



FITNESS & NUTRITION EXPERT PROGRAM

FITNESS SESSION 5:

Bioenergetics &
Cardiorespiratory System



What we are going to cover

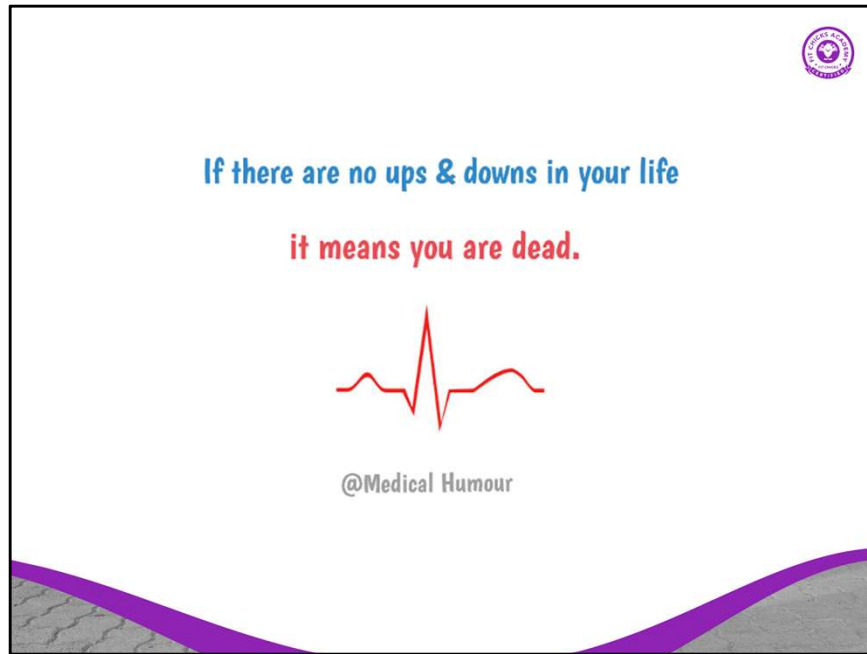


BIOENERGETICS

- Muscle Metabolism: The role of ATP
- How energy is created in the Human Body
 - Cellular Respiration and the different energy systems
- Burning Fat vs. Burning Carbs
- Why interval training is so effective
- Muscle soreness and recovery

CARDIORESPIRATORY CONCEPTS

- Anatomy of the Cardiorespiratory System
- Heart Rate, Blood Pressure, VO₂MAX, Stroke Volume, Cardiac Output,
- How to determine your Heart Rate Training Zone
- Training adaptations

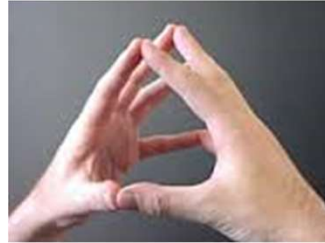


<https://me.me/i/if-there-are-no-ups-downs-in-your-life-3079860>



What you need before we start

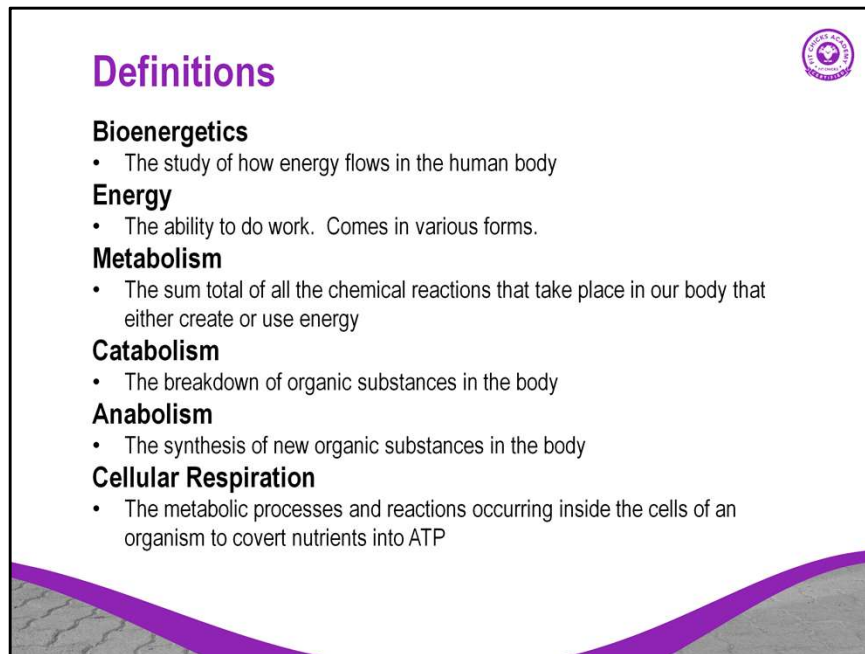
1. Water
2. Put your finger tips together
3. Take 3 deep breaths





Bioenergetics





Definitions

Bioenergetics

- The study of how energy flows in the human body

Energy

- The ability to do work. Comes in various forms.

Metabolism

- The sum total of all the chemical reactions that take place in our body that either create or use energy

Catabolism

- The breakdown of organic substances in the body

Anabolism

- The synthesis of new organic substances in the body

Cellular Respiration

- The metabolic processes and reactions occurring inside the cells of an organism to covert nutrients into ATP

http://kidshealth.org/teen/your_body/body_basics/metabolism.html

Every living organism needs these metabolic processes to live.

