Cardiovascular system

Cardiovascular control during exercise

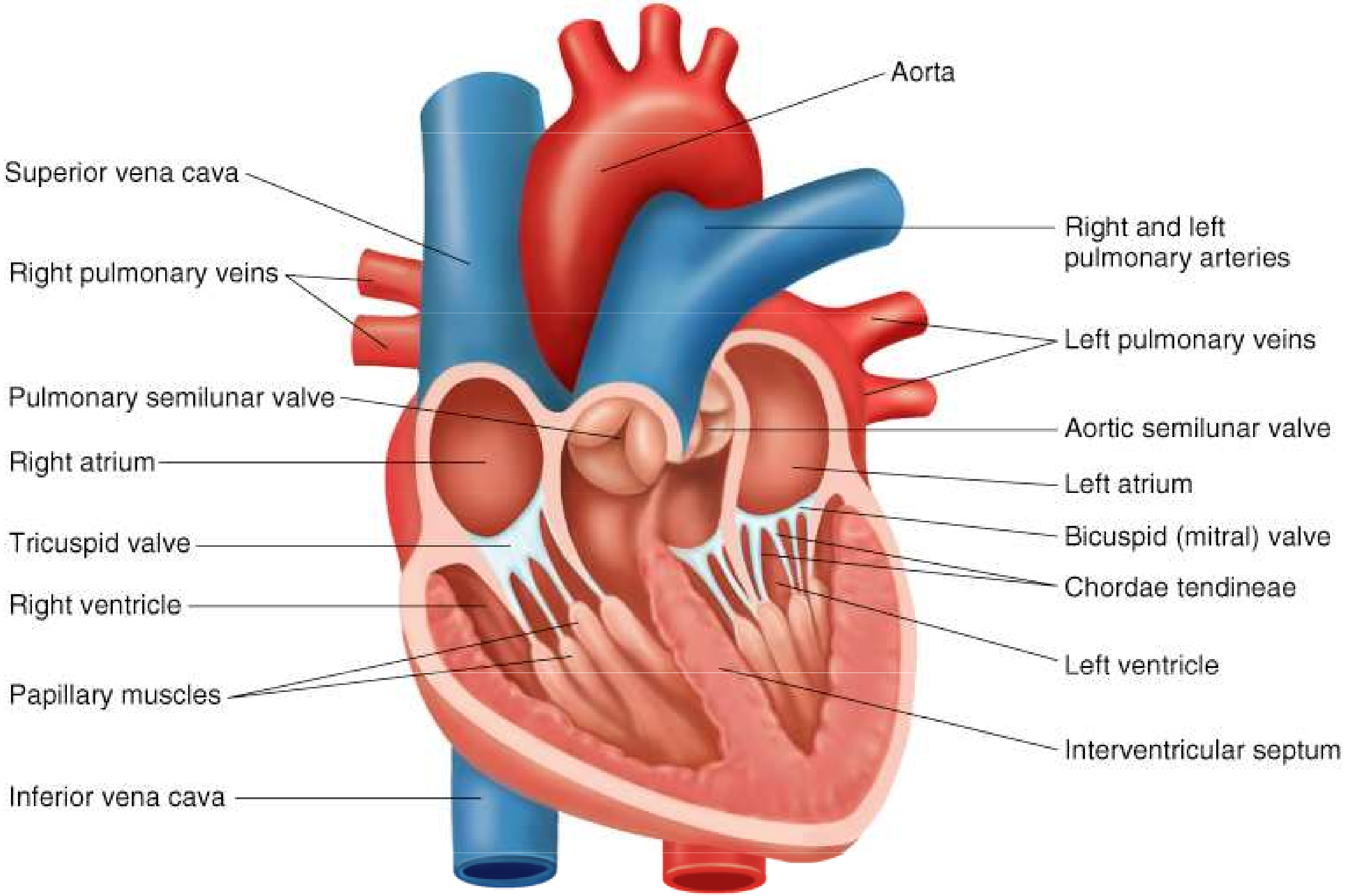
Major cardiovascular functions

- Delivery (e.g., oxygen and nutrients)
- Removal (e.g., carbon dioxide, lactate, other waste products)
- Transportation (e.g., hormones)
- Maintenance (e.g., body temperature, pH)
- Prevention (e.g., infection—immune function)

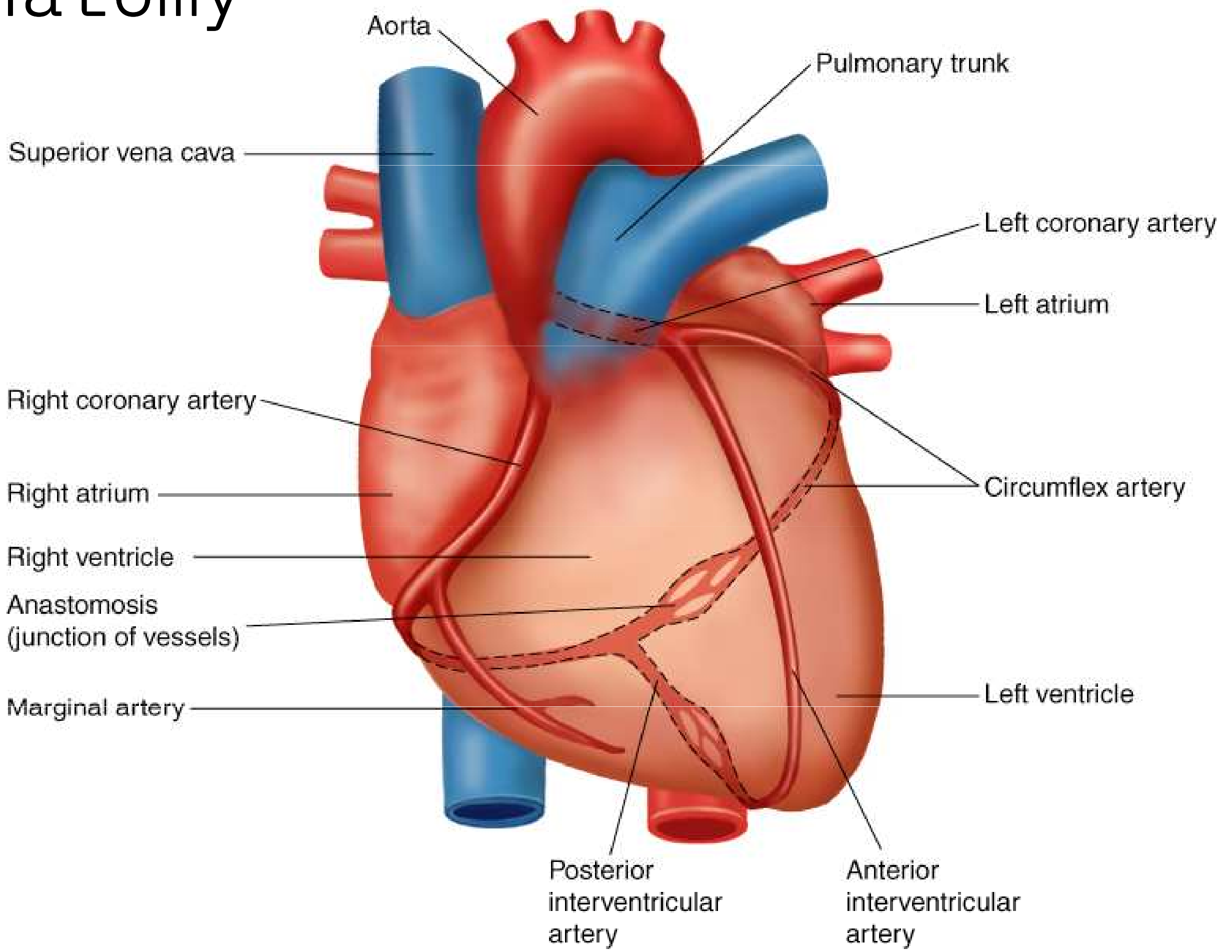
Cardiovascular system

- A pump – the heart
- A system of channels – the blood vessels
- A fluid medium - blood

Heart anatomy



Heart anatomy



Key points

- The two atria receive blood into the heart; the two ventricles send blood from the heart to the rest of the body.
- The left ventricle has a thicker myocardium due to hypertrophy resulting from the resistance against which it must contract.

Heart Rate

What is the average resting heart rate frequency?

Heart Rate

- **Resting heart rates** in adults tend to be between 60 and 80 beats/min. However, extended endurance training can lower resting heart rate to **40 beats/min or less.** This lower heart rate is thought to be due to decreased intrinsic heart rate and increased parasympathetic stimulation.

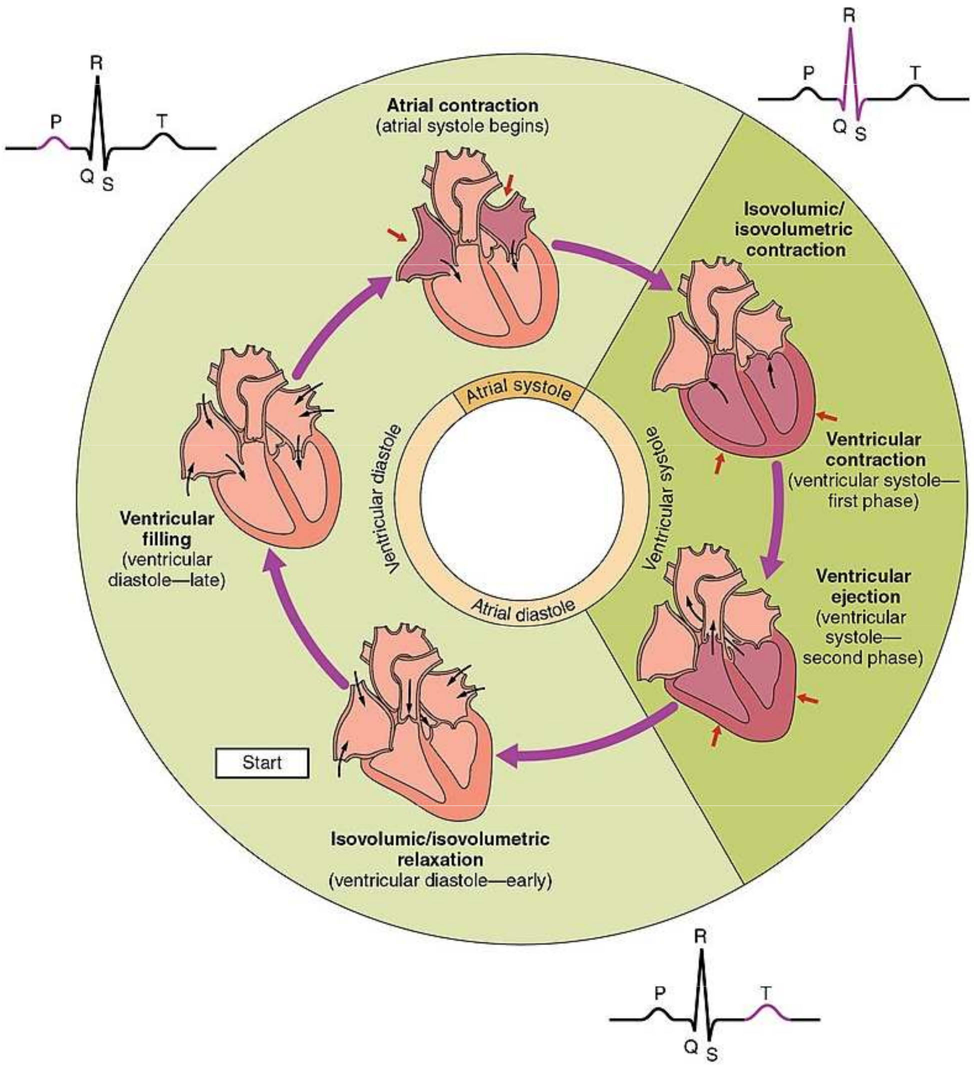
Cardiac Arrhythmias

- BRADYCARDIA – Resting heart rate **below 60 beats/min**
- TACHYCARDIA – Resting heart rate **above 100 beats/min**
- PREMATURE VENTRICULAR CONTRACTIONS (PVCs) – feels like skipped or extra beats
- VENTRICULAR TACHYCARDIA – three or more consecutive **PVCs** that can lead to **ventricular fibrillation** in which contraction of the ventricular tissue is uncoordinated

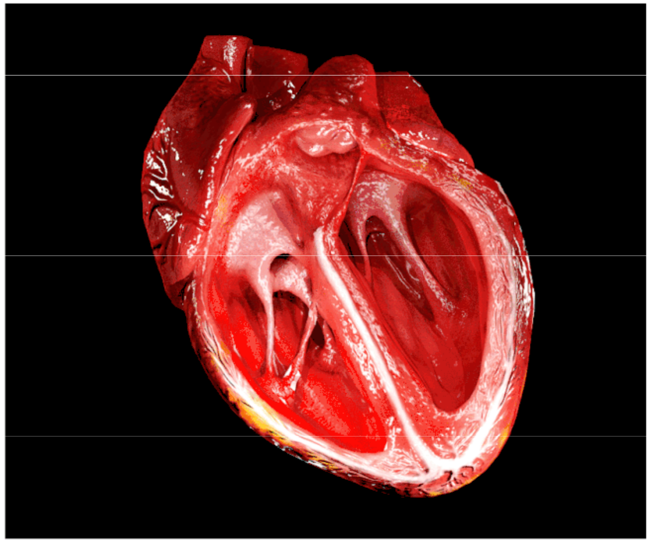
Cardiac cycle

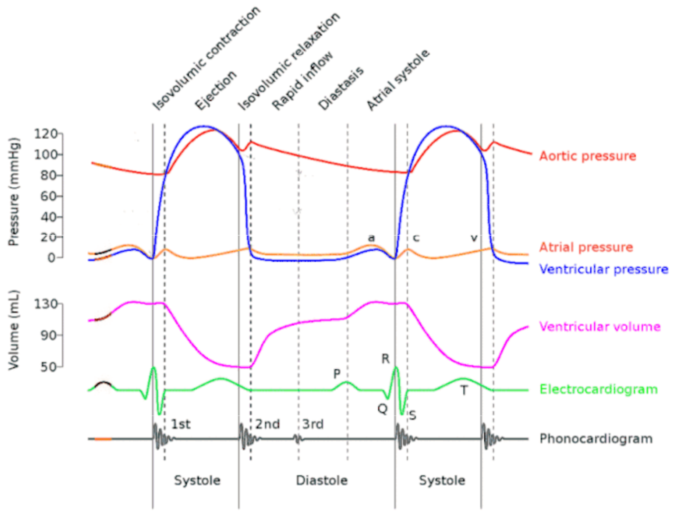
- The event that occurs between two consecutive heartbeats (systole to systole)

- Diastole—relaxation phase during which the chambers fill with blood - 62% of cycle duration
- Systole—contraction phase during which the chambers expel blood - 38% of cycle duration



