

UNITED STATES MARINE CORPS

FORCE FITNESS READINESS CENTER

THE BASIC SCHOOL

24191 GILBERT ROAD

QUANTICO, VIRGINIA 22134

STUDENT OUTLINE

ANATOMY AND PHYSIOLOGY II

FFIC1025

FORCE FITNESS INSTRUCTOR COURSE

M02MN1T

APPROVED BY: LtCol (Ret) Shusko, J. C. DATE: 20180412

LEARNING OBJECTIVESa. TERMINAL LEARNING OBJECTIVES

(1) Given a unit to train, supervise injury prevention, to increase a Marine and unit's readiness. (0919-TRNG-2004)

b. ENABLING LEARNING OBJECTIVES

(1) Without the aid of reference, identify the function of the human neurological system without error. (0919-TRNG-2004n)

(2) Without the aid of reference, identify the components of the nervous system without error. (0919-TRNG-2004o)

(3) Without the aid of reference, identify the functions of the human respiratory system without error. (0919-TRNG-2004p)

(4) Without the aid of reference, define VO2 max without error. (0919-TRNG-2004q)

(5) Without the aid of reference, define lactate threshold without error. (0919-TRNG-2004r)

(6) Without the aid of reference, identify the function of the human cardiovascular system without error. (0919-TRNG-2004s)

(7) Without the aid of reference, identify the components that are involved in the circulation of blood in the human body. (0919-TRNG-2004t)

(8) Without the aid of refernce, idenify the normal range for blood pressure without error. (0919-TRNG-2004u)

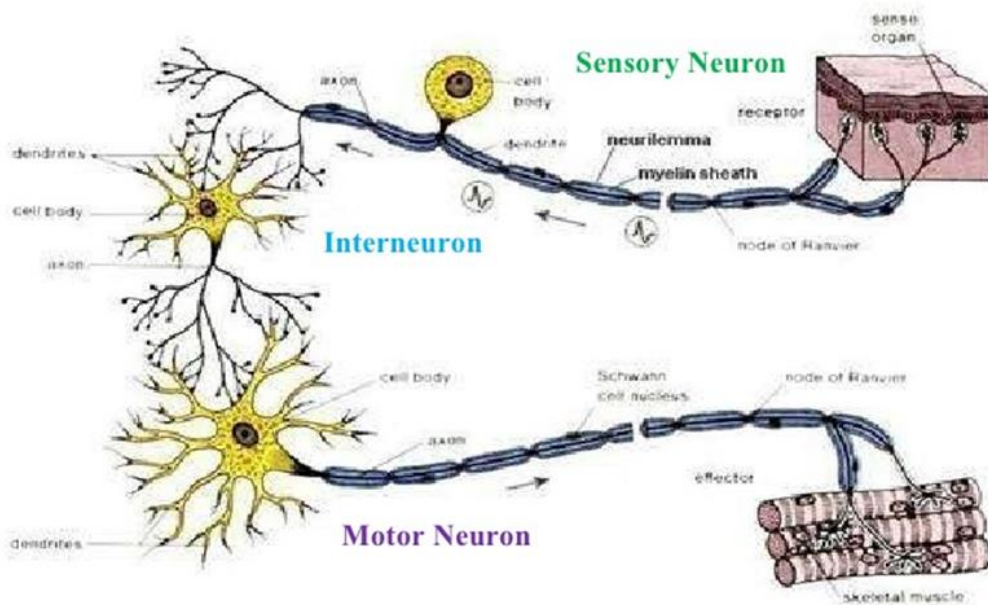
1. NEUROLOGICAL SYSTEM. Muscles are not able to function, contract, or perform movement on their own. The neurological system must provide signals and initiate the myofascial system.

a. Functions. The neurological system has three main functions; sensory, integrative, and motor functions.

(1) Sensory. Afferent (input) nerves detect internal/external stimuli and bring information to the central nervous system.

(2) Integrative. Integrative nerves collect, analyze, and store sensory information. These nerves make up the majority of the neurons of the body.

(3) Motor. Efferent nerves carry information out of the brain and spinal cord to the intended target, the target may be a muscle, gland, or organ.



b. Central Nervous System (CNS) and Peripheral Nervous System (PNS).