Martini, F.H., Ober, W.C., Bartholomew, E.F., Nath, J.I. (2013). Visual Essentials of Anatomy and Physiology. 559

Catabolism = breaking down - ex. Glycolysis

Anabolism = building up - ex. The synthesis of proteins from amino acids

Muscle Metabolism: Energy for Contraction

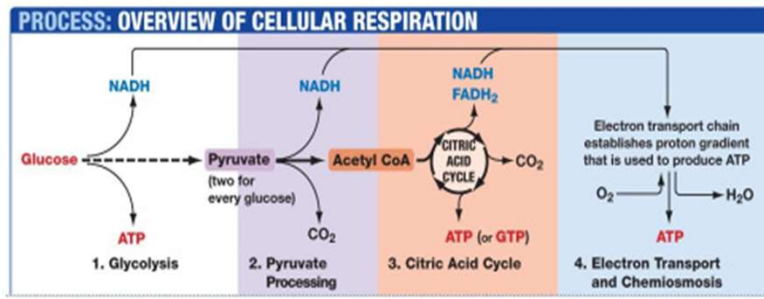
ATP or Adenosine Tri-Phosphate

- Energy-bearing molecule found in all living cells
- The currency of energy in our body
- When ATP gets broken down into ADP (Adenosine Di-Phosphate) energy is released from breaking the phosphate bond
- ATP is the only source used directly for contractile activities
- Available stores of ATP are depleted in 4-6 seconds
- ATP is regenerated by (Cellular Respiration):
 - Direct phosphorylation of ADP by Creatine Phosphate (CP)
 - Anaerobic pathway (glycolysis)
 - Aerobic respiration


Phosphorylation means adding a phosphorus molecule



Cellular Respiration



<https://biochemistry3rst.wordpress.com/tag/krebs-cycle/>



Cellular Respiration

- Cellular Respiration is the process by which organisms obtain energy from their diet.
- The food we eat is broken down into amino acids, lipids, and simple sugars (glucose).
- The glucose combines with oxygen to form carbon dioxide, water, and energy.
- This energy needs to be converted to ATP so that the body can use it.
- There are 3 steps to convert glucose to ATP:
 1. Glycolysis (anaerobic)
 2. Citric Acid Cycle (Krebs's cycle) (aerobic)
 3. The Electron Transport System (aerobic)

<https://biochemistry3rst.wordpress.com/tag/krebs-cycle/>

Glycolysis can be both anaerobic and aerobic. It depends on if there is oxygen present or not.

Anaerobic = no oxygen

Aerobic = oxygen



Anaerobic vs Aerobic Energy Systems

Anaerobic Energy Systems (without oxygen)

- Used at the beginning of exercise or during periods of high intensity
 - ATP-CP Phosphagen System
 - Glycolytic System

Aerobic Energy Systems (with oxygen)

- Used after 2 mins of activity during light to moderate exercise
 - Aerobic Glycolysis
 - Fatty Acid Oxidation

System	Power (rate of ATP production)	Capacity (total ability to produce ATP)	Fuels Used
phosphagen system	very high	very low	creatine phosphate stored ATP
glycolysis	high	low	blood glucose muscle & liver glycogen
aerobic system	low	very high	blood glucose muscle & liver glycogen adipose & intramuscular fat

<https://www.ideafit.com/fitness-library/the-three-metabolic-energy-systems>

ATP-CP Phosphagen System



ATP- CP Phosphagen system is the immediate energy source in the body

- During the first few seconds of exercise regardless of intensity, your body uses the ATP that is stored in your muscles. ATP use can occur very rapidly.
- Creatine Phosphate (CP) is a high energy compound stored in the cells at a concentration 4-5 times greater than ATP
 - Provides the most power
 - Provides a high rate of energy but at a low capacity
 - Lasts only 3 -15 seconds in an all-out activity
 - Following exercise, the CP must be replaced and this requires ATP. The ATP needed for this is aerobically produced.
- Examples: power lifting, jumping, sprinting, getting out of bed
- To train this energy system, you'd want to work with a work:rest ratio of about 1:12 or about 2 mins rest

<http://www.ptdirect.com/training-design/anatomy-and-physiology/the-atp-pc-system>

If activity continues beyond this immediate period, the body must rely on other energy systems to produce ATP as the limited stores of both ATP and PC will be exhausted and will need time to replenish.

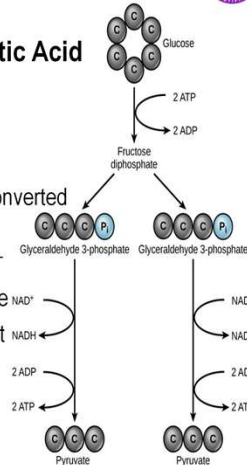
These stores are replenished after about two minutes rest.

You need about a 1:12 ratio for work to adequate recovery or about 2 mins

The Glycolytic System

The Glycolytic System is also known as the Lactic Acid System

- Breakdown Glucose to Pyruvic Acid (glycolysis)
- Occurs in the cytoplasm
- The pyruvic acid either enters the aerobic pathway or is converted into Lactic Acid
- Glycolysis yields 2 ATP, 2 Pyruvic acids, and 2 NADH +H⁺
- Lactic Acid will eventually lead to muscle fatigue and failure
 - It can be used as fuel by the liver, kidneys, and heart
 - Converted back into pyruvic acid by the liver
- Kicks in after 10 secs, lasts about 2 mins
- Ex. 400 meter dash, strength training, playing hockey
- To train this energy system, you'd work with 1:6 or 1:3 if you want to train the body to clear lactic acid faster



<https://i.pinimg.com/originals/2e/65/11/2e6511146ab8eedac0674bb51847126.jpg>

If glucose isn't readily available the body will breakdown glycogen into glucose (Glycogenolysis)

If neither glucose nor glycogen is available the body will form glucose from protein and fat (Gluconeogenesis)

NADH+H⁺ will yield 3 ATP each through the Electron Transport System – Part of the aerobic pathway

In glycolysis, glucose, a 6-carbon compound, is eventually **broken down** to two 3-carbon compounds called pyruvate molecules. Two ATP molecules are invested into this step so that a net gain of two ATP can be made, as well as two pyruvates and two NADH. This process occurs **without the presence of oxygen** in the cytoplasm of cells.

