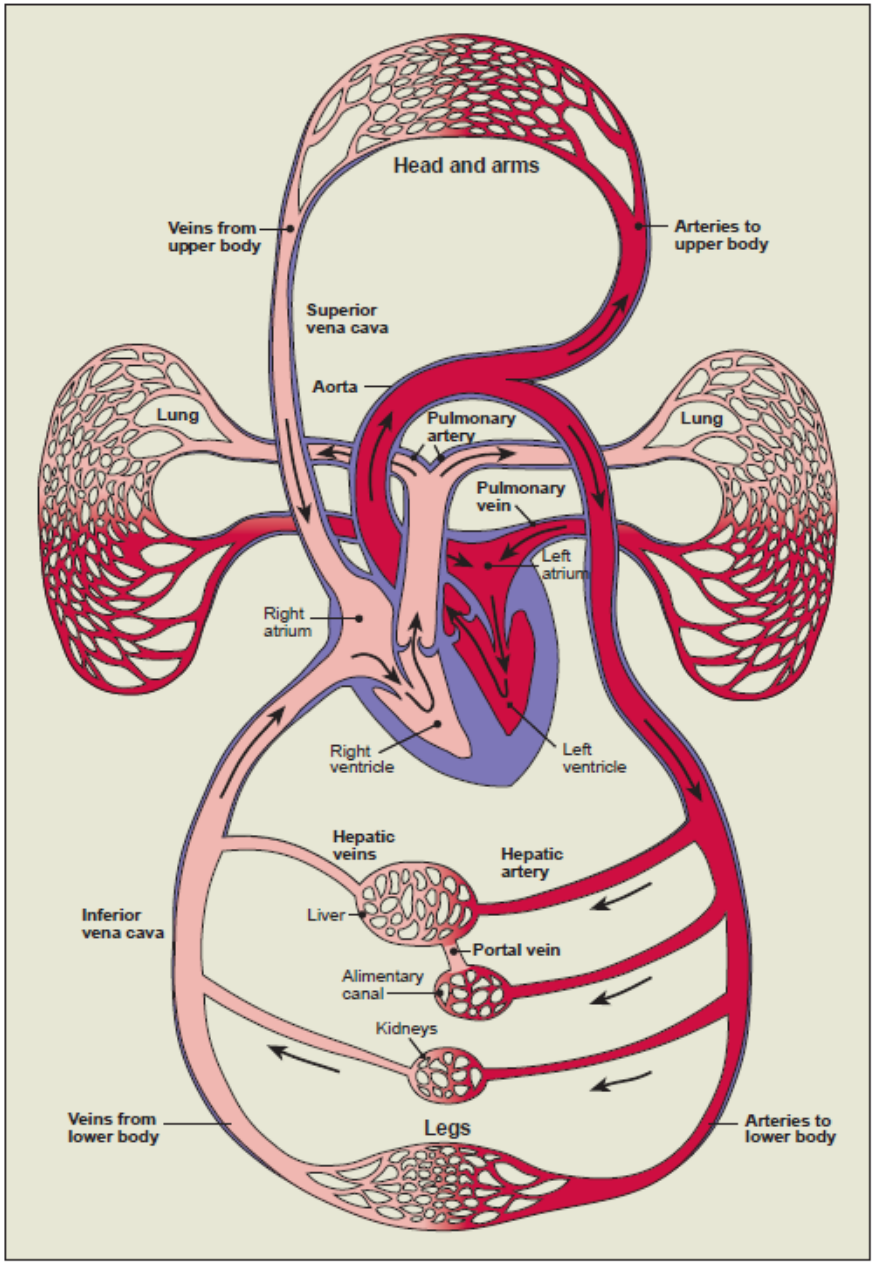
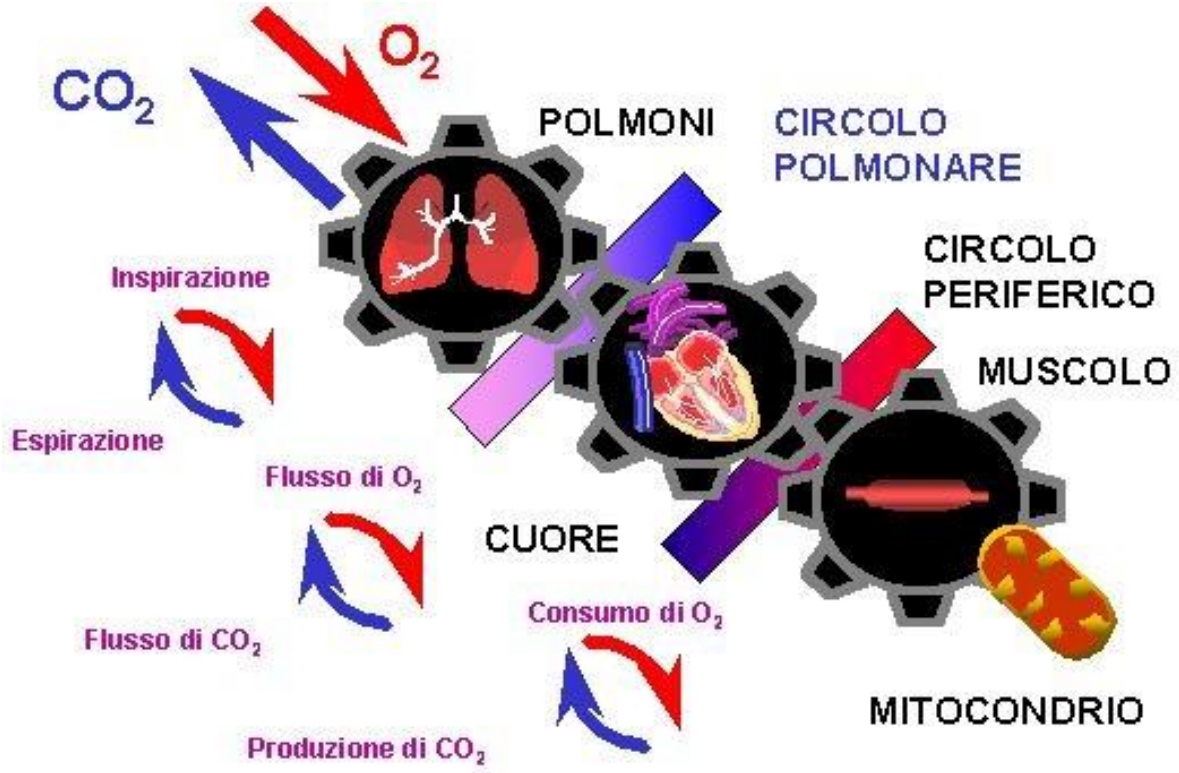

Head and arms
Veins from upper body
Arteries to upper body
Superior vena cava
Aorta
Lung
Pulmonary artery
Lung
Pulmonary vein
Left atrium
Right atrium
Right ventricle
Left ventricle
Hepatic veins
Hepatic artery
Inferior vena cava
Liver
Portal vein
Alimentary canal
Kidneys
Veins from lower body
Legs
Arteries to lower body

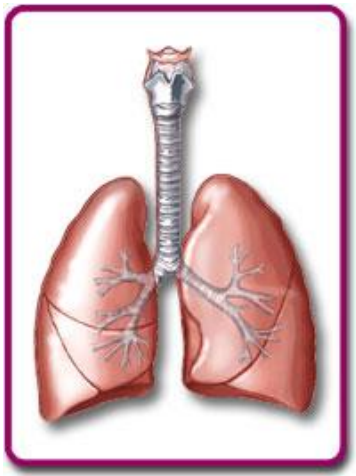
Diagramma di Wasserman

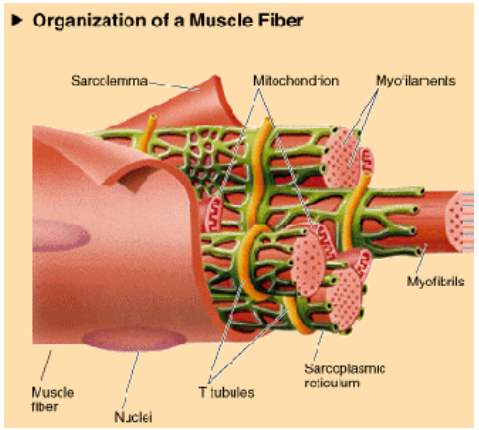


Wasserman gears

Chronic Adaptations

- Cardiovascular adaptations
- Respiratory adaptations
- Muscular adaptations



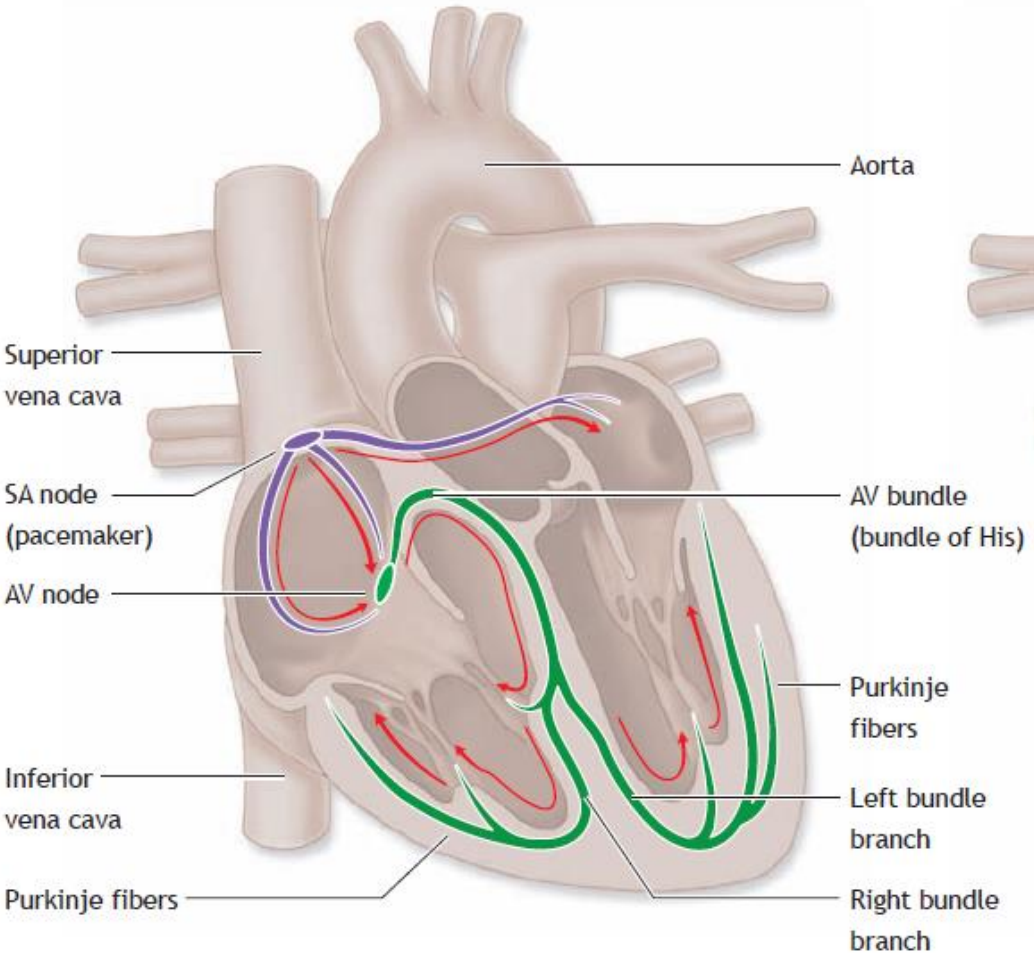


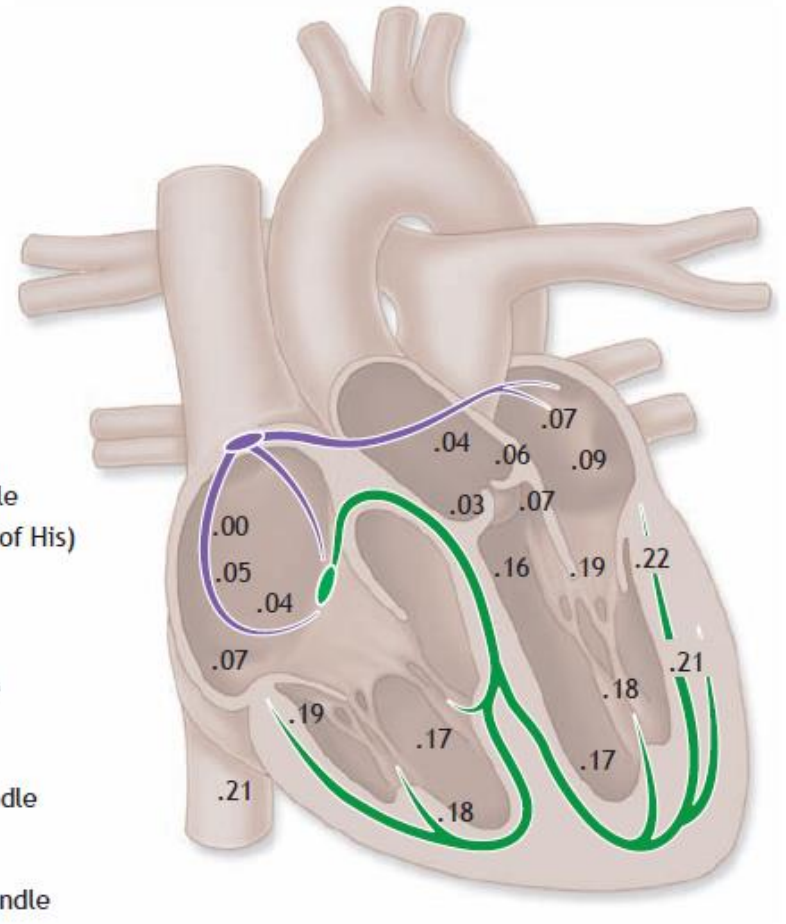
Componenti del Fitness Cardiocircolatorio

- Da cosa dipende
  - Frequenza Cardiaca (FC, HR)
  - Gittata Sistolica (GS, SV)
  - Portata Cardiaca (Q)
  - Pressione Arteriosa (PA)
  - Trasporto di O2 (sangue)

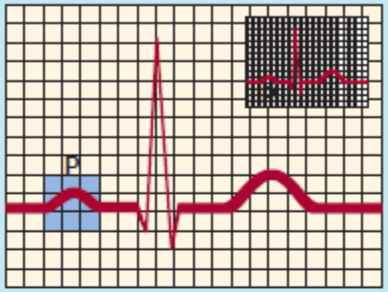
Freqenza Cardiaca (FC, HR)

- *n* battiti cardiaci nell'unità di tempo (min)
  - A riposo (FC basale)
  - Durante esercizio
    - Submassimale
    - Incrementale massimale


Aorta
Superior vena cava
SA node (pacemaker)
AV node
AV bundle (bundle of His)
Purkinje fibers
Inferior vena cava
Left bundle branch
Purkinje fibers
Right bundle branch

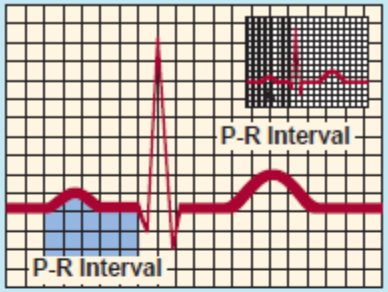

.07
.04
.06
.09
.03
.07
.00
.05
.16
.19
.22
.04
.07
.21
.18
.19
.17
.17
.21
.18

Atrial Depolarization (P-wave)



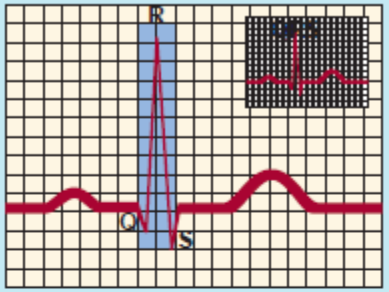
The depolarization of both atria is represented by the P-wave. The P-wave is the first ECG deflection.

P-R Interval



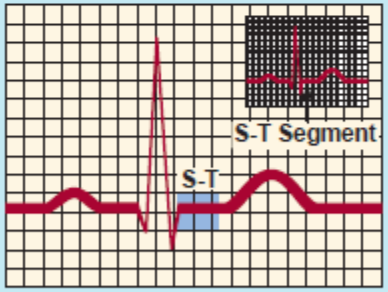
Electrical transmission from the atria to the venticles. Includes the P-wave and P-R Segment.

Ventricular Depolarization (QRS)



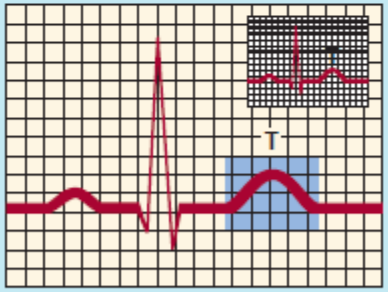
Ventricular depolarization is indicated by the QRS complex. The R-wave is the initial positive deflection; the negative deflection before the R-wave is the Q; the negative deflection after the R-wave is the S-wave.

Ventricular Repolarization (S-T Segment)



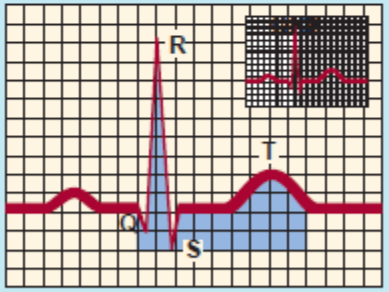
Earlier phase repolarization of both ventricles extends from the end of the QRS to the beginning of the T-wave. The point at which the S-T segment joins the QRS is known as the J (junction)-point.

Ventricular Repolarization (T-wave)

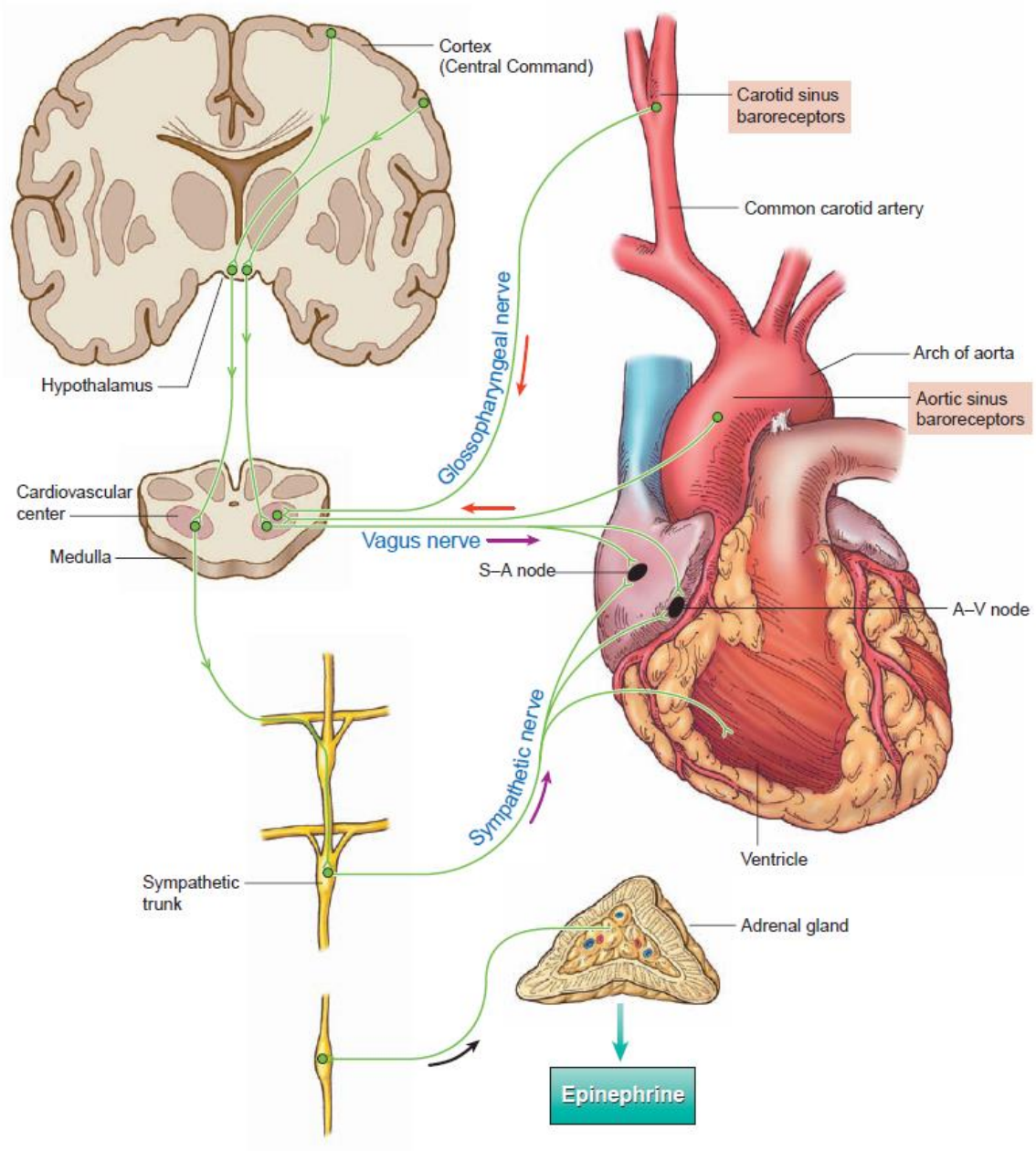


The repolarization of both ventricles is represented by the T-wave. The S-T segment and the T-wave are sensitive indicators of the oxygen demand-oxygen supply status of the ventricular myocardium.

Ventricular Depolarization and Repolarization (Q-T Interval)



Includes the QRS complex, S-T segment, and T-wave.