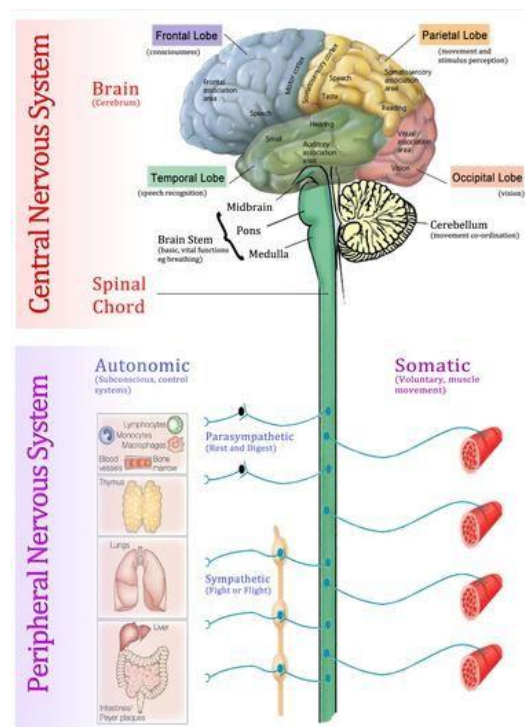
(1) CNS. The central nervous system (CNS) includes the brain and spinal cord. The central nervous system is complex and is the base of the nervous system.

(2) PNS. The peripheral nervous system (PNS) is considered anything outside of the CNS, cranial nerves, and their branches and sensory receptors.

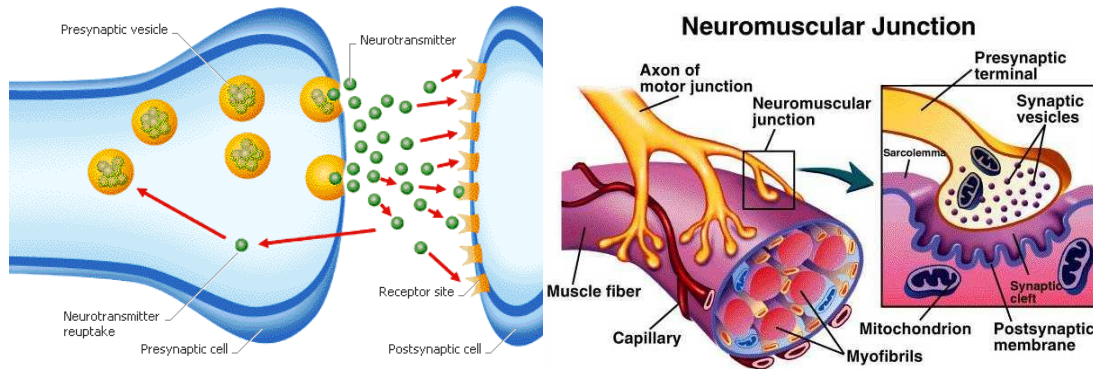
c. Autonomic nervous system

(1) Sympathetic nervous system. The sympathetic nervous system is commonly known as "the fight or flight response." It can accelerate heart rate, constrict blood vessels, and raise blood pressure. It decreases intestinal and glandular activity.

(2) Parasympathetic nervous system. The parasympathetic nervous system is the opposite of the sympathetic nervous system and is commonly known as the, "feed and breed." It will increase intestinal and glandular activity. It will decrease heart rate, increase vessel size, and decrease blood pressure.



d. Neurotransmitters. Over 50 neurotransmitters have been identified in the human body. Acetylcholine and norepinephrine are the two major neurotransmitters involved in physiological responses. Acetylcholine is primarily involved with motor neurons, skeletal, muscle and parasympathetic neurons. Dopamine is commonly associated with the pleasure and reward system of the brain. Natural reward system is affected by things such as food, sex, and drugs.



2. RESPIRATORY SYSTEM. The respiratory system includes the upper airway, lower airway, and the lungs. Breathing or the exchange of oxygen and carbon dioxide is critical to the cardiovascular system and muscular endurance of the athlete.

a. Functions

(1) Gas Exchange. Gas exchange is a vital life-sustaining process where we inhale oxygen (O₂) and exhale carbon dioxide (CO₂).

(2) Maintain pH. After the gas exchange, as oxygen is carried to all the cells in the body. It absorbs oxygen and produces carbon dioxide because of the cellular functions, which is then carried back to the lungs to be excreted. High levels of CO₂ in the blood decreases the pH level (increases the acidity) of the blood, so getting rid of it helps maintain the acid-base balance.