Cardiac Cycle



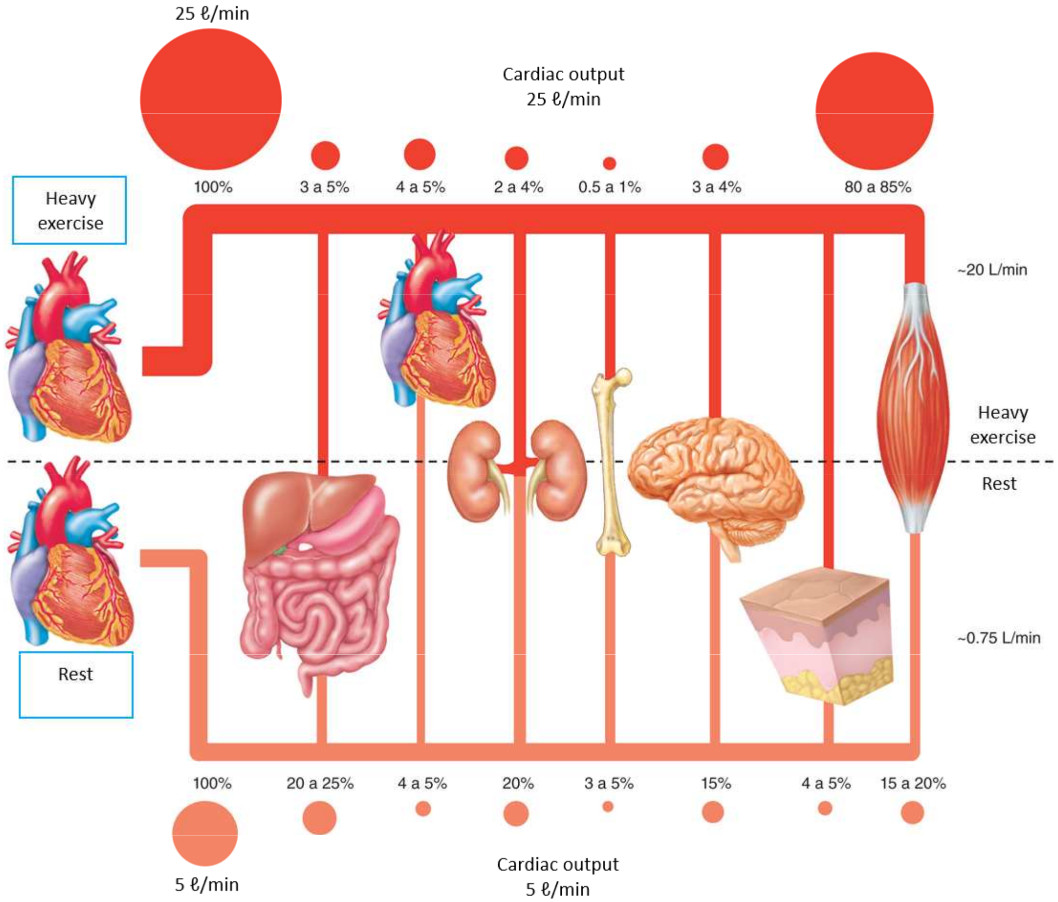


Stroke Volume and Cardiac Output

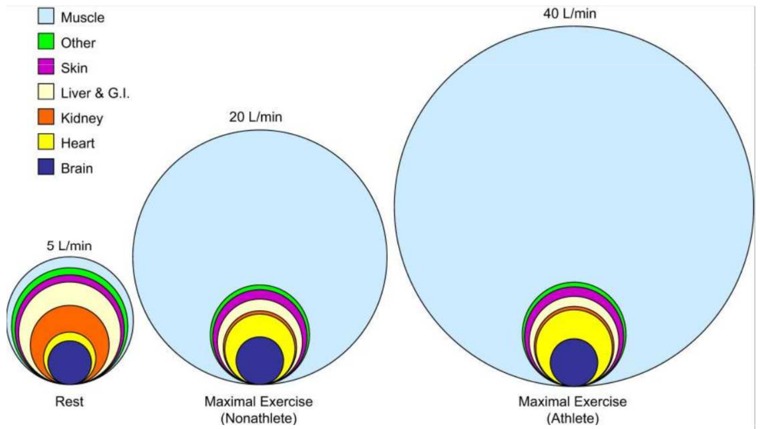
- **Stroke volume (SV)** is volume of blood pumped per contraction
- Average 50-100 ml
- **End-Diastolic Volume (EDV)** – blood volume in a ventricle before contraction
- **End-Systolic Volume (ESV)** – blood volume in a ventricle after contraction
- **SV = EDV – ESV**

- **Cardiac output (Q)** is the total volume of blood pumped by the ventricles per minute

Blood distribution



Fuente: Stuart Ira Fox: *Fisiología humana*, 14e: www.accessmedicina.com



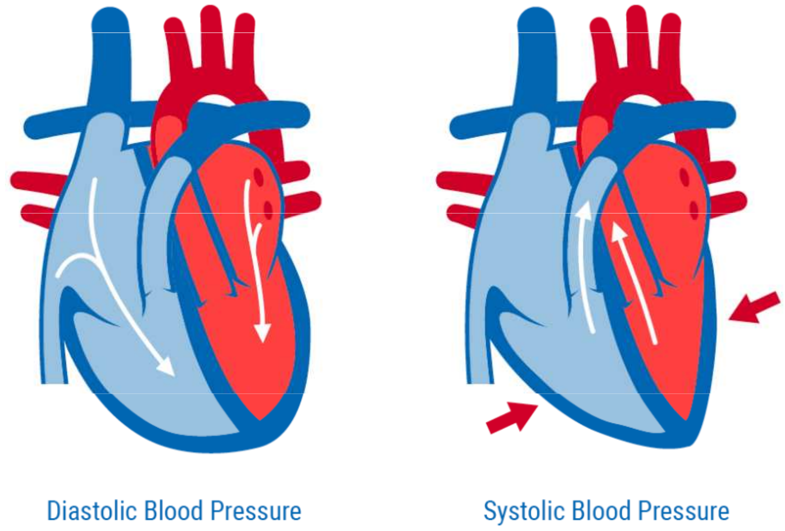
Total blood flow and its distribution during rest and brief exercise requiring VO_2 max

Blood pressure

- Systolic blood pressure (SBP) is the highest pressure and diastolic blood pressure (DBP) is the lowest pressure
- Mean arterial pressure (MAP)—average pressure exerted by the blood as it travels through arteries
- MAP = DBP + [0.333 ´ (SBP – DBP)]

- Rest Blood Pressure is about 120/80

- Hypertension: BP = more than 140/90
- Hypotension: BP = less than 90/60



BLOOD PRESSURE GUIDELINES

Blood Pressure Category	Systolic (mmHg)		Diastolic (mmHg)
NORMAL	<120	&	<80
ELEVATED	120 – 129	&	<80
HYPERTENSION STAGE 1	130 – 139	or	80 – 89
HYPERTENSION STAGE 2	140+	or	90+
HYPERTENSIVE CRISIS	180+	&/or	120+

Parameters affected by training

- Heart size
- Stroke Volume
- Heart rate
- Cardiac output
- Blood flow
- Blood pressure
- Blood volume

Cardiovascular Response to Acute Exercise

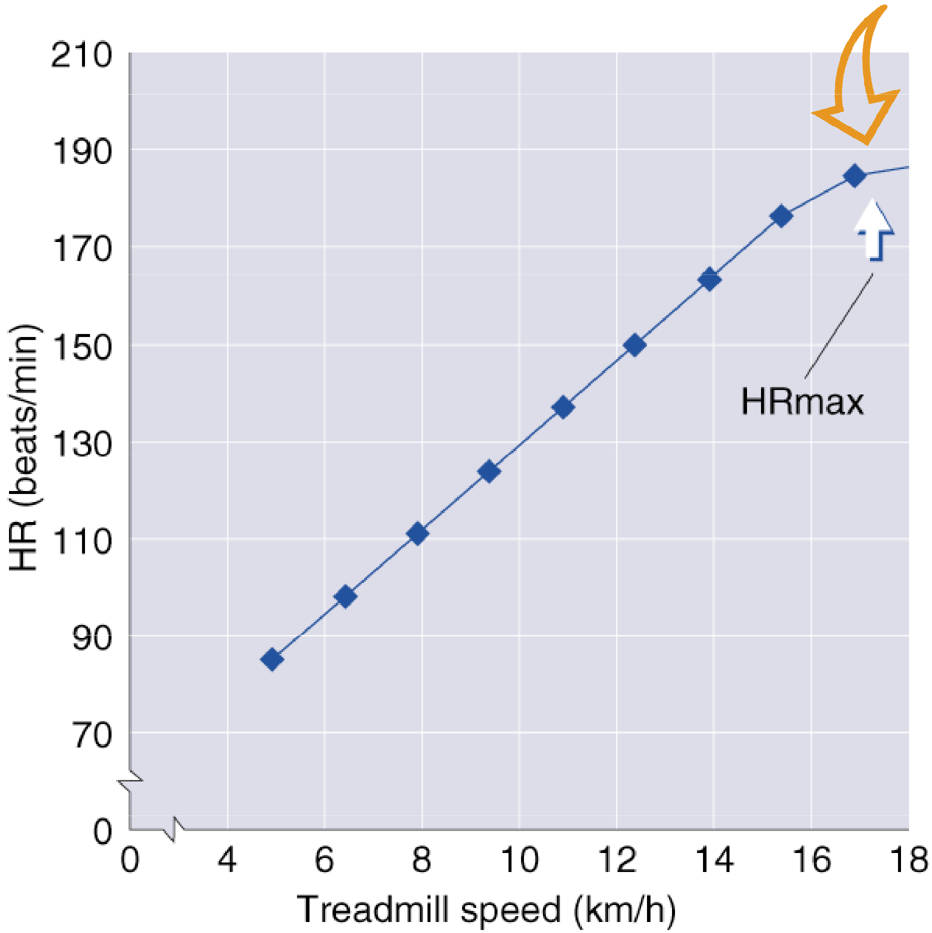
- Heart rate (HR) increases as exercise intensity increases up to maximal heart rate
- Stroke volume (SV) increases up to 40% to 60% VO_2max in untrained individuals and up to maximal levels in trained individuals.
- Increases in HR and SV during exercise cause cardiac output (Q) to increase
- Blood flow and blood press
- All result in allowing the body to efficiently meet the increased demands placed on it

Resting and Maximum Heart Rate

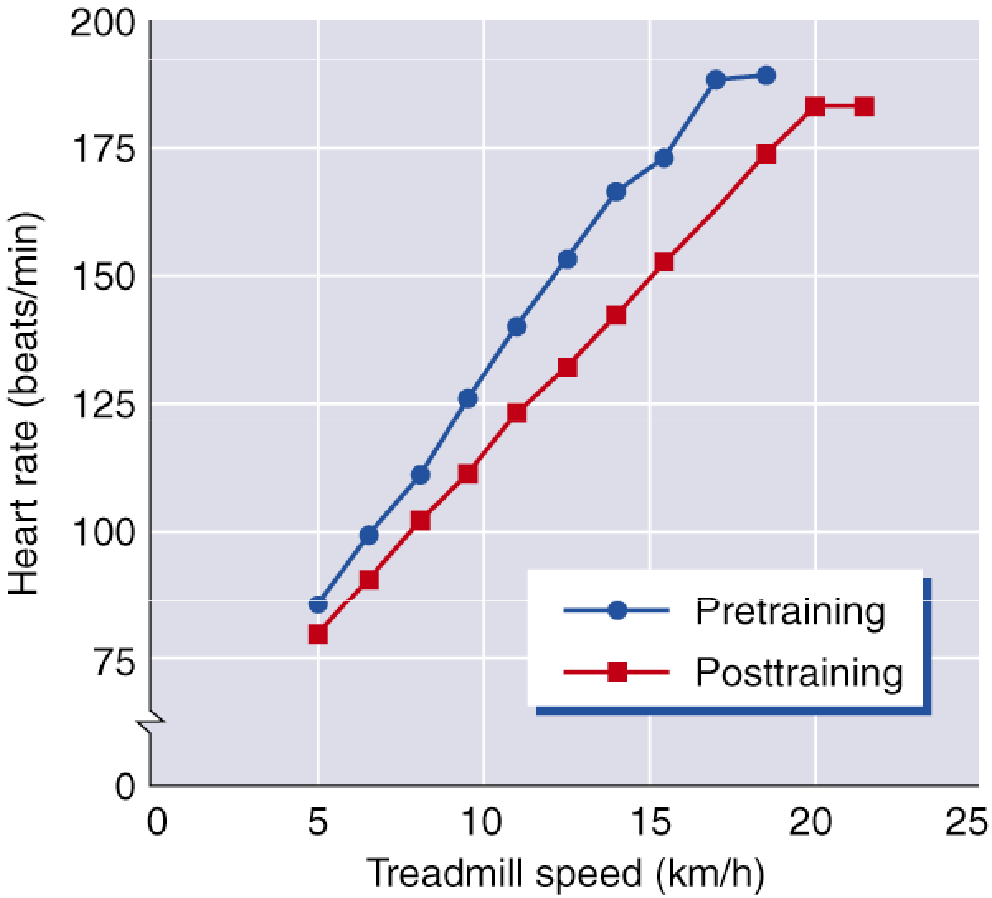
- RHR
- Averages 60 to 80 beats/min; can range from 28 to above 100 beats/min
- Tends to decrease with age and with increased cardiovascular fitness
- Is affected by environmental conditions such as altitude and temperature

- HRmax
- The highest heart rate value one can achieve in an all-out effort to the point of exhaustion
- Remains constant day to day and changes slightly from year to year
- Can be estimated:
  - HRmax = 220 – age in years or
  - HRmax = 208 – (0.7 x age)

Heart Rate and Intensity



Heart Rate and Training



Resting Heart Rate

- **Decreases with endurance training** likely due to more blood returning to heart and changes in autonomic control
- Sedentary individuals can decrease RHR by 1 beat/min per week during initial training, but several recent studies have shown small changes of less than 3 beats/min with up to 20 wk of training
- Highly trained endurance athletes may have resting heart rates of **30 to 40 beats/min**

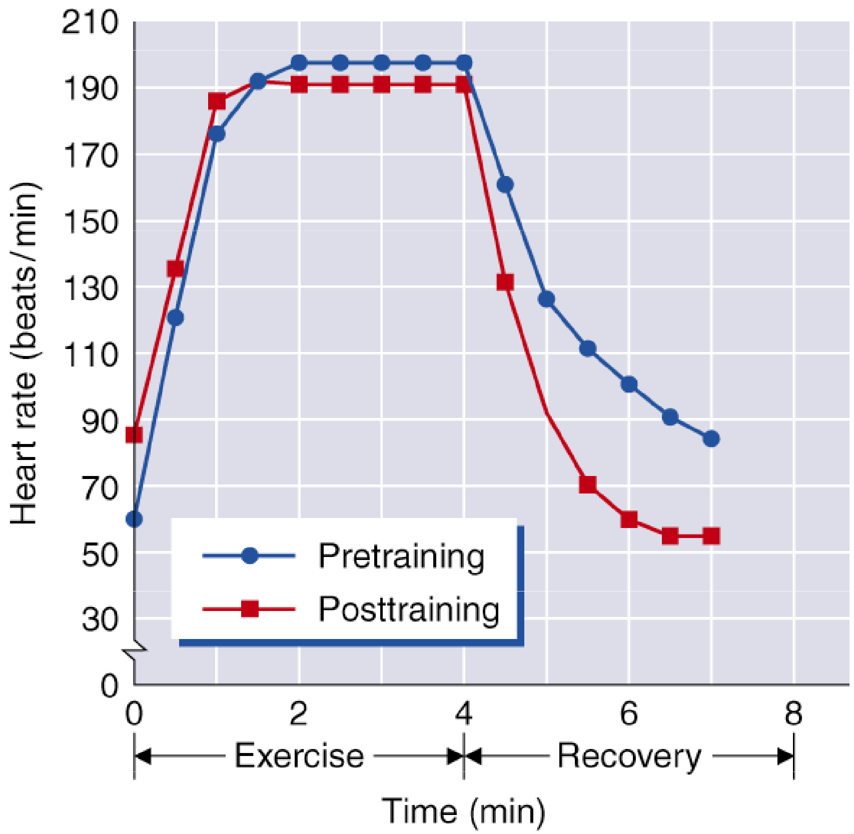
Heart Rate During Exercise

- SUBMAXIMAL
  - Decreases proportionately with the amount of training completed
  - May decrease by 10 to 30 beats/min after 6 months of moderate training at any given rate of work, with the decrease being greater at higher rates of work
- MAXIMAL
  - Remains unchanged or decreases slightly
  - A decrease might allow for optimal stroke volume to maximize cardiac output

Heart Rate Recovery Period

- The time after exercise that it takes your heart to return to its resting rate
- With training, heart rate returns to resting level more quickly after exercise
- Has been used as an index of cardiorespiratory fitness
- Conditions such as altitude or heat can affect it
- Should not be used to compare individuals to one another

