Energy systems

What are aerobic and anaerobic exercise?

- “Aerobic” means “needs oxygen.” Aerobic exercise uses a steady supply of oxygen during exercise, while burning both fat and carbohydrates for energy. It gets your heart rate up for longer periods of time. That’s why it’s commonly called “cardio.”
- Weight lifting and similar strength training activities are examples of anaerobic exercise. Anaerobic exercise involves a short burst of intense movement, while only burning carbohydrates for energy. It does not require oxygen.

Aerobic vs. anaerobic

- Aerobic exercise is any type of cardiovascular conditioning or "cardio." During cardiovascular conditioning, your breathing and heart rate increase for a sustained period of time. Examples of aerobic exercise include swimming laps, running, or cycling.
- Anaerobic exercises involve quick bursts of energy and are performed at maximum effort for a short time. Examples include jumping, sprinting, or heavy weight lifting.
- Your respiration and heart rate differ in aerobic activities versus anaerobic ones. Oxygen is your main energy source during aerobic workouts.
- During aerobic exercise, you breathe faster and deeper than when your heart rate is at rest. You're maximizing the amount of oxygen in the blood. Your heart rate goes up, increasing blood flow to the muscles and back to the lungs.

Aerobic vs. anaerobic

- During anaerobic exercise, your body requires immediate energy. Your body relies on stored energy sources, rather than oxygen, to fuel itself. That includes breaking down glucose.
- Your fitness goals should help determine whether you should participate in aerobic or anaerobic exercise. If you're new to exercise, you might want to start with aerobic exercises to build up endurance.
- If you've been exercising a long time or are trying to lose weight quickly, add anaerobic workouts into your routine. Sprints or high intensity interval training (HIIT) may help you meet your goals.

Benefits of aerobic exercise

- Aerobic exercise can offer numerous benefits for your health, including reducing your risk of a heart attack, type 2 diabetes or a stroke
- Other benefits of aerobic exercise include:
- can help you lose weight and keep it off
- may help lower and control blood pressure
- may increase your stamina and reduce fatigue during exercise
- activates immune systems, making you less likely to get colds or the flu
- strengthens your heart
- boosts mood
- may help you live longer than those who don't exercise

Risks of aerobic exercise

- Aerobic exercise can benefit almost anyone..
- If you're new to aerobic exercise, it's important to start slowly and work up gradually to reduce your risk of an injury. For example, start by walking 5 minutes at a time and add 5 minutes each time until you're up to a 30-minute brisk walk.

Benefits of anaerobic exercise

- Anaerobic exercise can be beneficial if you're looking to build muscle or lose weight. It can also be beneficial if you've been exercising for a long time, and are looking to push through an exercise plateau and meet a new goal. It may also help you maintain muscle mass as you age.
- Other benefits include:
- strengthens bones
- burns fat
- builds muscle
- increases stamina for daily activities like hiking, dancing, or playing with kids

Risks of anaerobic exercise

- Anaerobic exercise can be hard on your body. On a 1 to 10 scale for perceived exertion, high intensity anaerobic exercise is anything over a seven. It's not typically recommended for fitness beginners.
- Get your doctor's approval before adding anaerobic workouts to your routine. Work with a certified fitness professional who can help you create an anaerobic program based on your medical history and goals.
- For workouts like HIIT and weight training, a fitness professional can also demonstrate the correct exercise techniques. Performing the exercises with proper technique is important for preventing an injury.

How often should you do aerobic vs. anaerobic exercise?

- The American Heart Association recommends healthy adults get at least 30 minutes of moderate-intensity aerobic exercise at least 5 days a week, or at least 25 minutes of vigorous aerobic activity 3 days a week. You can also add in strength training two times a week to round out your routine.
- Anaerobic exercises can be taxing on the body. With a doctor's approval and the help of a certified fitness professional, anaerobic exercises can be added into your weekly exercise routine.
- Perform anaerobic exercise like HIIT workouts no more than two or three days each week, always allowing for at least one full day of recovery in-between.

How long should my workout be?