(3) Voice/Sound production. As air escapes through the vocal cords (larynx) sounds are produced.

b. Breathing

(1) Inspiration. When a person breaths "in" it is considered inhalation. During inhalation the diaphragm contracts and air rushes in due to negative pressure. The abdominals push out anteriorly.

(2) Expiration. When a person breaths "out" it is considered expiration. Expiration is considered passive in normal breathing, this occurs with the diaphragm relaxing. The abdominals draw back in.

(3) Exercise breathing. During activity, the body employs other muscles to increase oxygen volume into the lungs. The intercostal muscles, sternocleidomastoid, and scalene muscles are used to increase inspiration. During activity other muscles are employed to help with expiration: abdominal muscles (all), and intercostal muscles contract.

c. Anatomy

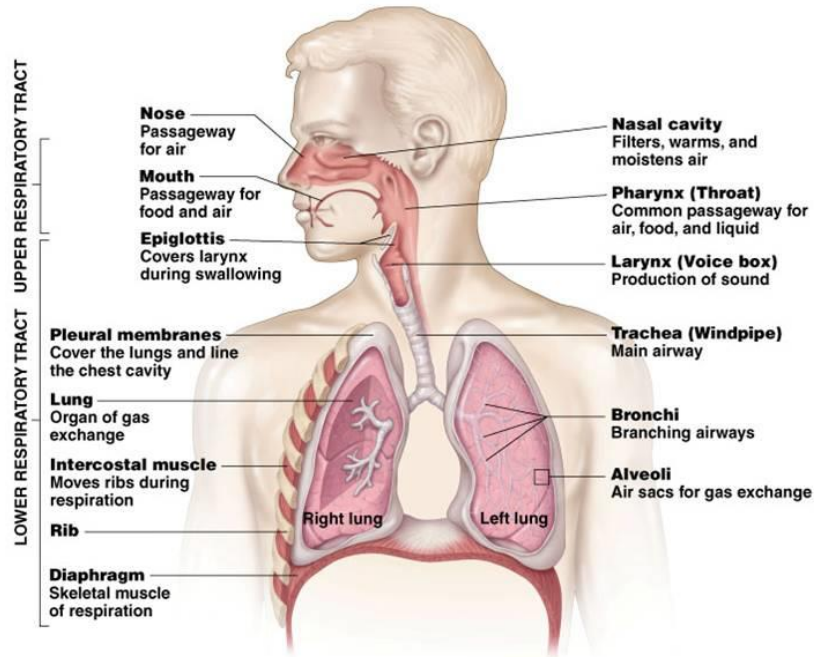
(1) General. Anatomy of the respiratory system includes the nose, pharynx, larynx, bronchi, and lungs.

(2) Upper Respiratory system. The upper respiratory system includes the anatomy of the nose, pharynx, trachea, and associated structures.

(3) Lower respiratory system. The lower respiratory system includes the anatomy of the larynx, trachea, bronchi, bronchioles, alveolar ducts, and alveoli.

(4) Diaphragm. The diaphragm is a dome shaped muscle that pulls on the central tendon to initiate breathing, creating a negative pressure.

(5) Lungs. The human body has 2 lungs, 3 lobes on the right and 2 lobes on the left. The lungs are critical in exchanging CO₂ and O₂ gases during breathing. This exchange of gas occurs at the capillaries where the alveoli has a lower O₂ concentration than the air in the alveoli which has been inhaled. Both alveoli and capillaries have walls which are only one cell thick and allow gases to diffuse across them.



d. Breathing Rate.

(1) The rate at which we inhale and exhale is controlled by the respiratory center within the brain. The breathing rate is controlled by chemoreceptors within the main arteries which monitor the levels of O₂ and CO₂ within the blood. If oxygen saturation falls, ventilation accelerates to increase the volume of O₂ inspired. If you are in a low oxygen environment, your breathing rate will increase without conscious effort.