Aerobic Glycolysis and Fatty Acid Oxidation



Aerobic Glycolysis and Fatty Acid Oxidation occur via the Citric Acid Cycle and Electron Transport System

- Produces 95% of ATP during rest and light to moderate exercise
- Uses stored glycogen, then bloodstream glucose, then pyruvic acid from glycolysis, and then free fatty acids to create energy (ATP)
- Provides fuel after 2 mins
- System is only really limited by cardiorespiratory ability to deliver oxygen

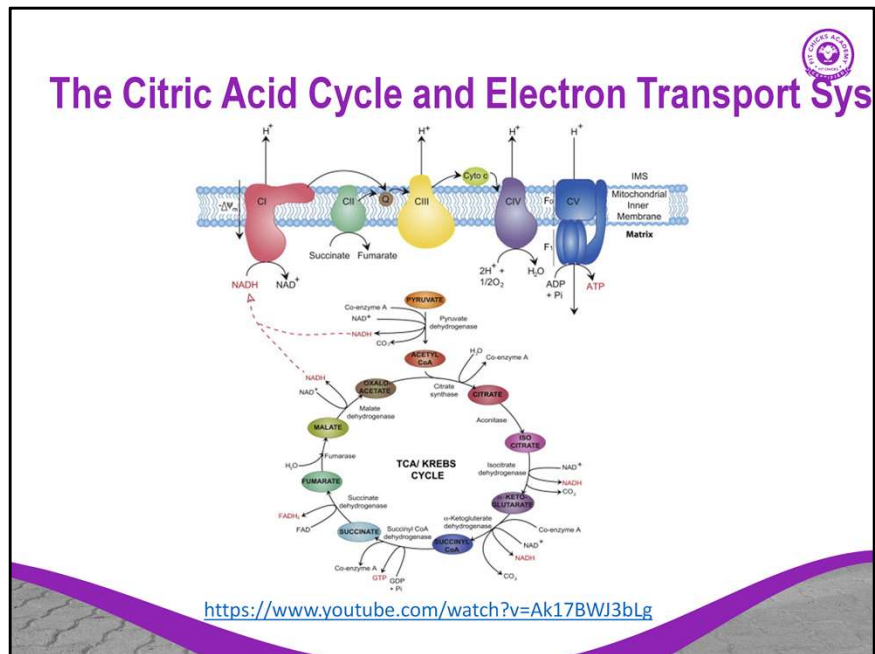
The Citric Acid Cycle or Krebs' Cycle

- Occurs in the inner membrane of the mitochondria
- The two pyruvates from glycolysis are used and each cycle through a series of oxidative reactions

The Electron Transport System or Chain

- The final step in aerobic metabolism
- Yields the most ATP via $\text{NADH}+\text{H}^+$ and FADH_2 (Electron Carriers)

<https://www.khanacademy.org/science/biology/cellular-respiration-and-fermentation/overview-of-cellular-respiration-steps/v/overview-of-cellular-respiration>

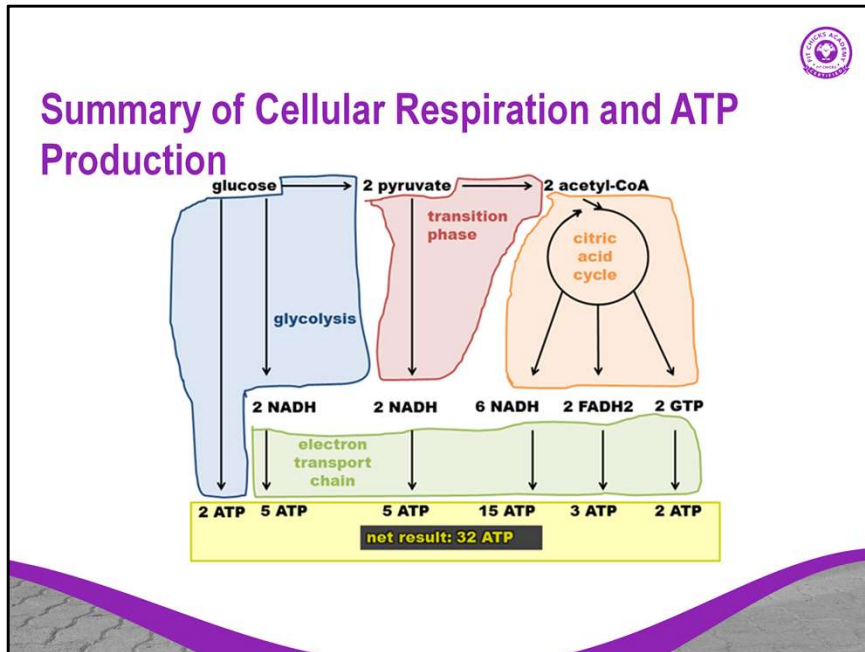


https://www.researchgate.net/figure/Bioenergetics-of-the-electron-transport-chain-and-the-TCA-Kerbs-cycle-Pyruvate-is_fig1_233737352



Aerobic Glycolysis vs Fatty acid oxidation

- Uses glucose as fuel
 - Moderate intensity exercise
 - Ex. running, a fitness class, a swim
 - To train this system: A sustained effort, or a 1:1 with active 'rest' portions
- Uses fat as fuel
 - Low intensity exercise
 - Ex. Yoga, walking, sitting
 - To train this system: A sustained effort, or a 1:1 with active 'rest' portions