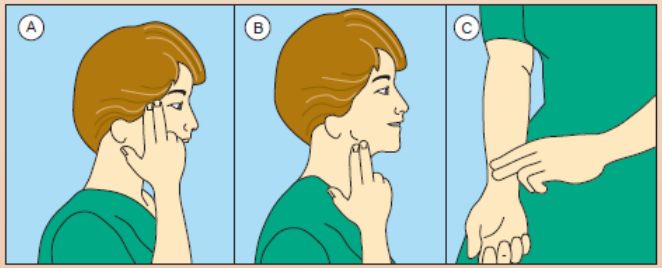

Cortex
(Central Command)
Carotid sinus
baroreceptors
Common carotid artery
Glossopharyngeal nerve
Arch of aorta
Aortic sinus
baroreceptors
Hypothalamus
Cardiovascular
center
Medulla
Vagus nerve
S–A node
A–V node
Sympathetic nerve
Ventricle
Sympathetic
trunk
Adrenal gland
Epinephrine

FC basale

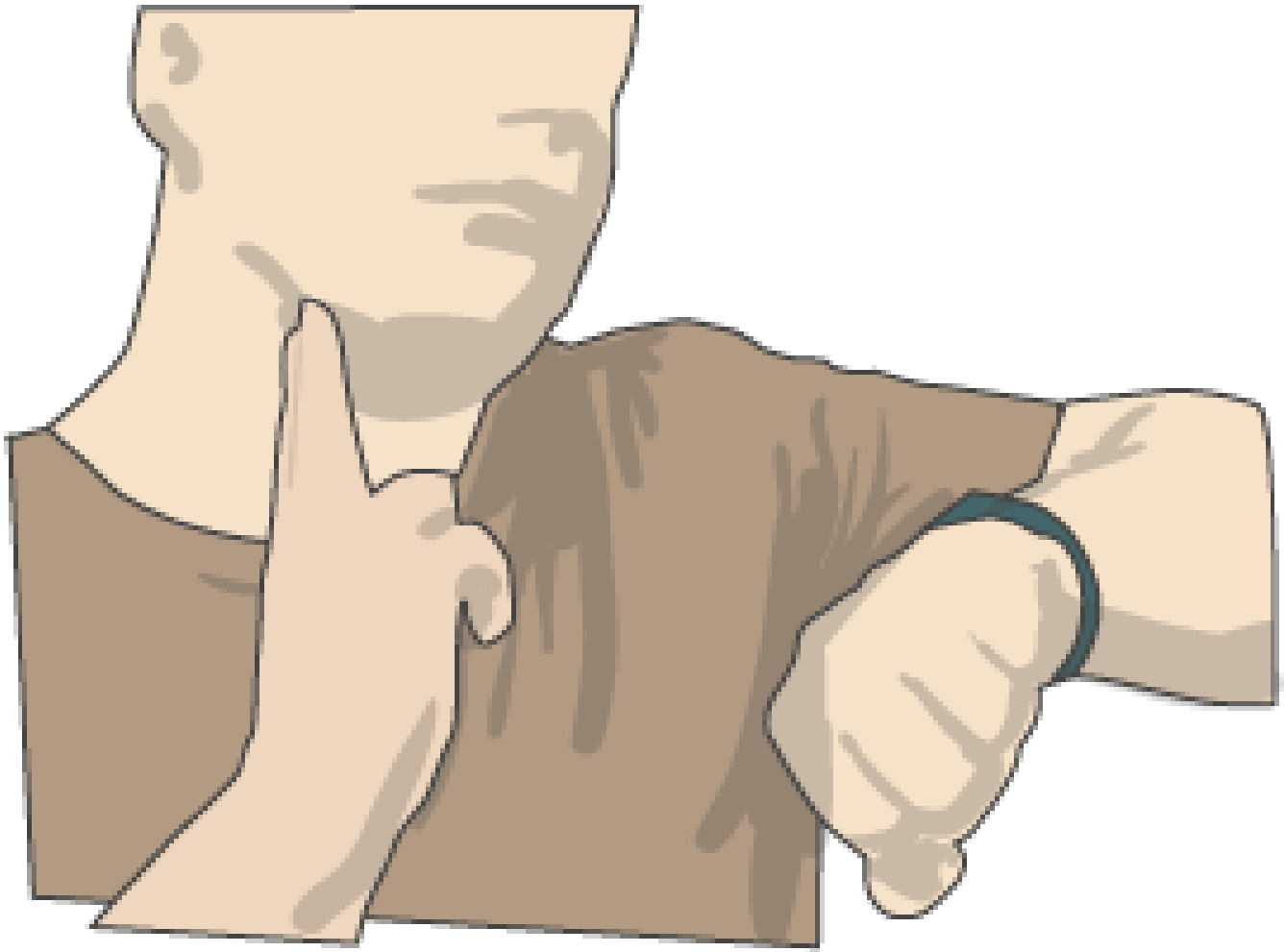
- v.n.: 60-80/min
- In atleti (di durata): 28-40/min
- Diminuisce con l’età
- Quando misurarla?

Table 1 Heart Rate (in beats per minute; bpm) Conversion. Find the Number of Pulse Counts for 6, 10, or 15 Seconds; Read Across for the bpm

6-S COUNT	PER MIN 10-S PER RATE	COUNT	MIN 15-S RATE	COUNT	PER MIN RATE
4	40	7	42	10	40
5	50	8	48	11	44
6	60	9	54	12	48
7	70	10	60	13	52
8	80	11	66	14	56
9	90	12	72	15	60
10	100	13	78	16	64
11	110	14	84	17	68
12	120	15	90	18	72
13	130	16	96	19	76
14	140	17	102	20	80
15	150	18	108	21	84
16	160	19	114	22	88
17	170	20	120	23	92
18	180	21	126	24	96
19	190	22	132	25	100
20	200	23	138	26	104
21	210	24	144	27	108
22	220	25	150	28	112
		26	156	29	116
		27	162	30	120
		28	168	31	124
		29	174	32	128
		30	180	33	132
		31	186	34	136
		32	192	35	140
		33	198	36	144
		34	204	37	148
		35	210	38	152
		36	216	39	156
		37	222	40	160
				41	164
				42	168
				43	172
				44	176
				45	180
				46	184
				47	188
				48	192
				49	196
				50	200
				51	204
				52	208
				53	212
				54	216
				55	220



Three typical locations for palpating pulse: (**A**) temporal; (**B**) carotid; and (**C**) radial arteries.


© topendsports.com


LIGHT
POLAR
UP
1 2 3 5
172
345 KCAL
32:15 3
BACK
RCX5
DOWN
RCX

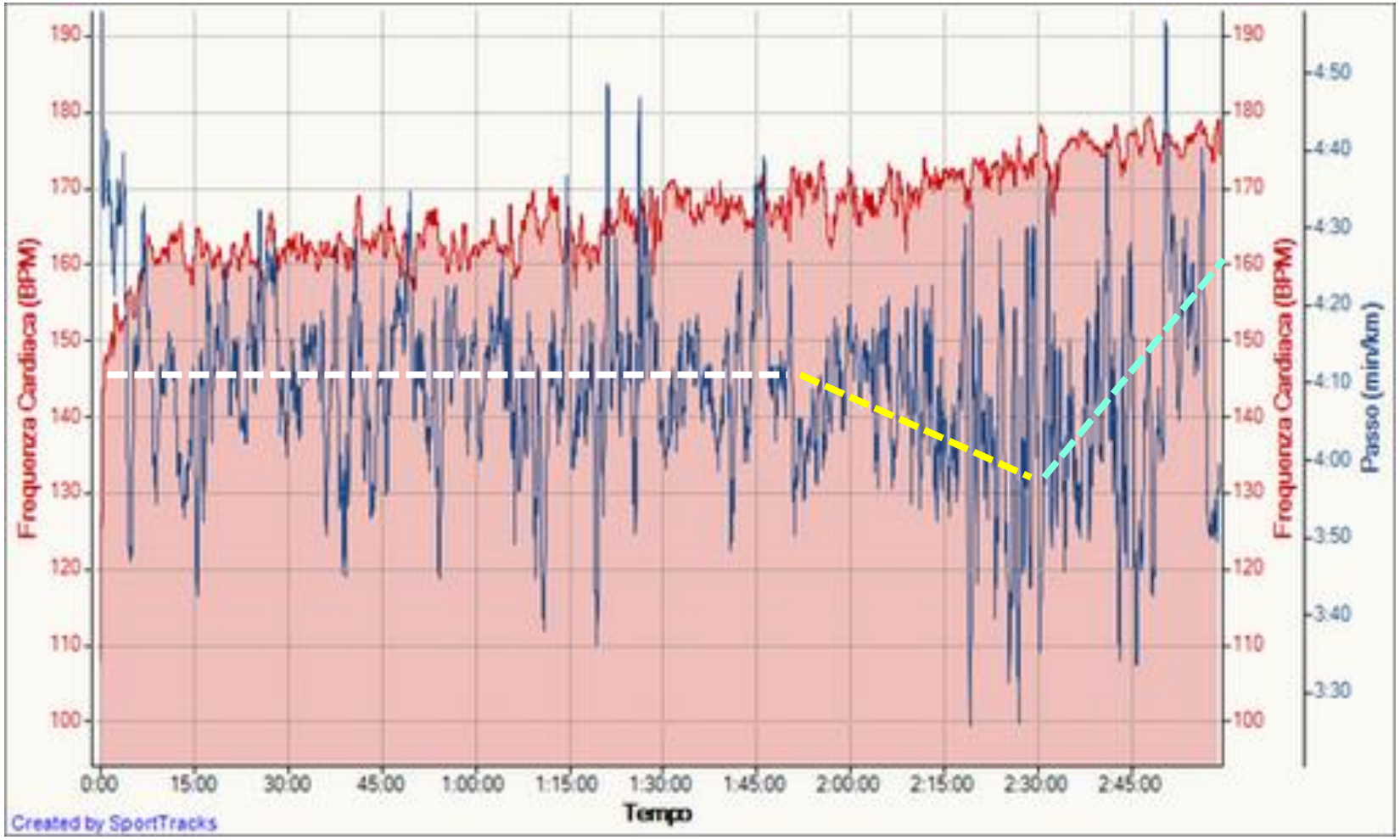

POLAR

Frequenza cardiaca basale

Classification	Resting Heart Rate (bpm)	
	Men	Women
Low	35–56	39–58
Moderately low	57–61	59–63
Less than average	62–65	64–67
Average	66–71	68–72
Greater than average	72–75	73–77
Moderately high	76–81	78–83
High	82–103	84–104

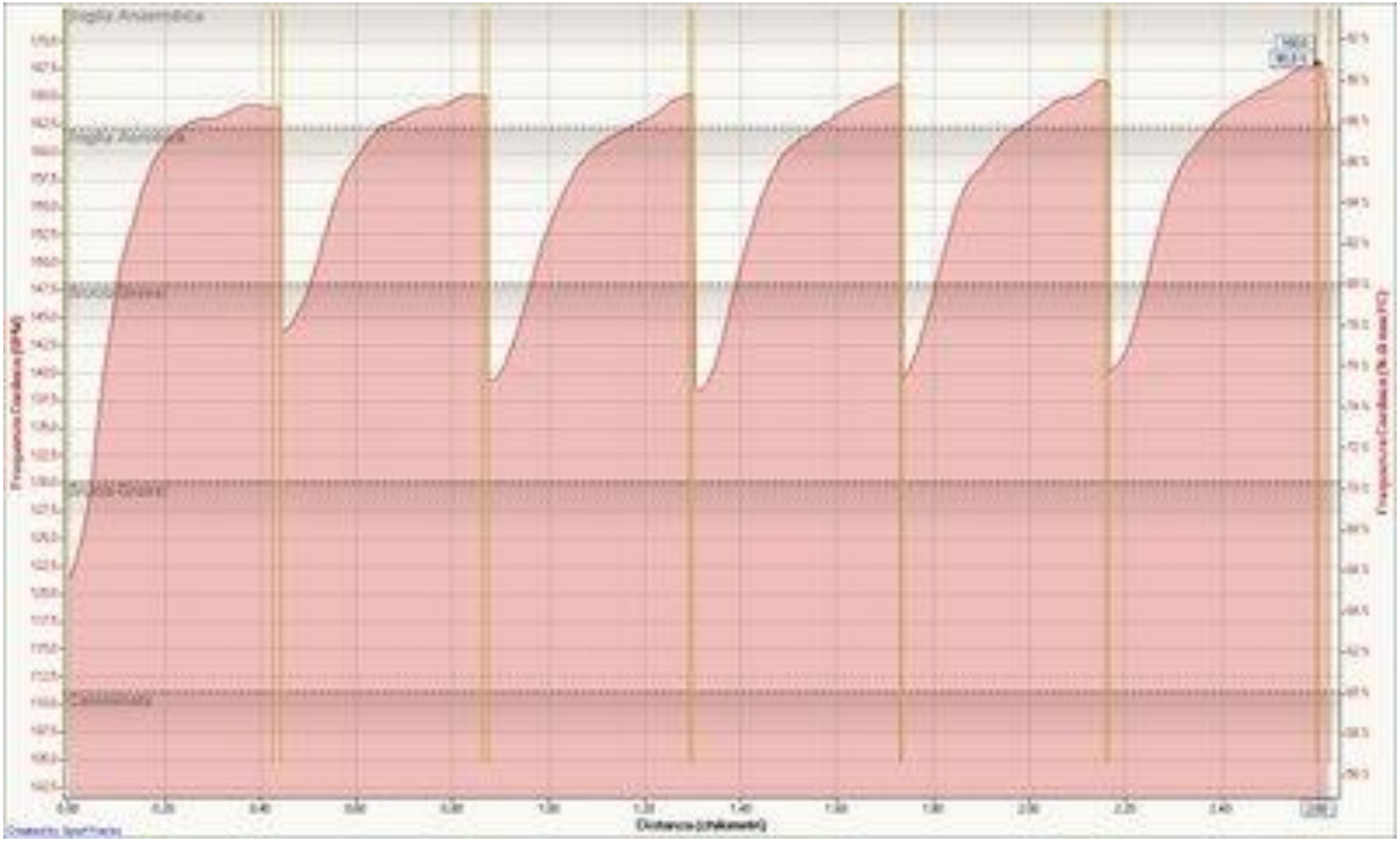
FC cardiaca allenante

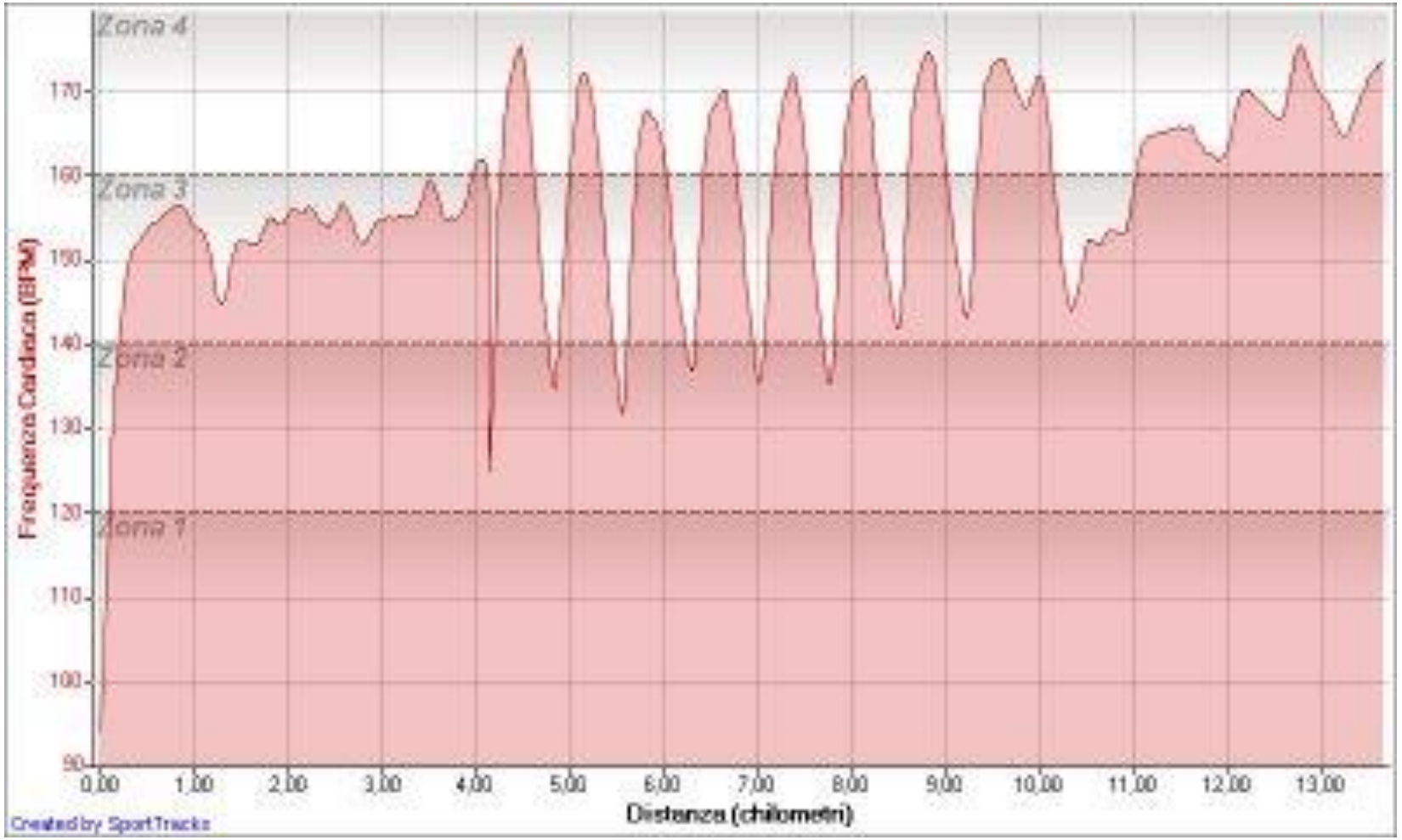
FC durante esercizio submassimale

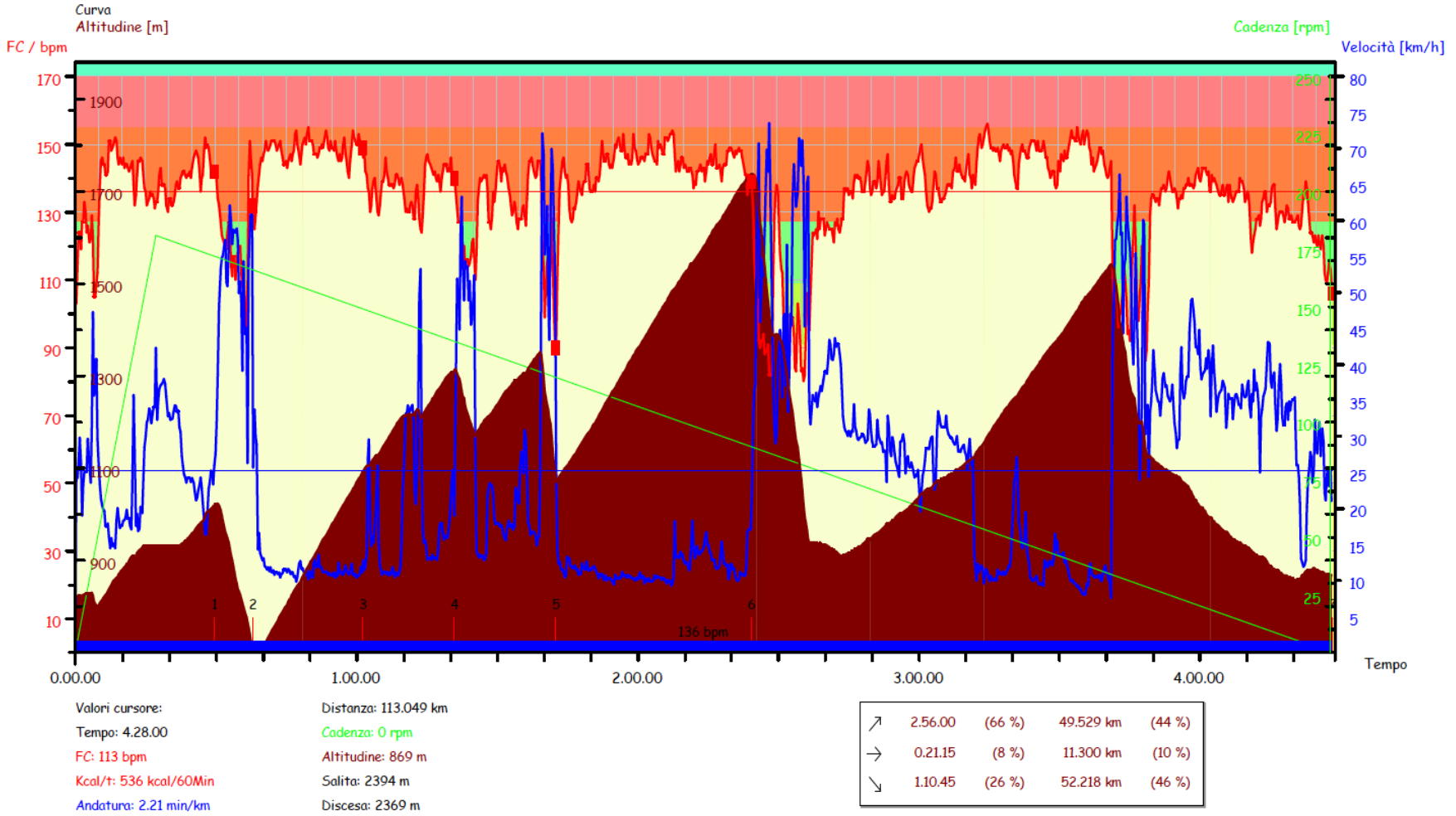

Frequenza Cardiaca (BPM)
190
180
170
160
150
140
130
120
110
100
0:00
15:00
30:00
45:00
1:00:00
1:15:00
1:30:00
1:45:00
2:00:00
2:15:00
2:30:00
2:45:00
Tempo
Frequenza Cardiaca (BPM)
Passo (min/km)
4:50
4:40
4:30
4:20
4:10
4:00
3:50
3:40
3:30
Created by SportTracks


178
14:01
8.10
Frequenza Cardiaca (BPM)
Passo (min/km)
Distanza (chilometri)
175
170
165
160
155
150
145
140
135
130
125
120
115
110
1:05:00
1:00:00
55:00
50:00
45:00
40:00
35:00
30:00
25:00
20:00
15:00
10:00
5:00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
9.00
Created by SportTracks


Zona 5
Zona 4
Zona 3
Zona 2
Zona 1
90 %
85 %
80 %
75 %
70 %
65 %
60 %
55 %
50 %
45 %
Frequenza Cardiaca (% di max FC)
0:00
10:00
20:00
30:00
40:00
50:00
1:00:00
1:10:00
1:20:00
1:30:00
1:40:00
Tempo
Created by SportTracks


Soglia Anaerobica
Soglia Aerobica
Distanza (chilometri)


Zona 4
Zona 3
Zona 2
Zona 1
170
160
150
140
130
120
110
100
90
Frequenza Cardiaca (BPM)
0,00
1,00
2,00
3,00
4,00
5,00
6,00
7,00
8,00
9,00
10,00
11,00
12,00
13,00
Distanza (chilometri)
Created by SportTracks



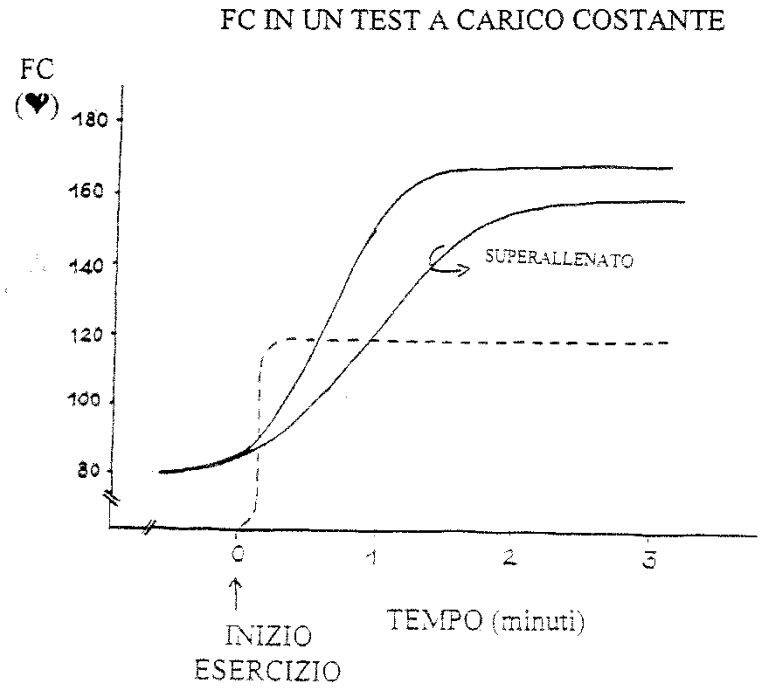
Valori cursore:
Tempo: 4.28.00
FC: 113 bpm
Kcal/t: 536 kcal/60Min
Andatura: 2.21 min/km

Distanza: 113.049 km
Cadenza: 0 rpm
Altitudine: 869 m
Salita: 2394 m
Discesa: 2369 m

↗	2.56.00	(66 %)	49.529 km	(44 %)
→	0.21.15	(8 %)	11.300 km	(10 %)
↘	1.10.45	(26 %)	52.218 km	(46 %)