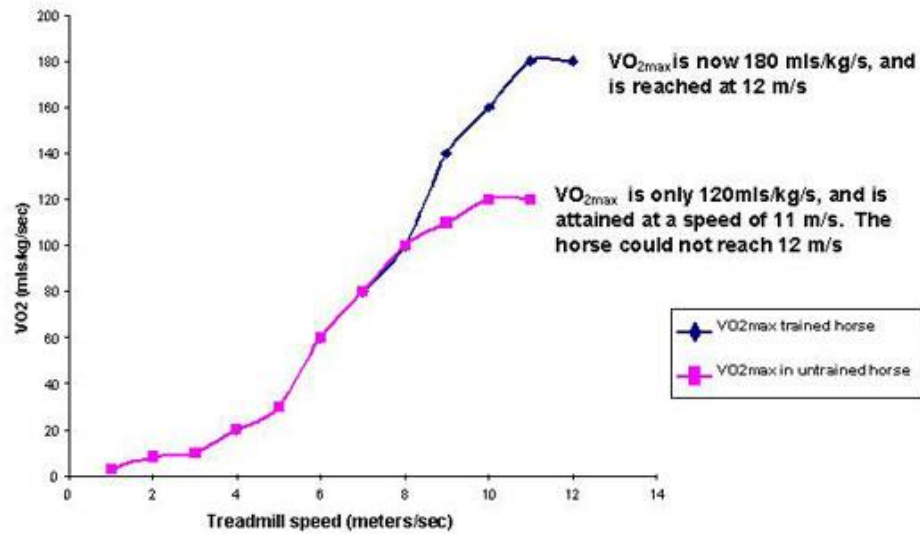
(2) If levels of carbon dioxide (through exercise) increase, a substance known as carbonic acid is released into the blood which causes Hydrogen ions (H⁺) to be formed. An increased concentration of H⁺ in the blood stimulates increased ventilation rates. This also occurs when lactic acid is released into the blood following high intensity exercise.

e. VO₂ Max. A high correlation has been shown between VO₂ max and aerobic endurance events. VO₂ max is a measure of maximum volume of oxygen that can be used. As the effort increases, so does the demand of oxygen. While endurance training programs should focus on increasing VO₂ max, other factors include lactate threshold, biomechanics, high efficiency of using fat for energy, and a high percentage of Type I fibers.

Women Age (years)						
Rating (ml/kg/min)	18-25	26-35	36-45	46-55	56-65	65+
excellent	> 56	> 52	> 45	> 40	> 37	> 32
good	47-56	45-52	38-45	34-40	32-37	28-32
above average	42-46	39-44	34-37	31-33	28-31	25-27
average	38-41	35-38	31-33	28-30	25-27	22-24
below average	33-37	31-34	27-30	25-27	22-24	19-21
poor	28-32	26-30	22-26	20-24	18-21	17-18
very poor	< 28	< 26	< 22	< 20	< 18	< 17

Men Age (years)						
Rating (ml/kg/min)	18-25	26-35	36-45	46-55	56-65	65+
excellent	> 60	> 56	> 51	> 45	> 41	> 37
good	52-60	49-56	43-51	39-45	36-41	33-37
above average	47-51	43-48	39-42	36-38	32-35	29-32
average	42-46	40-42	35-38	32-35	30-31	26-28
below average	37-41	35-39	31-34	29-31	26-29	22-25
poor	30-36	30-34	26-30	25-28	22-25	20-21
very poor	< 30	< 30	< 26	< 25	< 22	< 20