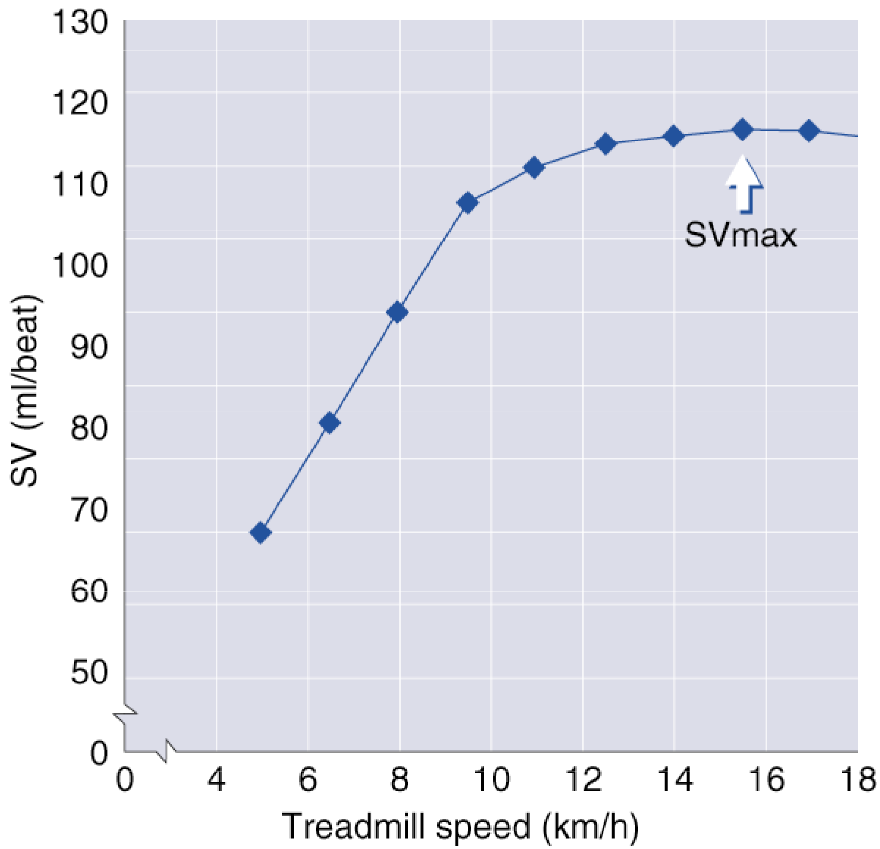
Heart Rate Recovery Period and Training



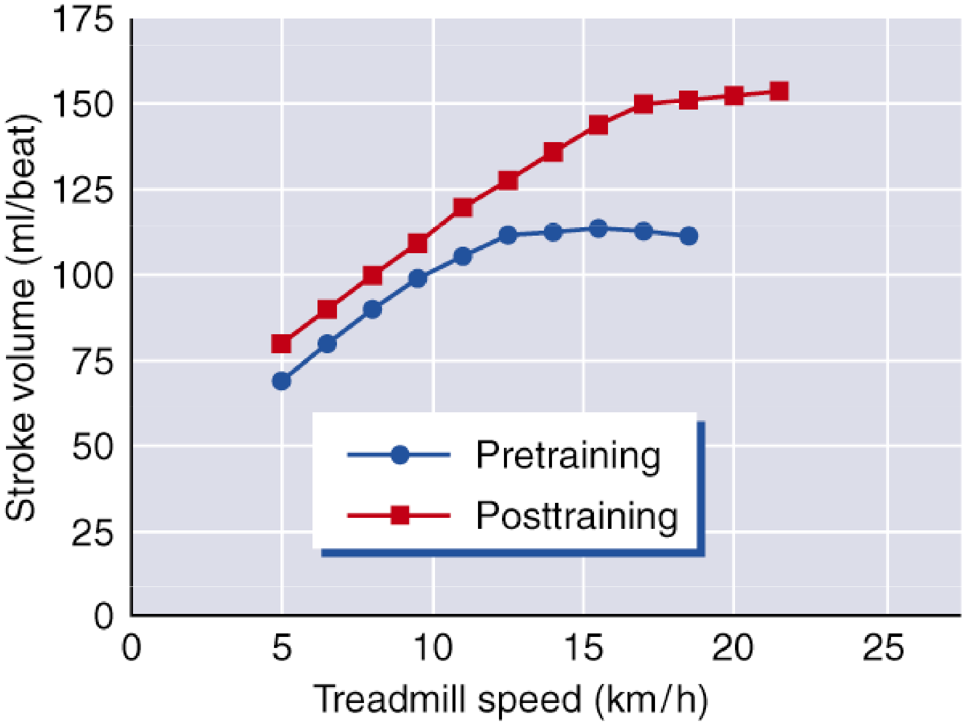
Stroke Volume

- Determinant of cardiorespiratory endurance capacity at maximal rates of work
- Increases with increasing rates of work up to intensities of 40% to 60% of max or higher
- May continue to increase up through maximal exercise intensity, generally in highly trained athletes
- Magnitude of changes in SV depends on position of body during exercise

Stroke Volume and Intensity



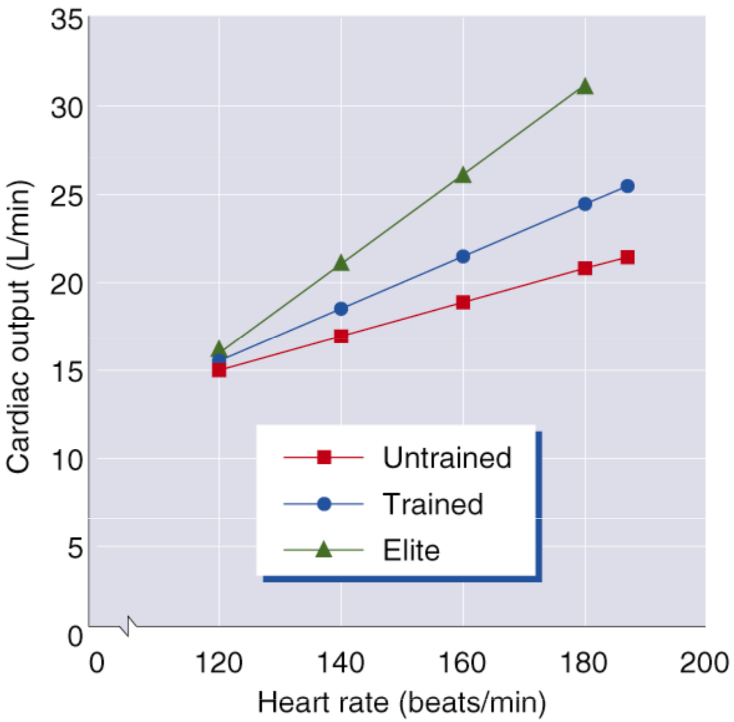
Stroke Volume and Training

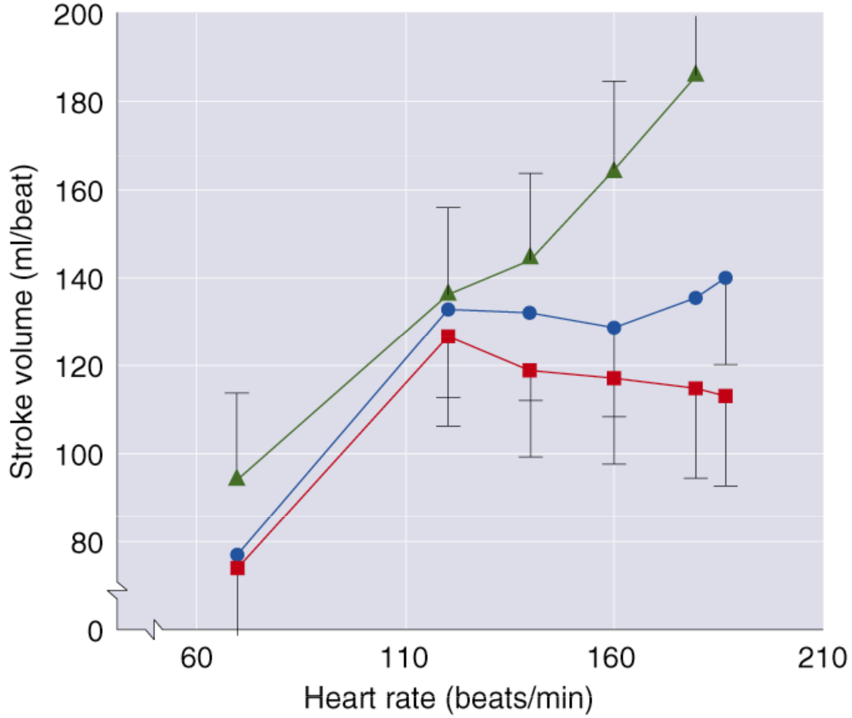


Stroke Volumes (SV) for Different States of Training

Subjects	SVrest (ml)	SVmax (ml)
Untrained	50-70	80-110
Trained	70-90	110-150
Highly trained	90-110	150-220

Changes in Q and SV with Increasing Rates of Work

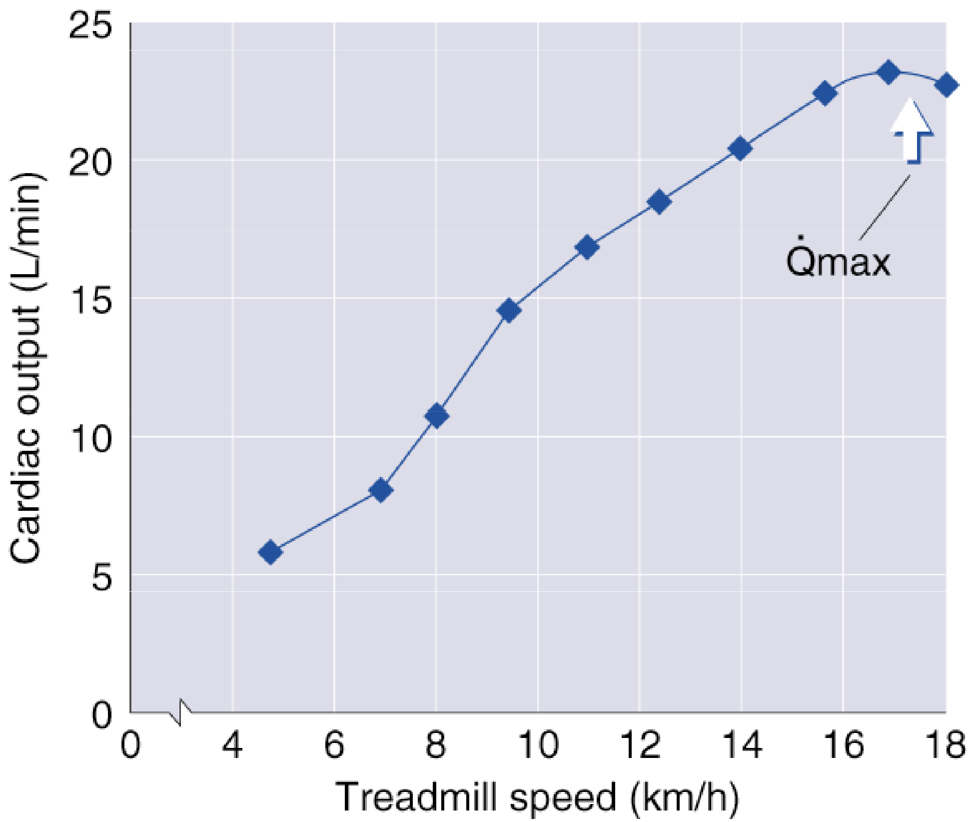




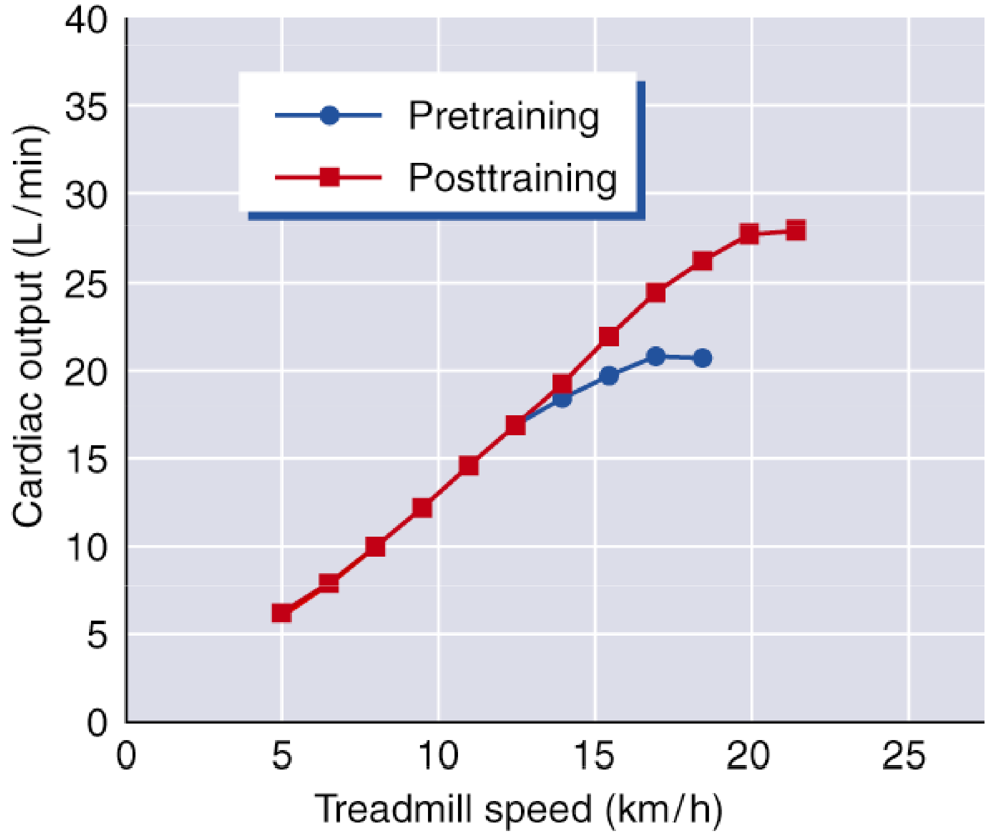
Cardiac Output

- Resting value is approximately 5.0 L/min.
- Increases directly with increasing exercise intensity to maximal values of between 20 to 40 L/min
- The magnitude of increase varies with body size and endurance conditioning.
- When exercise intensity exceeds 40% to 60%, further increases in Q are more a result of increases in HR than SV since SV tends to plateau at higher work rates.

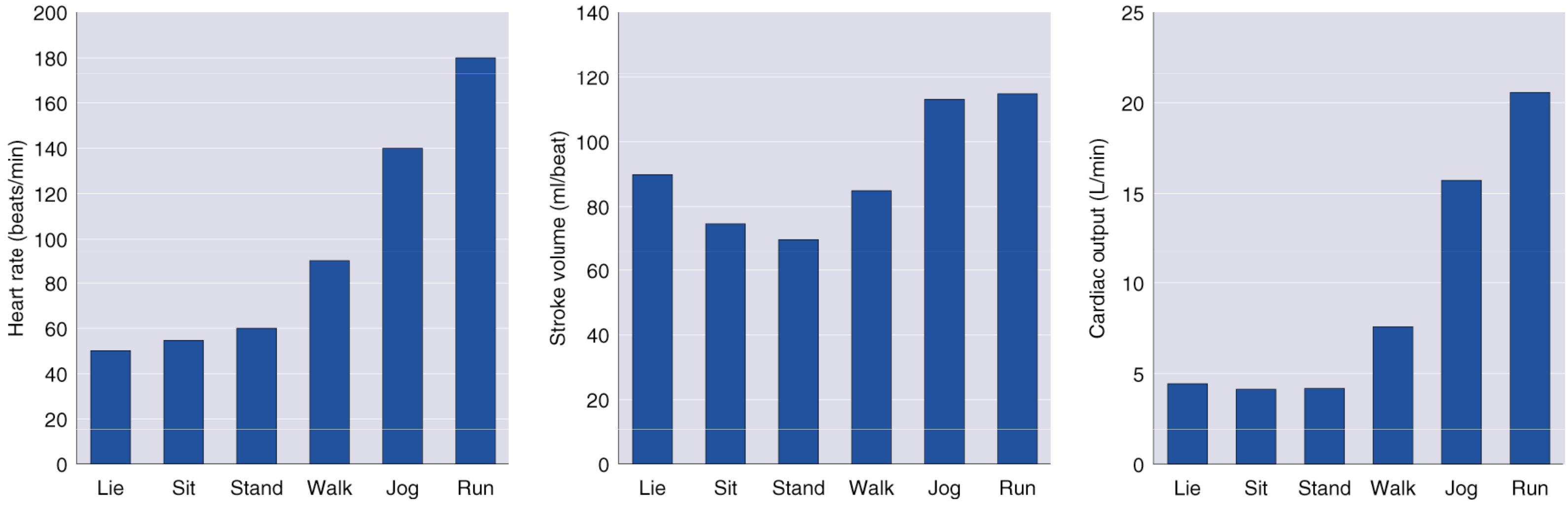
Cardiac Output and Intensity



Cardiac Output and Training



Changes in HR, SV, and Q with Changes in Position and Exercise Intensity

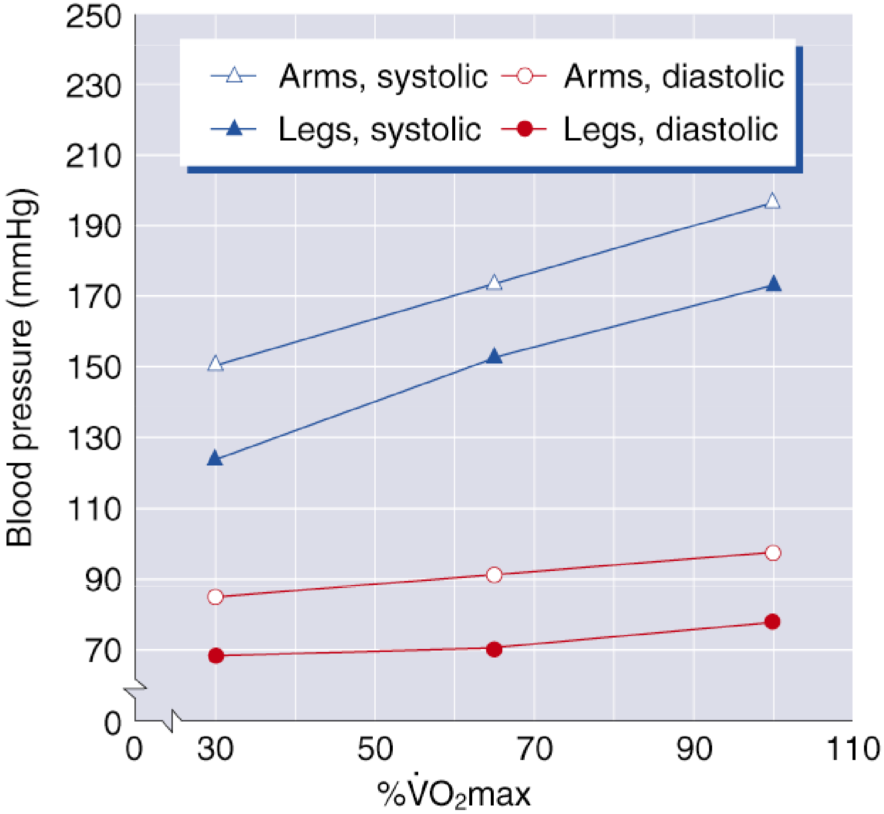


Blood Pressure

- Cardiovascular Endurance Exercise
  - Systolic BP increases in direct proportion to increased exercise intensity
  - Diastolic BP changes little if any during endurance exercise, regardless of intensity