<http://www.cureffi.org/wp-content/uploads/2013/11/energy-flow-diagram.png>

Summary of the Energy Systems



Characteristics	Anaerobic systems		Aerobic system	
	ATP-CP (alactic)	Anaerobic glycolysis (lactic acid)	Aerobic (glycolysis)	Aerobic (lipolysis)
Duration (predominant)	6–10 seconds	30–60 seconds	2–3 hours	>4 hours
Peak power	2–5 seconds	5–15 seconds	Not applicable	Not applicable
Intensity (% HR _{max})	Not applicable	Not applicable	>75–100%	Rest – 75%
Intensity (% VO _{2max})	Not applicable	Not applicable	>65–100%	Rest – 65%
Perceived exertion	Maximal	Maximal	Moderate–very hard	Very light–moderate
Fuel source(s)	CP	Carbohydrate	Mostly carbohydrate Fat	Mostly fat Carbohydrate
ATP yield (per molecule)	<1	2	36–38	>100
Byproducts	C + P	Lactic acid (Lactate + H ⁺)	H ₂ O + CO ₂ + heat	H ₂ O + CO ₂ + heat
[Blood lactate] (mM)	Not applicable	>6	2–16	<2
Training effect	Alactic power	Alactic power Alactic capacity Lactic power Lactic capacity	Aerobic power Aerobic capacity	Aerobic power Aerobic capacity Fat oxidation
Typical events	100 m track sprint	400 m track sprint 100 m freestyle	10 000 m run 40 km TT (cycling)	Ironman triathlon Road cycling (4 + hours)

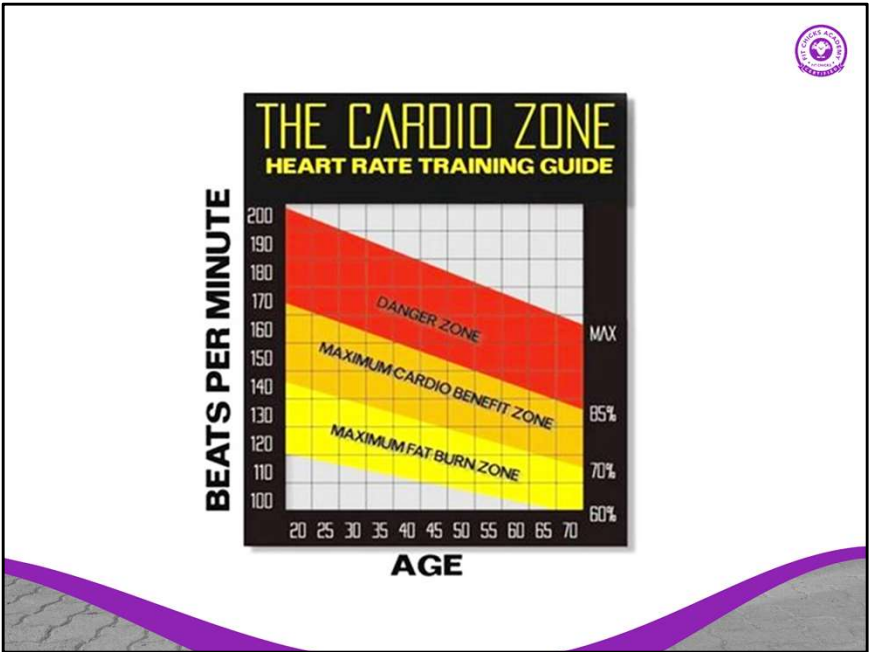
<https://mur0016sportscience.weebly.com/energy-systems.html>



Energy Systems for Different Activities

Sport	ATP-PC	Anaerobic Glycolytic	Aerobic
Basketball	60	20	20
Field events (shotput, discuss, javelin)	90	10	0
Golf swing	95	5	0
Gymnastics	80	15	5
Hockey	50	20	30
Rowing	20	30	50
Running (distance)	10	20	70

This chart shows the % of which system is used for each activity





Absolute vs. Relative Fat Burn

- At lower exercise intensities more fat is burned relative to glycogen
- At 50% of your max heart rate, your body burns a ratio of 60% fat to 40% glycogen. At 75% of your max heart rate, the ratio is 35% to 65%
- At even higher intensities, the ratio is even lower.
- But it's all about calories. You burn a lot more calories when you workout intensely than you do when you are sitting on the couch.

30 Minutes of Exercise	Fat Calories Burned	Glycogen Calories Burned	Total Calories Burned
Low Intensity Group (50%)	120	80	200
High Intensity Group (75%)	140	260	400

<http://www.builtlean.com/2013/04/01/fat-burning-zone-myth/>

So if your goal is fat loss, is it better to work out at a lower intensity or higher intensity?

The 'Fat Burning Zone' Ignores

EPOC

EPOC- Excess Post-Exercise Oxygen Consumption

- Used during recovery after intense exercise
- Body must balance hormones, replenish ATP, repair cellular damage, metabolize lactic acid
- All this burns calories! Therefore, the body temp and metabolic rate is increased
- Although EPOC will happen with both aerobic and anaerobic exercise, it's much greater with anaerobic exercise
- Anaerobic exercise (ex. HIIT) has been found to result in greater fat loss, even though the subjects expended fewer than half as many calories during exercise. The reason is thought to be due to EPOC.
- EPOC is sometimes called 'afterburn'



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http://en.wikipedia.org/wiki/Excess_post-exercise_oxygen_consumption

<https://www.youtube.com/watch?v=SLgNRg3mh6s>

Muscle Soreness and Recovery



Muscle Soreness

- Acute muscle soreness may be pain due to ischemia, accumulation of end products (H^+ and H_2O)
- Delayed onset muscle soreness (DOMS)
 - Not directly related to lactate buildup
 - Observed with eccentric vs concentric contractions
 - Symptoms include: increased muscle enzymes and myoglobin, tissue damage (small micro tears), local muscle pain, soreness, and swelling