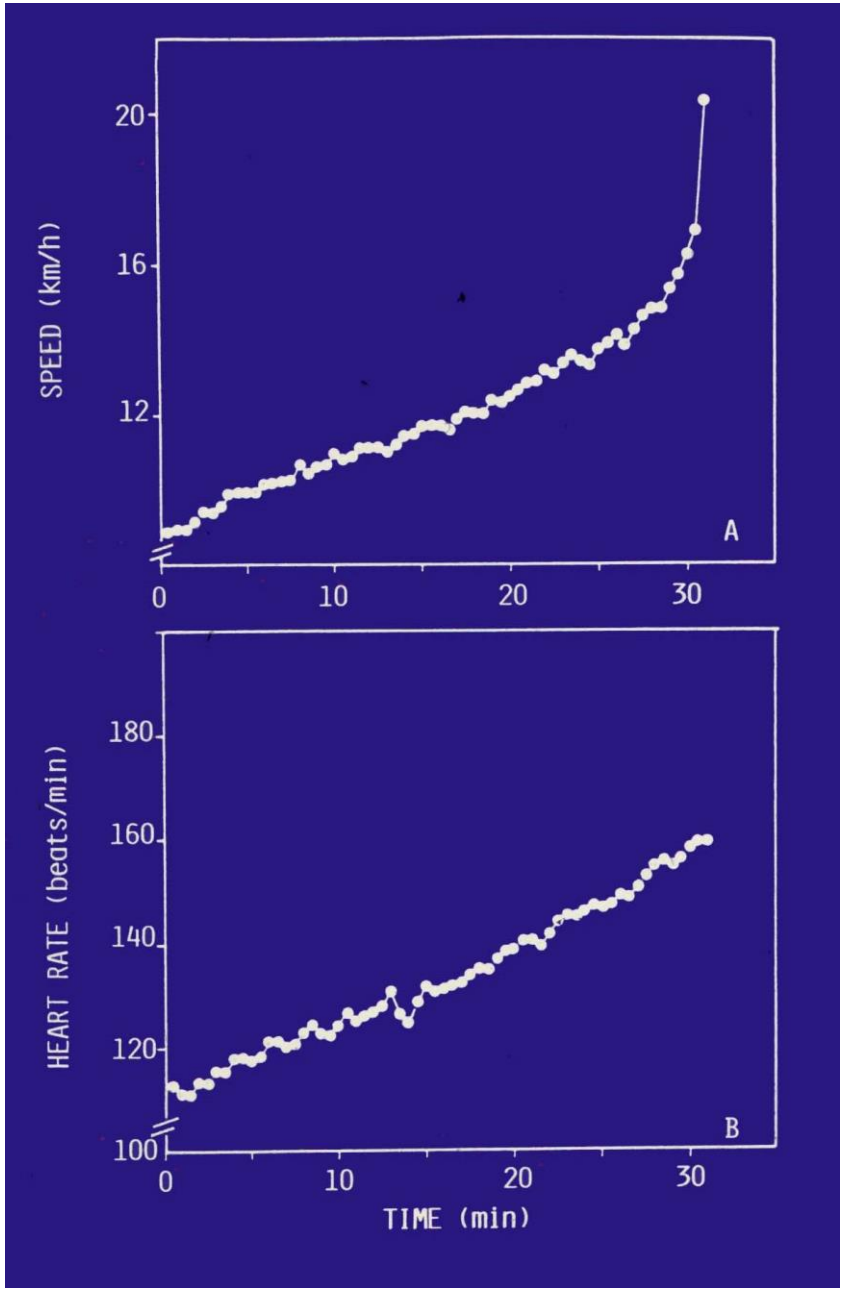
Utente	Andrea Tomè	Data	08/05/2011	FC	136 / 156		
Esercizio	BasicUse	Ora	7.31.01	Velocità	2.22 / 0.49		
Sport	Ciclismo	Durata	4.28.25.2	Cadenza	181 / 181		
Squadra	Squadra Polar	Distanza	113.1 km				
Nota				Salita	2400 (-0.7%)		
				Selezione	0.00.00 - 4.28.15 (4.28.15.0)		

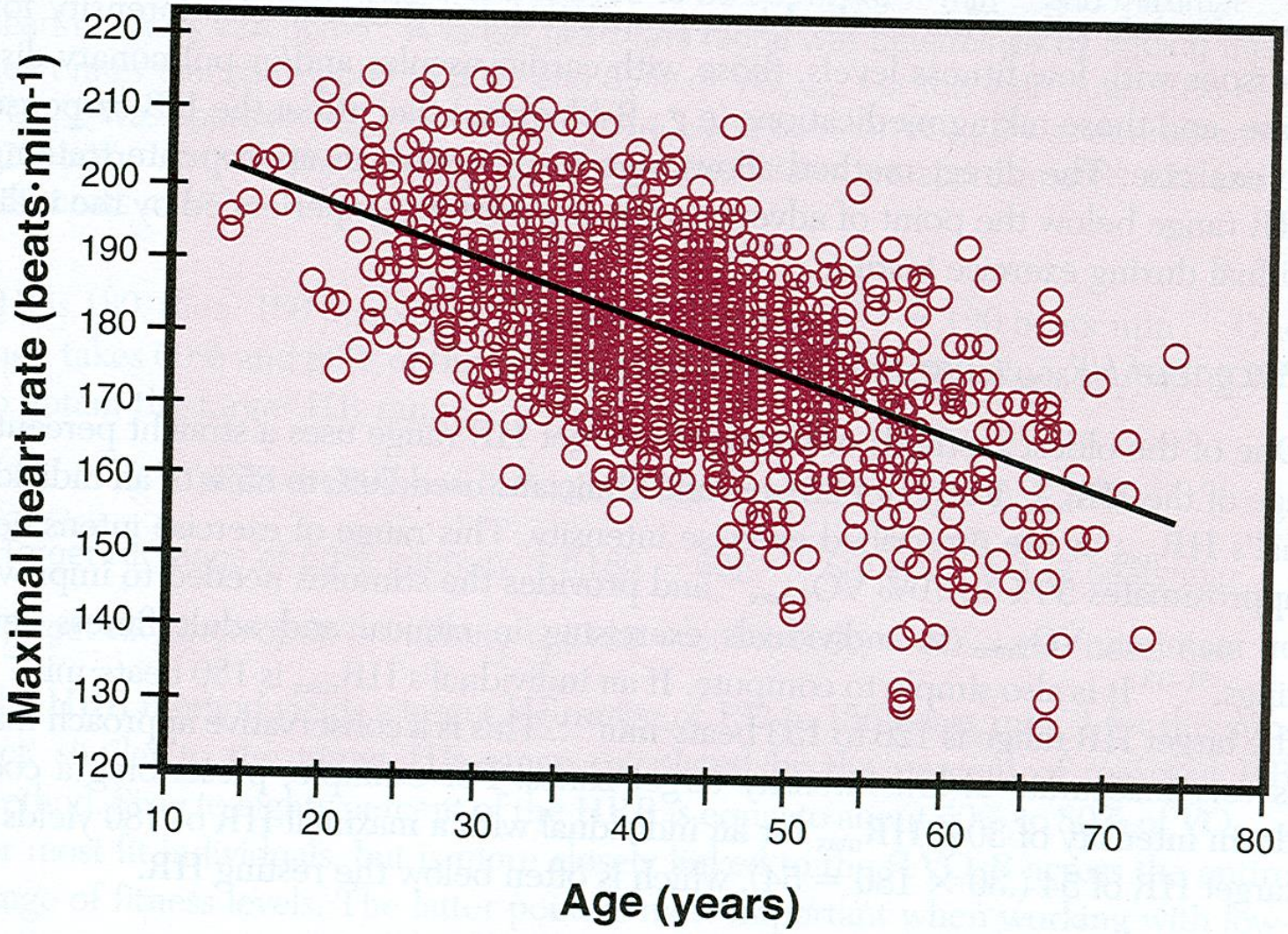
FC e superallenamento

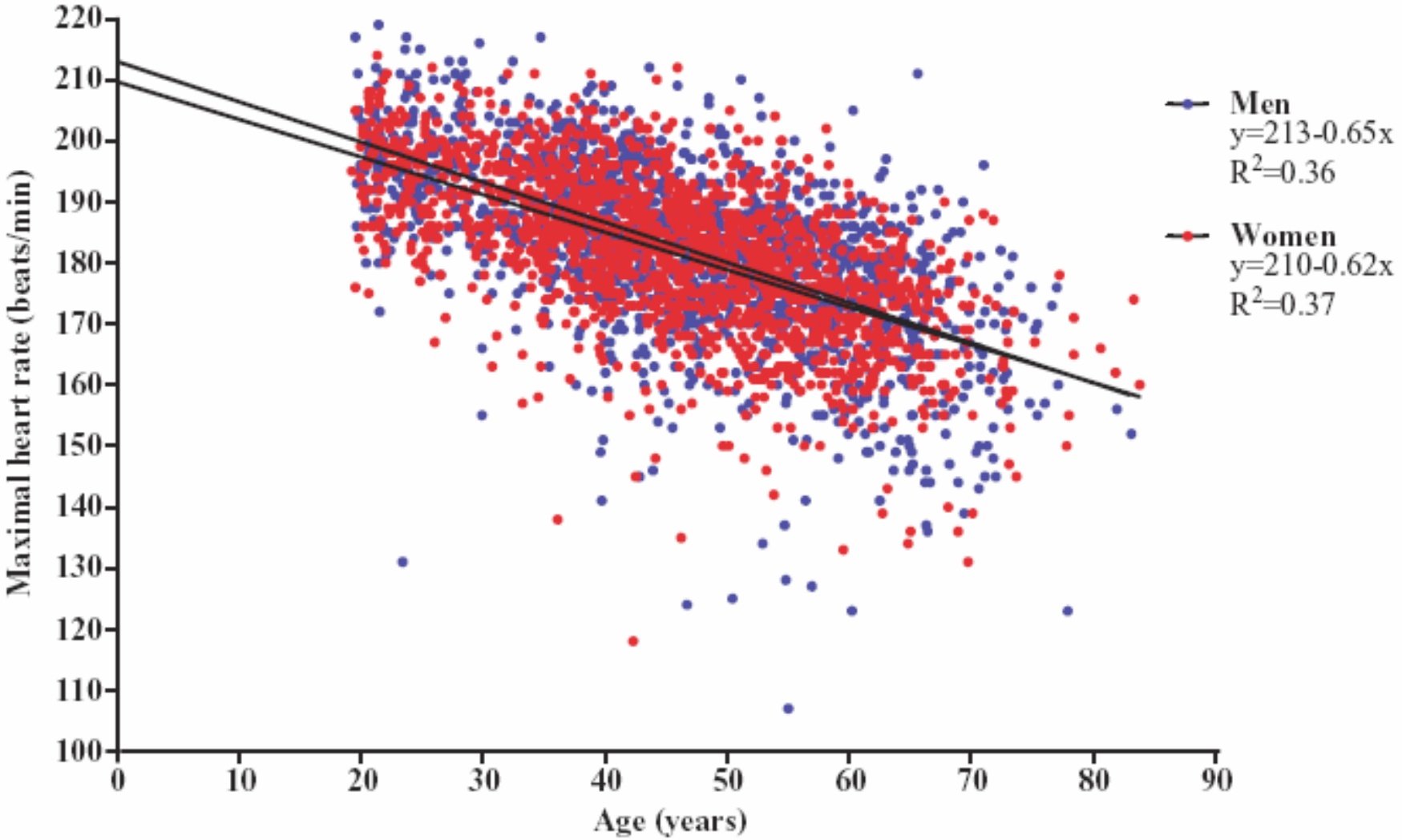


FC massima

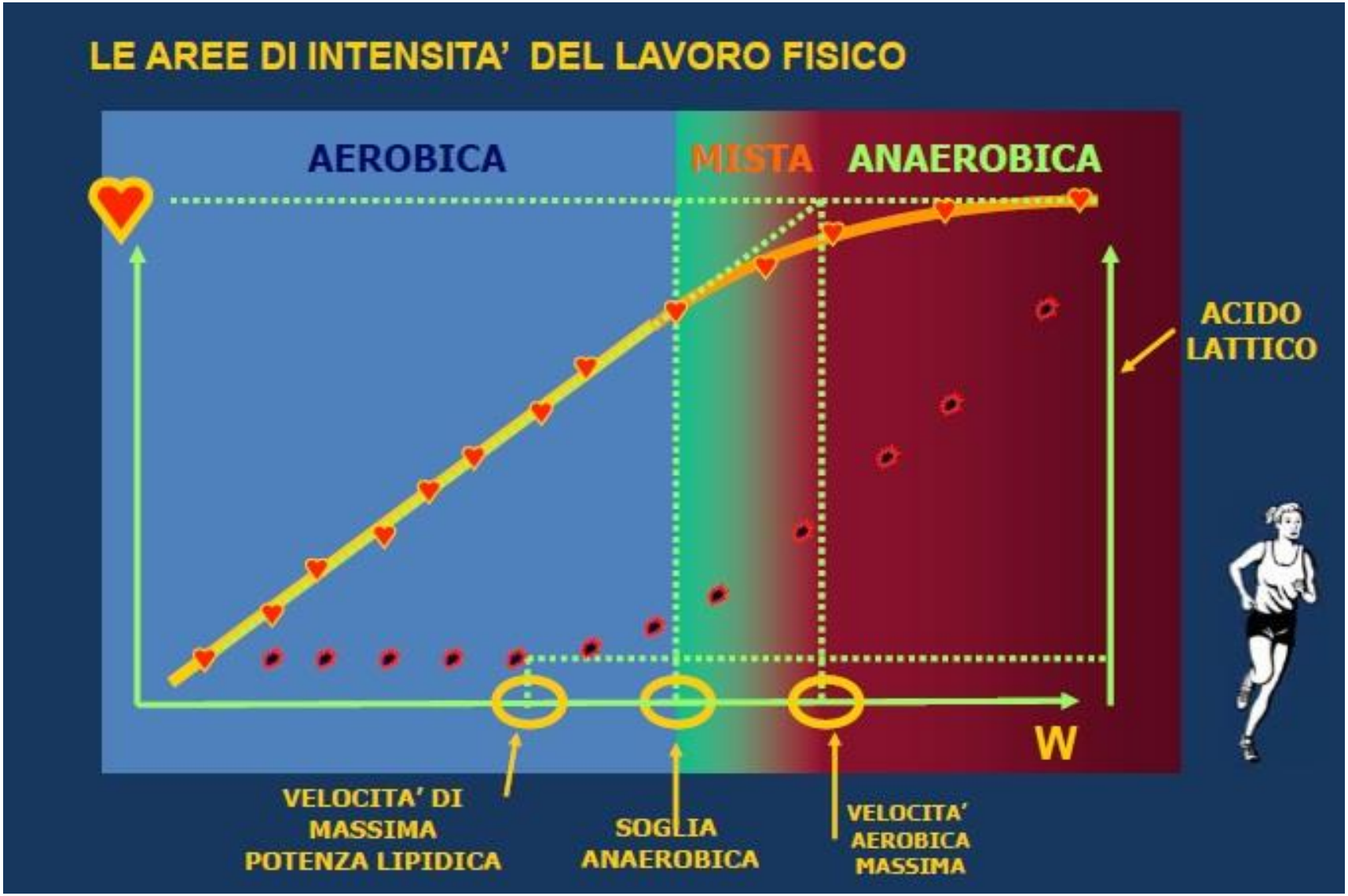
- Come raggiungerla?
- Come misurarla?
- Limiti del valore teorico [220-età (a)]
- A cosa serve?


SPEED (km/h)
20
16
12
A
0
10
20
30
HEART RATE (beats/min)
180
160
140
120
100
B
0
10
20
30
TIME (min)

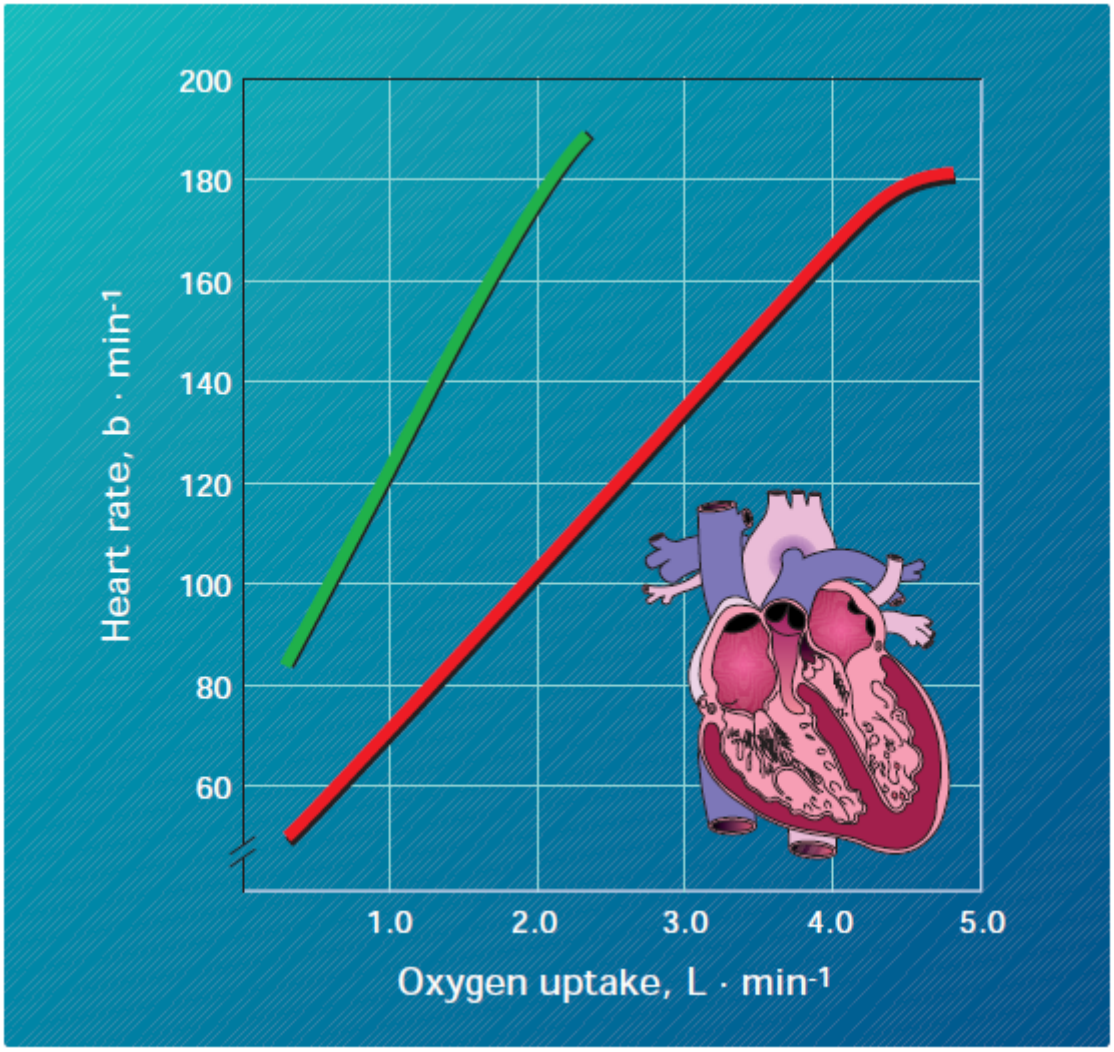

Maximal heart rate (beats·min-1)
220
210
200
190
180
170
160
150
140
130
120
10
20
30
40
50
60
70
80
Age (years)


Maximal heart rate (beats/min)
220
210
200
190
180
170
160
150
140
130
120
110
100
0
10
20
30
40
50
60
70
80
90
Age (years)
Men
y=213-0.65x
R2=0.36
Women
y=210-0.62x
R2=0.37

A cosa serve FC?



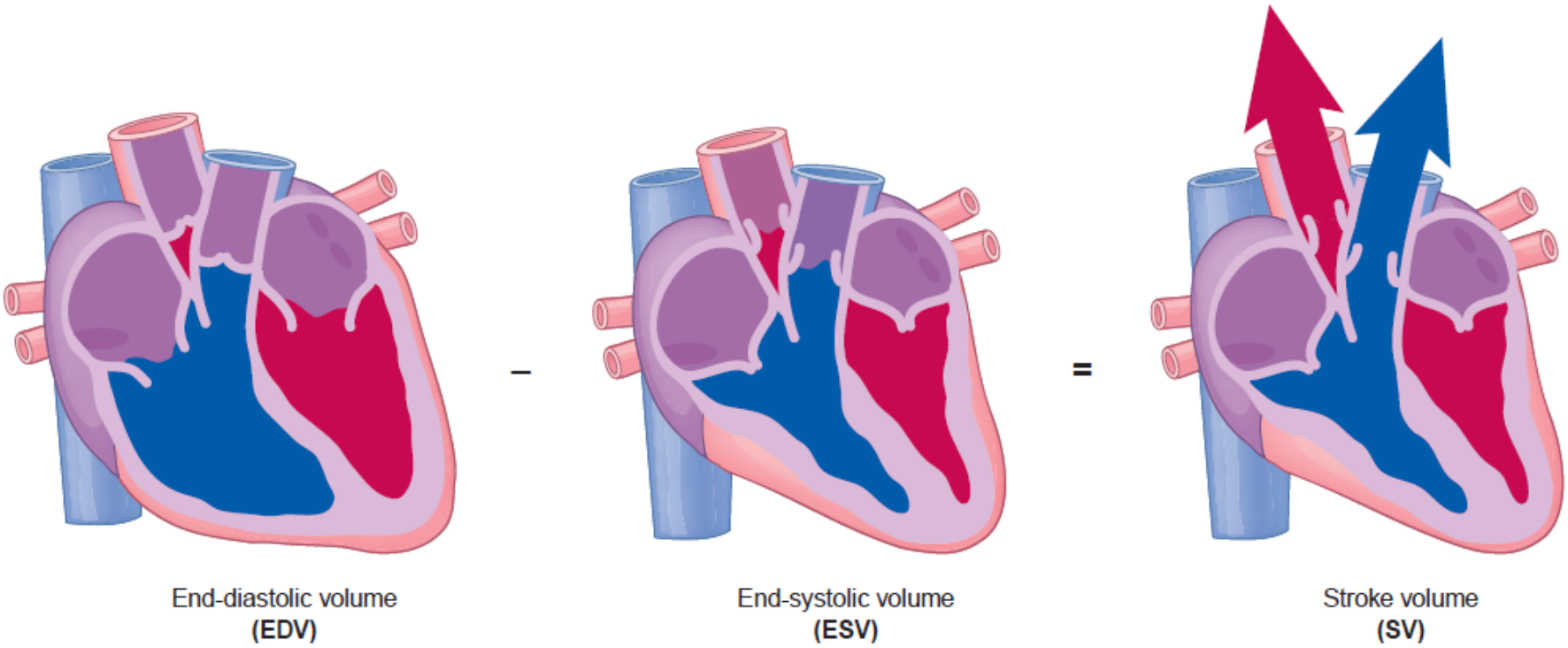
	Target zone	% of max HR bpm range	Example duration	Training benefit
Maximize Performance	5 MAXIMUM 	90–100% 171–190 bpm	Less than 5 minutes	***Benefits:*** Increases maximum sprint race speed ***Feels like:*** Very exhausting for breathing and muscles ***Recommended for:*** Very fit persons with athletic training background
	4 HARD 	80–90% 152–171 bpm	2–10 minutes	***Benefits:*** Increases maximum performance capacity ***Feels like:*** Muscular fatigue and heavy breathing ***Recommended for:*** Fit users and for short exercises
Improve Fitness	3 MODERATE 	70–80% 133–152 bpm	10–40 minutes	***Benefits:*** Improves aerobic fitness ***Feels like:*** Light muscular fatigue, easy breathing, moderate sweating ***Recommended for:*** Everybody for typical, moderately long exercises
Lose Weight	2 LIGHT 	60–70% 114–133 bpm	40–80 minutes	***Benefits:*** Improves basic endurance and helps recovery ***Feels like:*** Comfortable, easy breathing, low muscle load, light sweating ***Recommended for:*** Everybody for longer and frequently repeated shorter exercises
	1 VERY LIGHT 	50–60% 104–114 bpm	20–40 minutes	***Benefits:*** Improves overall health and metabolism, helps recovery ***Feels like:*** Very easy for breathing and muscles ***Recommended for:*** Basic training for novice exercisers, weight management and active recovery


200
180
160
140
120
100
80
60
Heart rate, b · min-1
1.0
2.0
3.0
4.0
5.0
Oxygen uptake, L · min-1