- Resistance Exercise
  - Exaggerates BP responses to as high as 480/350 mmHg

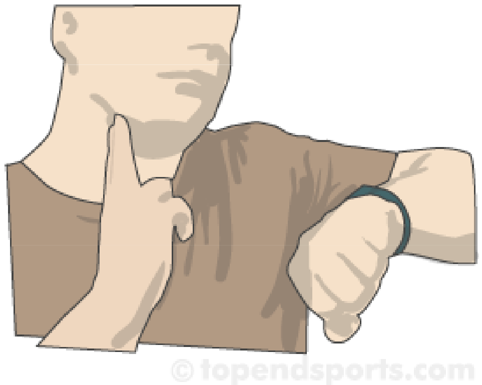
Blood Pressure Responses

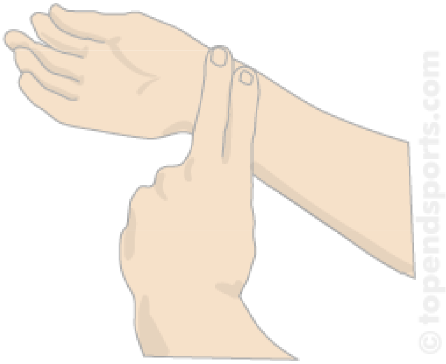


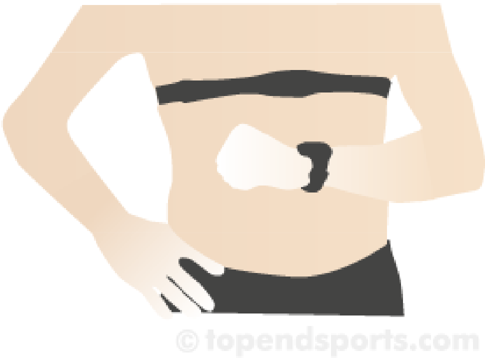
Cardiovascular Adaptations to Training

- Left ventricle size and wall thickness increase
- Resting, submaximal, and maximal stroke volume increases
- Maximal heart rate stays the same or decreases
- Cardiac output is better distributed to active muscles and maximal cardiac output increases
- Blood volume increases, as does red cell volume, but to a lesser extent
- Resting blood pressure does not change or decreases slightly, while blood pressure during submaximal exercise decreases

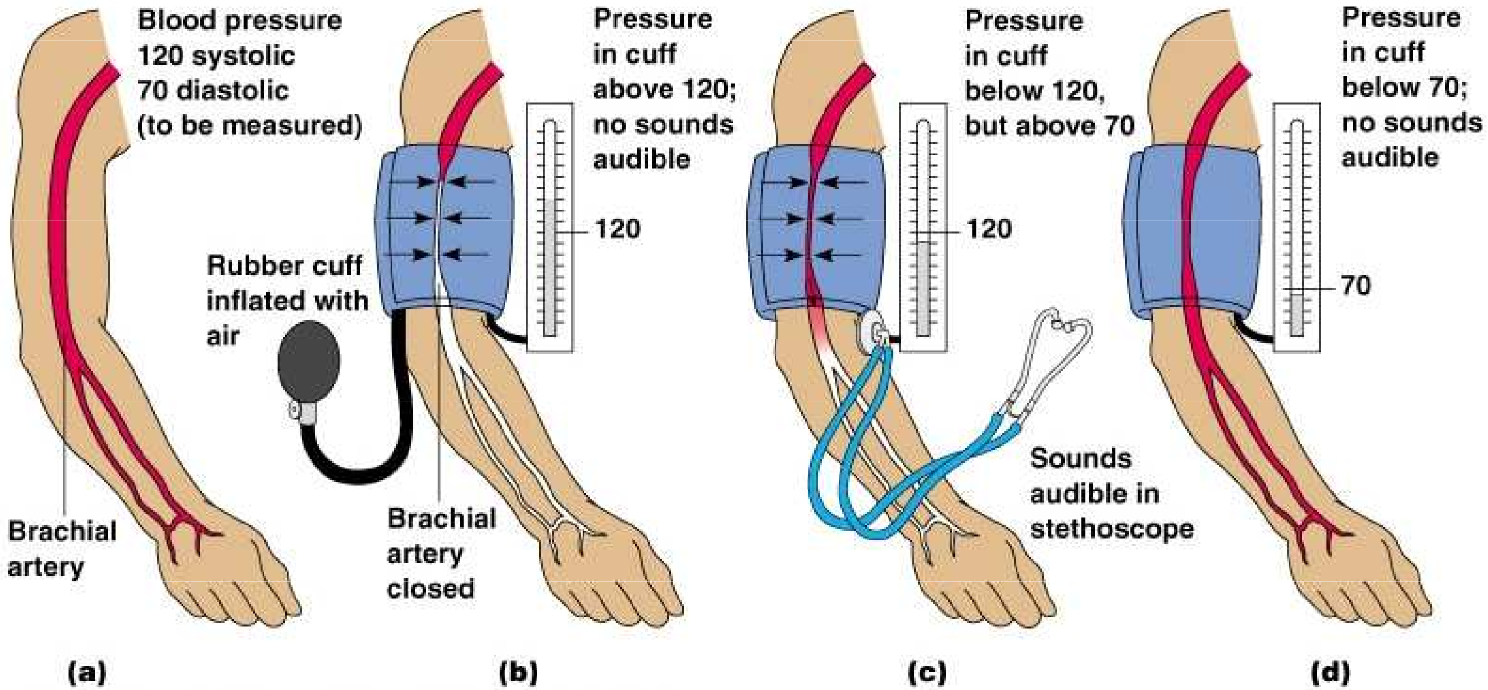
Heart rate measurements





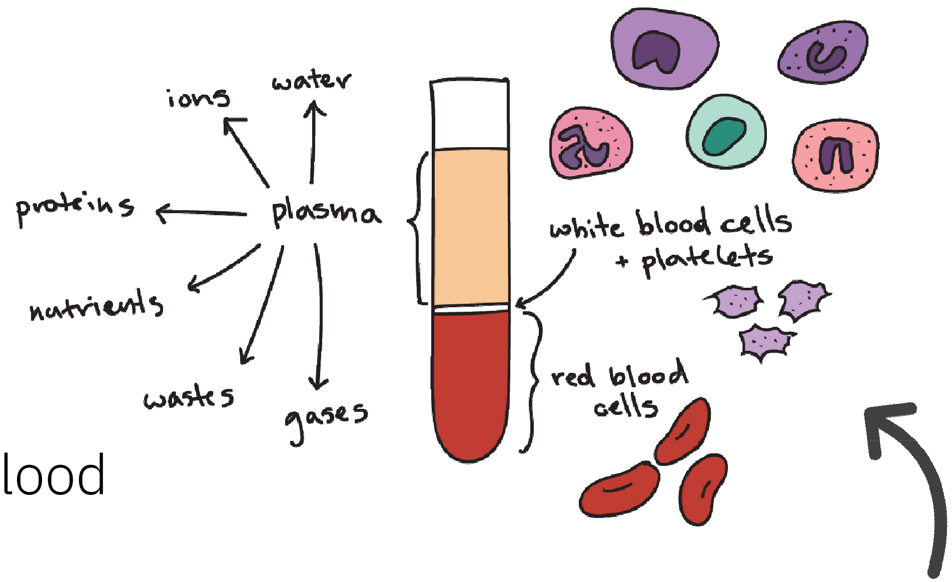


Blood pressure measurements



Blood

- Connective tissue (the only fluid tissue in the body)
- Accounts for approx. 7% of body weight
- An adult individual has approx. 5liters of blood
- Blood composition
  - Plasma (55%)
    - 91% water
    - 8% proteins – albumin, globulin (transportation)
    - 1% other molecules
  - Formed elements (45%)
    - 99% red blood cells (erythrocytes) – carry oxygen
    - <1% white blood cells (leukocytes) – protect from pathogens
  - Platelets (<1%)



Blood placed in a centrifuge

* Erythrocytes and platelets do not possess all the typical organelles and they can not divide – they are replaced by stem cells in the bone marrow

Blood hematocrit, viscosity

$$* \, Hematocrit = \frac{Formed\ elements}{Total\ blood\ volume}$$

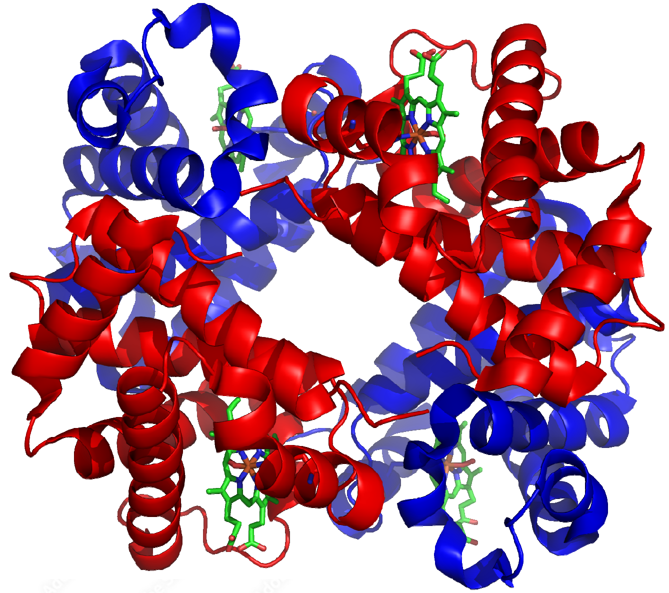
- Blood viscosity = thickness of the blood
- The more viscous, the more resistant to flow
- Higher hematocrits result in higher blood viscosity

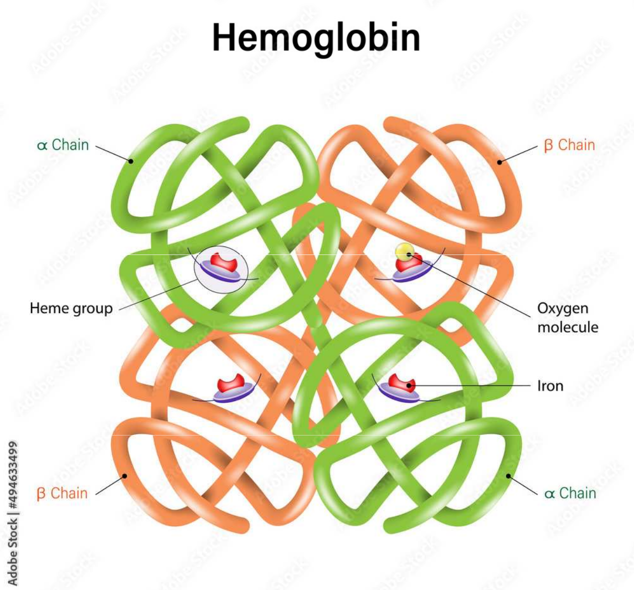
Blood functions

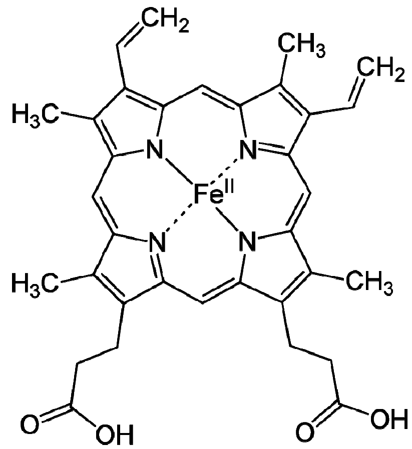
- Delivers oxygen to tissues
- Delivers nutrients such glucose, amino acids or fatty acids – dissolved in blood or attached to carrier proteins
- Transports waste products – CO_2, Urea, Lactic acid
- Transports hormones
- Protects from pathogens (Immunological functions) – white blood cells, Antibodies
- Regulates temperature
- Buffers and balances acid base homeostasis
- Coagulation (to stop bleeding)

Hemoglobin (Hb)

- Hb comprises **4 globin** subunits – two α and two β units
- Each globin is attached to a **heme b group** with an **iron atom** at the center
- Each **heme b group** can carry one oxygen molecule attached to the iron atom
- Hb is present in two forms (influenced by partial pressures and pH)
    - Relaxed (R)
    - Tense (T)
    - Different absorption spectra - used for oxygen levels measurements



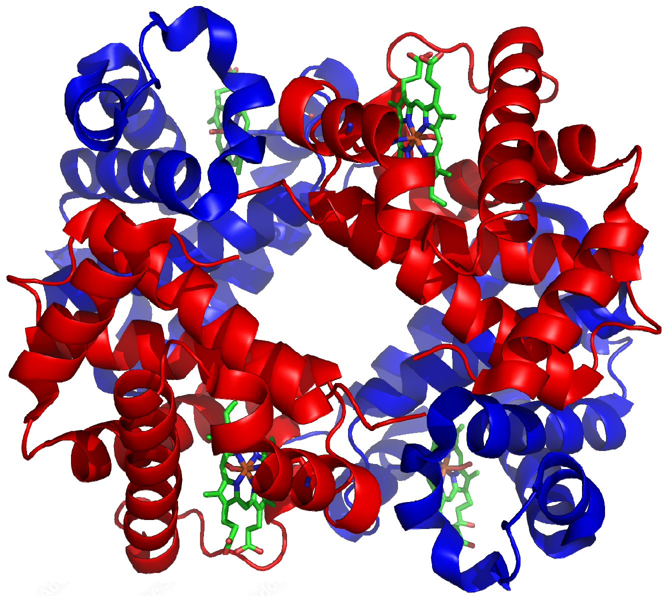


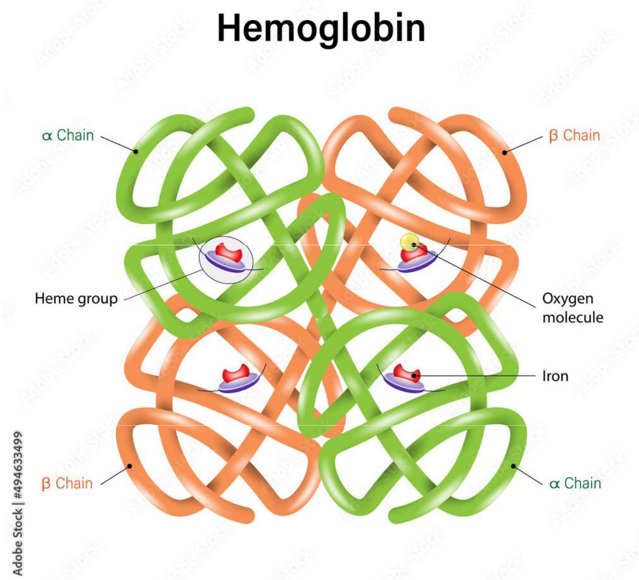


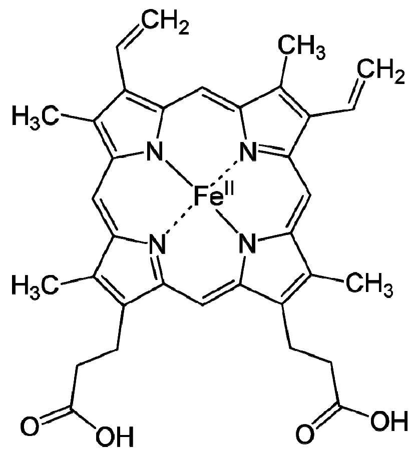
Heme b group

Hemoglobin (Hb)