Muscle Recovery

- Possible decreased muscle force
- Body initiates inflammatory response to repair muscle
- Once soreness has occurred, you are protected from an increase in soreness for 3-4 weeks
- After each bout of same activity, recovery rate is faster

Ischemia – low blood flow

Increase pressure in the muscle which stimulates pain receptors

Some muscle enzymes and myoglobin are muscle specific but when the muscle is damaged they find their way into the bloodstream

Myoglobin – the muscles version of hemoglobin, iron binding molecule

Decreased muscle force can persist for several weeks (after running a marathon)

Cardiorespiratory Concepts



Cardiorespiratory Concepts

The cardiorespiratory system =

- The cardiovascular system + the respiratory system

Cardiovascular System

- Heart, Arteries, Veins, Capillaries

Respiratory System

- Upper respiratory system:
 - Nose, Nasal cavity, Sinuses, Pharynx
- Lower Respiratory System:
 - Larynx, Trachea, Bronchi, Bronchioles,

Together, they carry oxygen to all cells of the body, and remove waste products, including carbon dioxide.

Cardiorespiratory Fitness

- The ability of the circulatory and respiratory systems to supply oxygen to skeletal muscles during sustained physical activity

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http://en.wikipedia.org/wiki/Cardiorespiratory_fitness

<Http://hes.ucfsd.org/gclaypo/repiratorysys.html>

Martini, F.H., Ober, W.C., Bartholomew, E.F., Nath, J.I. (2013). Visual Essentials of Anatomy and Physiology. 559

Respiratory System

Respiration/Ventilation = Breathing

Mouth or Nose

- Air is warmed and filtered and passed through the larynx and pharynx

Trachea (windpipe)

- Carries air towards the lungs

Bronchi

- The trachea splits into two bronchi, one leads to the left lung and the other to the right

Bronchioles

- Once within the lungs the bronchi continue to divide into these smaller tubes

Alveoli

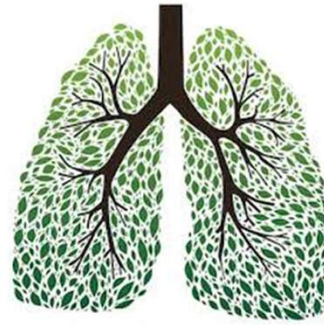
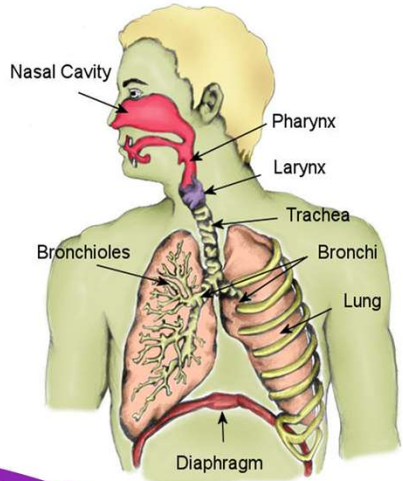
- The bronchioles end in small sacs called alveoli. This is where the gas exchange takes place



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http://www.teachpe.com/anatomy/respiratory_system.php

Respiratory System



VO₂ Max

- The maximum amount of oxygen that someone can use during maximal exercise
- Considered the best indicator of an athlete's cardiovascular fitness
- The more oxygen you can use during high intensity exercise, the more ATP you can produce
- Measure in ml of Oxygen used in 1 min per kg of body weight
- Tests are done under strict protocol in Sports Performance Labs



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http://sportsmedicine.about.com/od/anatomyandphysiology/a/VO2_max.htm

VO₂ Max



MAXIMAL OXYGEN UPTAKE NORMS FOR MEN (ml/kg/min)

	18-25 years old	26-35 years old	36-45 years old	46-55 years old	56-65 years old	65+ years old
excellent	>60	>56	>51	>45	>41	>37
good	52-60	49-56	43-51	39-45	36-41	33-37
average	47-51	43-48	39-42	35-38	32-35	29-32
average	42-46	40-42	35-38	32-35	30-31	28-28
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

MAXIMAL OXYGEN UPTAKE NORMS FOR WOMEN (ml/kg/min)

	18-25 years old	26-35 years old	36-45 years old	46-55 years old	56-65 years old	65+ years old
excellent	56	52	45	40	37	32
good	47-56	45-52	38-45	34-40	32-37	28-32
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
average	33-37	31-34	27-30	25-27	22-24	19-22
poor	28-32	26-30	22-26	20-24	18-21	17-18
very poor	<28	<26	<22	<20	<18	<17

source: these norms have been derived from several and now unknown sources



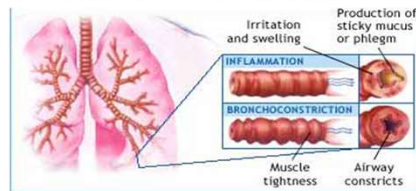
<https://endurelite.com/blogs/free-nutrition-supplement-and-training-articles-for-runners-and-cyclists/the-two-things-every-endurance-athlete-should-focus-on-improving-for-optimal-performance-part-1>

<https://www.therunningcenter.com/vo2-max-testing-max-heart-rate-testing/>

VO₂ max testing can be done on a treadmill or bicycle, and either incline, speed or resistance can be manipulated.