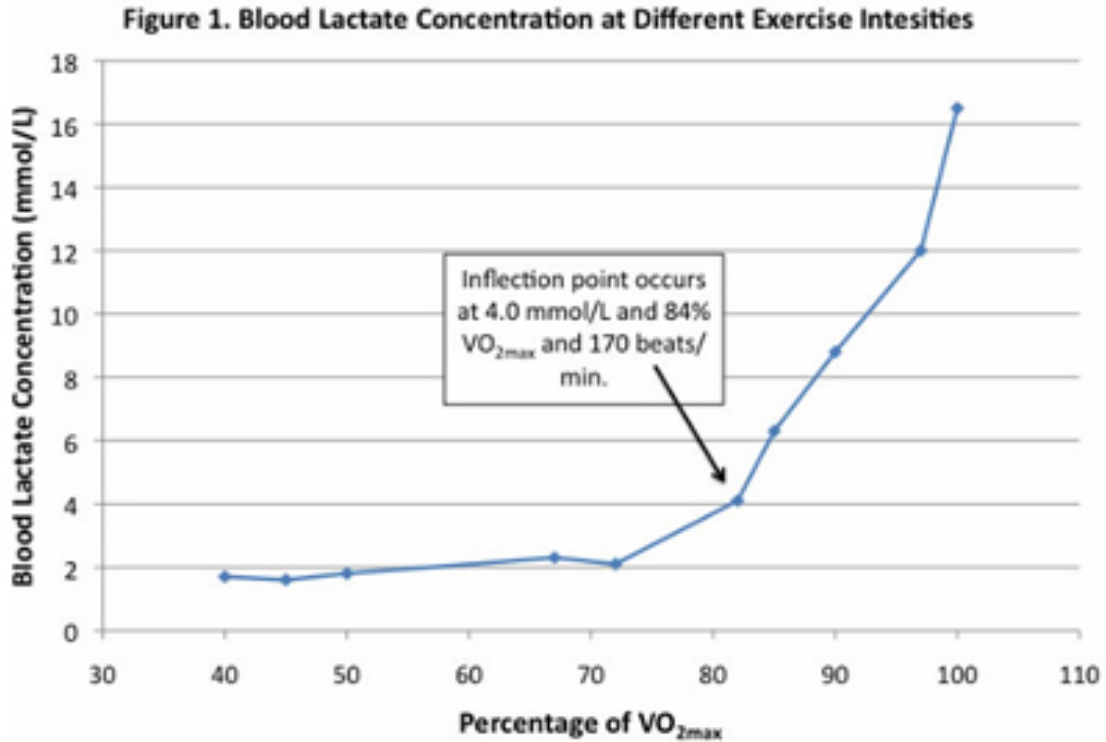
Fig 4: VO_{2max} in an elite athlete Before and After 2 months of aerobic training



f. Lactate Threshold. Lactate threshold is the rapid accumulation of blood lactate above base concentration.

(1) Athletes with similar VO₂ max values, able to sustain aerobic energy production at the highest percentage of his/her VO₂ max values without accumulating large amounts of lactic acid in muscle and blood, will usually be superior. Some studies have shown that lactate threshold is a better measure of aerobic endurance performance.

(2) Lactate accumulation is not the cause of soreness or fatigue.



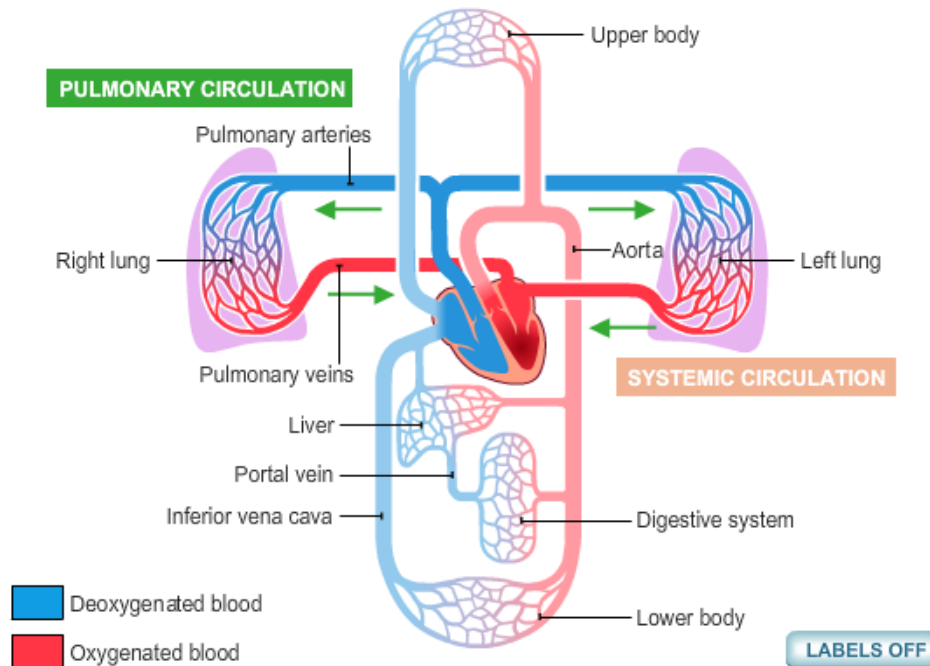
3. CARDIOVASCULAR SYSTEM. The cardiovascular system has four main components: blood, heart, vessels, and capillaries.

a. Functions

(1) Transportation. The cardiovascular system transports oxygen, carbon dioxide, nutrients, heat, and waste products from cells.