- Approx. 250 million Hemoglobin molecules per one red blood cell!
- 100 ml of blood contains ~14-18 g of Hb in men and ~12-14 in women (1 g of Hb combines with 1.34 ml of oxygen)
- There are ~20.1 ml of O_2 per 100 ml of arterial blood (15 g of Hb x 1.34 ml of O_2/g of Hb) in men and ~17.4 ml of O_2 per 100 ml of arterial blood (13 g x 1.34) in women
- Low iron leads to iron-deficiency anemia, reducing the body's capacity to transport oxygen—this is more of a problem in women than men







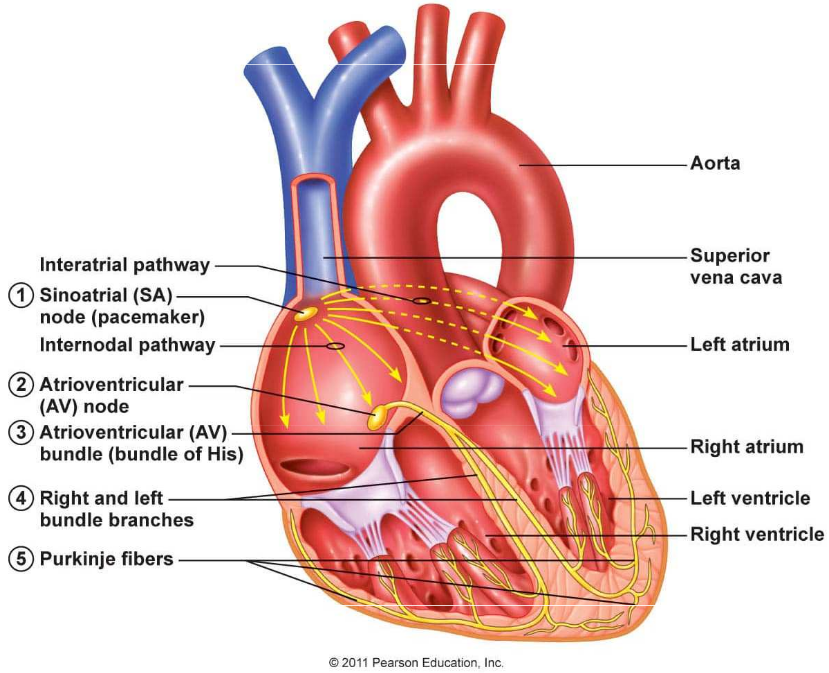
Heme b group

Blood KEY POINTS

- Blood and lymph transport materials to and from body tissues
- Blood is about 55% to 60% plasma and 40% to 45% formed elements (white and red blood cells and blood platelets)
- Oxygen travels through the body by binding to hemoglobin in red blood cells
- An increase in blood viscosity results in resistance to flow

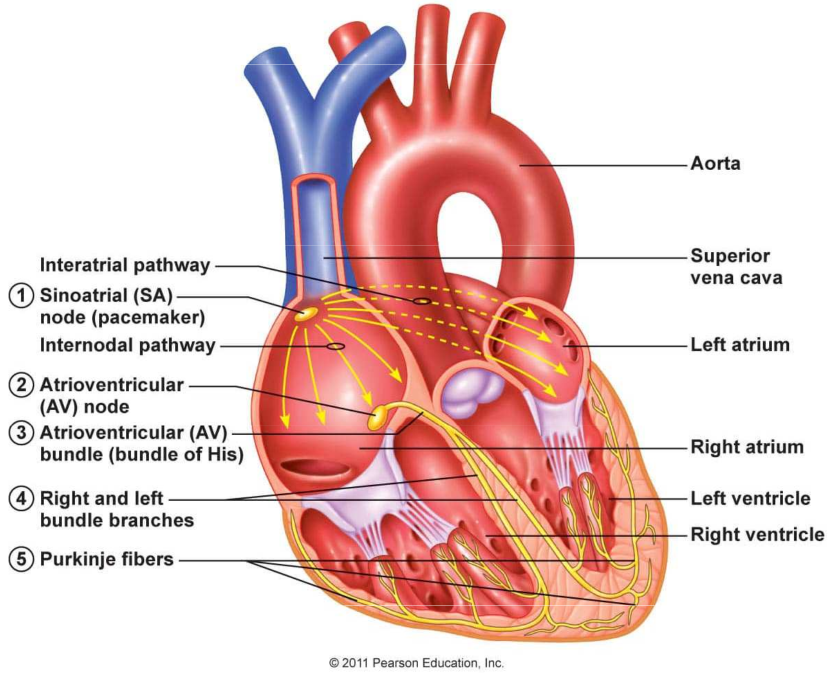
Intrinsic Conduction System

- Cells of Intrinsic conduction system (ICS) generate their own electrical impulses
- Sinoatrial node (SA node) - the pacemaker – it generates electrical impulses the fastest and sets the rhythm for the rest of ICS
- Atrioventricular node (AV node)
- AV bundle
- Bundle branches
- Purkinje fibers (subendocardial conducting network) – contractions of the ventricles

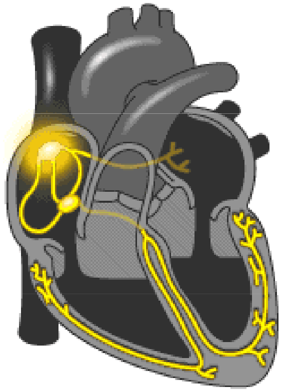


Intrinsic Conduction System

- Cells of Intrinsic conduction system (ICS) generate their own electrical impulses
- Sinoatrial node (SA node) - the pacemaker – it generates electrical impulses the fastest and sets the rhythm for the rest of ICS; heavily controlled
- Atrioventricular node (AV node)
- AV bundle
- Bundle branches
- Purkinje fibers (subendocardial conducting network) – contractions of the ventricles

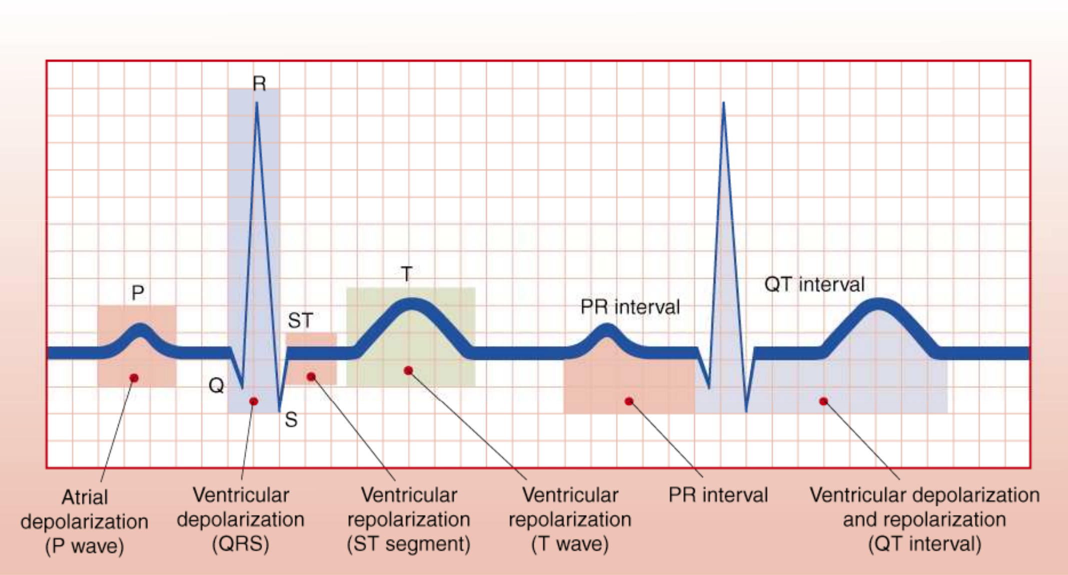


Intrinsic Conduction System



Electrocardiogram (ECG)

- Printout shows the heart's electrical activity – can be used to monitor cardiac changes
- The P wave – atrial depolarization
- The QRS complex – ventricular depolarization and atrial repolarization
- ST segment – plateau of action potential, ventricles pump blood
- The T wave – ventricular repolarization (diastole)



b

KEY POINTS – Cardiovascular system

- The pacemaker of the heart is the SA node; it establishes heart rate and coordinates conduction
- The autonomic nervous system or the endocrine system can alter heart rate and contraction strength
- An ECG records the heart's electrical function and can be used to detect cardiac disorders

Vascular system

- Arteries
- Arterioles
- Capillaries
- Venules
- Veins

Carry blood away from the heart

Carry blood back to the heart

Pulmonary VEINS carry oxygenated blood from the lungs to the heart

Pulmonary ARTERIES carry blood with lower oxygen levels to the lungs

Vascular system

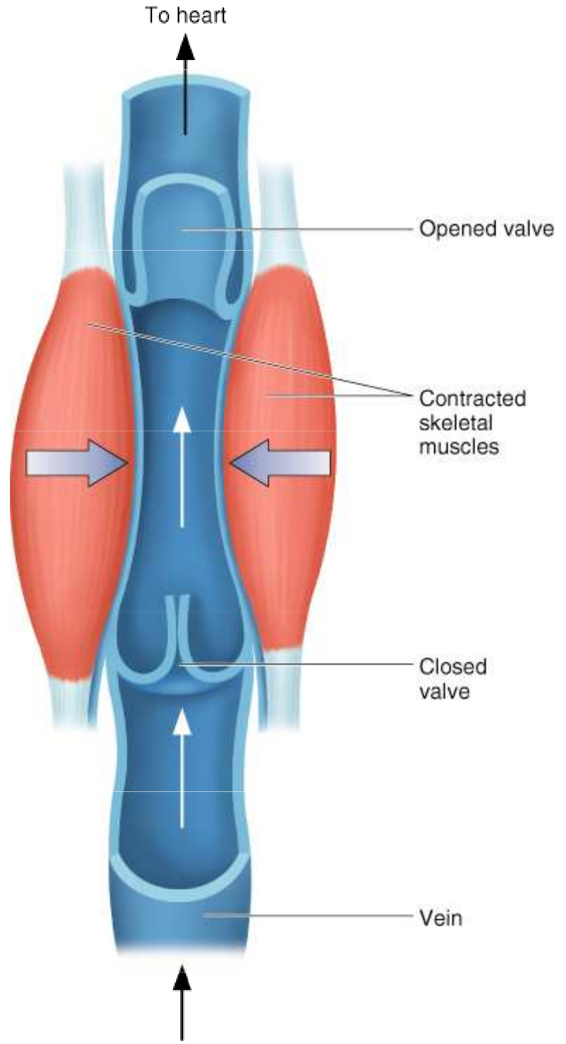
- Arteries
- Arterioles
- Capillaries
- Venules
- Veins

Vascular system

- Arteries
- Arterioles
- Capillaries
- Venules
- Veins

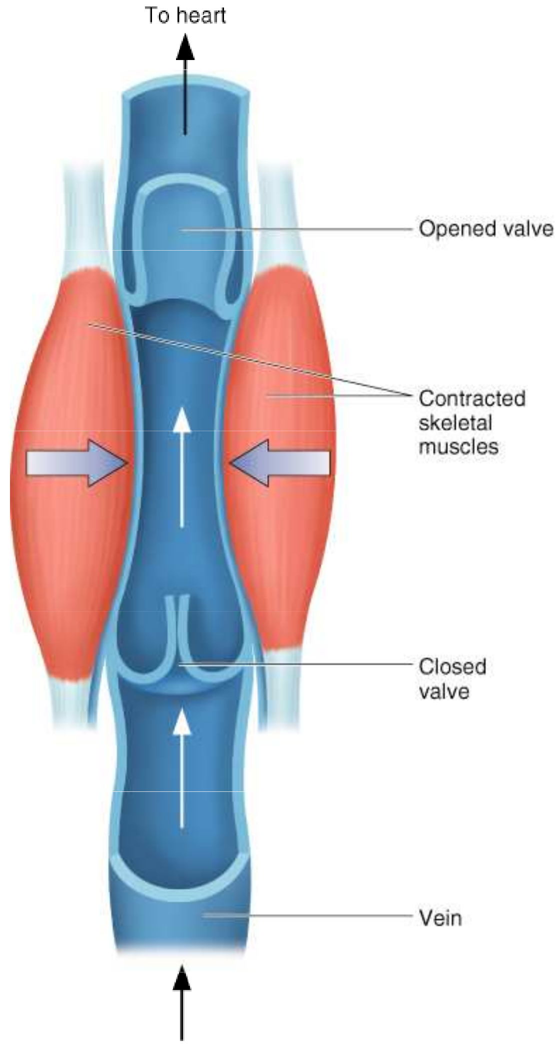
Vascular system

- Arteries
- Arterioles
- Capillaries
- Venules
- Veins



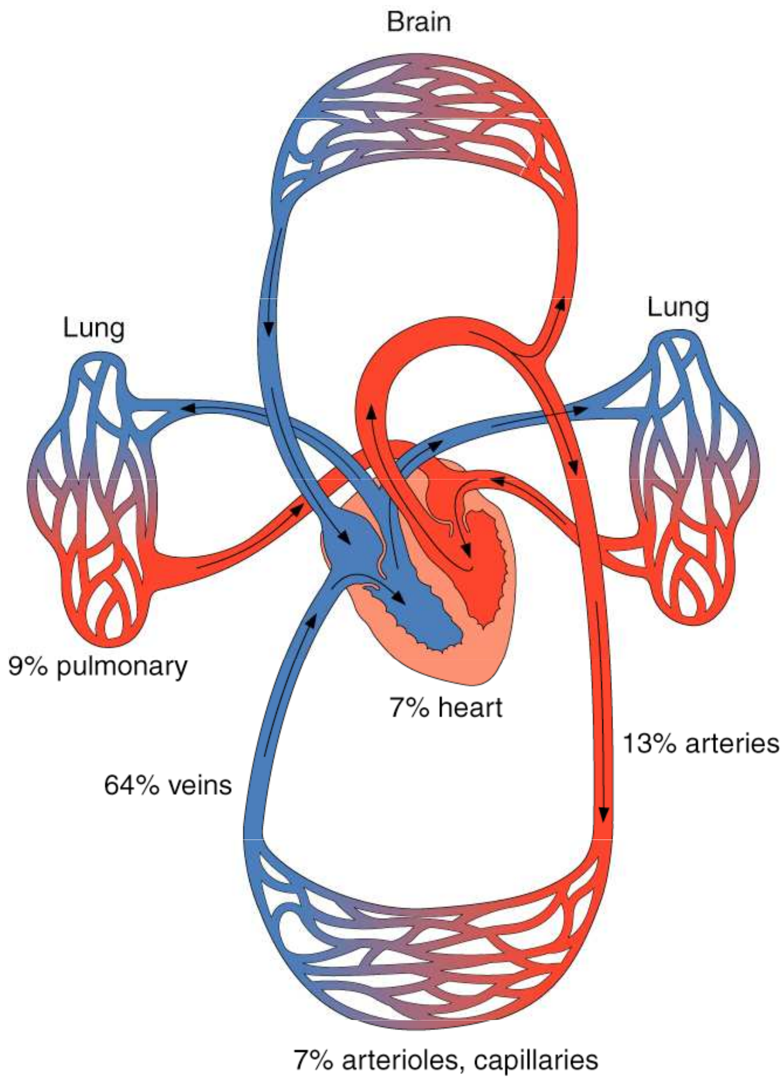
Vascular system

- Arteries
- Arterioles
- Capillaries
- Venules
- Veins



Blood distribution

- Matched to overall metabolic demands
- Autoregulation—arterioles within organs or tissues dilate or constrict in response to the local chemical environment
- Extrinsic neural control—sympathetic nerves within walls of vessels are stimulated causing vessels to constrict
- Determined by the balance between mean arterial pressure and total peripheral resistance