Asthma and Exercise

- Chronic inflammatory disease of the airway that causes shortness of breath, chest tightness, coughing, wheezing
- Best options are those with short, intermittent bursts
 - Ex. Volleyball, baseball, gymnastics
- Endurance activities might prove challenging (swimming can be an exception, due to the warm, moist air)
- Cold weather cardio should be avoided
 - Ex. Hockey, cross-country skiing




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<https://www.youtube.com/watch?v=4aK76DoxKGk>

<https://asthma.ca/what-is-asthma/>



Cardiovascular System

Heart

- Propels blood and maintains blood pressure

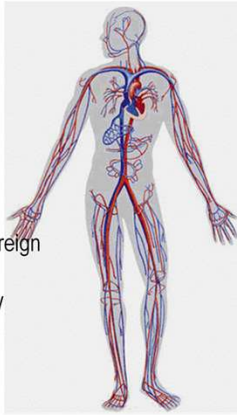
Blood

- Distributes oxygen, carbon dioxide, and blood cells
- Delivers nutrients and hormones
- Transports wastes (ex. carbon dioxide)
- Assists in temperature regulation and hydration of cells
- Defense against disease and blood loss
 - White blood cells and antibodies defend against foreign germs
 - Clotting mechanisms prevent blood loss after injury

Blood Vessels

- Arteries
 - Carry blood away from the heart
- Veins
 - Carry blood to the heart
- Capillaries
 - Permit diffusion between blood and interstitial fluid

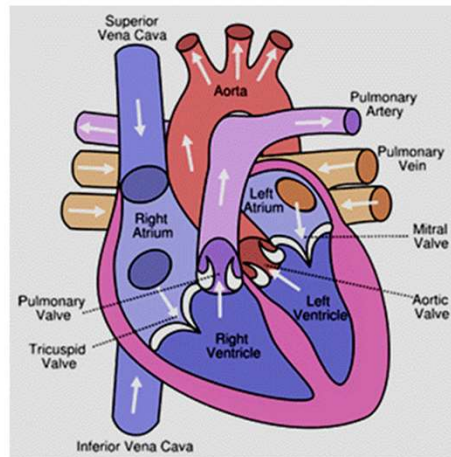
We circulate about 5L per minute



<http://www.innerbody.com/image/cardov.html#full-description>

Martini, F.H., Ober, W.C., Bartholomew, E.F., Nath, J.I. (2013). Visual Essentials of Anatomy and Physiology. 385

Blood vessels are the body's highways that allow blood to flow quickly and efficiently from the heart to every region of the body and back again.

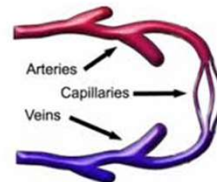


<https://www.youtube.com/watch?v=T2iVqTckmPQ>



Blood Flow

- Blood gets pumped from the heart into the aorta
- The aorta branches off into other arteries that carry the blood away from the heart
- The arteries branch off into arterioles
- Arterioles branch into capillaries
 - capillaries carry blood very close to the cells of the tissues of the body in order to exchange gases, nutrients, and waste products.
- The capillaries then form venules
- The venules turn into veins that carry the blood back to the heart



All I'm sa'in is circulation is the name of the game

Heart → Arteries → Arterioles → Capillaries → Venules → Veins → Heart

Capillaries



Blood Pressure

The pressure caused by the blood against the walls of the arteries or veins

Systolic

- The top number
- Peak pressure
- When the heart is pumping out blood

Diastolic

- The bottom number
- Lower pressure
- When the heart is filling back up with blood

Normal resting Blood pressure is 120/80

When we exercise, our BP goes up temporarily because there is more blood required by the working muscles

https://www.youtube.com/watch?v=qWti317qb_w

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https://www.youtube.com/watch?v=qWti317qb_w



Blood Pressure

Normal Blood Pressure

The pressure of blood in the vessels when the heart beats:
systolic pressure

The pressure between beats when the heart relaxes:
diastolic pressure

less than
120/80 mmHg

millimeters of mercury

High blood pressure

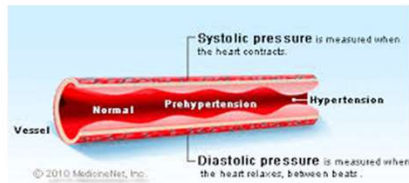
140/90 mmHg or higher

Prehypertension

between 120-139 mmHg and/or 80-89 mmHg

Normal blood pressure

less than 120/80 mmHg



Resting Heart Rate



Heart Rate (pulse)

- The number of times your heart beats per minute

RHR = Resting heart rate

- The amount of beats per minute when at rest.
- Good indicator of cardiovascular fitness

Good places to take pulse are

- Carotid Artery
- Radial artery

Variable that affect RHR are

- Age
- Gender
- Cardiovascular fitness
- Medications or drugs

Normal RHR between 60-100bpm with average of 72

Above 100 bpm you might want to see a doctor

might want to check into heart rate app
take a moment for everyone to take their RHR



Let's take our RHR!



Resting Heart Rate



Resting Heart Rate for MEN

	Age	18-25	26-35	36-45	46-55	56-65	65+
Athlete		49-55	49-54	50-56	50-57	51-56	50-55
Excellent		56-61	55-61	57-62	58-63	57-61	56-61
Good		62-65	62-65	63-66	64-67	62-67	62-65
Above Average		66-69	66-70	67-70	68-71	68-71	66-69
Average		70-73	71-74	71-75	72-76	72-75	70-73
Below Average		74-81	75-81	76-82	77-83	76-81	74-79
Poor		82+	82+	83+	84+	82+	80+

Resting Heart Rate for WOMEN

	Age	18-25	26-35	36-45	46-55	56-65	65+
Athlete		54-60	54-59	54-59	54-60	54-59	54-59
Excellent		61-65	60-64	60-64	61-65	60-64	60-64
Good		66-69	65-68	65-69	66-69	65-68	65-68
Above Average		70-73	69-72	70-73	70-73	69-73	69-72
Average		74-78	73-76	74-78	74-77	74-77	73-76
Below Average		79-84	77-82	79-84	78-83	78-83	77-84
Poor		85+	83+	85+	84+	84+	84+

Stroke volume

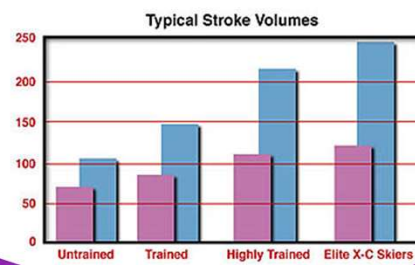


Stroke Volume

- Amount of blood ejected by the left ventricle per beat

Average SV for a male is 70ml per beat

As we get more fit, our SV increases



https://en.wikipedia.org/wiki/Stroke_volume



Relationship between SV and RHR

Why does RHR go down when we are fitter?