Gittata Sistolica (GS, *Stroke Volume,* SV)

- Quantità di sangue che ad ogni battito cardiaco viene immessa nel grande circolo da parte del ventricolo sinistro (mL/b).
  - GS basale
  - GS durante esercizio

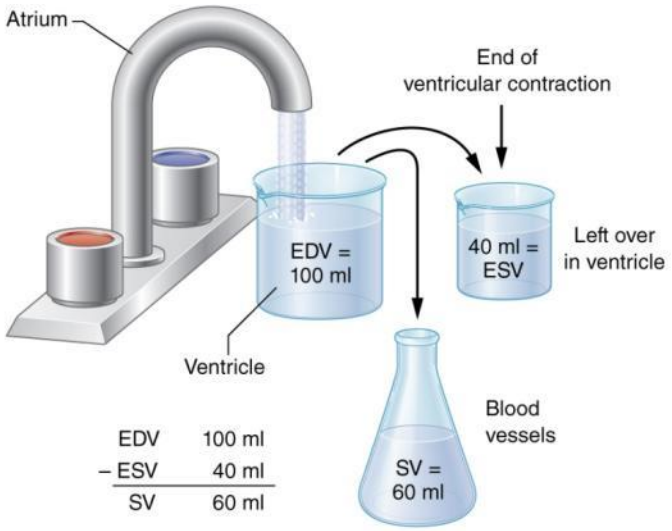
EDV – ESV = SV



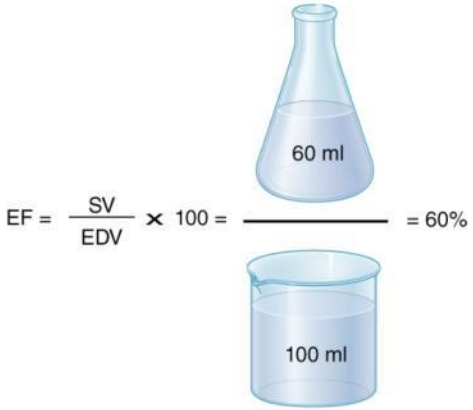
Volume telediastolico

Volume telesistolico

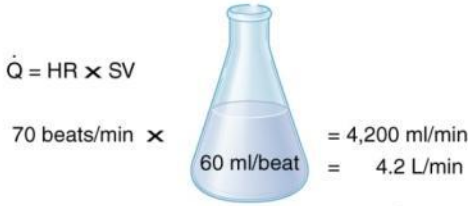
Gittata Sistolica



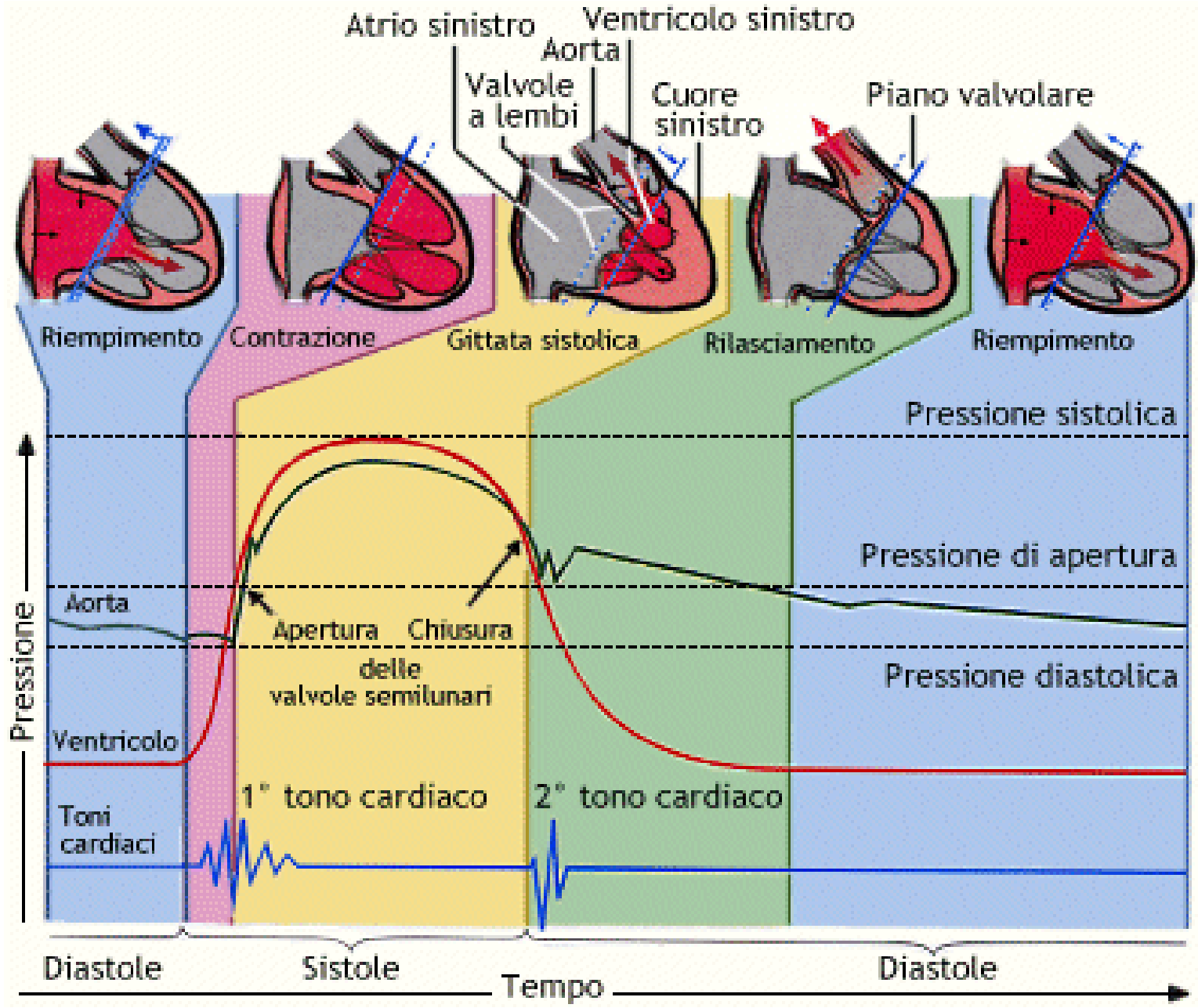
a Calculation of stroke volume (SV), the difference between end-diastolic volume (EDV) and end-systolic volume (ESV)



b Calculation of ejection fraction (EDV)



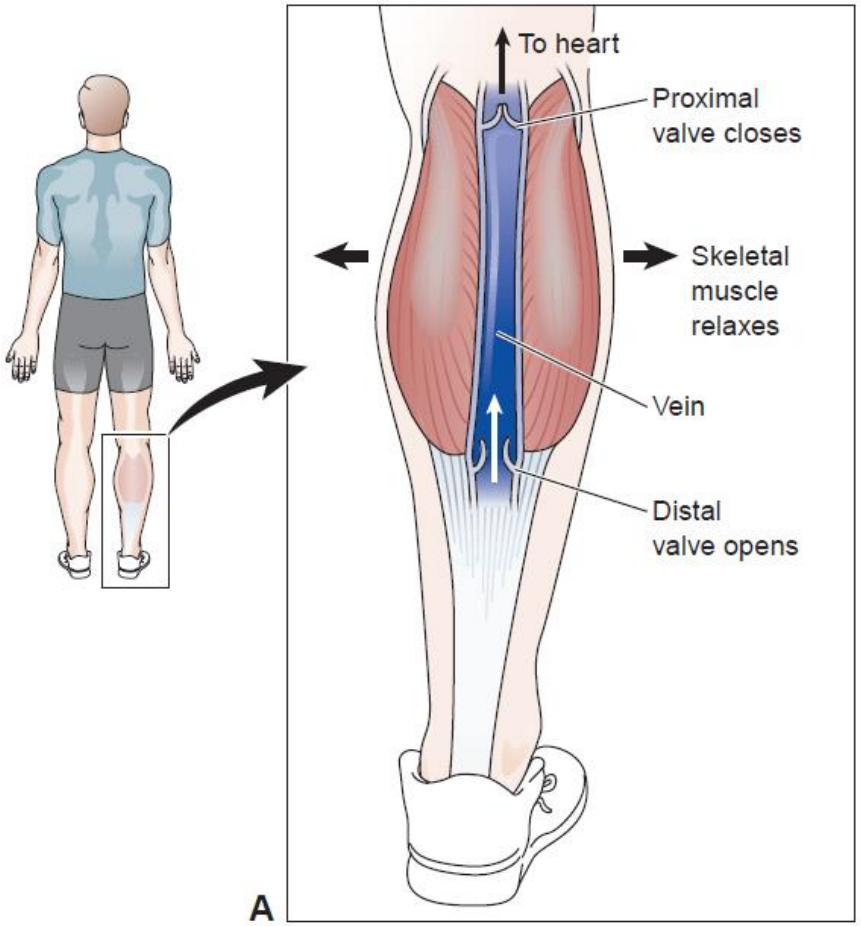
c Calculation of cardiac output ($\dot{Q}$)

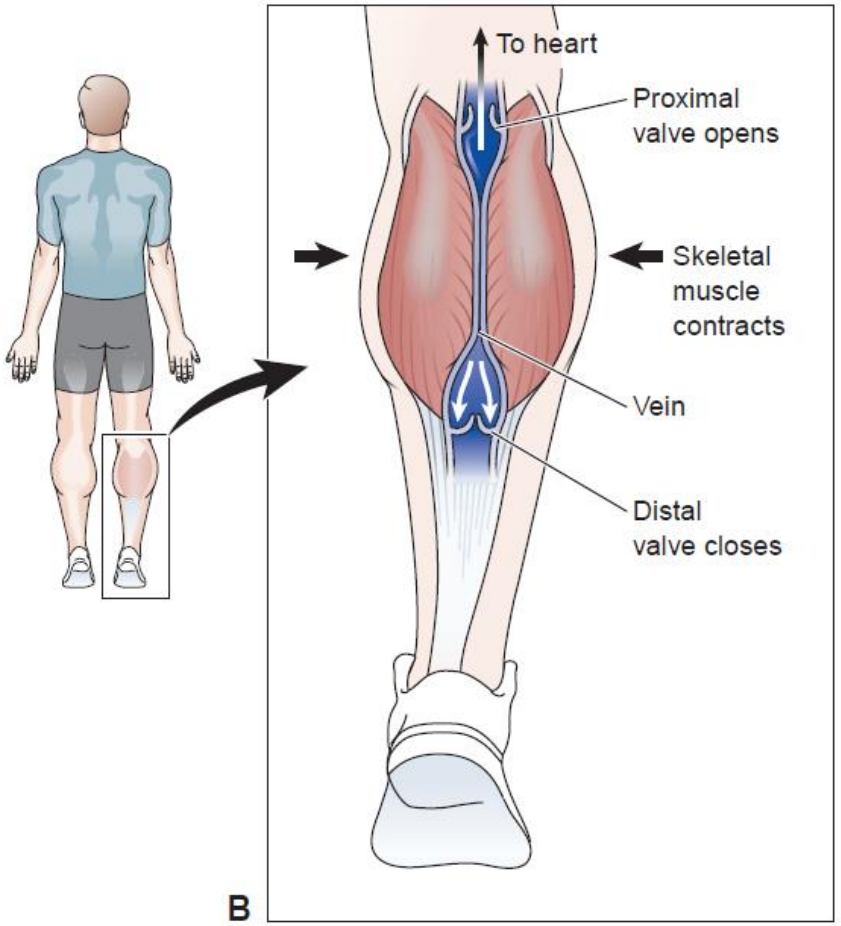

Atrio sinistro
Ventricolo sinistro
Aorta
Valvole a lembi
Cuore sinistro
Piano valvolare
Riempimento
Contrazione
Gittata sistolica
Rilasciamento
Riempimento
Pressione sistolica
Pressione di apertura
Pressione diastolica
Pressione
Aorta
Apertura delle valvole semilunari
Chiusura
Ventricolo
1° tono cardiaco
2° tono cardiaco
Toni cardiaci
Diastole
Sistole
Diastole
Tempo

GS, fattori determinanti

- Ritorno venoso
- Distensibilità ventricolare
- Contrattilità ventricolare
- Pressione arteriosa (aortica e polmonare)

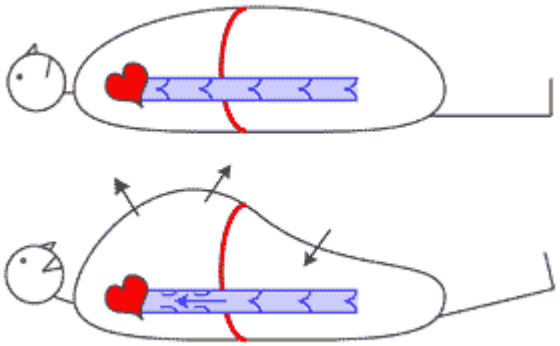
Pompa muscolare

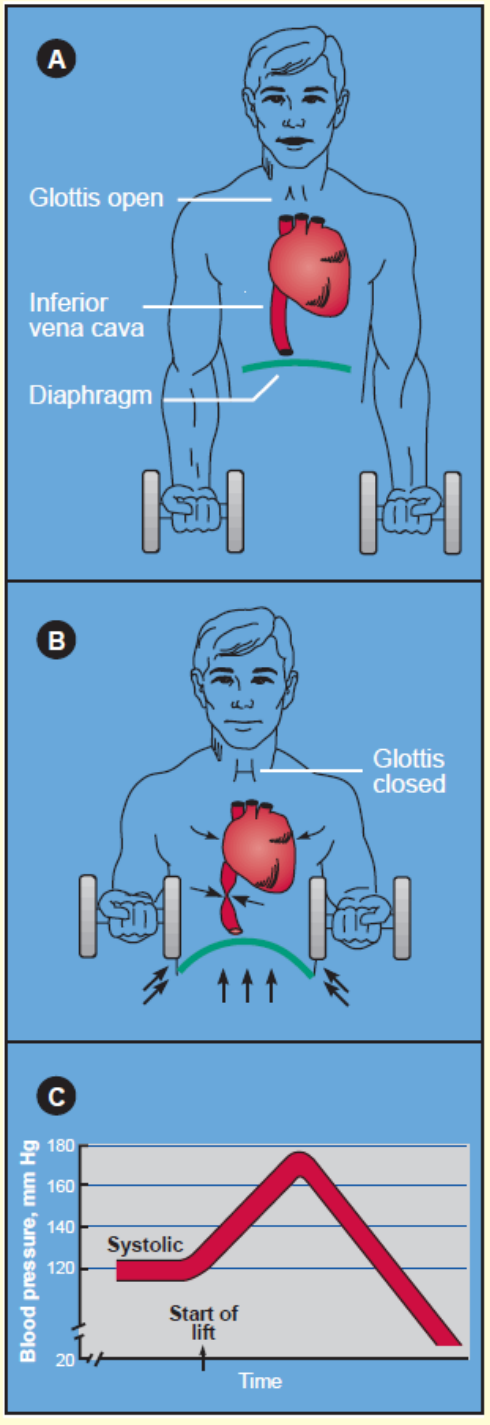




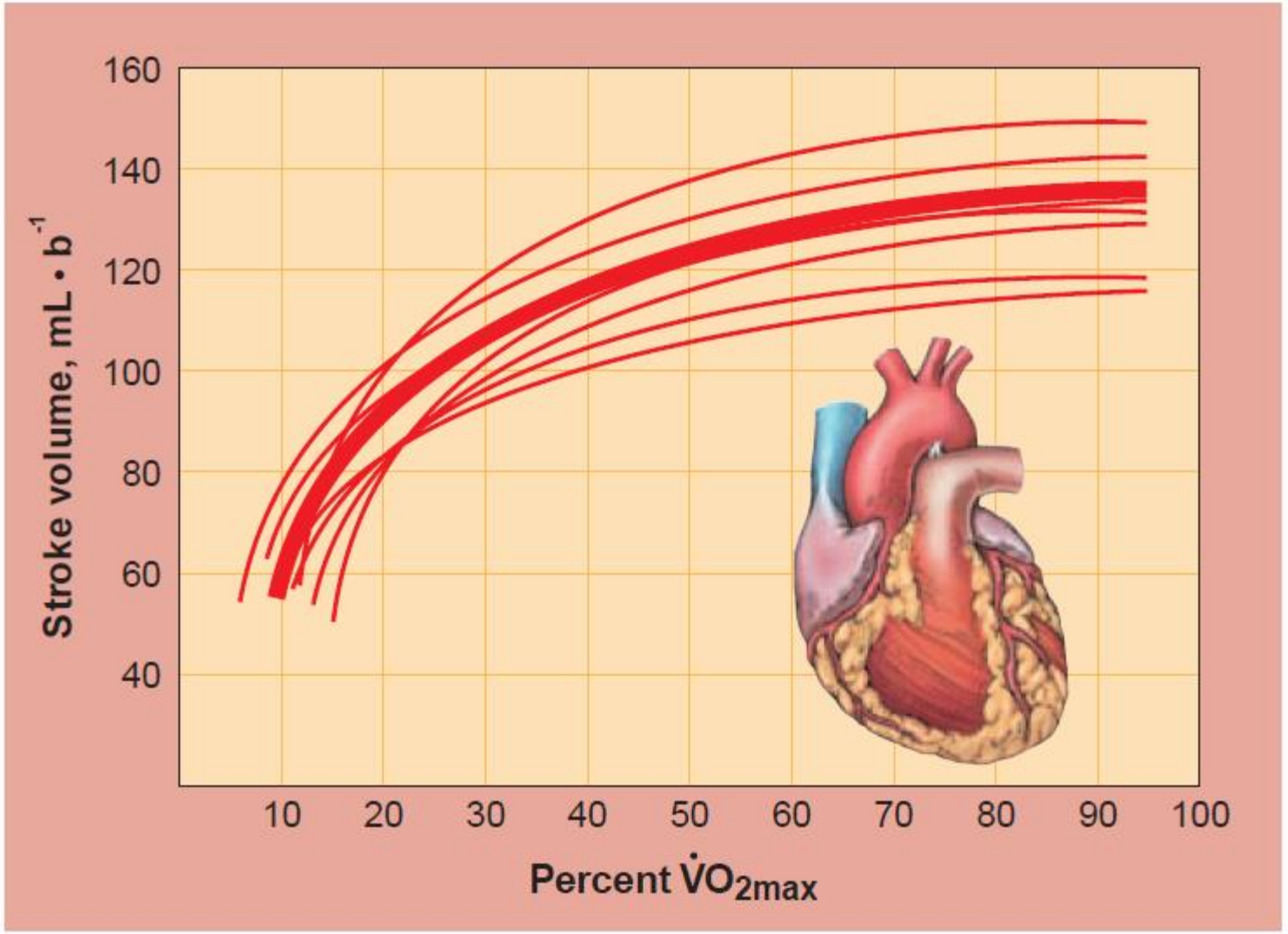
Pompa Respiratoria

- Aumento e diminuzione della pressione intratoracica, rispettivamente durante espirazione ed inspirazione, facilitano il ritorno venoso.

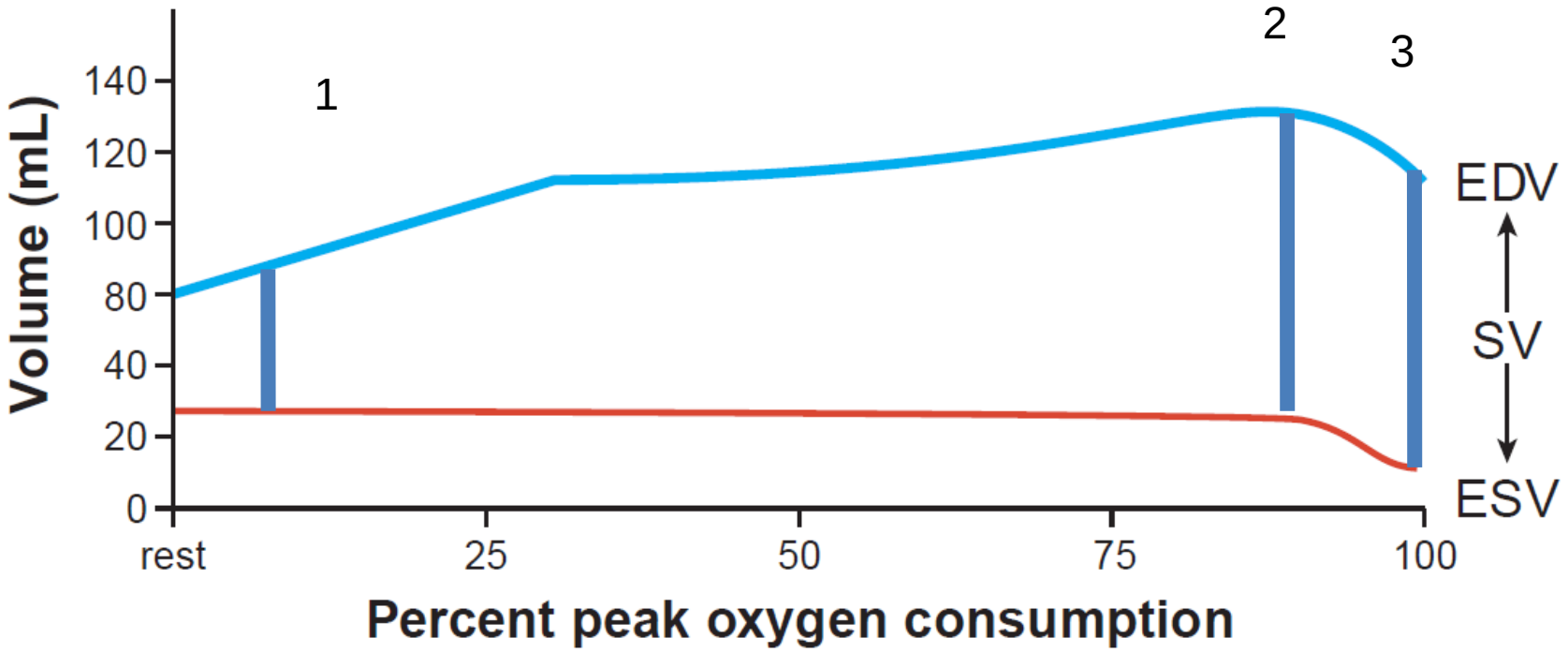


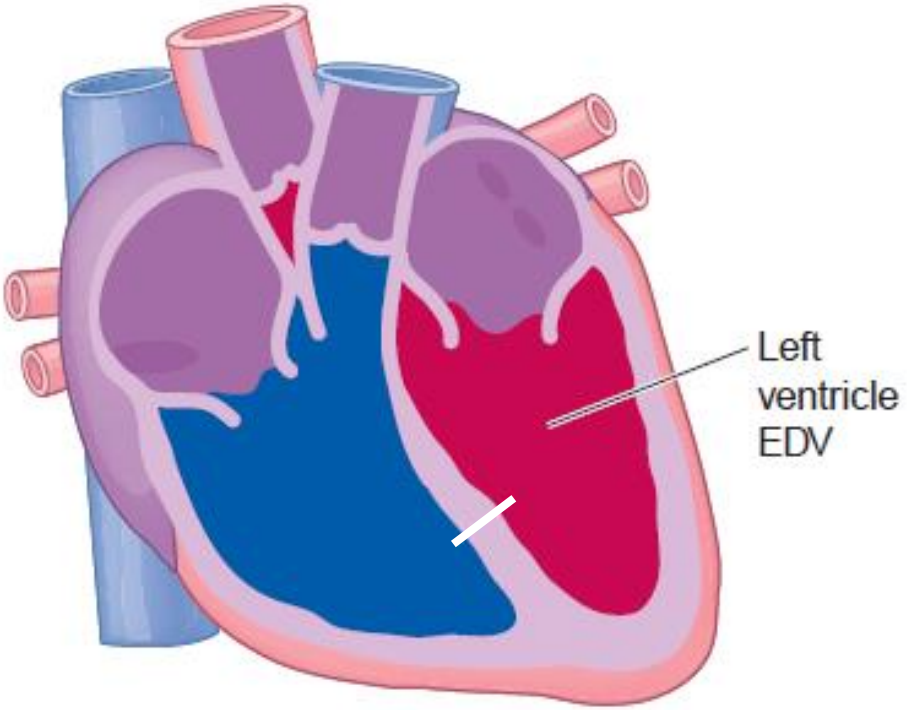

A
Glottis open
Inferior vena cava
Diaphragm
B
Glottis closed
C
Blood pressure, mm Hg
180
160
140
120
20
Systolic
Start of lift
Time

Ritorno venoso e attività fisica.