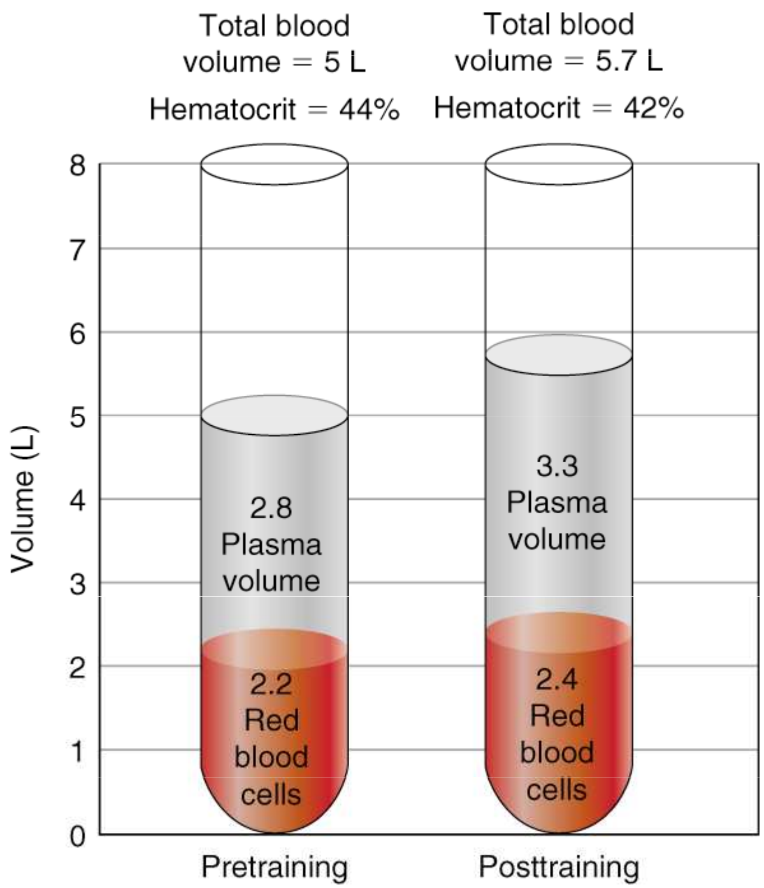
Blood Flow Increases with Training

- **Increased capillarization** of trained muscles (higher capillary-to-fiber ratio)
- **Greater opening** of existing capillaries in trained muscles
- More effective **blood redistribution**—blood goes where it is needed
- **Blood volume increases**

Blood Volume and Training

- Endurance training, especially intense training, increases blood volume
- Blood volume increases due primarily to an increase in plasma volume (increases in ADH, aldosterone, and plasma proteins cause more fluid to be retained in the blood)
- Red blood cell volume increases, but increase in plasma volume is higher; thus, hematocrit decreases
- Blood viscosity decreases, thus improving circulation and enhancing oxygen delivery
- Changes in plasma volume are highly correlated with changes in SV and VO_2max.

Blood and Plasma Volume and Training



Cardiovascular Adaptations to Training

- **Left ventricle** size and wall thickness increase
- Resting, submaximal, and maximal **stroke volume increases**
- **Maximal heart rate** stays the same or decreases
- **Cardiac output** is better distributed to active muscles and maximal cardiac output increases
- **Blood volume** increases, as does red cell volume, but to a lesser extent
- **Resting blood pressure** does not change or decreases slightly, while **blood pressure** during submaximal exercise decreases

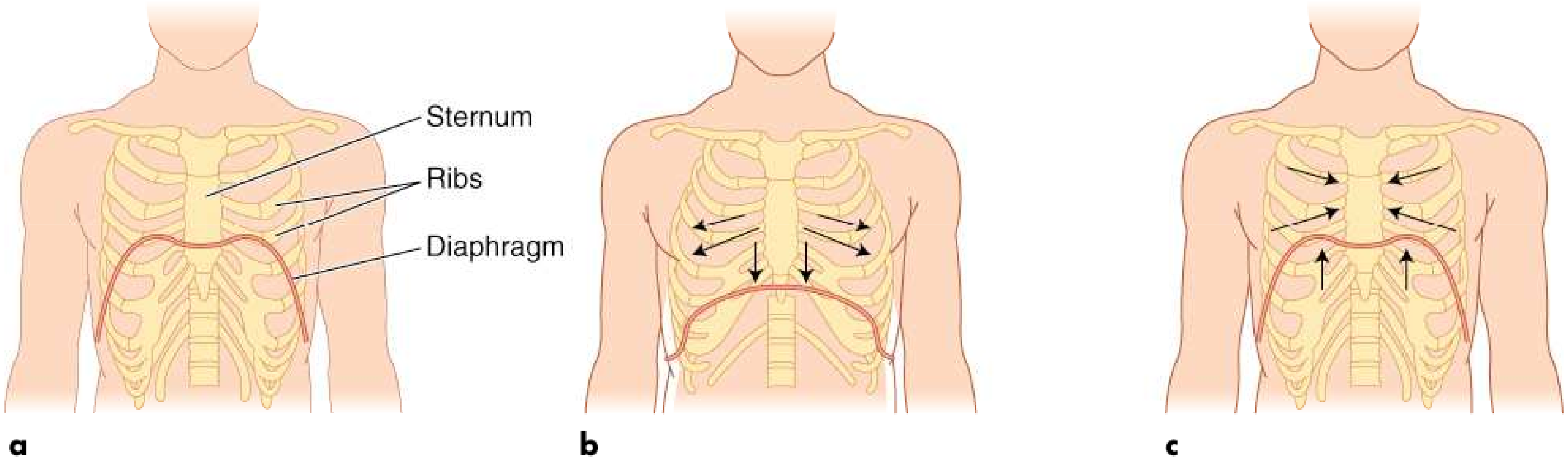
Respiratory system

Respiratory regulation during exercise

Respiration

- Respiration - delivery of oxygen to and removal of carbon dioxide from the tissue
- External respiration—ventilation and exchange of gases in the lung
  - **Pulmonary ventilation** – movement of air into and out of the lungs—inspiration and expiration
  - **Pulmonary diffusion** – exchange of oxygen and carbon dioxide between the lungs and blood
- Internal respiration—exchange of gases at the tissue level (between blood and tissues)

External respiration



Rest

Inspiration

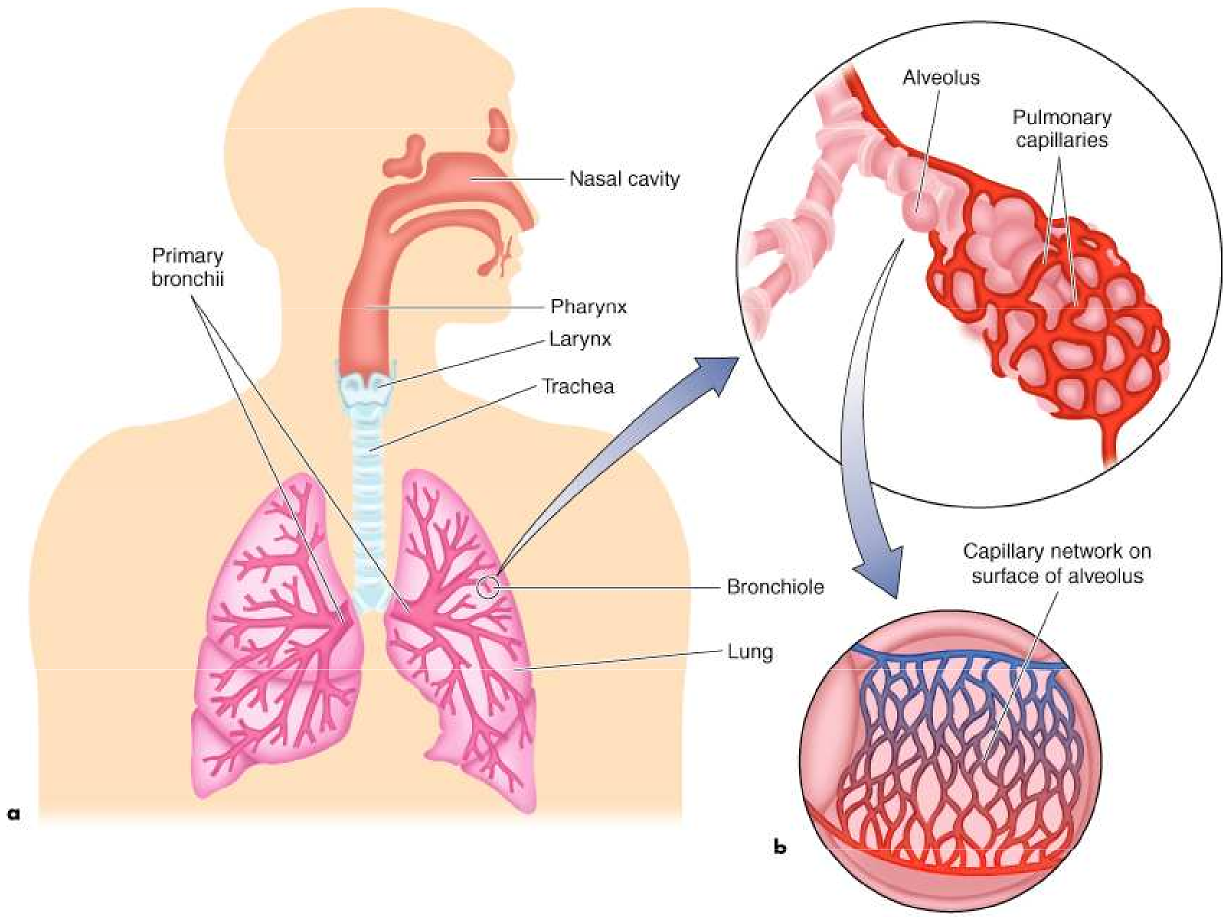
The diaphragm contracts to pull downwards and chest muscles contract to pull open the chest

Expiration

The diaphragm and the chest muscles relax allowing the lungs to spring back to normal relaxed size – this pushes the air out

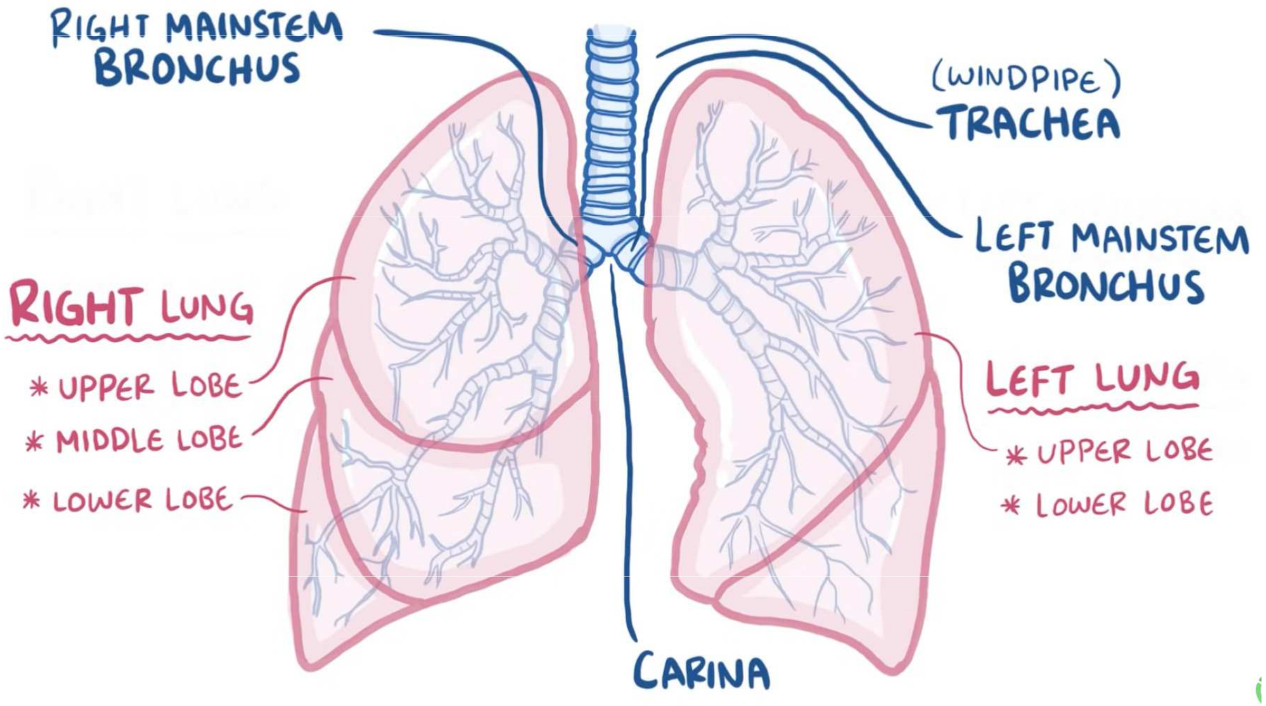
Pulmonary ventilation

- Nasal cavity – lined by cells that release mucus
- Mucus – sticky and salty, contains lysozymes
- Nasal hair covered in mucus catch large particles, dust, pollen etc.
- Paranasal sinuses – help the air to circulate to get warm and moist
- Air flow

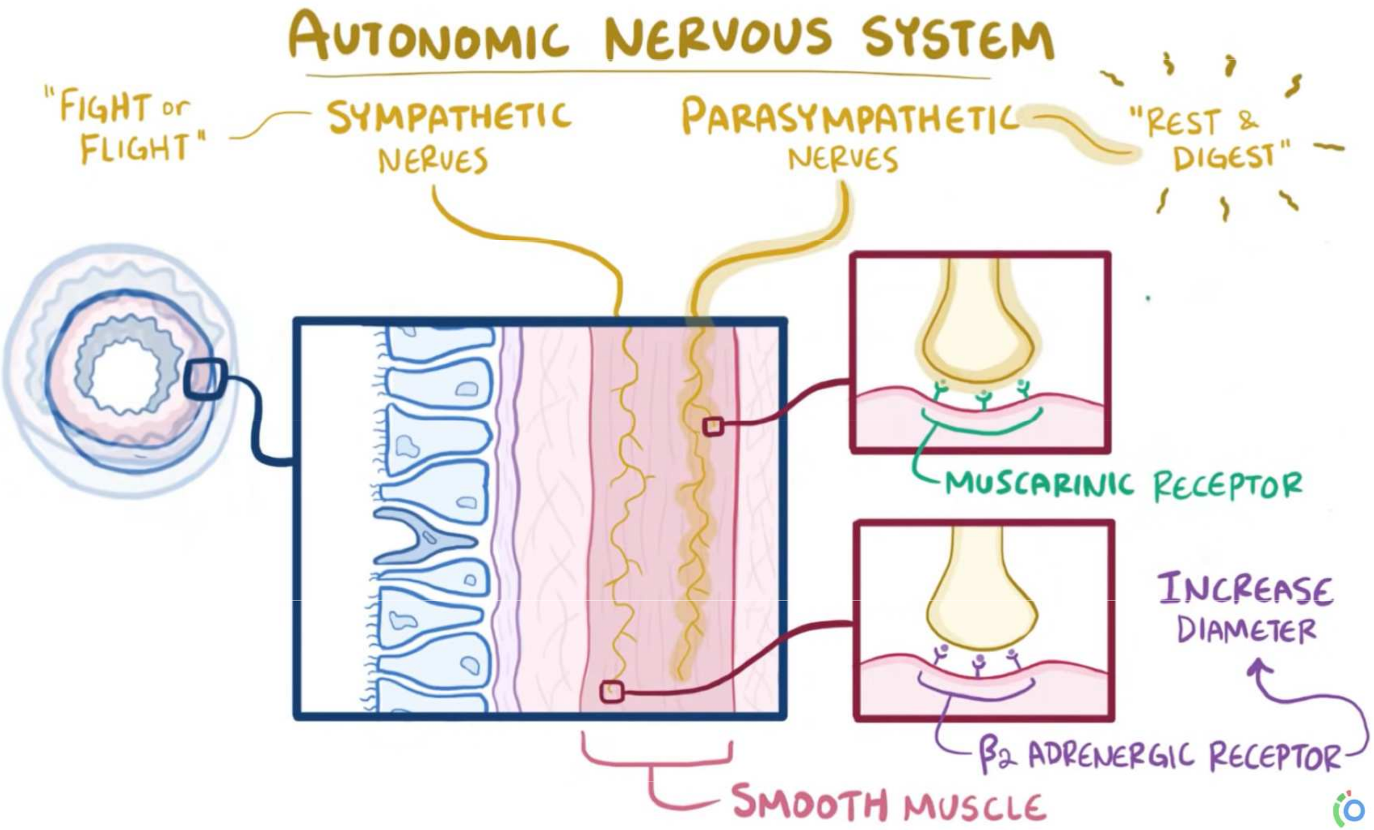


Pulmonary ventilation

- Lungs' lobes
- Trachea and the first three generations of bronchi use cartilage rings for support
- Then the bronchi narrow down to bronchioles
  - No cartilage
  - 15-20 generations