- The heart is a muscle that gets bigger and stronger as we get fitter
- A bigger and stronger heart causes more blood to be pumped each beat;
- Therefore, SV goes up.
- With increased SV, we are circulating more blood per beat
- Since we are circulating more blood per beat, we don't need as many beats
- Therefore RHR goes down!

Cardiac Output



Cardiac Output (Q)

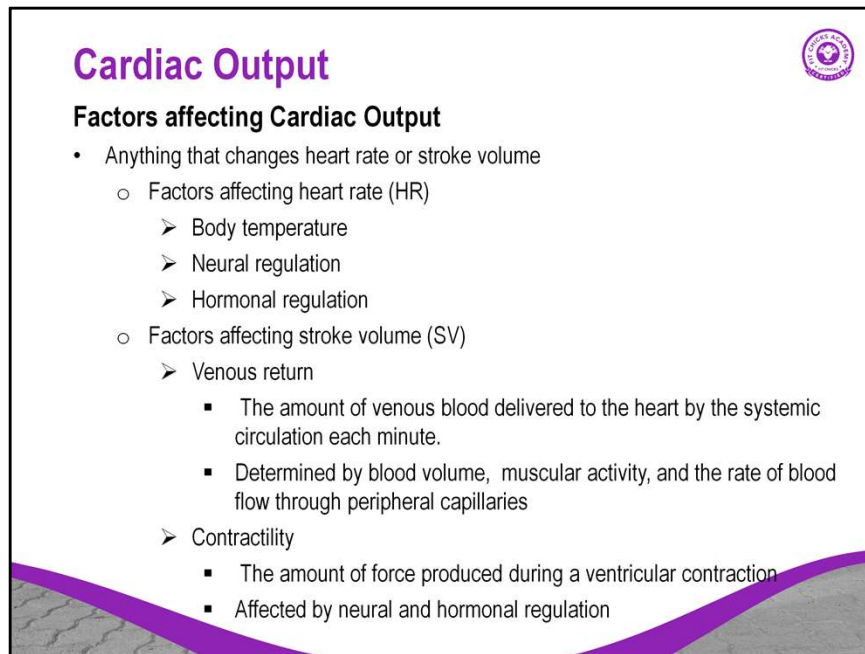
- The amount of blood pumped by the left ventricle in one minute
- Measured in L/min
- Can vary greatly depending on metabolic demands

$$Q = SV \times HR$$

Ex. Heart rate is 75bpm and stroke volume is 80ml/beat

- Must convert 80 ml to L = 0.08L
- $Q = SV \times HR$
= 0.08 L/beat x 75 beats/min
= 6 L/min

Martini, F.H., Ober, W.C., Bartholomew, E.F., Nath, J.I. (2013). Visual Essentials of Anatomy and Physiology. 450



Cardiac Output

Factors affecting Cardiac Output

- Anything that changes heart rate or stroke volume
 - Factors affecting heart rate (HR)
 - Body temperature
 - Neural regulation
 - Hormonal regulation
 - Factors affecting stroke volume (SV)
 - Venous return
 - The amount of venous blood delivered to the heart by the systemic circulation each minute.
 - Determined by blood volume, muscular activity, and the rate of blood flow through peripheral capillaries
 - Contractility
 - The amount of force produced during a ventricular contraction
 - Affected by neural and hormonal regulation

Martini, F.H., Ober, W.C., Bartholomew, E.F., Nath, J.I. (2013). *Visual Essentials of Anatomy and Physiology*. 450

Body temp rises – HR goes up

Body temp decreases – HR goes down

Sympathetic (fight or flight) regulation increases HR, parasympathetic (rest and digest) decreases HR

Hormones that increase HR – epinephrine and thyroid hormones



Max Heart Rate

Human heart can only beat 220 x per minute (only a young child)

HR Max

- $220 - \text{Age}$

To determine a target HR %

- $(220 - \text{age}) \times \%$

So let's figure out 55% of my MAX HR (I'm 34)

- Ex. $(220 - \text{Age}) \times \%$
= $(220 - 34) \times 55\%$
= $(186) \times 0.55$
= 102bpm

HR Zones



50-70% Low Intensity

- Ideal range for warming up and cooling down
- Helps to improve blood flow and circulation to your working muscles.
- It is also the desired zone for LISS (low intensity steady state training), such as walking.
- This is the “Fat Burning Zone”

70-80% Moderate Intensity

- Great for developing endurance and burning calories.
- Training in this zone will cause your body to rely on both carbs and fats for energy.
- This is a good zone for building general fitness.

80- 95% High Intensity

- This is anaerobic zone and therefore not sustainable for a long time
- It takes you out of your comfort zone (HIIT training)
- This is going to give maximum EPOC

Let's Practice



Denise is 25 years old and is looking for her target heart rate zone for LISS (50-70%)



Let's Practice - Denise

We need to calculate Denise's HR at both 50% and 70% to get her target HR for LISS

Lower target heart rate:

$$(220-25) \times .5$$

$$= 195 \times .5$$

$$= 97.5$$

Upper target heart rate:

$$(220-25) \times .7$$

$$= 195 \times .7$$

$$= 136.5$$

So, Denise's target heart rate for her goals would be between 98 to 137bpm

Heart Rate Reserve



Heart Rate Reserve

- The difference between resting heart rate (RHR) and maximum heart rate (HR_{Max})
- Once you know HRR it can be used to estimate aerobic exercise training zones

$$HRR = HR_{Max} - RHR$$

- To calculate HR at a given training intensity (HR zone percentage), add the given % of HRR to RHR

$$\text{Target HR} = [(HR_{Max} - RHR) \times \% \text{ of target intensity}] + RHR$$

- This gives you an estimate of aerobic exercise at a target intensity

https://support.polar.com/ca-en/support/faqs/Heart_Rate_Reserve_HRR

Using HRH to calculate target intensity will give a more specific heart range for your client because it takes into account resting HR.