- When it comes to aerobic exercise, think FITT: frequency, intensity, type, and time. The Centers for Disease Control and Prevention recommends getting the equivalent of 30 minutes of moderate-intensity aerobic exercise a day, five days a week. Or 25 minutes of vigorous aerobic exercise, three days a week.
- The CDC also recommends doing muscle-strengthening activities at least twice a week. A single set of 12 repetitions for each muscle group may be enough to maintain your strength. You can increase the number of sets to increase your muscle mass. It's important to allow your body time to recover between workouts, by resting a day or two between strength training sessions.

What's the point of warming up?

- Warming up before exercise can help prevent injuries.
- With aerobic exercise, warming up gradually increases your heart rate and body temperature. To warm up, the American Heart Association suggests doing your planned activity at a lower intensity for the first 5 to 10 minutes. For example, start by walking or jogging if you're going for a run. Or bike around the block at a gentle pace before hitting a mountain-biking trail.
- For strength training sessions, warm up by moving and stretching the areas you plan to target. For example, walk briskly for a few minutes to get your body moving. Then dynamically stretch your arms before bicep curls or your hamstrings before leg presses.

Why do I need to cool down?

- Cooling down after an intense workout is crucial. It helps your heart rate and body temperature gradually return to normal. Stopping suddenly could make you feel ill or even pass out.
- To cool down, consider walking for a few minutes until your heart rate has dropped to normal. Then take some time to stretch. Stretching can help prevent the buildup of lactic acid and may help reduce muscle stiffness and cramping after exercise.
- Rehydrating is also an important part of cooling down, no matter what type of exercise you've done. Be sure to drink water before, during, and after your workout. You can also replenish your energy with healthy snacks that combine carbohydrates and protein.

Better together

- Aerobic and anaerobic exercise both have their benefits. Including both aerobic and strength training activities in your regular workout routine will give you the best of both worlds.
- Varying your workouts can help keep exercise interesting. It may help you reach your fitness goals a little faster. For example, try a mix of different aerobic activities, such as running, hiking, cycling, and dancing. Dedicate different strength training sessions to different muscle groups. This will give them time to recover between workouts.
- Including a variety of aerobic and strength training activities in your routine may help you reach your fitness goals faster.

Energy Systems

ATP is generated through 3 different energy systems

- The energy system the body generates it through depends on the intensity and the duration of the exercise being performed
- ATP-PC system = very quick explosive exercise
- Lactic Acid system= Moderately intense exercise lasting several minutes
- Aerobic system= Long duration exercise

Anaerobic and Aerobic An anaerobic energy system is one that does not require oxygen to generate ATP An aerobic energy system is one that does require oxygen to generate ATP

ATP-PC

ATP-PC system •Is an anaerobic energy system •Used for explosive exercises lasting 8-10 seconds •Generates ATP very quickly but only limited supply (runs out quick) •The most inefficient energy system

ATP-PC system- How it works •ATP is stored in the muscles and liver for quick access •ATP stores run out in 2-3 seconds •When you move ATP is broken down to ADP +P to generate energy for the body to use. •When the Phosphate is split that's where the energy comes from

ATP stores in the muscle run out very quickly therefore we must generate more

VERY useful for quick explosive exercises, generates ATP very quickly but also runs out quickly

ATP-PC : HOW IT WORKS

•Phosphate creatine (PC) is another compound stored in the muscle

•Is broken down to P+C to release energy for ADP to combine with the extra Phosphate •However PC stores also run out quickly and that is why ATP-PC system only lasts for 10seconds •

PC stores back to 98% after 3 minutes of rest PC P C Energy ADP P Energy ATP

- Eg: Heavy Weight lifting, 100m sprint

LACTIC ACID ENERGY SYTEM

- Also known as the Anaerobic energy system
- Breaks down glucose and glycogen to form ATP
- Generating ATP through this energy system also produces lactic acid
- Lactic acid causes our body to fatigue
- Therefore can only be used for exercises lasting 2-3 minutes
- Lactic build up makes muscles feel heavy and tired

LACTIC ACID SYSTEM : HOW IT WORKS ?