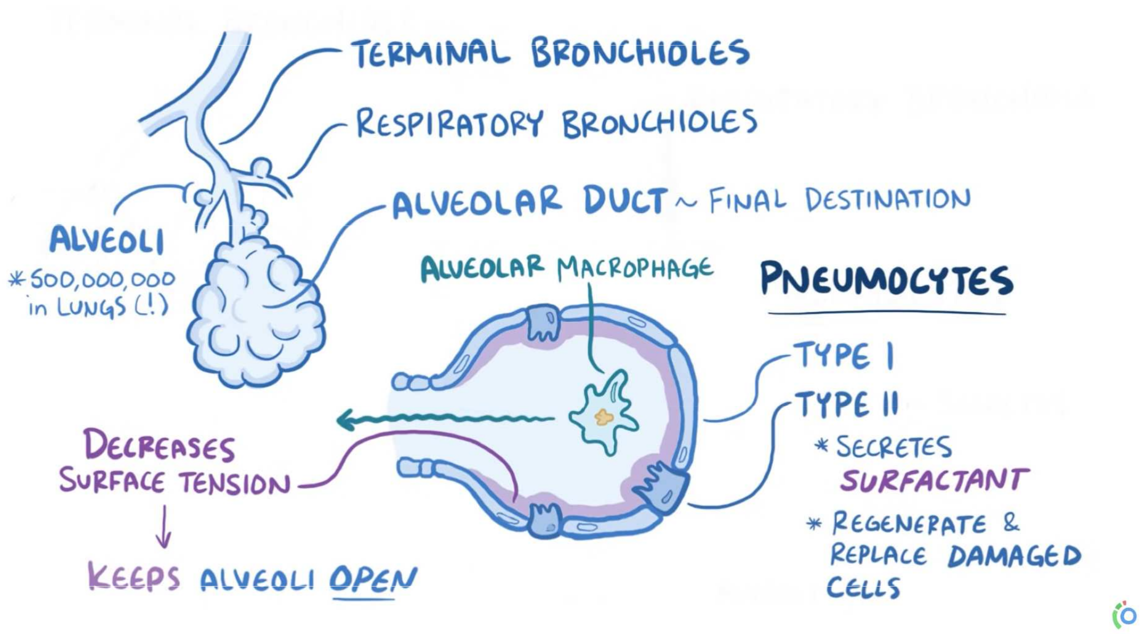


Respiration



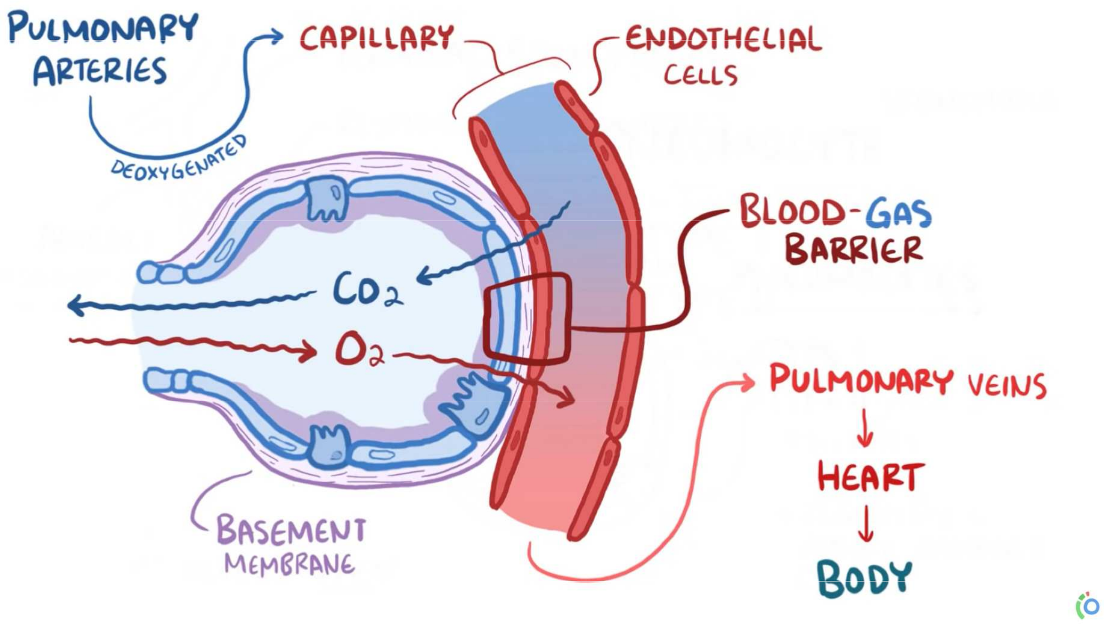
Pulmonary ventilation

- Terminal bronchioles
- Respiratory bronchioles
- Alveoli – about 500 000 000 in the lungs
- Alveolar duct – the destination of the inhaled air
- Pneumocytes
  - Type I
  - Type II - surfactant



Pulmonary diffusion

- **BLOOD-GAS barrier:** pneumocytes, endothelial cells and basement membrane (proteins)
- **Deoxygenated blood** arrives via pulmonary arteries
- Replenishes blood's **oxygen supply** that has been depleted for oxidative energy production
- **Carbon dioxide** is removed and breathed out
- **Oxygenated blood** via pulmonary veins – to the heart – to the body



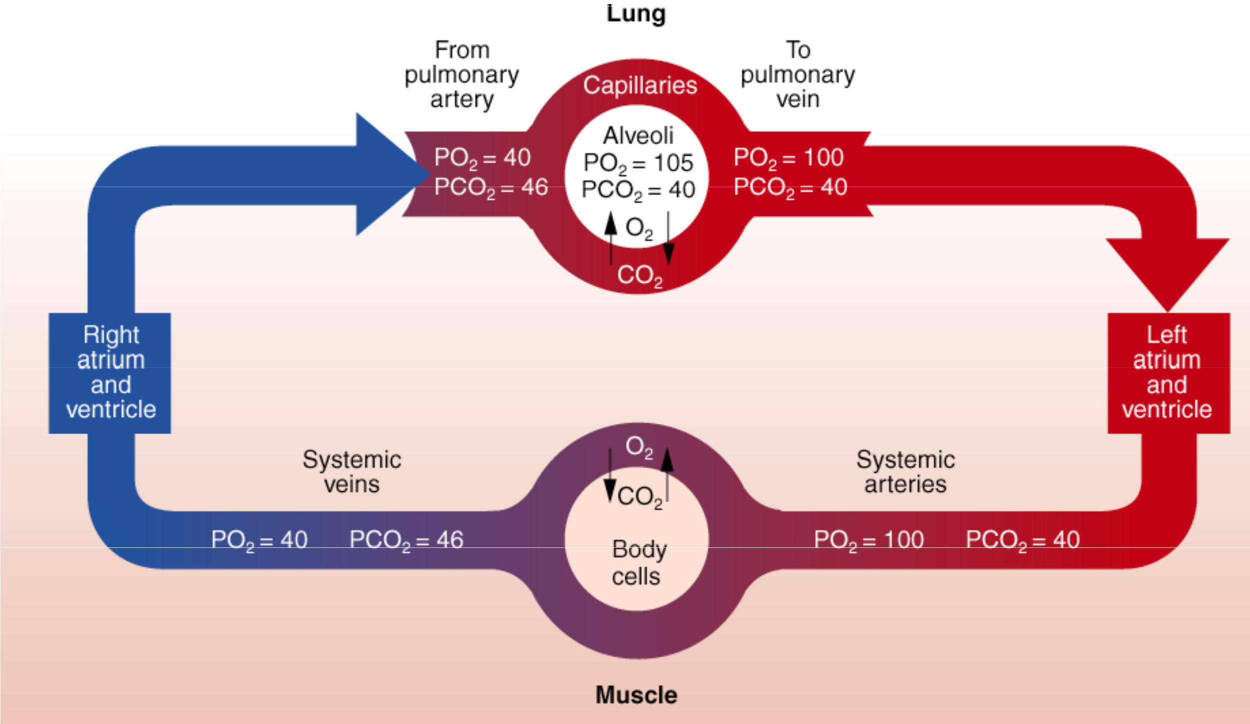
Did you know?

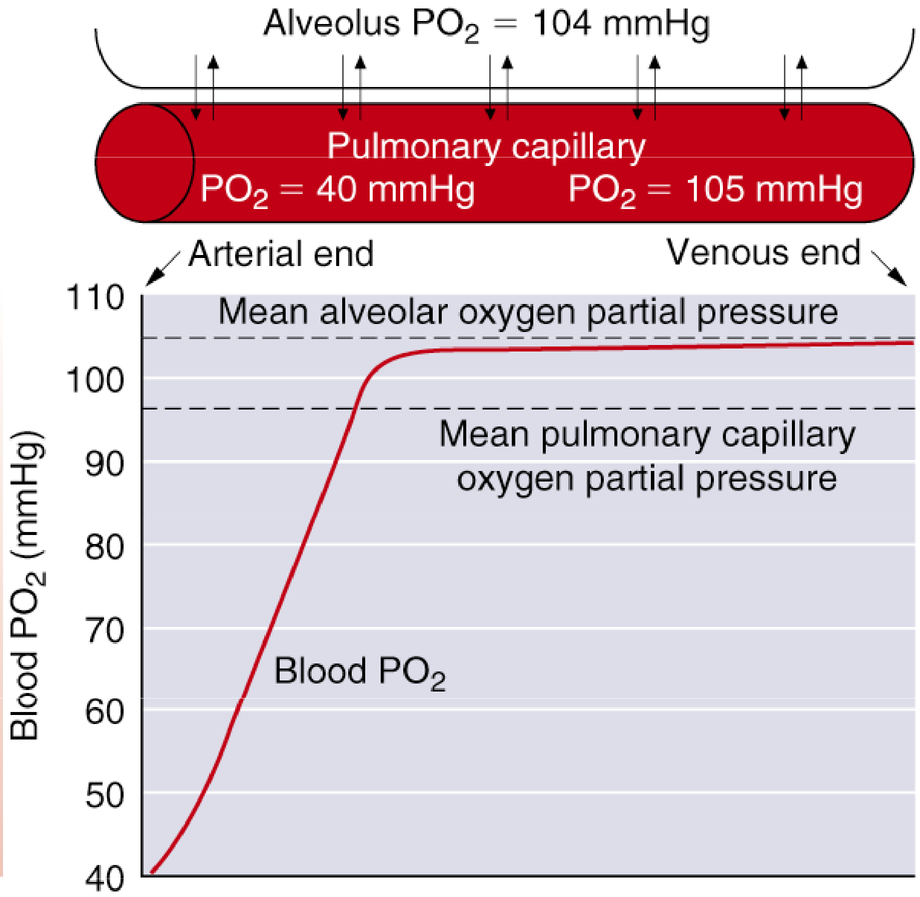
- Differences in the partial pressures of gases in the alveoli and in the blood create a pressure gradient across the respiratory membrane. This difference in pressures leads to diffusion of gases across the respiratory membrane. The greater the pressure gradient, the more rapidly oxygen diffuses across it.

Gases – partial pressure and exchange

- **Atmospheric air** is a mixture of gases – each with its own **partial pressure** contributes to the total atmospheric pressure
- **Alveolar air** differs from atmospheric air
- The **gas exchange** occurs between the alveolar air and the blood in capillaries by **diffusion** – the flow down their **concentration gradient** or **partial pressure gradient**
- The composition of alveolar air is closely monitored
- Gas exchange depends on:
  - **The magnitude of partial pressure gradient** (influenced also by altitude)
  - **Solubility** (nitrogen is plentiful in the air but does not diffuse into the blood)
  - **Thickness** of the pulmonary membrane

PO_2 AND PCO_2 IN BLOOD





Partial Pressures of Respiratory Gases at Sea Level

Gas	% in dry air	Partial pressure (mmHg)				
		Dry air	Alveolar air	Arterial blood	Venous blood	Diffusion gradient
Total	100.00	760.0	760	760	706	0
H_2O	0.00	0.0	47	47	47	0
O_2	20.93	159.1	105	100	40	60
CO_2	0.03	0.2	40	40	46	6
N_2	79.04	600.7	568	573	573	0

KEY POINTS – Pulmonary diffusion

- **Pulmonary diffusion** is the process by which **gases are exchanged** across the respiratory membrane in the alveoli to the blood and vice versa
- The amount of gas exchange depends on **the partial pressure** of each gas, its **solubility**, and **temperature**
- Gases diffuse along a pressure gradient, moving from an area of higher pressure to lower pressure
- **Oxygen diffusion capacity increases as you move from rest to exercise**
- The pressure gradient for CO_2 exchange is less than for O_2 exchange, but carbon dioxide's diffusion coefficient is 20 times greater than that of oxygen's, so CO_2 crosses the membrane easily

Oxygen Transport

- Hemoglobin concentration largely determines the oxygen-carrying capacity of blood (>98% of oxygen transported)
- Increased H+ (acidity) and temperature of a muscle allows more oxygen to be unloaded there
- Training affects oxygen transport in muscle

Carbon Dioxide Transport

- Dissolved in blood plasma (7% to 10%)
- As bicarbonate ions resulting from the dissociation of carbonic acid (60% to 70%)
- Bound to hemoglobin (carbaminohemoglobin) (20% to 33%)

Factors of Oxygen Uptake and Delivery

- Oxygen content of blood
- Amount of blood flow
- Local conditions within the muscle

KEY POINTS – External an Internal Respiration

- **Oxygen** is largely transported in the blood **bound to hemoglobin** and small amounts are transported dissolved in the blood plasma
- **Hemoglobin saturation** decreases when PO2 or pH decreases, or if temperature increases. These factors increase oxygen unloading in a tissue that needs it
- Hemoglobin is usually 98% saturated with oxygen which is higher than what our bodies require, so the blood's oxygen-carrying capacity seldom limits performance
- Carbon dioxide is transported in the blood as bicarbonate ion, in blood plasma or bound to hemoglobin
- The difference in the oxygen content of arterial and mixed venous blood—reflects the amount of oxygen taken up by the tissues
- Carbon dioxide exchange at the tissues is similar to oxygen exchange except that it leaves the muscles and enters the blood to be transported to the lungs for clearance

Breathing frequency (BF)

Breathing frequency is the number of breaths taken within a set amount of minute:

BF rest = 16 (breaths per minute) (10 in endurance)

BF (light exercise) = 20-30

BF (moderate exercise) = 30-40

BF (heavy exercise) = 50-60

Tidal volume (VT)

Tidal volume (l) is the amount of air inspired or expired during normal quiet respiration.