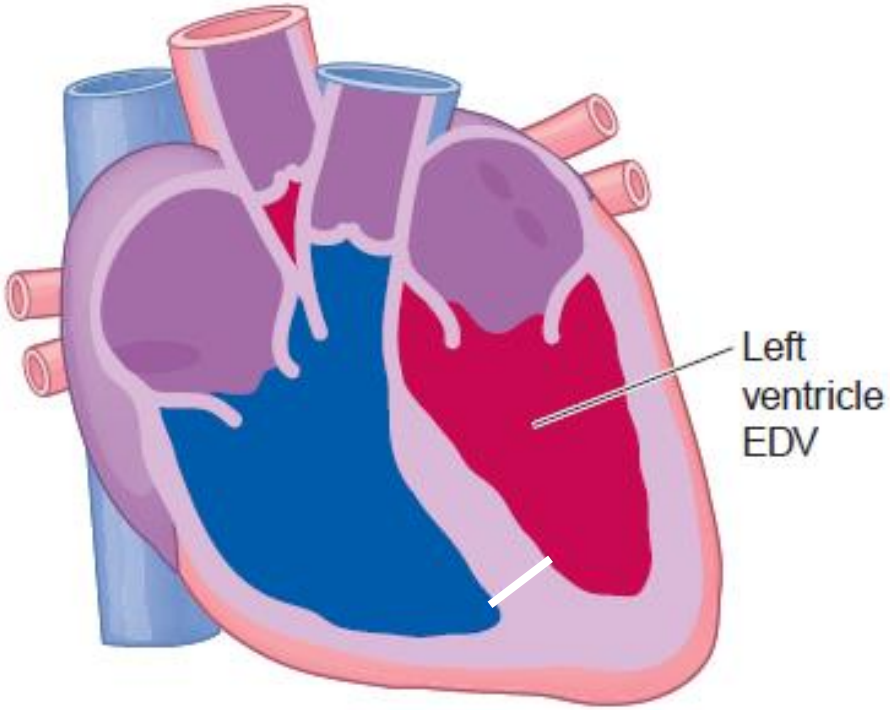

160
140
120
100
80
60
40
Stroke volume, mL • b-1
10
20
30
40
50
60
70
80
90
100
Percent V̇O2max

SV durante esercizio incrementale





Endurance training



Weight training

Quick Review

- Venoconstriction of large veins caused by sympathetic stimulation may increase venous return to the heart, but this mechanism to increase venous return may not apply to skeletal muscle.
- The muscle pump increases venous return because of the compression of veins by the expansion of muscles during contraction and the presence of one-way valves in large veins.
- The respiratory pump increases venous return because of the increases and decreases in intrathoracic pressure during expiration and inspiration, respectively.

Portata Cardiaca [Cardiac Output (*Q*, L/min)]

- Quantità di sangue che viene immessa (pompata dal cuore) nel grande circolo nell'unità di tempo.

$$Q = HR \cdot SV$$

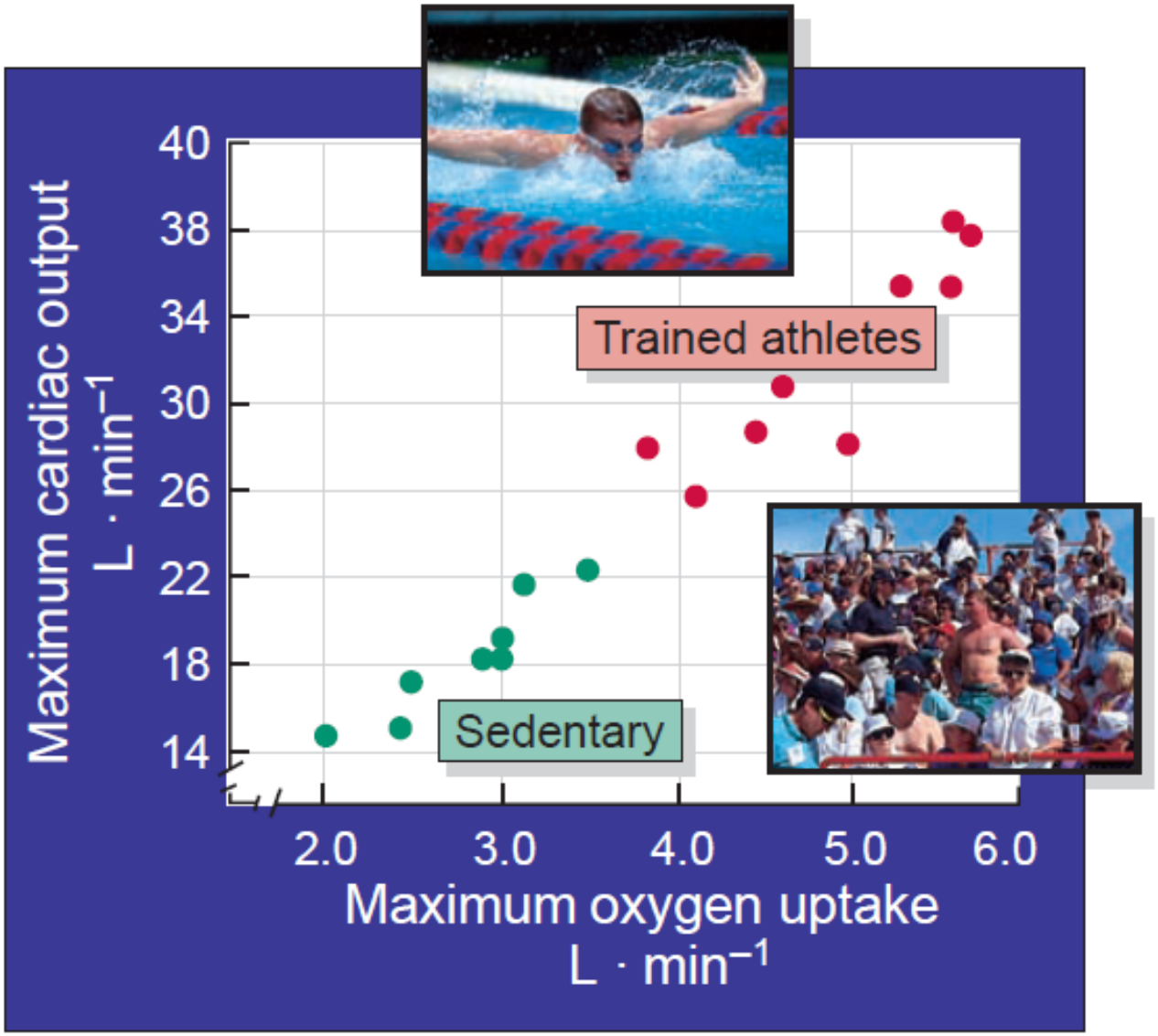
  - *Q* basale
  - *Q* durante esercizio

A riposo

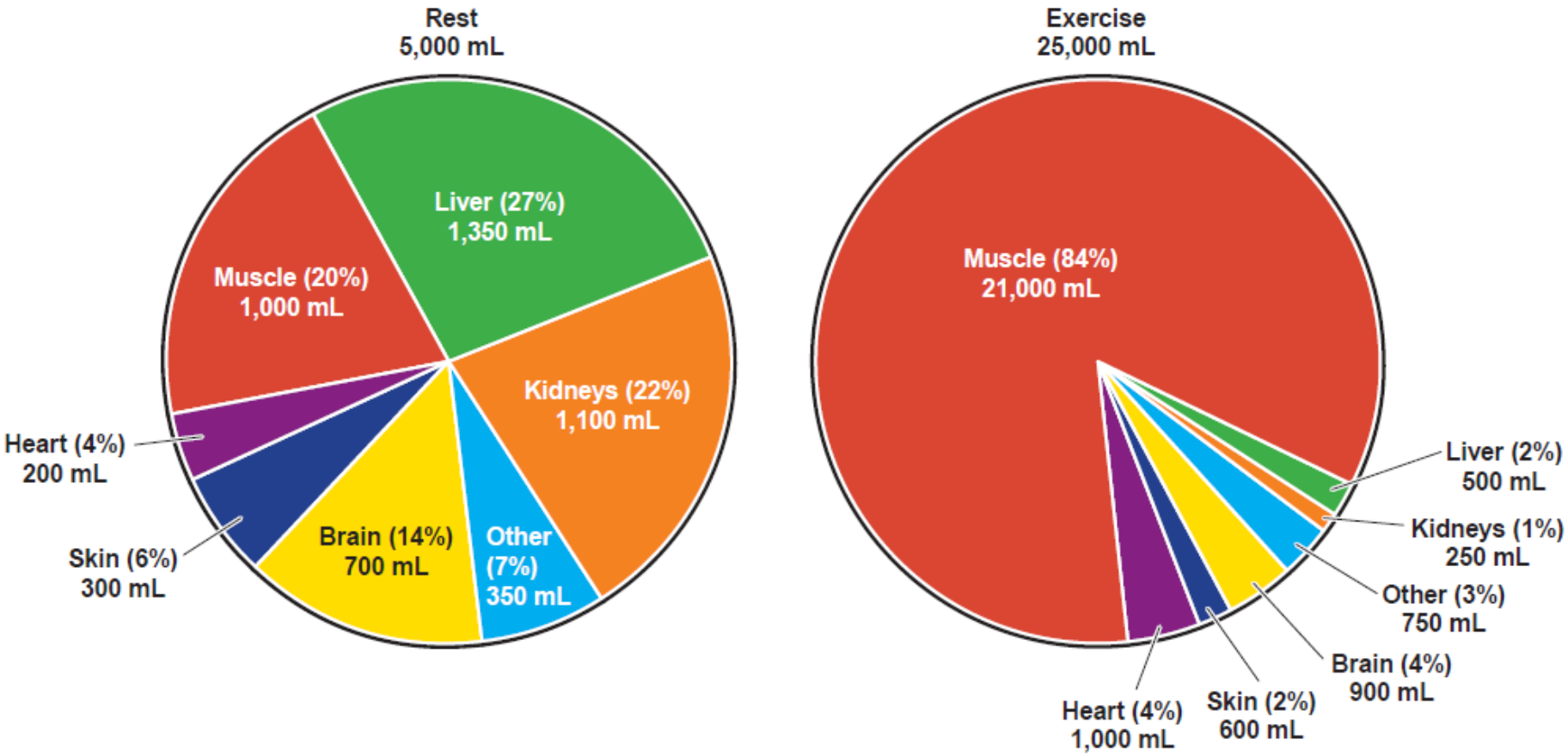
	Cardiac Output Rate ($mL \cdot min^{-1}$)	Heart Stroke Rate ($b \cdot min^{-1}$)	Heart Stroke Volume ($mL \cdot b^{-1}$)
Untrained	5000	70	71
Trained	5000	50	100

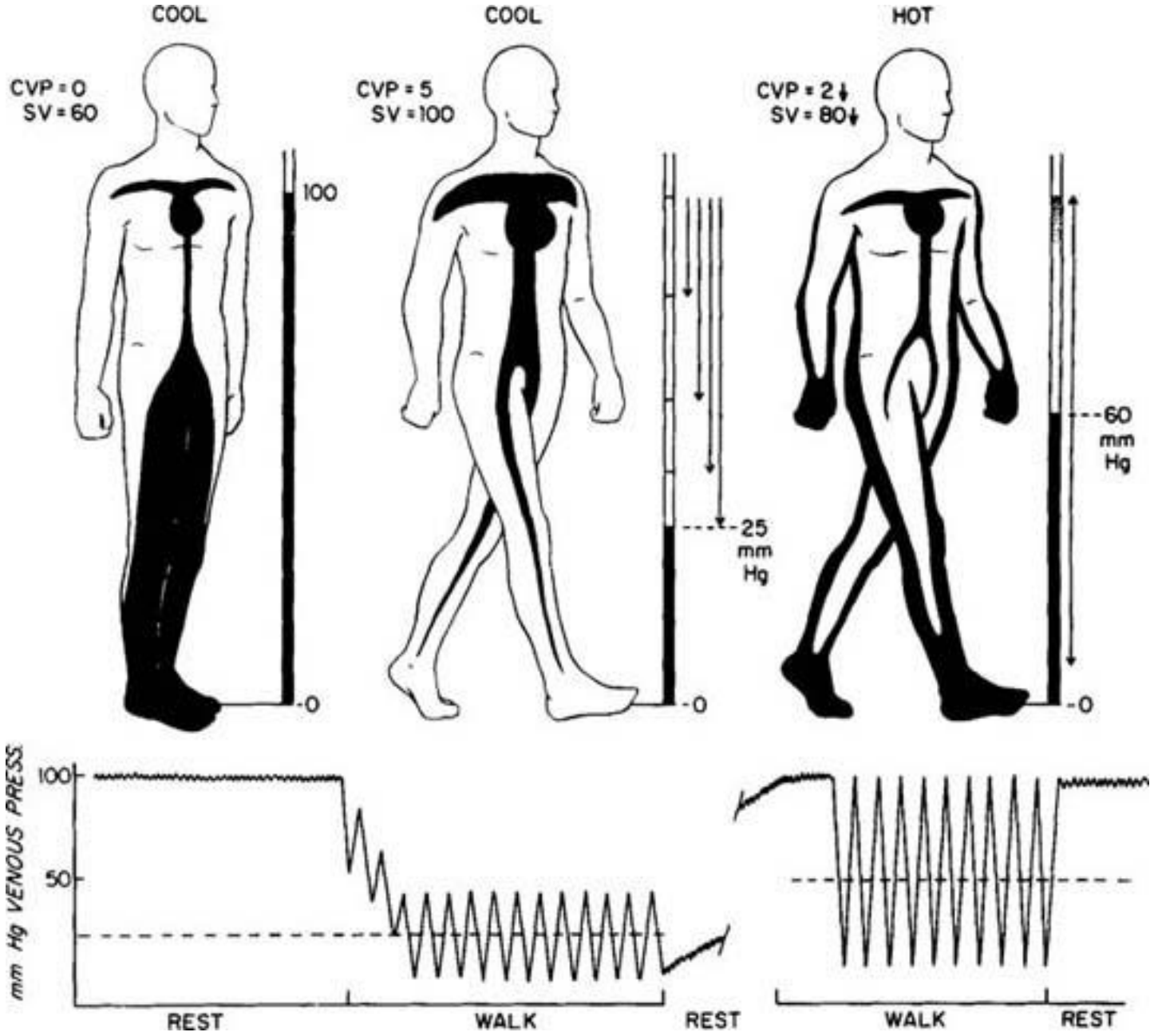
Sforzo massimale

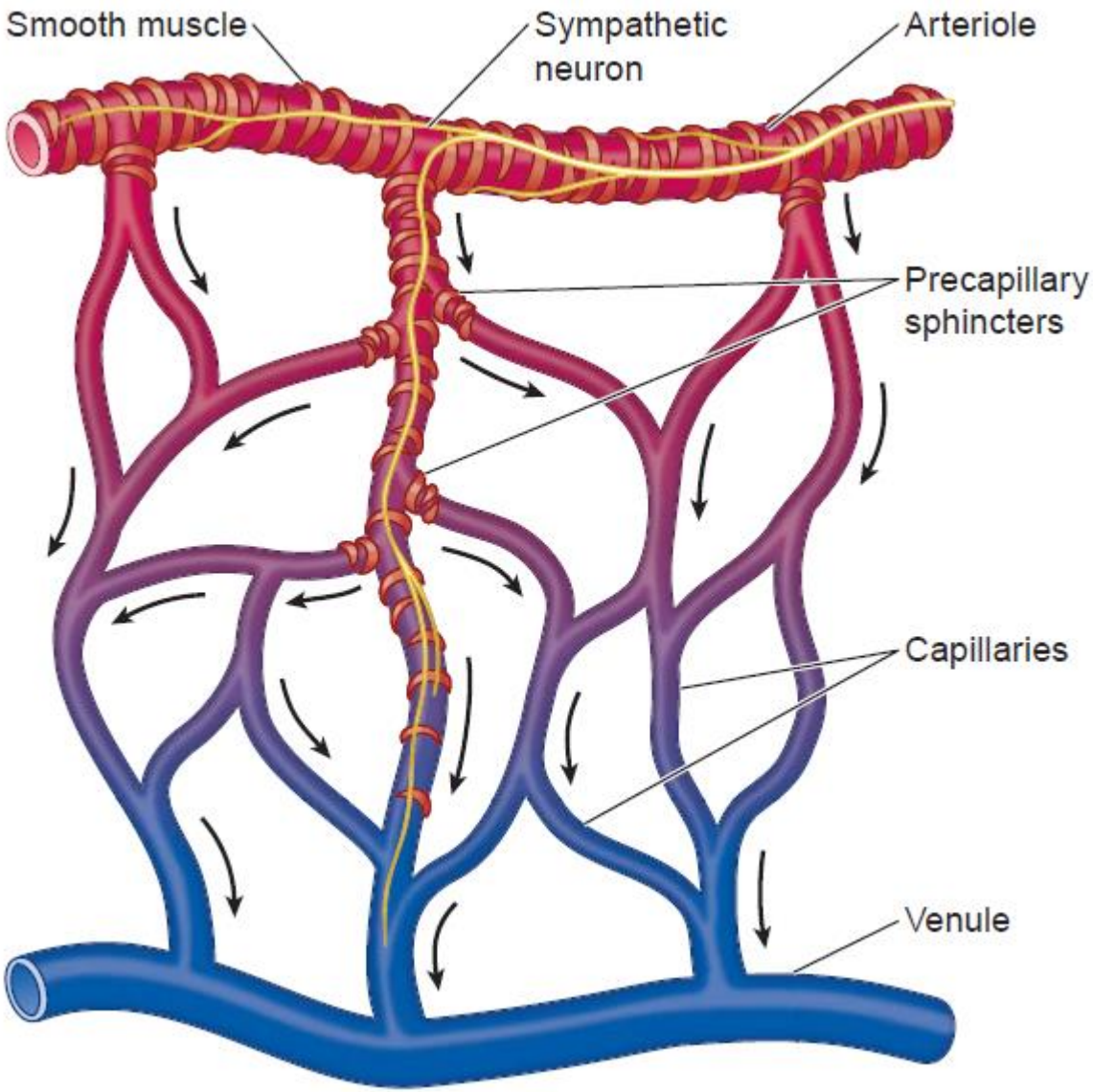
	Cardiac Output Rate ($mL \cdot min^{-1}$)	Heart Stroke Rate ($b \cdot min^{-1}$)	Volume ($mL \cdot b^{-1}$)
Untrained	22,000	195	113
Trained	35,000	195	179


Maximum cardiac output
L · min⁻¹
40
38
34
30
26
22
18
14
2.0
3.0
4.0
5.0
6.0
Maximum oxygen uptake
L · min⁻¹
Trained athletes
Sedentary

Distribuzione della Q

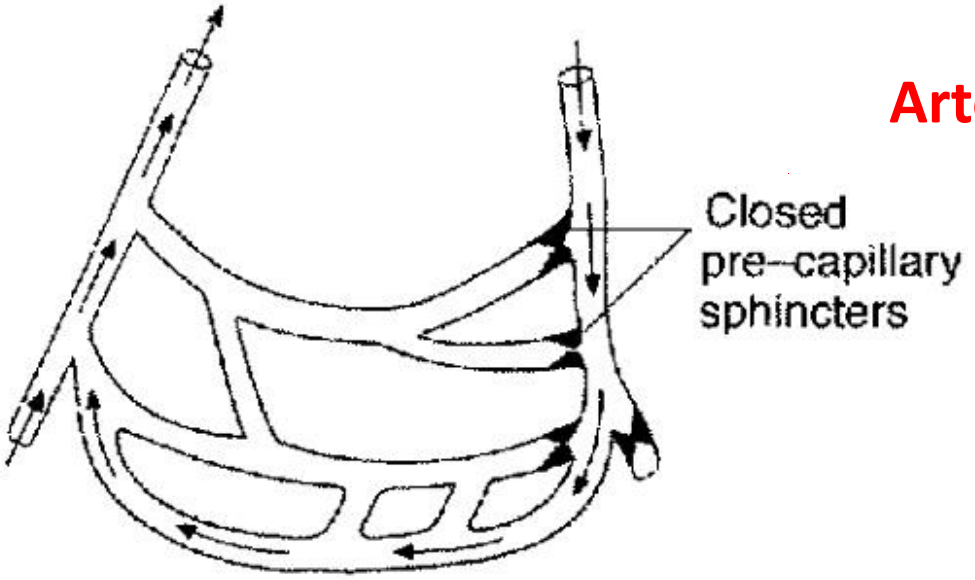

Rest
5,000 mL
Liver (27%)
1,350 mL
Muscle (20%)
1,000 mL
Kidneys (22%)
1,100 mL
Heart (4%)
200 mL
Skin (6%)
300 mL
Brain (14%)
700 mL
Other
(7%)
350 mL
Exercise
25,000 mL
Muscle (84%)
21,000 mL
Liver (2%)
500 mL
Kidneys (1%)
250 mL
Other (3%)
750 mL
Brain (4%)
900 mL
Heart (4%)
1,000 mL
Skin (2%)
600 mL


COOL
CVP = 0
SV = 60
100
0
COOL
CVP = 5
SV = 100
25
mm
Hg
0
HOT
CVP = 2↓
SV = 80↓
60
mm
Hg
0
mm Hg VENOUS PRESS.
100
50
REST
WALK
REST
WALK
REST

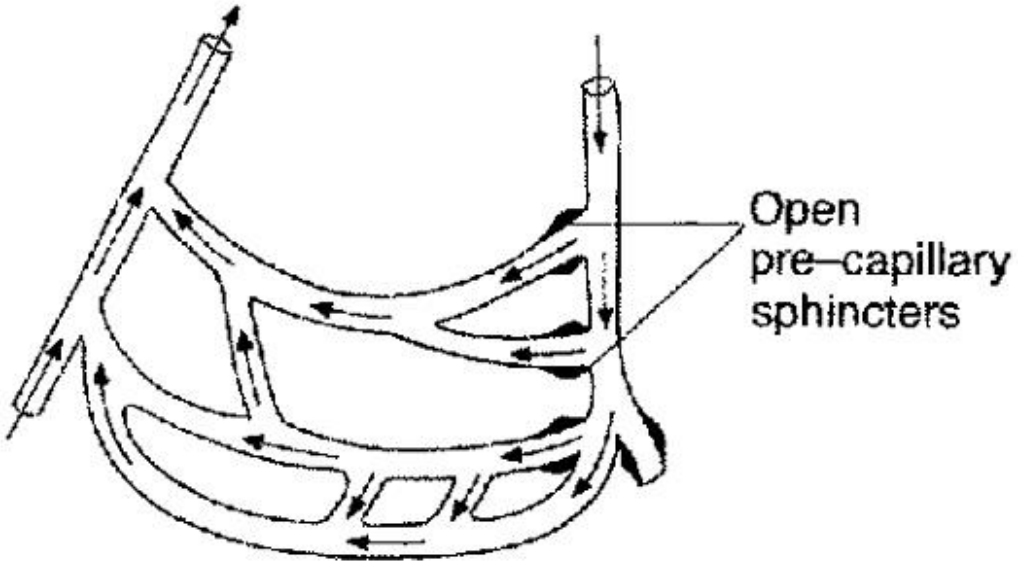

Smooth muscle
Sympathetic neuron
Arteriole
Precapillary sphincters
Capillaries
Venule