(2) Regulation. The cardiovascular system regulates bodily functions such as pH and adjustment of body temperature.

(3) Protection. The cardiovascular system responds to injury and disease by the formation of clots; it also fights infections and carries antibodies.



b. Anatomy. The three main parts of the cardiovascular system are the vessels, blood, and heart.

(1) Blood. Whole blood has several components that include cells and blood plasma. When whole blood is separated, one can see all the components.

(a) Blood Plasma. Blood plasma is a straw colored liquid of blood, and consists of about 90% water. You can see how water is essential to the cardiovascular system.

(b) Formed Elements. The remaining part of whole blood is considered formed elements. About 99% of formed elements are red blood cells. Red blood cells transport oxygen and carbon dioxide. Therefore, you can assume how important red blood cells are to the cardiovascular system.

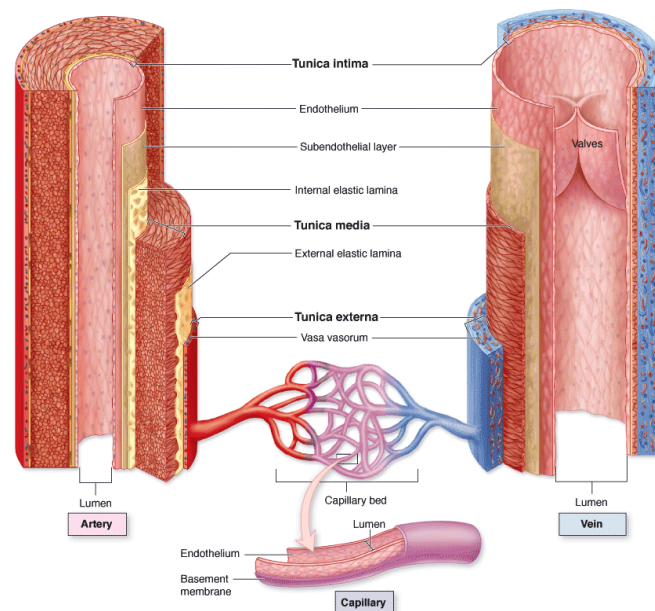
(2) Heart. The heart is the muscle pump that cycles blood throughout the body. This specialized muscle is unique in its properties. The heart has 4 chambers and is directly connected to the lungs and major vessels of the body.

(3) Vessels

(a) Arteries. Arteries are blood vessels which carry blood away from the heart. All of which, with the exception of the pulmonary artery, carry oxygenated blood. The most widely known artery within the human body is the aorta, or formal artery

(b) Veins. Veins are blood vessels that typically carry deoxygenated (or very low levels of oxygen) blood back to the heart. The exception to this rule is the pulmonary vein, which carries oxygenated blood from the lungs back to the heart, ready to be pumped through the rest of the body.

(c) Capillaries. Capillaries are the smallest of all blood vessels and form the connection between veins and arteries. Here, the capillaries form a capillary bed, which is a vast expanse of very small vessels forming a network throughout the muscle. These microscopic vessels exchange nutrients and waste.



Sources: Mescher AL: Junqueira's Basic Histology: Text and Atlas, 12th Edition. <http://www.accessmedicine.com>
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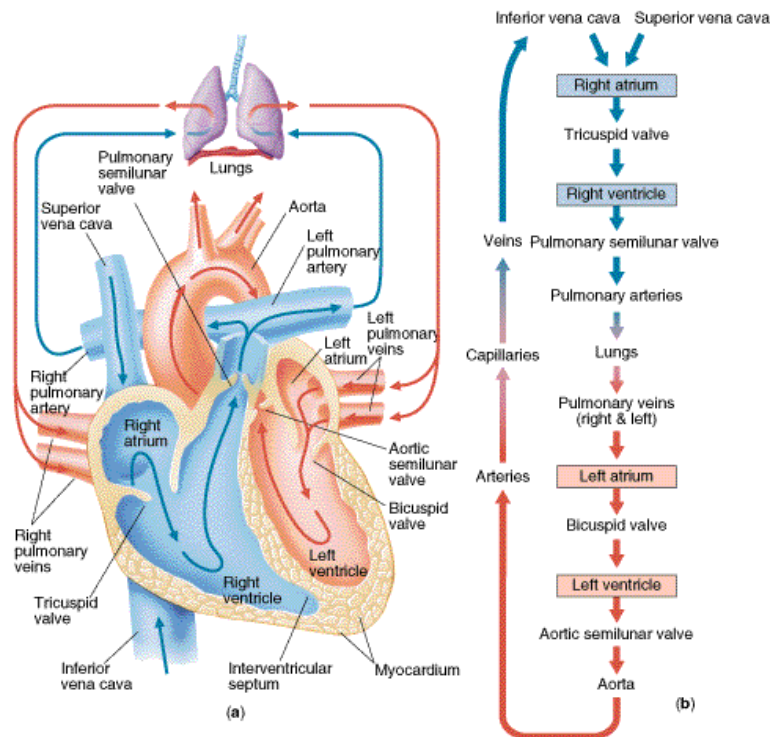
c. Circulation of Blood