V_T rest = 0,5 l (1 l in endurance)

V_T (light exercise) = 1-1,5 l

V_T (moderate exercise) = 1,5-2 l

V_T (heavy exercise) = 2-3 l

Pulmonary ventilation

Ventilation (VE) is the product of tidal volume (TV) and breathing frequency (f):

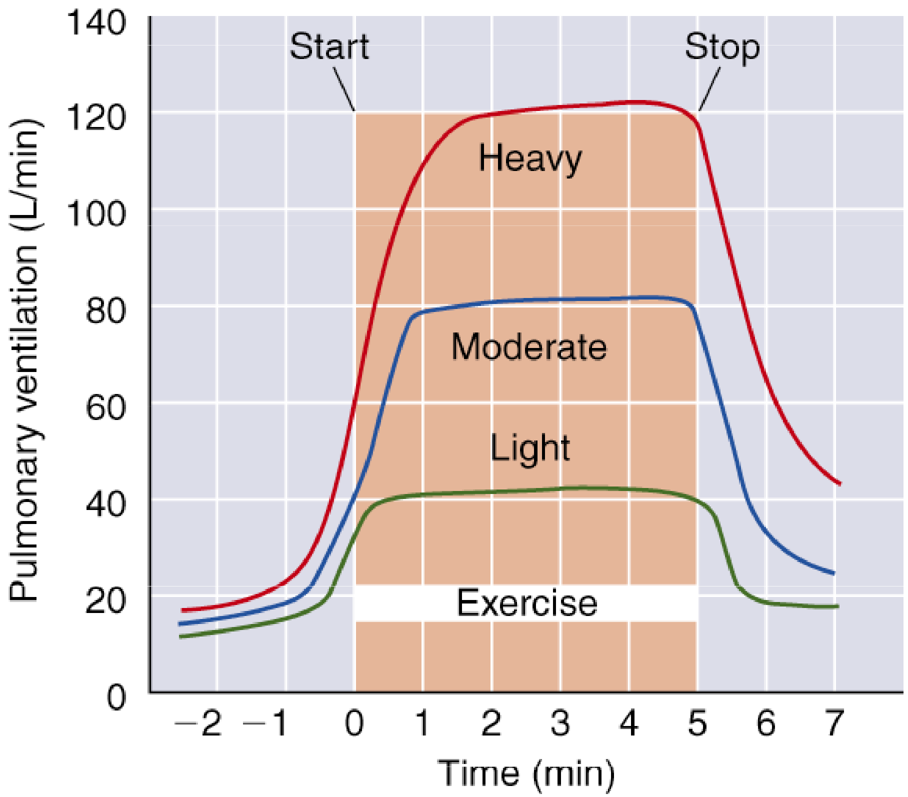
V_E rest = 8 l

V_E (light exercise) = 40 l

V_E (moderate exercise) = 80 l

V_E (heavy exercise) = 120l (180l in endurance)

Ventilatory Response to Exercise



Breathing Terminology

Dyspnea = shortness of breath

Hypervetilation = increase in ventilation that exceeds the metabolic need for oxygen. Voluntary hyperventilation, as is often done before underwater swimming, reduces the ventilatory drive by increasing blood pH

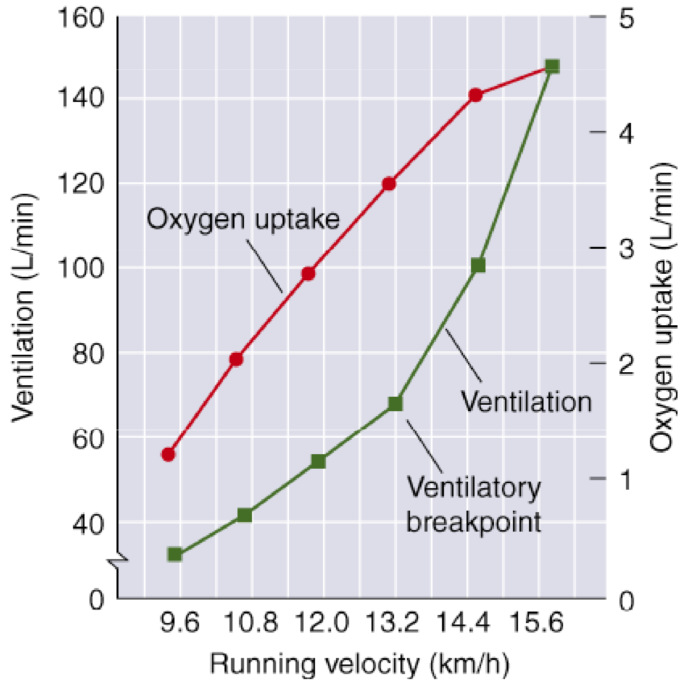
Ventilatory Equivalent for Oxygen

- The ratio between V_E and VO_2 in a given time frame
- Indicates breathing economy
- At rest—V_E/VO_2 = 23 to 28 L of air breathed per L VO_2 per minute
- At max exercise—V_E/VO_2 = 30 L of air per L VO_2 per minute
- Generally V_E/VO_2 remains relatively constant over a wide range of exercise levels

Ventilatory Breakpoint

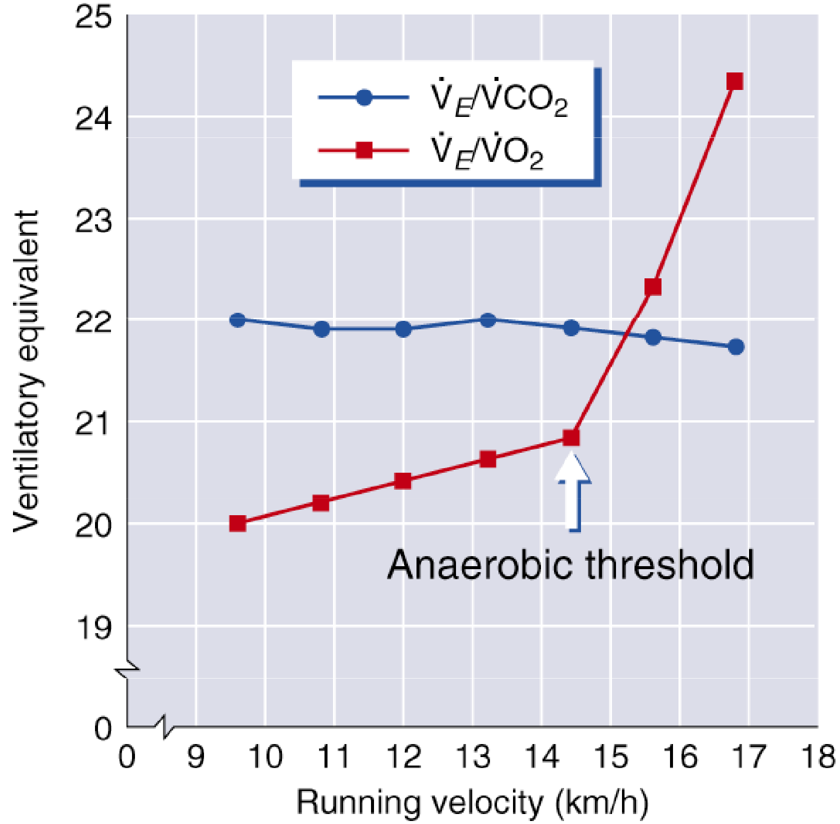
- The point during intense exercise at which ventilation increases disproportionately to the oxygen consumption
- When work rate exceeds 55% to 70% VO_2max, oxygen delivery can no longer match the energy requirements so energy must be derived from **anaerobic glycolysis**
- Anaerobic glycolysis **increases lactate levels**, which **increase CO_2 levels** (buffering), triggering a respiratory response and **increased ventilation**

Running speed (km/h)	$\dot{V}_E/\dot{V}O_2$
9.6	21.5
10.8	20.0
12.0	20.4
13.2	20.3
14.4	24.9
15.6	33.3

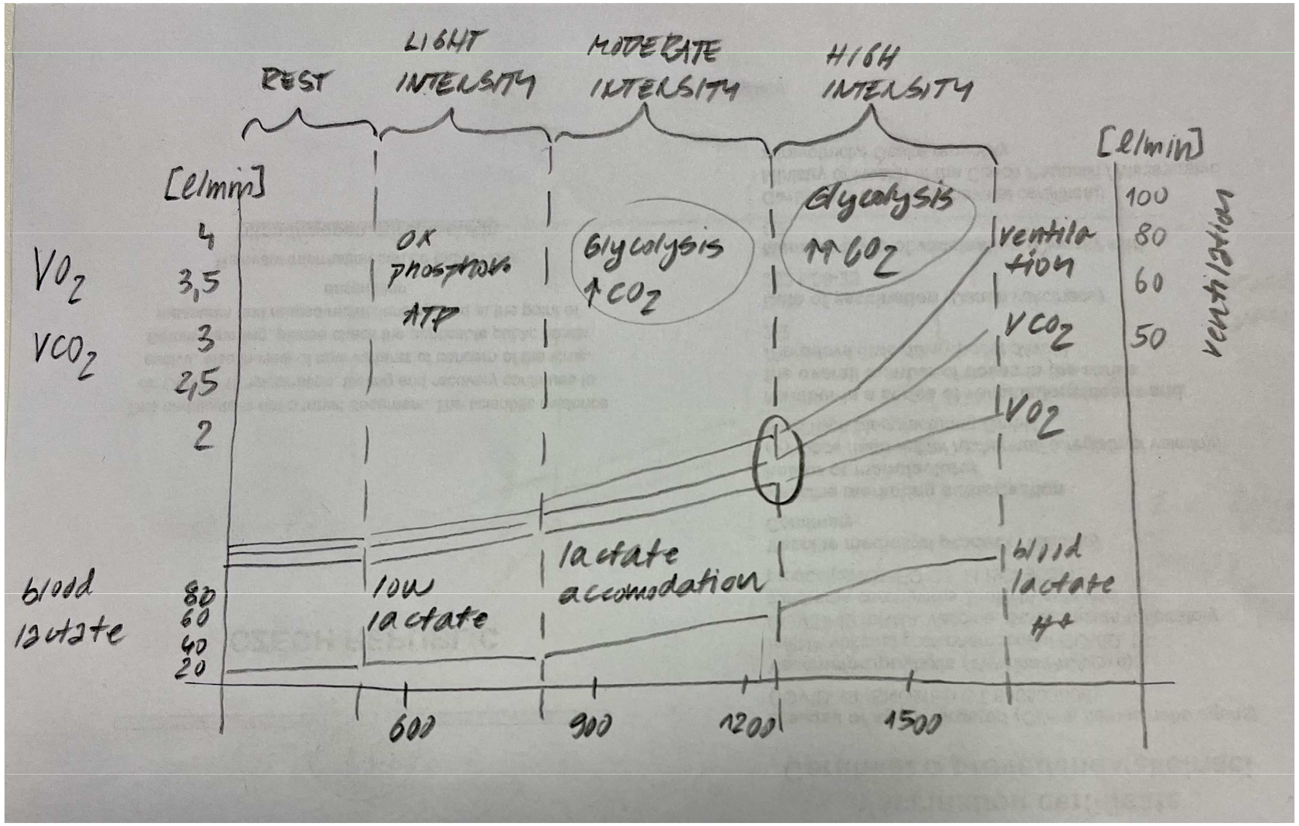


Anaerobic Threshold

- The point during intense exercise at which **metabolism** becomes **increasingly more anaerobic**
- Reflects the lactate threshold under most conditions, though the relationship is not always exact
- An increase in V_E/VO_2 without an concomitant increase in the ventilatory equivalent for carbon dioxide (V_E/VCO_2)



Anaerobic Threshold



Pulmonary Ventilation

- The respiratory centres in the brain stem set the rate and depth of breathing
- Chemoreceptors respond to increases in CO_2 and H^+ concentrations or to decreases in blood oxygen levels by increasing respiration
- Ventilation increases at the initiation of exercise due to inspiratory stimulation from muscle activity. As exercise progresses, increase in muscle temperature and chemical changes in the arterial blood further increase ventilation

Pulmonary Ventilation

- During mild, steady-state exercise, ventilation parallels oxygen uptake
- The ventilatory breakpoint is the point at which ventilation increases disproportionately to the increase in oxygen consumption
- Anaerobic threshold is identified as the point at which V_E/VO_2 shows a sudden increase, while V_E/VCO_2 stays stable. It generally reflects lactate threshold

Respiratory Limitations to Performance

- Respiratory muscles may use up to 11% of total oxygen consumed during heavy exercise and seem to be more resistant to fatigue during long-term activity than muscles of the extremities
- Pulmonary ventilation is usually not a limiting factor for performance, even during maximal effort, though it can limit performance in highly trained people
- Airway resistance and gas diffusion usually do not limit performance in normal healthy individuals, but abnormal or obstructive respiratory disorders can limit performance

KEY POINTS – Respiratory Adaptations to Training

- Pulmonary ventilation increases during maximal effort after training; you can improve performance by training the inspiratory muscles
- Pulmonary diffusion increases at maximal work rates
- The a-vO2 diff increases with training due to more oxygen being extracted by tissues
- The respiratory system is seldom a limiter of endurance performance
- All the major adaptations of the respiratory system to training are most apparent during maximal exercise

VO_2 Adaptations to Training

Oxygen consumption (VO_2) is

- unaltered or slightly increased at rest
- unaltered or slighted decreased at submaximal rates of work
- increased at maximal exertion (VO_2max—increases range from 0% to 93%)

Factors Affecting VO_2max

Level of conditioning—the greater the level of conditioning the lower the response to training

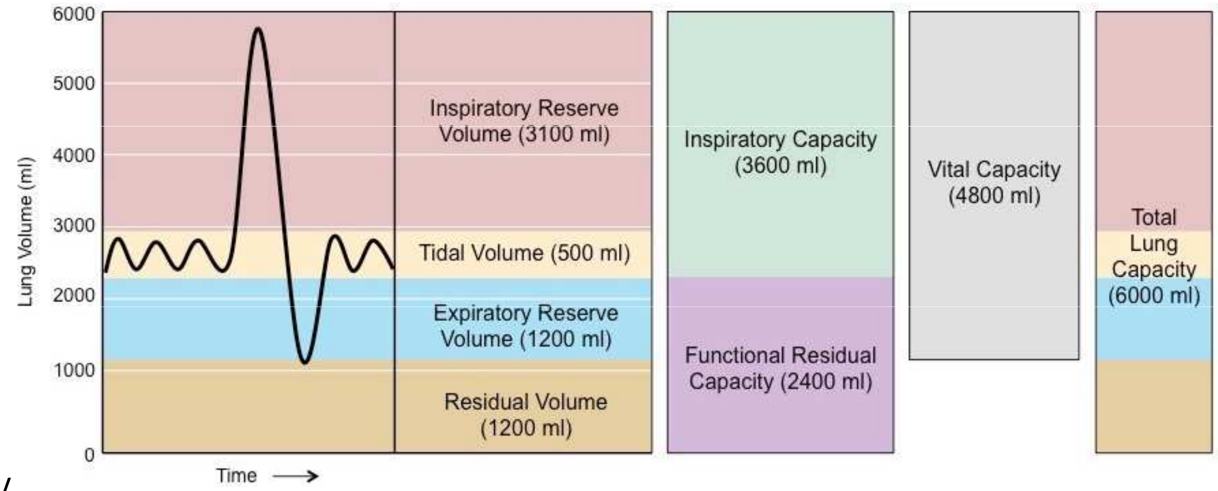
Heredity—accounts for slightly less than 50% of the variation as well as an individual's response to training

Age—decreases with age are associated with decreases in activity levels as well as decreases in physiological function

Sex—lower in women than men (20% to 25% lower in untrained women; 10% lower in highly trained women)

Specificity of training—the closer training is to the sport to be performed, the greater the improvement and performance in that sport

Vital Capacity



- Vital capacity is the maximum amount of air that can be forcefully expired after a maximum inspiration

  VC females = 3-4 l

  VC males = 4-5.5 l

- From the pulmonary function test the vital capacity testing is the most frequently used. It could be performed „slowly“ (VC) and/or as fast and forced as possible (forced vital capacity, FVC)

Vital Capacity

Calcultae your predicted value of the vital capacity:

Males:

Predict. VC (ml) = [27.63 – (0.112 x age (yrs)] x height (cm)

Females:

Predict. VC (ml) = [21.78 – (0.101 x age (yrs)] x height (cm)

Compare your measured values with the predicted values and express them as a percentage of the predicted values

Vital Capacity

Calcultae your predicted value of the vital capacity:

Males:

Predict. VC (ml) = [27.63 – (0.112 x age (yrs)] x height (cm)

Females:

Predict. VC (ml) = [21.78 – (0.101 x age (yrs)] x height (cm)

Compare your measured values with the predicted values and express them as a percentage of the predicted values

BTPS

All the pulmonary volumes should be standardiesd, i.e. converted from actual conditions (ATPS) to the BTPS conditions (Body Temperature and atmospheric Pressure completly Saturated with water vapour at body temperature).

BTPS for Czech Republic is 1.09

Thank You!