Vene

Arterie



Capillary network in resting muscle

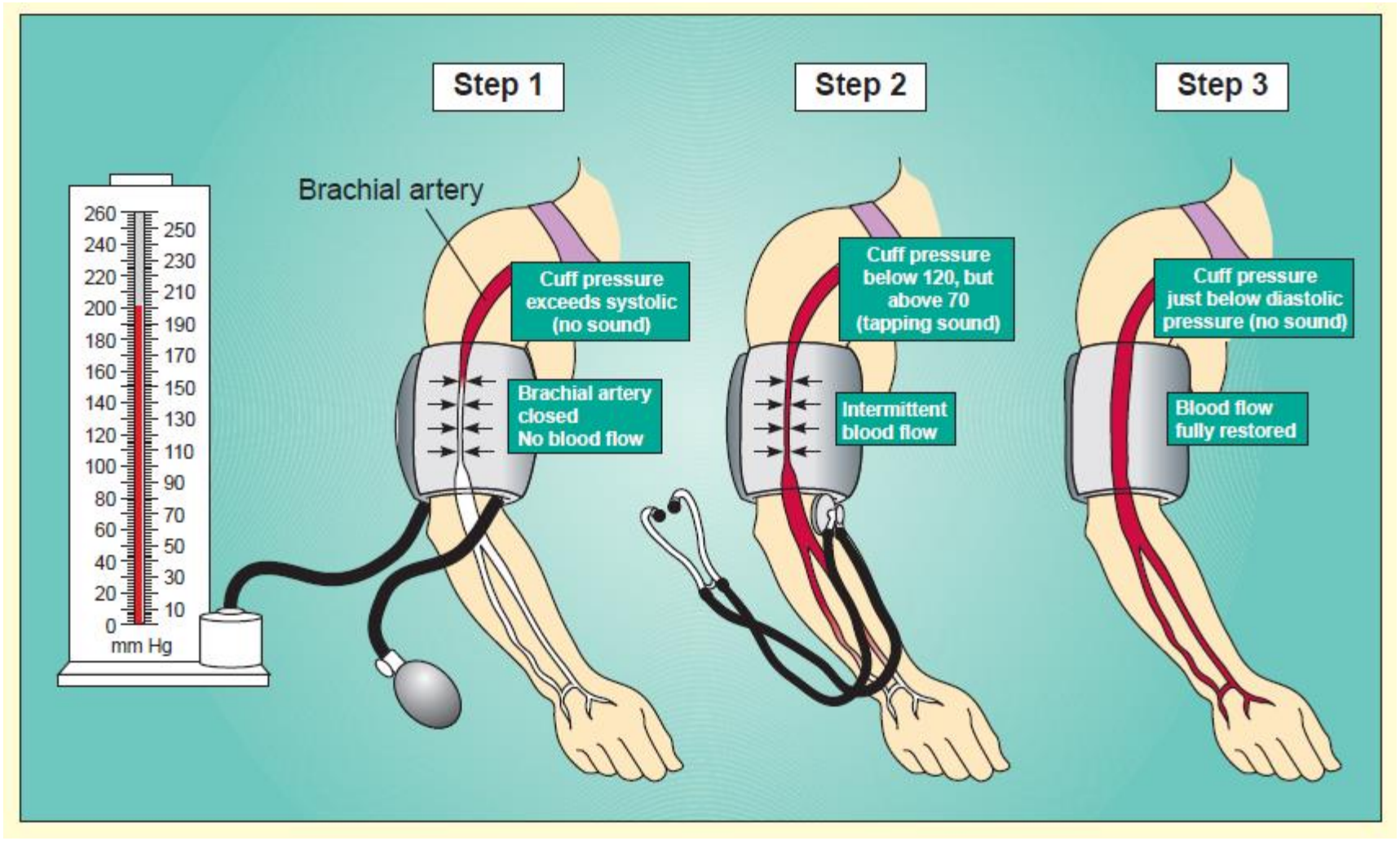


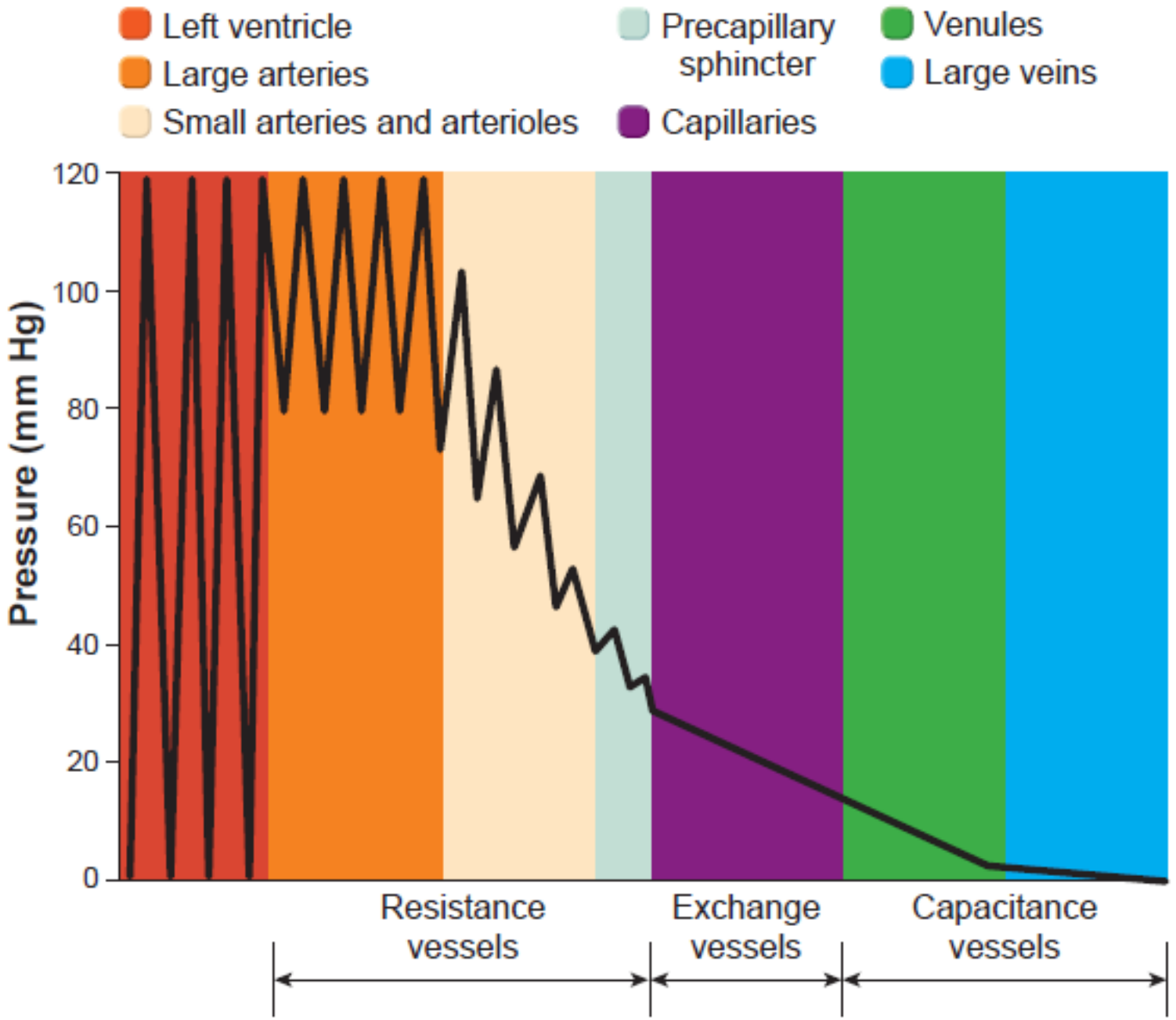
Capillary network in active muscle

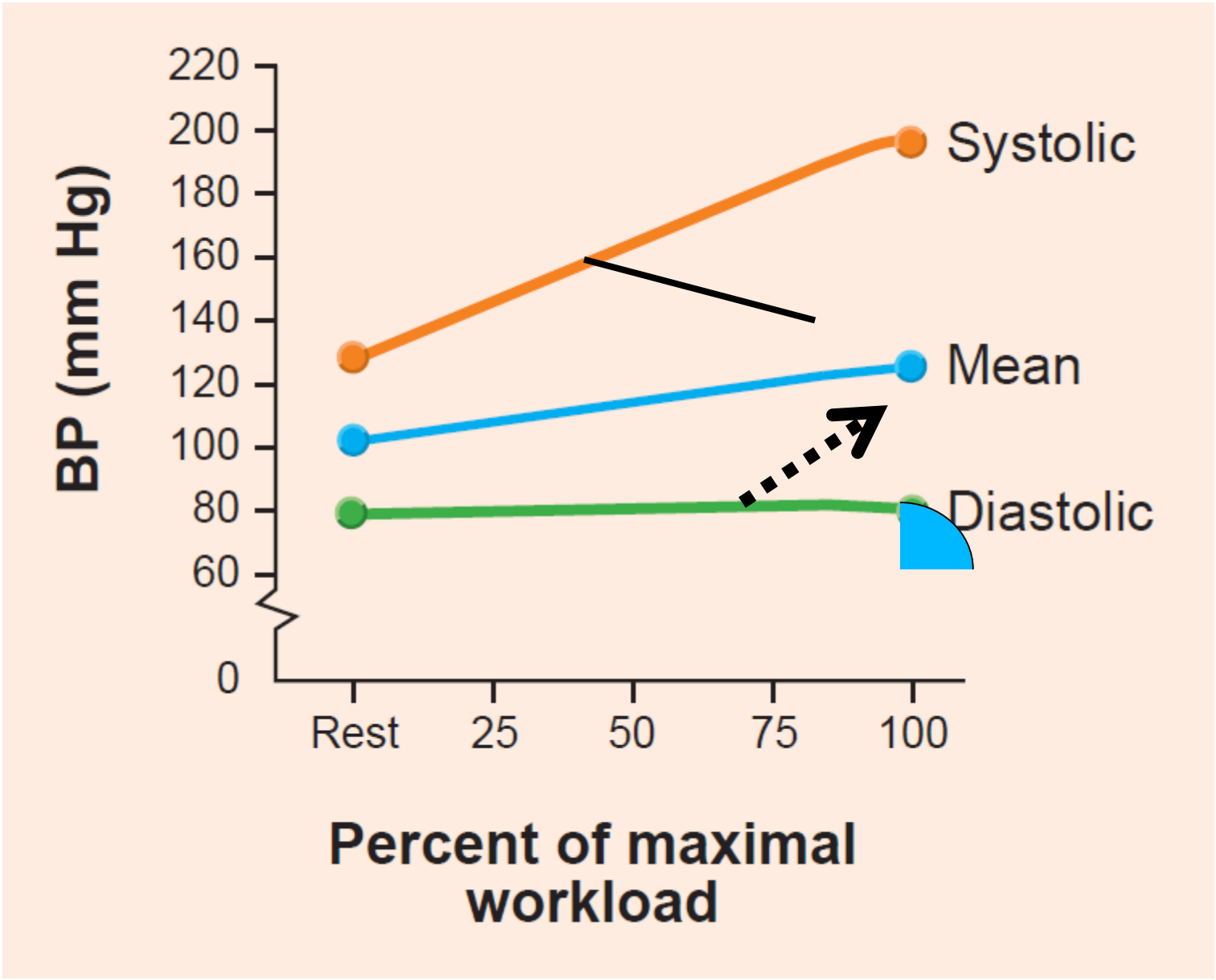
Quick Review

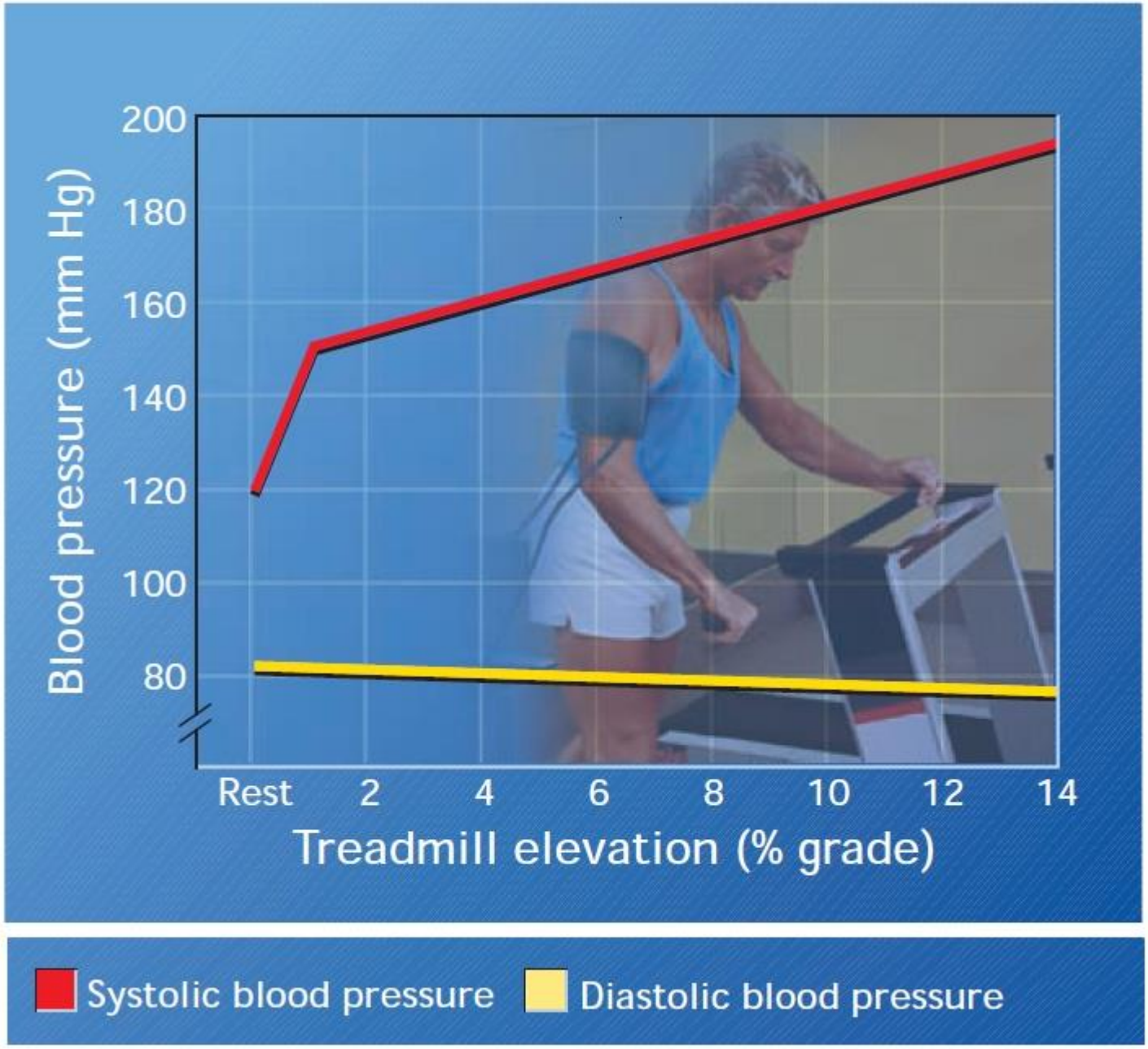
- During exercise, blood is redistributed so that active skeletal muscle receives the vast majority of cardiac output, which increases oxygen delivery to the tissue.
- During activity, vasoconstriction, vasodilation, and precapillary sphincters are used to increase blood flow to active skeletal muscle and decrease blood flow to inactive tissue.
- Vasoconstriction and vasodilation are controlled by both extrinsic and intrinsic factors.

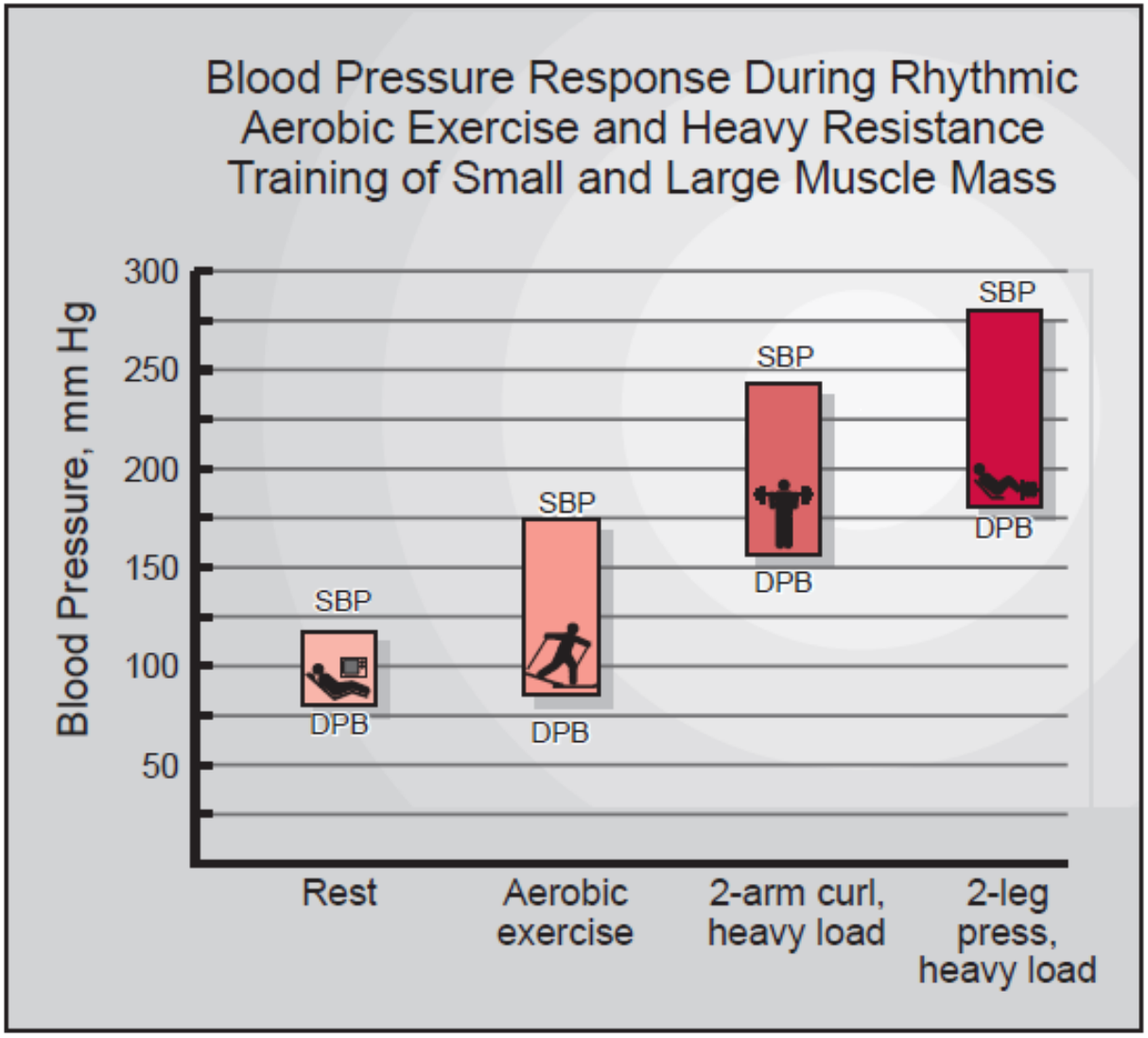
Pressione Arteriosa (PA, mmHg)


Step 1
Step 2
Step 3
Brachial artery
260
240
220
200
180
160
140
120
100
80
60
40
20
0
250
230
210
190
170
150
130
110
90
70
50
30
10
mm Hg
Cuff pressure exceeds systolic (no sound)
Brachial artery closed No blood flow
Cuff pressure below 120, but above 70 (tapping sound)
Intermittent blood flow
Cuff pressure just below diastolic pressure (no sound)
Blood flow fully restored


Left ventricle
Large arteries
Small arteries and arterioles
Precapillary sphincter
Capillaries
Venules
Large veins
Pressure (mm Hg)
120
100
80
60
40
20
0
Resistance vessels
Exchange vessels
Capacitance vessels

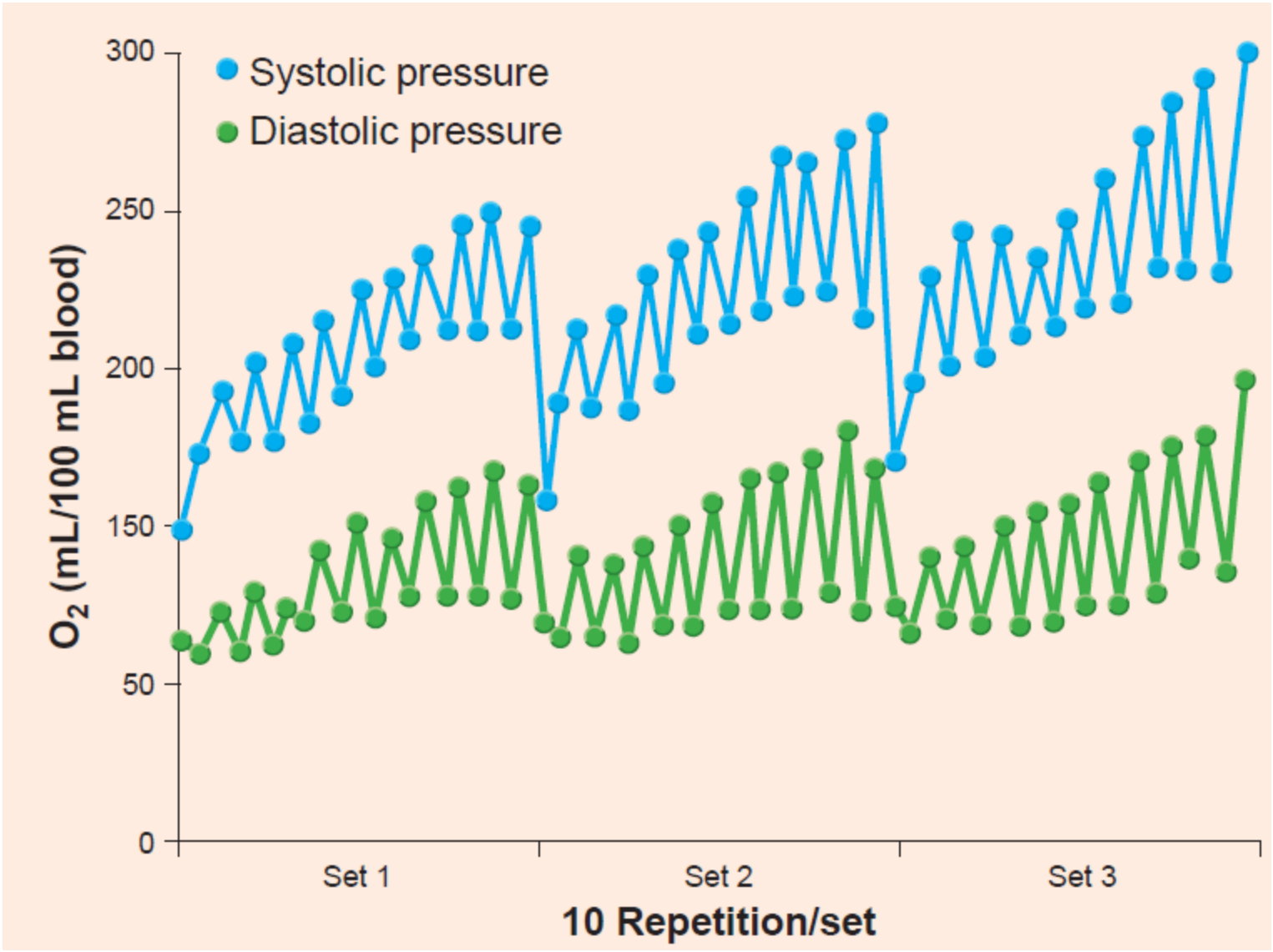

BP (mm Hg)
220
200
180
160
140
120
100
80
60
0
Rest
25
50
75
100
Systolic
Mean
Diastolic
Percent of maximal workload


Blood pressure (mm Hg)
200
180
160
140
120
100
80
Rest
2
4
6
8
10
12
14
Treadmill elevation (% grade)
Systolic blood pressure
Diastolic blood pressure


Blood Pressure Response During Rhythmic Aerobic Exercise and Heavy Resistance Training of Small and Large Muscle Mass
Blood Pressure, mm Hg
300
250
200
150
100
50
SBP
DPB
SBP
DPB
SBP
DPB
SBP
DPB
Rest
Aerobic exercise
2-arm curl, heavy load
2-leg press, heavy load

Systolic and Diastolic Blood Pressure in Dynamic Arm and Leg Exercise

	Systolic Pressure (mm Hg)		Diastolic Pressure (mm Hg)	
% Peak Oxygen Consumption	Arms	Legs	Arms	Legs
25	150	132	90	70
40	165	138	93	71
50	175	144	96	73
75	205	160	103	75


Systolic pressure
Diastolic pressure
300
250
200
150
50
0
O_2 (mL/100 mL blood)
Set 1
Set 2
Set 3
10 Repetition/set

Doppio prodotto max

PA x FC al picco dello sforzo

esempio:

PAmax = 200 mmHg

Fcmax = 150/min

DPmax = 200 x 150 = 30.000

Trasporto di O_2 (Sangue)

Trasporto dei gas nel sangue

- **Trasporto di O_2**
  - **Ossiemoglobina:** O_2 legato a emoglobina
  - Globuli Rossi contengono emoglobina e trasportano il 98% di O_2
  - **Desossiemoglobina:** emoglobina libera (da O_2)
  - Concentrazione of emoglobina nel sangue determina la quantità di O_2 che può essere trasportata.