For example: Target intensity 70 % HRR for a person with HR_{max} 201 bpm and HR_{rest} 50 bpm

$$\begin{aligned} \text{Exercise HR} &= [(201-50) \times 70\%] + 50 \\ &= (151 \times .7) + 50 \\ &= 105.7 + 50 \end{aligned}$$

Exercise HR=155 bpm

If you didn't use RHR and the heart rate reserve calculation and just calculated a 70% target intensity you would get a different number:

$$\begin{aligned} \text{Exercise HR} &= (220 - \text{age}) \times 70\% \\ &= 201 \times .70 \end{aligned}$$

Exercise HR=140 bpm

Without knowing resting heart rate, this persons target HR at 70% would be 140bpm but knowing RHR, their target HR at 70% would actually be 155bpm. If they were just going by max HR then this client would be working at a lower capacity then what they should be.



Let's Practice!

$$\text{Target HR} = [(\text{HR}_{\text{Max}} - \text{RHR}) \times \% \text{ of target intensity}] + \text{RHR}$$

Don is 36 and has a RHR of 72 and wants to do HIIT training (80-95% of Max HR). What should his target HR be during the high intensity intervals?



Lower Target Heart Rate

We need to calculate both Don's Lower target (80%) and upper target (95%)

$$\text{Target HR} = [(\text{HR}_{\text{Max}} - \text{RHR}) \times \% \text{ of target intensity}] + \text{RHR}$$

$$\text{Target HR} = [(220 - 36) - \text{Resting Heart Rate}] \times \% + \text{RHR}$$

$$\text{Target HR} = [(184) - 72] \times \% + \text{RHR}$$

$$\text{Target HR} = [(112) \times 0.80] + \text{RHR}$$

$$\text{Target HR} = 89.6 + \text{RHR}$$

$$\text{Target HR} = 89.6 + 72$$

$$\text{Target HR} = 162$$

So, Don's lower target HR is 162bpm which is 80% max intensity

First we calculate Max heart rate (220-age):

Then we calculate HRR ($\text{HR}_{\text{Max}} - \text{RHR}$):

Then we calculate % target HR:

Going back to the previous discussion about target HR. If you didn't know Don's RHR then you would just use the (220-age) x Target % which would give you 147bpm. With this as his target, he would be working at a lower capacity and not actually reaching his 80% target.



Upper Target Heart Rate

We do the same thing to calculate Don's upper target heart rate

$$\text{Target HR} = [(\text{HR}_{\text{Max}} - \text{RHR}) \times \% \text{ of target intensity}] + \text{RHR}$$

$$\text{Target HR} = [(220 - 36) - \text{RHR}] \times \% + \text{RHR}$$

$$\text{Target HR} = [(184) - 72] \times \% + \text{RHR}$$

$$\text{Target HR} = [(112) \times 0.95] + \text{RHR}$$

$$\text{Target HR} = 106.4 + \text{RHR}$$

$$\text{Target HR} = 106.4 + 72$$

$$\text{Target HR} = 178$$

So, Don's upper target heart rate is 178bpm which is at 95% max intensity

Therefore, Don's target heart rate for HIIT (80-95% of HR max) is **162 – 178 bpm**



Measuring Exertion

There are other ways to measure exertion other than HR

Modified Borg Scale

- Measures the exerciser's **Rate of Perceived Exertion (RPE)**
- Borg scale 6-20
- Modified Borg scale 1-10 (More widely used)
 - 1 - 4: No effort, daily living
 - 5 - 7: Light Effort, body temperature is raised, breathing a little heavier but can talk and sustain for a long period of time
 - 7 - 8: Definitely feels like work. Breathing heavier but can still talk. Sustainable for 15-40 mins, depending on fitness
 - 8 - 9.5: Everything you have. Breathless. Can't sustain it longer than 1 min or so.

Measuring Exertion

Talk Test

- **Aerobic**
 - Should be able to talk, but not sing!
- **Anaerobic**
 - Should be able to answer a question, but not ask it!



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FITT for Cardio

Frequency

- 3-5 x per week

Intensity

- 50-85% of HR Max

Time

- 20 - 45 mins

Type

- LISS (50-75%) for cardiovascular endurance adaptations
- HIIT (75-90%) for fat loss and to train for certain sports



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Quiz!

What is ATP?

Define Aerobic vs. Anaerobic

Which energy system produces the most ATP?

Which energy system would I be using if I am working at very high intensity?

Explain why I shouldn't stay in my Fat Burning Zone

What is EPOC?

What's normal BP? Stroke Volume?

Why does our HR go down when we get fitter?

What is HRR?



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Recap

BIOENERGETICS

- Muscle Metabolism: the role of ATP
- How energy is created in the Human Body
 - Cellular Respiration and the different energy systems
- Interval Training
- Burning Fat vs. Burning Carbs
- Why interval training so effective
- Muscle soreness and recovery

CARDIORESPIRATORY CONCEPTS

- Anatomy of the Cardiorespiratory System
- Heart Rate, Blood Pressure, VO₂MAX, Stroke Volume, Cardiac Output,
- How to determine your Heart Rate Training Zone
- Training adaptations



**Any questions or inquiries,
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