(1) Start. We will start this discussion with the blood starting in the left ventricle. The blood in the left ventricle is oxygenated, typically shown in RED. That blood will exit out of the aorta and supply oxygenated blood to the entire body

until it reaches the capillaries. Oxygenated blood is carried by arteries. Exception: the pulmonary artery contains de-oxygenated blood.

(2) Exchange. Once the oxygenated blood reaches the capillaries, exchange is ready to occur. Around the entire body, the exchange of carbon dioxide and oxygen is necessary to maintain function. In order for carbon dioxide to be removed, it passes across the walls of the capillaries into the blood stream. This is where Red (oxygenated) blood transfers to Blue (de-oxygenated) blood which is carrying carbon dioxide. This is easily seen in the lungs where carbon dioxide is exchanged for oxygen.

(3) Return. Once the oxygen is released into the target tissue through the capillaries, the blood is ready to return to the heart and lungs for re-oxygenation. The blood returns through the right atrium into the heart.



d. Regulation of HR

(1) Hormones. Hormones regulate the heart rate using epinephrine and norepinephrine. Consider the hormones that are released with the "fight or flight" response.

(2) Age, gender, physical fitness. As age increases, maximum heart rate decreases. Females tend to have lower heart rates compared to men. Physical fitness has a large impact on heart rate. If the heart muscle becomes stronger and more efficient (cardio output increases), the body is able to circulate blood with less effort and less energy.

e. Cardiac Output

(1) Equation. The oxygenated blood pumped out of the left ventricle is a key measurement of efficiency. If more blood is ejected per beat, more blood volume is circulated, thus becoming more efficient. Cardiac output is the volume of blood ejected from the left ventricle into the aorta each minute. Units are measured in mL/ min. (In the equation of $CO = SV \times HR$)

(2) Stroke volume = milliliter per beat

(3) Heart rate = beat per minute

f. Blood Pressure

(1) Definition. Blood Pressure is the force exerted by the blood against the vessel wall. Blood pressure is highest in arteries and gradually decreases as it passes through arterioles, capillaries, venules and finally, veins.

(2) Blood pressure. Blood pressure is a variable and can increase due to exercise where the cardiac output increases thus forcing more blood through the arteries, or by altering the peripheral resistance. This occurs by vasoconstriction, increasing in blood viscosity (thickness) and changing in shape or size of the vessels. The regulation of blood pressure is the responsibility of the sympathetic and parasympathetic nervous systems.

Blood Pressure Category	Systolic mm Hg (upper #)	Diastolic mm Hg (lower #)
Normal	less than 120	and less than 80
Prehypertension	120 – 139	or 80 – 89
High Blood Pressure (Hypertension) Stage 1	140 – 159	or 90 – 99
High Blood Pressure (Hypertension) Stage 2	160 or higher	or 100 or higher
<u>Hypertensive Crisis</u> (Emergency care needed)	Higher than 180	or Higher than 110

(3) Neurological system on vessels. The sympathetic and parasympathetic system can change the diameter of the arteries, which are called vasoconstriction and vasodilation.

SUMMARY: The nervous system is a highly integrated system that plays a key role in muscle activation and muscle contraction. While we think about the cardiovascular system and respiratory system as the main components in endurance training, it is important to remember they are equally important in anaerobic training.

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