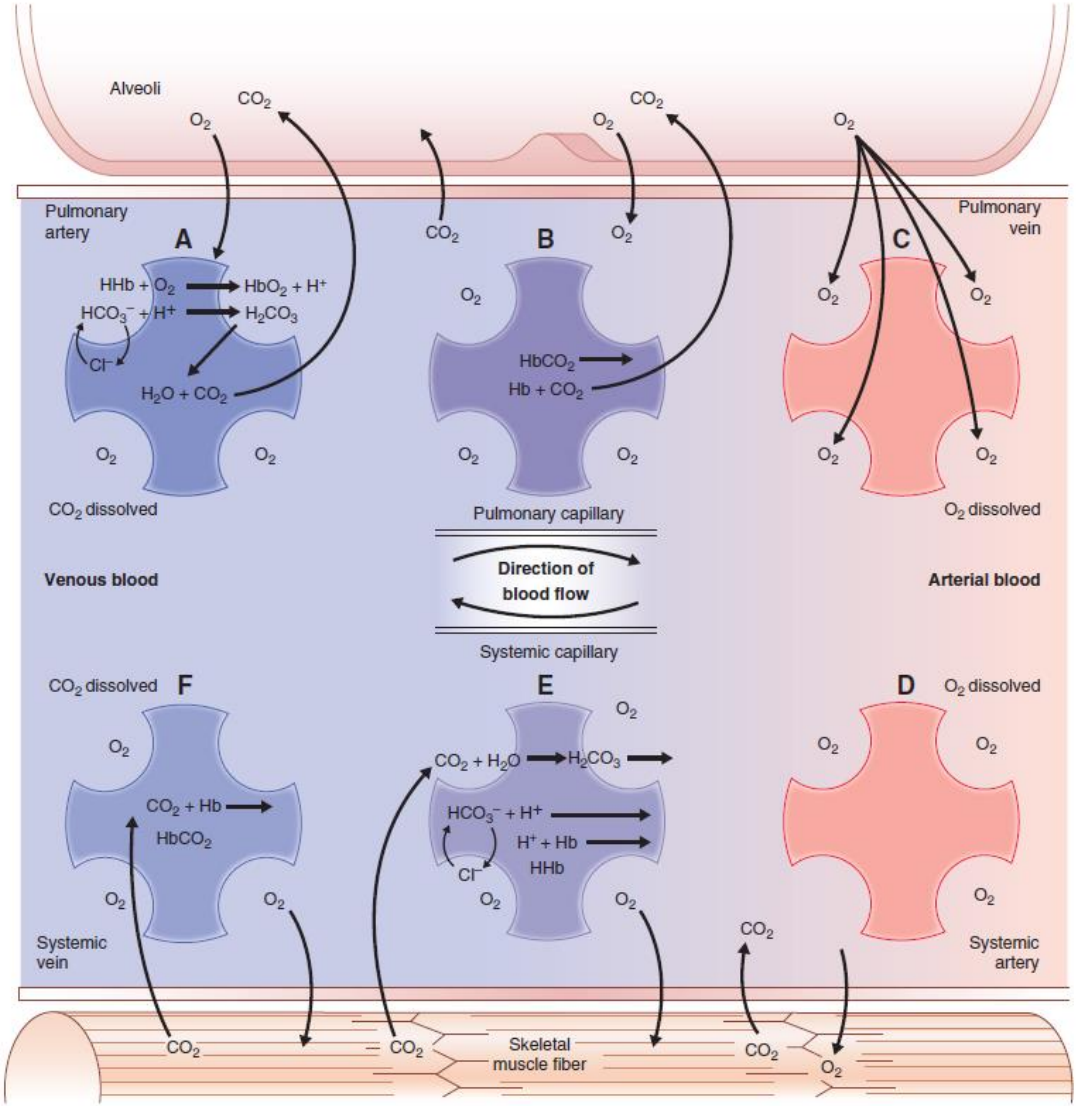
Trasporto dei gas nel sangue

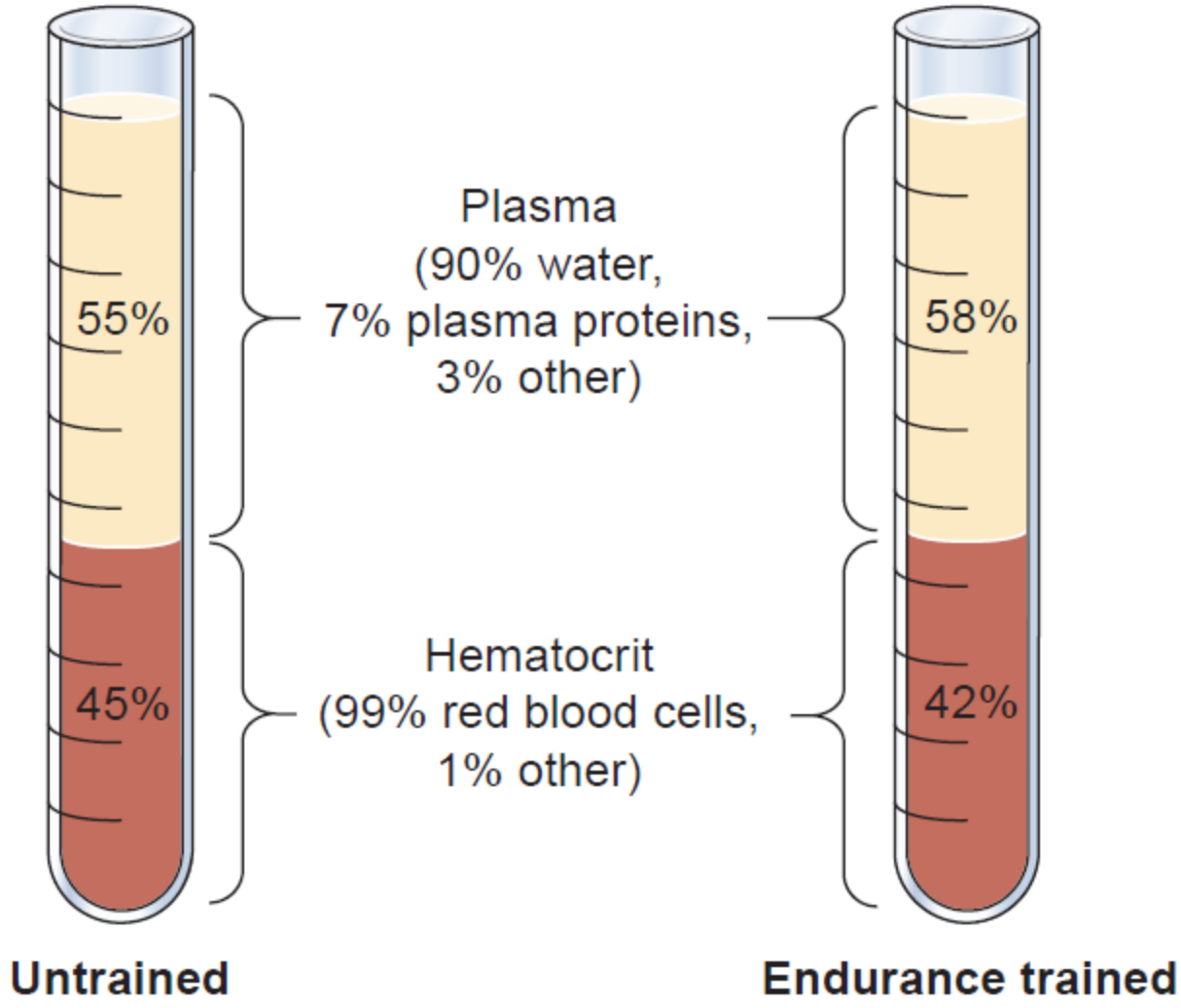
- **Trasporto di CO_2**
  - 7% - disciolta nel sangue
  - 20% - legata a Hb
  - 70% - trasportata dai bicarbonati*

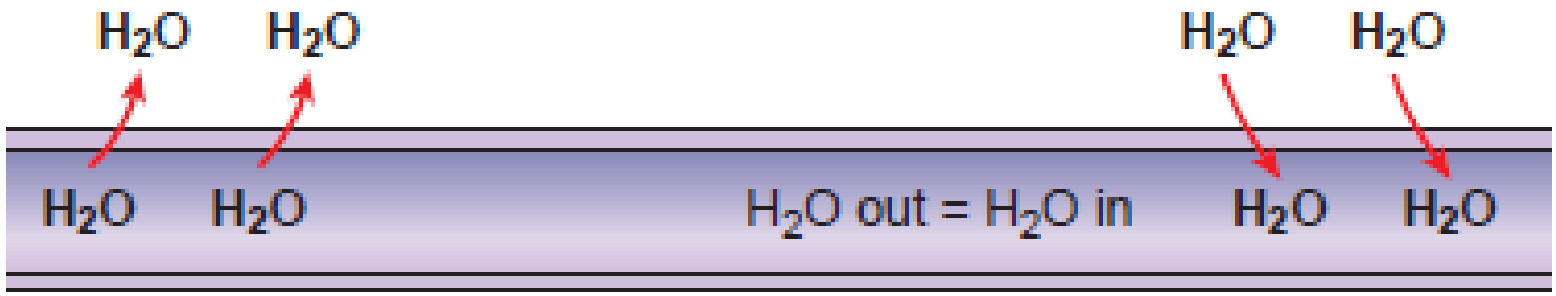
* Ventilazione e Metabolismo

Trasporto di O2 e CO2

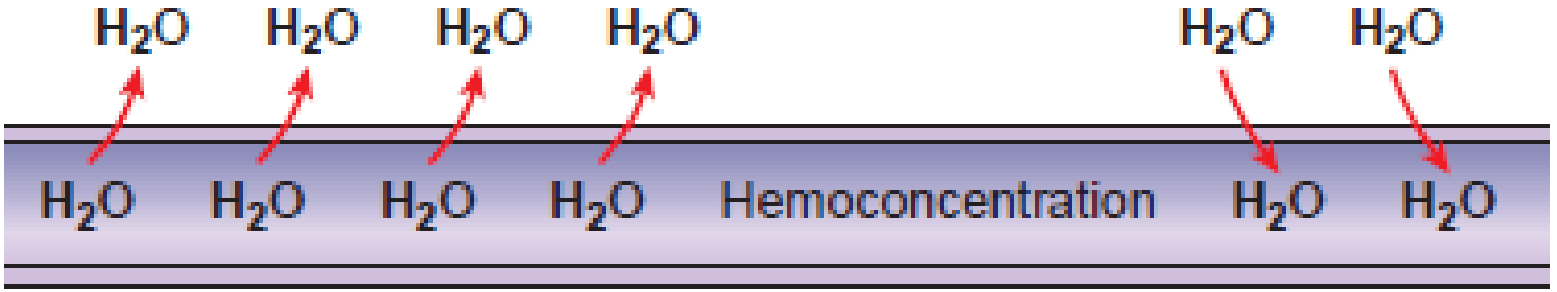
Visione d'insieme



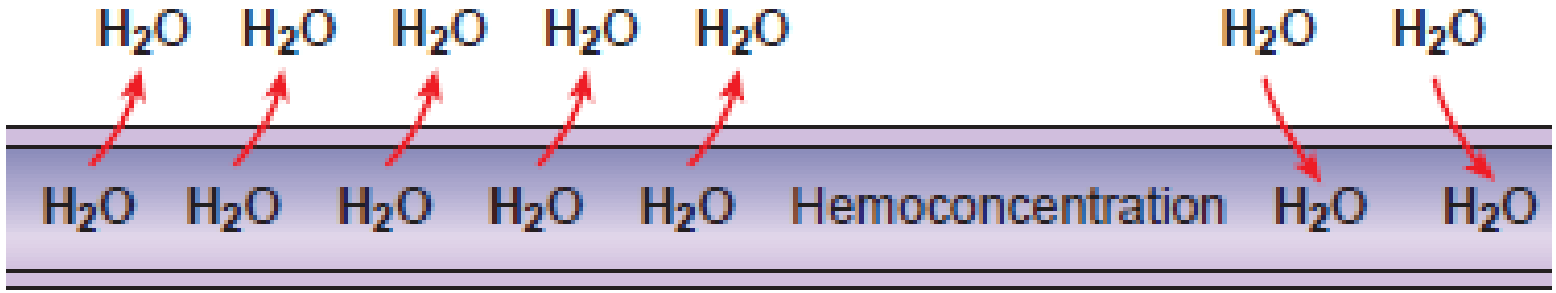

Plasma
(90% water,
7% plasma proteins,
3% other)
55%
58%
Hematocrit
(99% red blood cells,
1% other)
45%
42%
Untrained
Endurance trained


H2O H2O H2O H2O
H2O H2O H2O out = H2O in H2O H2O

A


H2O H2O H2O H2O H2O H2O
H2O H2O H2O H2O Hemoconcentration H2O H2O

B


H2O H2O H2O H2O H2O H2O H2O
H2O H2O H2O H2O H2O Hemoconcentration H2O H2O

C

- Esercizio Acuto - Emoconcentrazione
- Esercizio Cronico - Emodiluizione

Adattamenti periferici

- O_2 Delivery
- O_2Utilization

Differenza artero-venosa

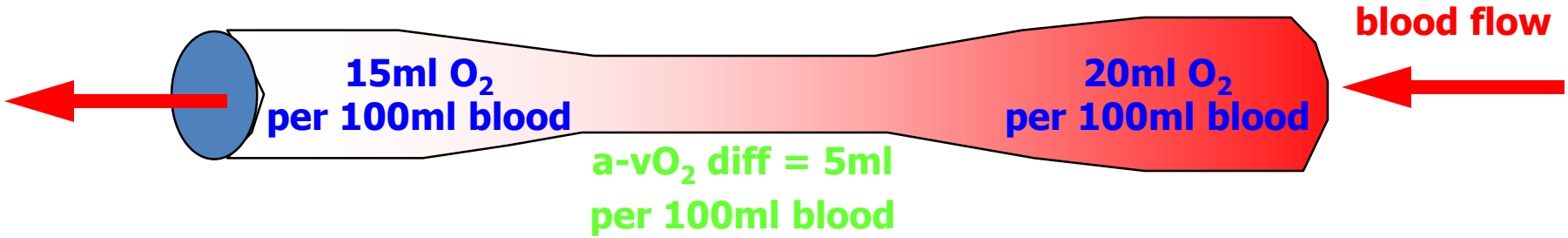
- Differenza in contenuto di O_2 fra sangue arterioso e venoso.
  - Indica quanto O_2 è stato utilizzato dalla periferia (muscolo che lavora).
  - Dipende dal rapporto *Delivery/Utilization*
  - Quanto O_2 il sistema cardiocircolatorio porta al muscolo
  - Quanto O_2 il muscolo è in grado di utilizzare

ARTERIOVENOUS OXYGEN DIFFERENCE

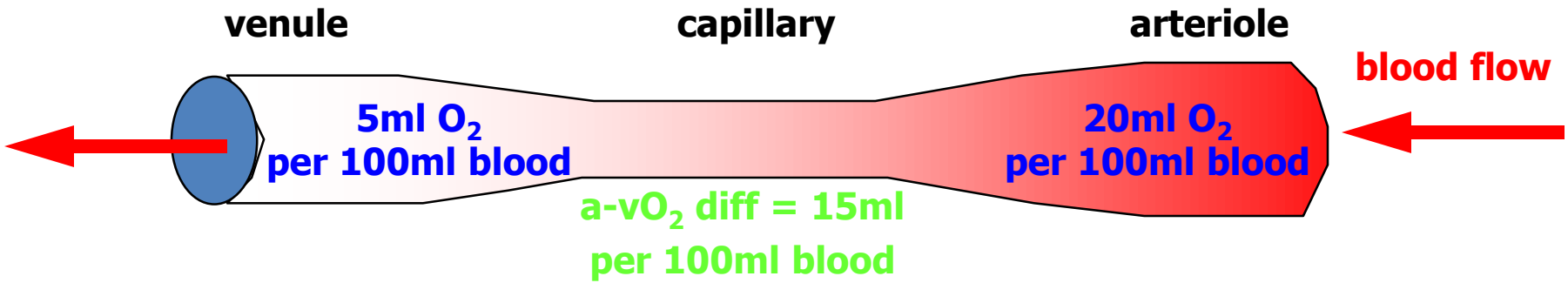
a-vO_2 diff

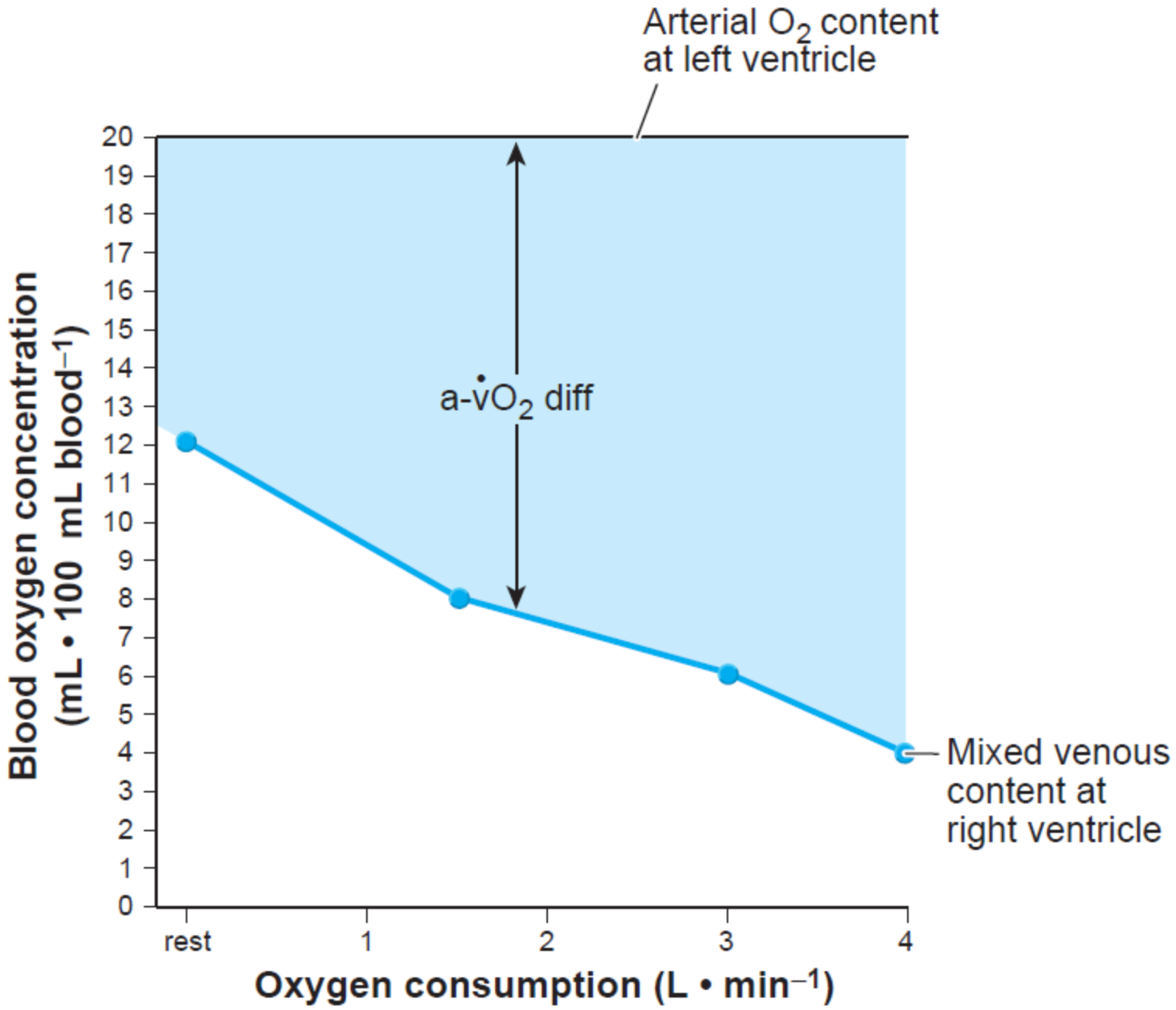
- this expresses the difference between the oxygen carried by blood in arteries and veins
- and represents the amount of oxygen delivered to working tissue in the capillary system

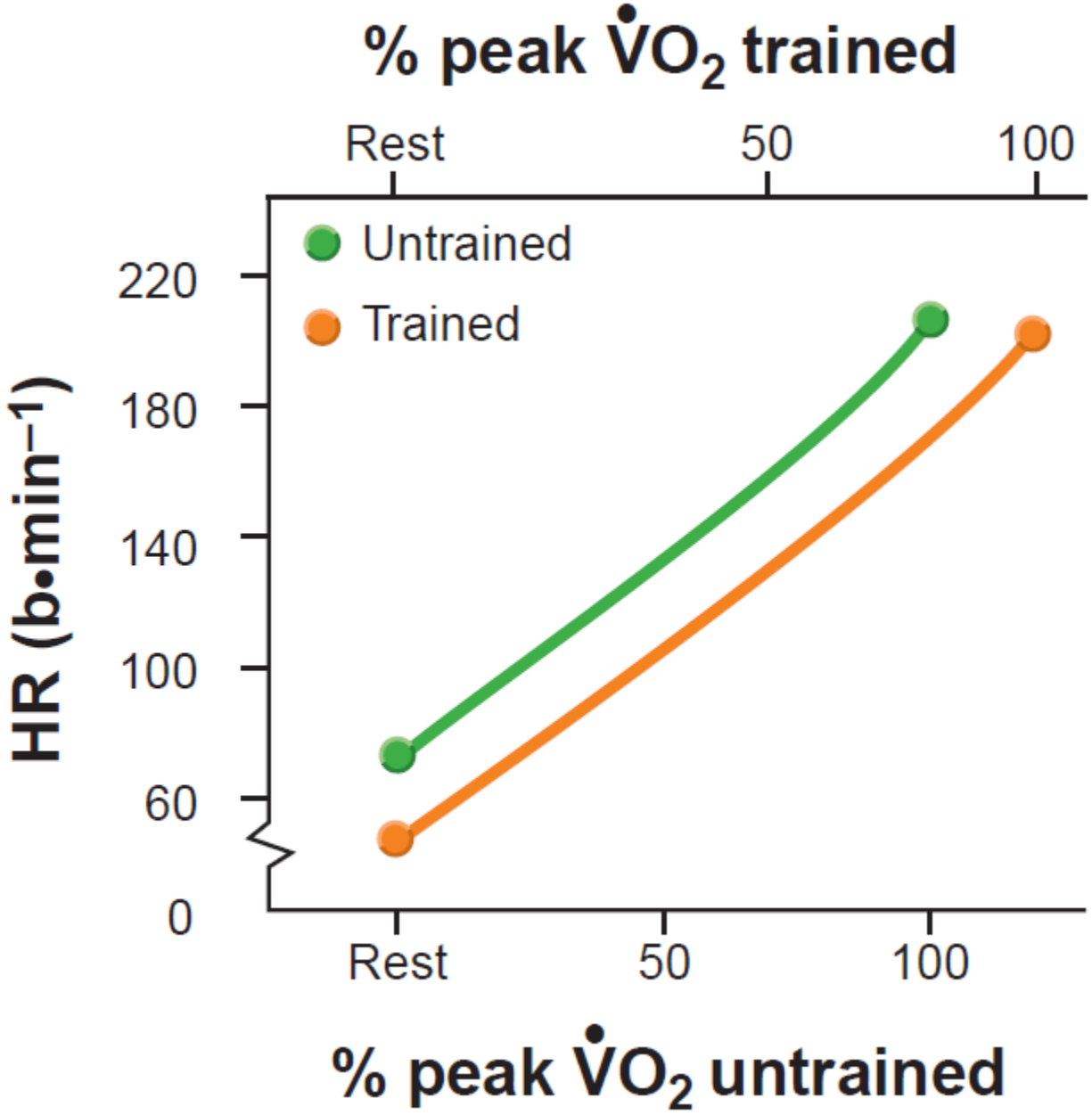
a-vO_2 diff - AT REST

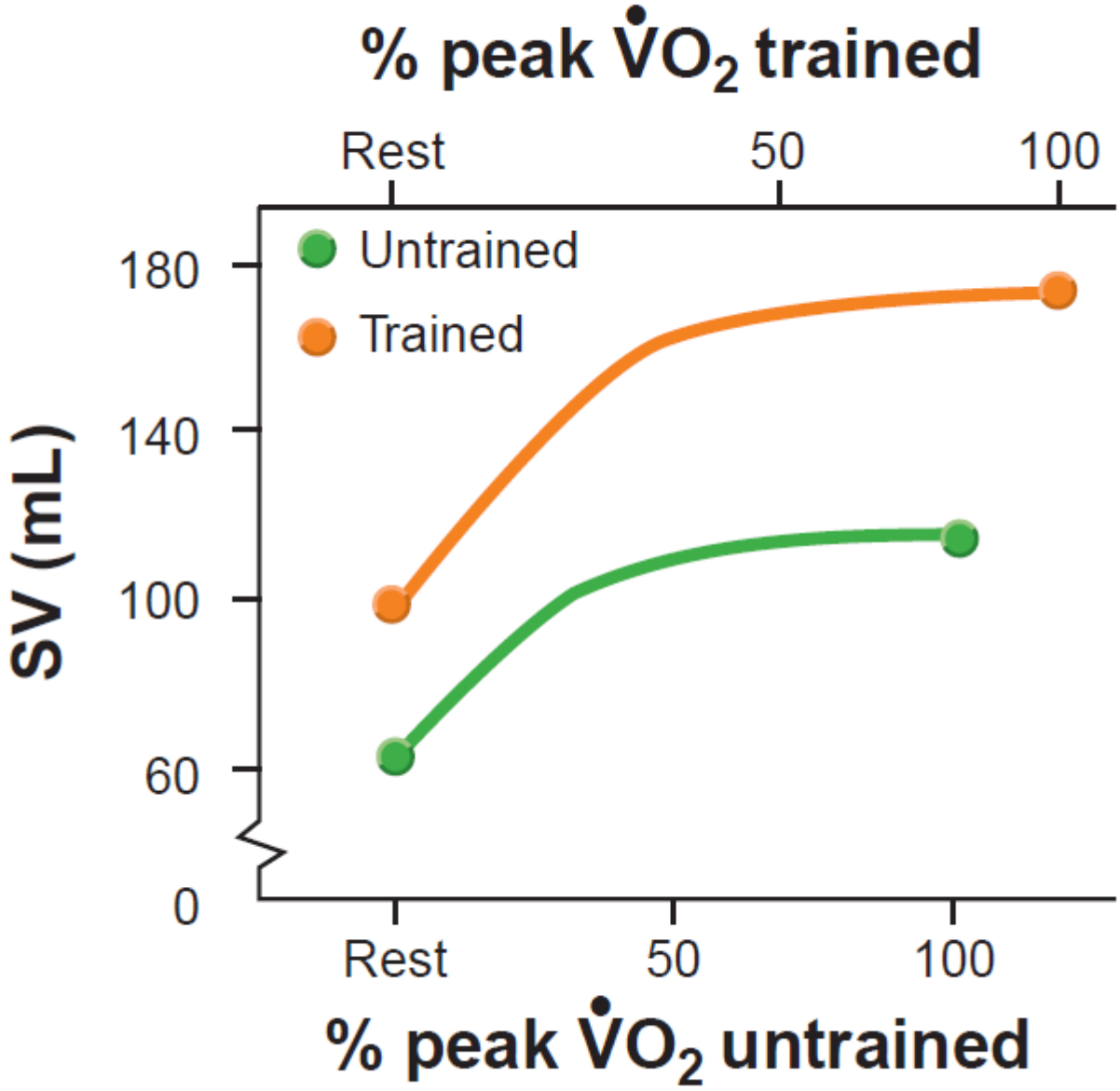


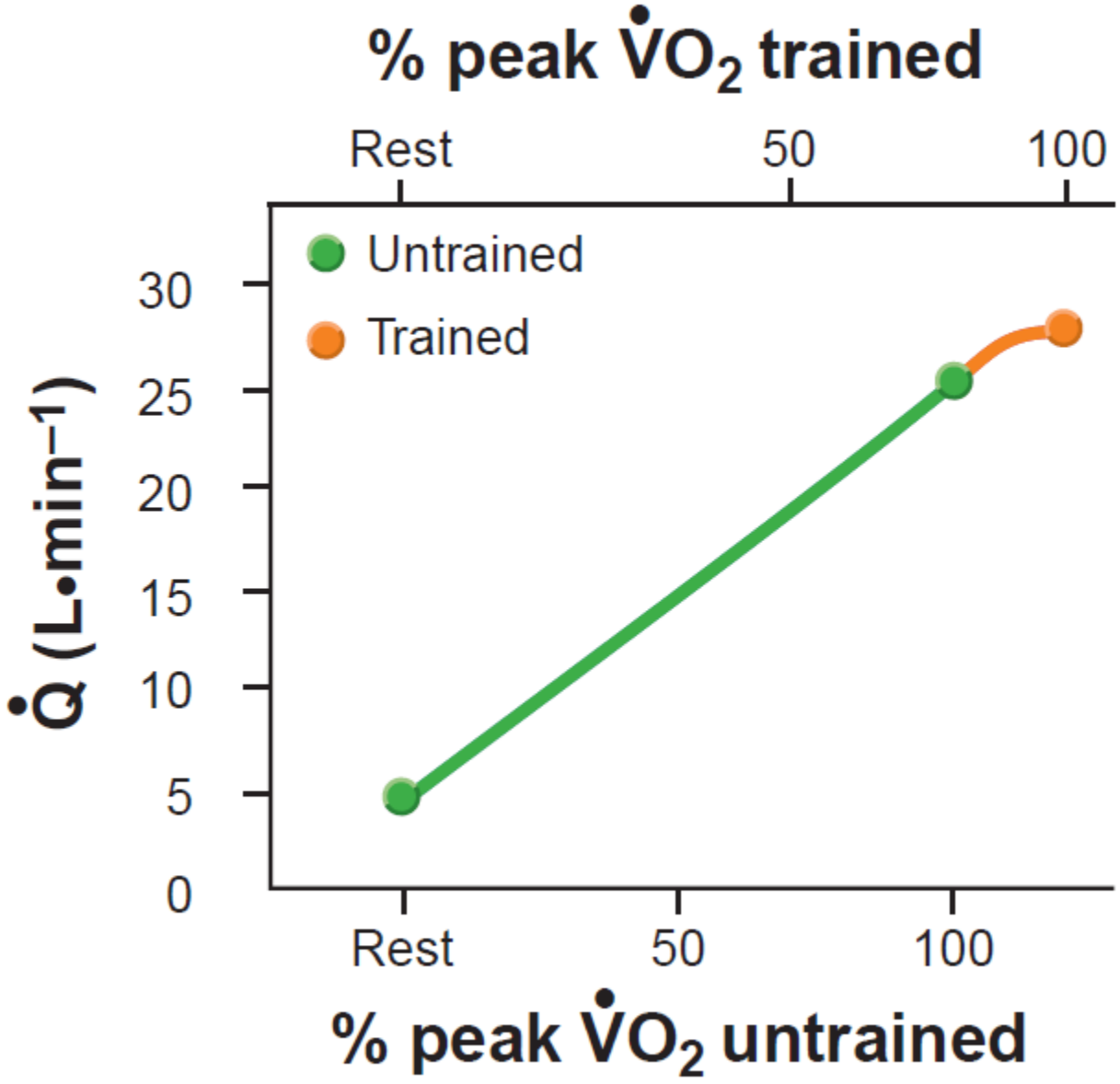
a-vO_2 diff - DURING INTENSE EXERCISE

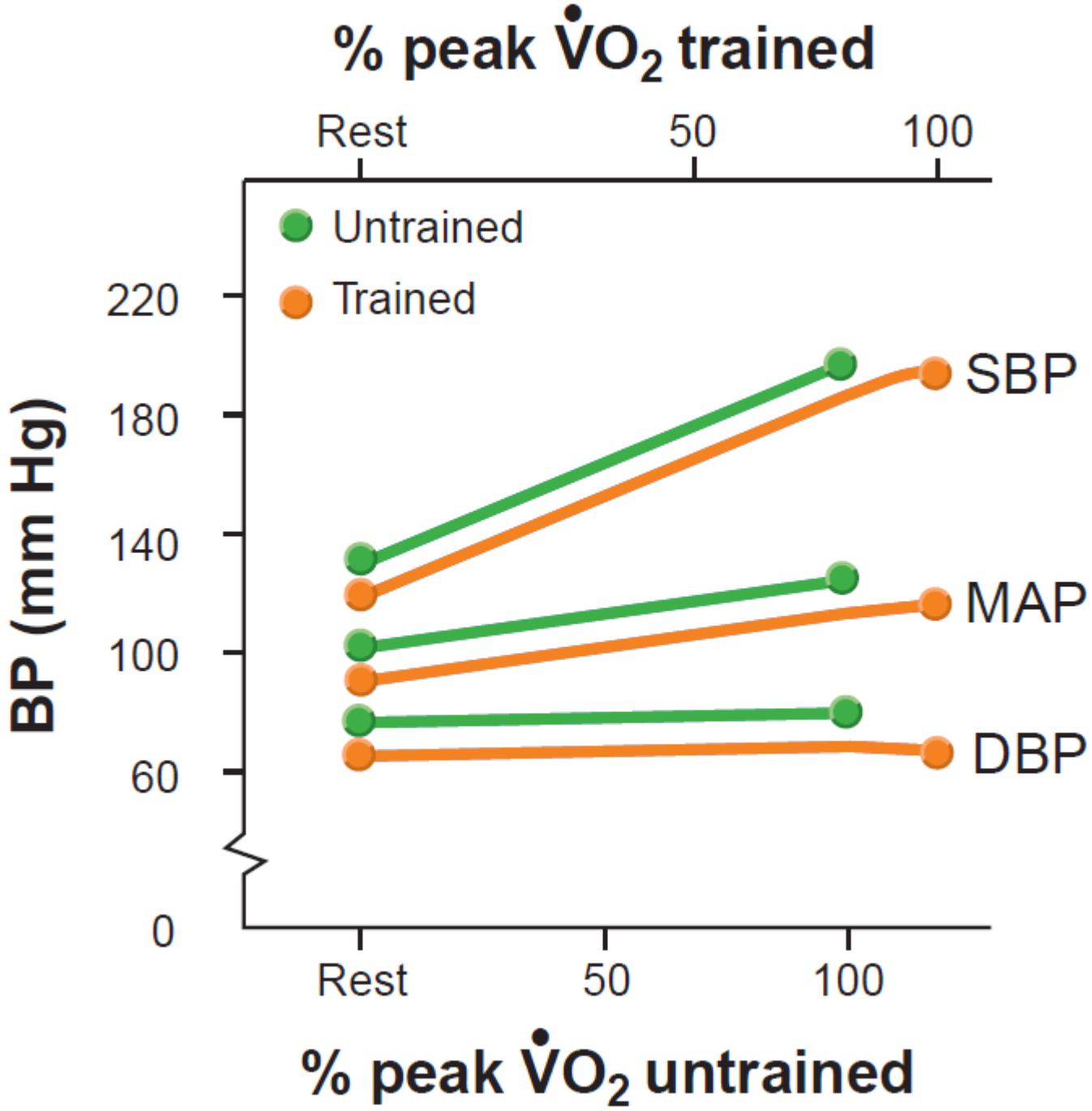


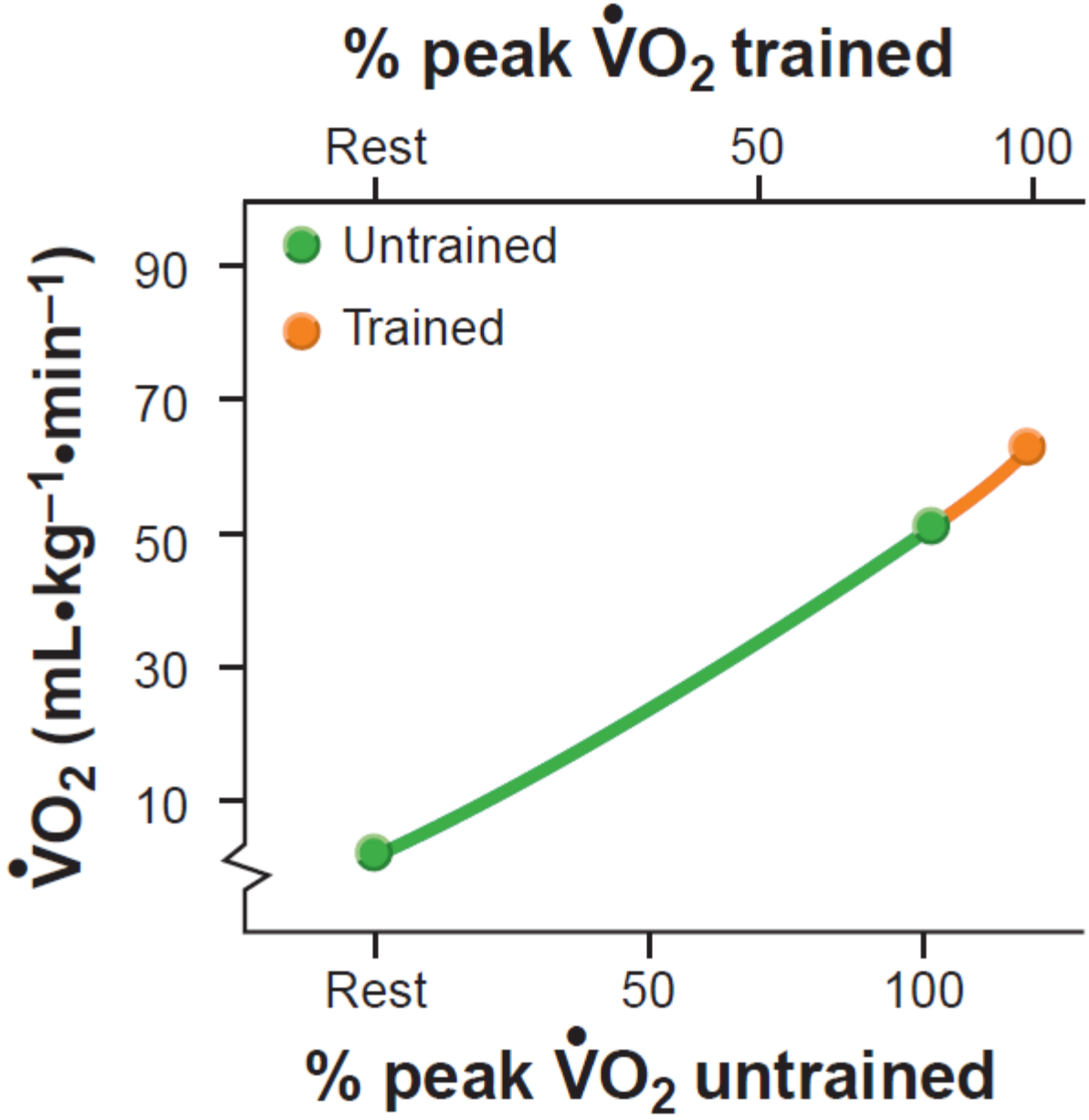

Arterial O_2 content at left ventricle
a-$\dot{v}O_2$ diff
Mixed venous content at right ventricle
Blood oxygen concentration (mL • 100 mL blood^{-1})
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
rest
1
2
3
4
Oxygen consumption (L • min^{-1})


% peak $\dot{V}O_2$ trained
Rest
50
100
Untrained
Trained
220
180
140
100
60
0
HR (b•min^{-1})
Rest
50
100
% peak $\dot{V}O_2$ untrained

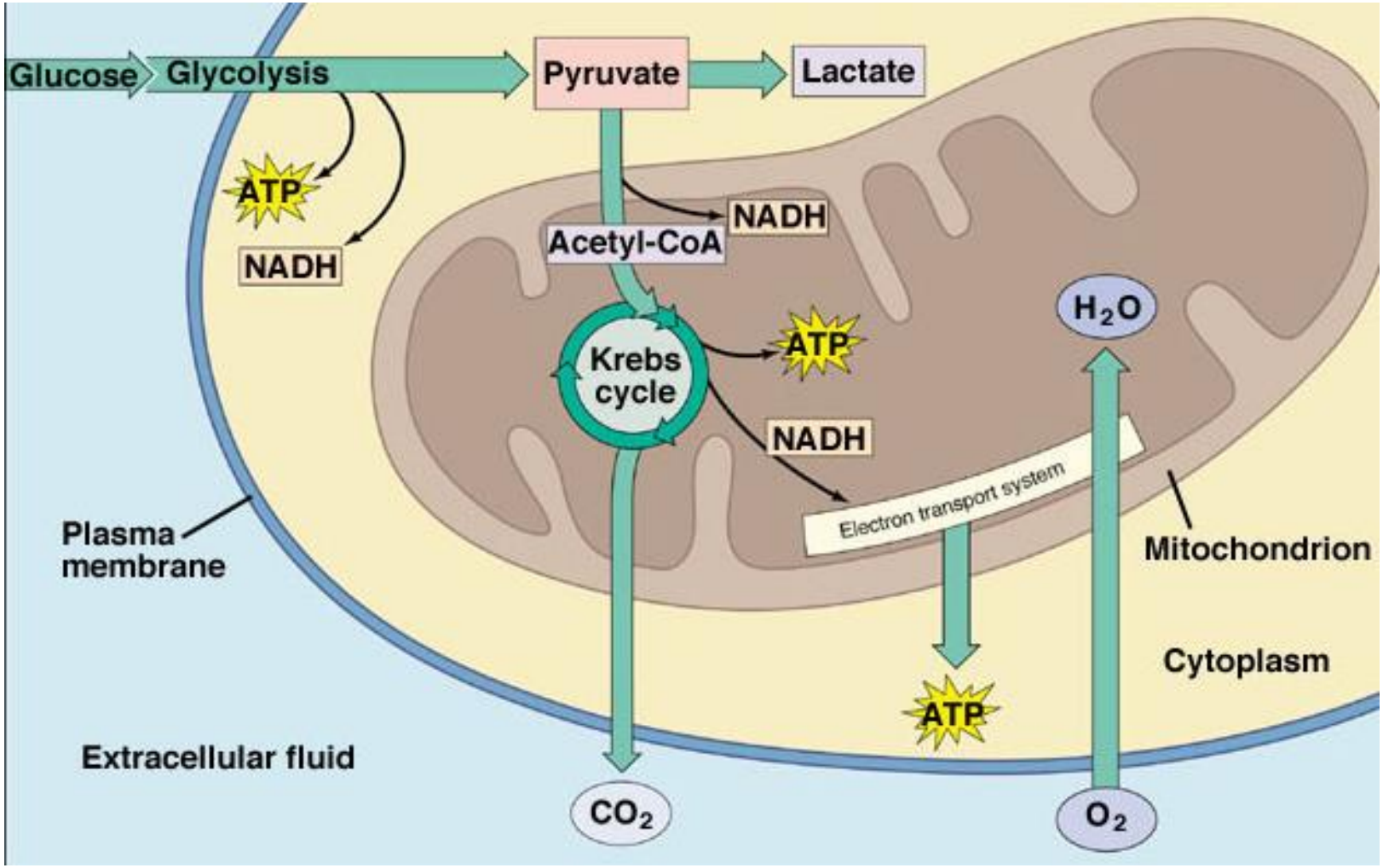

% peak $\dot{V}O_2$ trained
Rest
50
100
Untrained
Trained
180
140
100
60
0
SV (mL)
Rest
50
100
% peak $\dot{V}O_2$ untrained


% peak $\dot{V}O_2$ trained
Rest
50
100
Untrained
Trained
30
25
20
15
10
5
0
$\dot{Q}$ (L•min^{-1})
Rest
50
100
% peak $\dot{V}O_2$ untrained


% peak $\dot{V}O_2$ trained
Rest
50
100
Untrained
Trained
220
180
140
100
60
0
BP (mm Hg)
SBP
MAP
DBP
Rest
50
100
% peak $\dot{V}O_2$ untrained


% peak $\dot{V}O_2$ trained
Rest
50
100
Untrained
Trained
90
70
50
30
10
$\dot{V}O_2$ (mL•kg^{-1}•min^{-1})
Rest
50
100
% peak $\dot{V}O_2$ untrained

Periferia


Glucose
Glycolysis
Pyruvate
Lactate
ATP
NADH
Acetyl-CoA
NADH
Krebs cycle
ATP
NADH
Electron transport system
H_2O
Plasma membrane
Mitochondrion
Cytoplasm
ATP
Extracellular fluid
CO_2
O_2

Metabolic and physiological values for healthy trained and untrained men

Variable	Untrained	Trained	%age diff
Glycogen (mM)	85	120	41
Mitochondria Volume (% Muscle cell)	2.15	8	272
Resting ATP (mM)	3	6	100
Resting PC (mM)	11	18	64
Aerobic enzymes (mM)	5-10	15-20	133
Max Lactate (mM)	110	150	36
Max stroke Vol (mL)	120	180	50
Max cardiac output (L/min)	20	30-40	75
Resting HR (bpm)	70	40	-43
VO2 max (mL/kg/min)	30-40	65-80	107
Blood Volume (L)	4.7	6	28

Aerobic Energy Systems Adaptations

Aerobic training also causes important peripheral changes.

- ↑ capillarisation
- ↑ mitochondria density
- ↑ oxidative enzymes

Adaptation	Endurance Training	Strength Training
Left ventricular mass	Increased	Increased
Left ventricular wall thickness	Increased	Increased
Left ventricular end-diastolic volume	Increased	Little change
Stroke volume	Increased	Little change
Cardiac output	Little change	Little change
Systolic blood pressure	Decreased	Decreased
Diastolic blood pressure	Decreased	Decreased
Plasma volume	Increased	Little change
Red blood cell mass	Increased	Little change
Hematocrit	Slight decrease	Little change
Blood volume	Increased	Little change
Large artery capacitance	Increased	Unclear