- Lactic acid energy system-How it works •When the muscles run out of PC stores must generate ATP another way – lactic acid energy system •Body breaks down glucose or glycogen to generate ATP through a process called Anaerobic glycolysis or just glycolysis
- If oxygen is not present the body will also produce lactic acid in the process
- 1 molecule of glucose will produce 2 molecules of ATP
- 1 molecule of glycogen will produce 3 molecules of ATP
- Glycogen is stored in the muscles and live

Eg: 400 run

AEROBIC SYSTEM

- Most efficient energy system – also slowest
- Can only generate ATP in the presence of oxygen
- Is used for long distance events or exercises lasting longer than 5 minutes

AEROBIC SYSTEM: HOW IT WORKS

- Begins the same way the lactic acid energy system does- breakdown of glucose and glycogen
- If oxygen IS present lactic acid will not be produced and instead more ATP is formed through Aerobic glycolysis
- Generates ATP much slower than Anaerobic glycolysis and even more slower than ATP-PC system therefore is used for low intensity/long duration exercise.
- With oxygen 1 glucose molecule generates 36 molecules of ATP
- 1 glycogen molecule generates 37 molecules of ATP Fatty acids are broken down to produce 129ATP

- Eg: Marathon, Long distance cycling

Oxygen deficit and steady state VO2

- **Oxygen deficit refers to the delay in oxygen uptake at the** onset of exercise.
- **Steady state VO2** is the plateau in oxygen uptake which is attained within 1- 4 minutes of constant exercise.
- **Trained subjects will reach steady state faster than** untrained subjects.
- This is likely because trained subjects have improved aerobic response to exercise stimulus.

Oxygen deficit and debt/EPOC during light and heavy exercise

- **The term "oxygen debt" should not be used in exercise** physiology.
- Excess Post-exercise Oxygen Consumption (EPOC) is a more correct term for the elevated VO2 seen after exercise.
- **Oxygen deficit** occurs at the onset of exercise when workload is greater than aerobic metabolism which can support exercise load.
- Takes time to increase aerobic metabolism from rest to exercise load
- The difference between the metabolic need and the aerobic contribution is the O2 deficit.
- **Steady State** is reached once the aerobic metabolism meets the workload demand. The workload must remain constant and if the workload is greater than VO2max, steady state will never be reached.
- **Oxygen Debt** is Following the exercise bout, O2 consumption is elevated for a period of time which is referred to as O2 debt.
- Paying back the deficit:- The debt is composed of a rapid and a slow component.

Oxygen deficit and debt/EPOC during light and heavy exercise

- **Resynthesis of PC** synthesized rapidly within minutes
- Restoration of muscle and blood O2 stores restored more quickly than PC stores Potential factors contributing to O2 debt (fast)
- **Potential factors contributing to O2 debt (slow)**
- Lactate removal possibly slow
- Elevated body temperature may be elevated for prolonged period
- Post-exercise elevation in HR and breathing
- Probably there will be Elevations in hormones (epinephrine, norepinephrine)

Removal of Lactate Following Exercise

- **Metabolic Response to Short-Term Intense Exercise**
- High-intensity, short-term exercise (0-10 seconds):- ATP production through ATP-PC system
- Intense exercise longer than 20 seconds :- ATP production via anaerobic glycolysis
- High-intensity exercise longer than 60 seconds:- ATP production primarily through oxidative mechanisms
- **Metabolic Response to Prolonged Exercise**
- Exercise longer than 10 minutes :- ATP production primarily from aerobic metabolism
- Steady state oxygen uptake can generally be maintained
- Prolonged exercise in a hot/humid environment or at high intensity the Steady state will not be achieved which causes Upward drift in oxygen uptake over time
- **Metabolic Response to Exercise: Incremental Exercise** •
- Oxygen uptake increases linearly until VO2max is reached and No further increase in VO2 with increasing work rate
- Physiological factors influencing VO2max :- Ability of cardiorespiratory system to deliver oxygen to muscles and Ability of muscles to take up the oxygen and produce ATP aerobically

Incremental exercise

- Incremental exercise and VO2max
- **the lactate threshold is an inflection point where** concentrations in the blood increase exponentially with an increase in workrate it will often correspond to the ventilatory threshold where an individual's breathing becomes labored Lactate Threshold
- **Potential mechanisms to explain the lactate threshold** phenomenon is low muscle oxygen as the individual exercises at a higher intensity, oxygen availability in the muscle is insufficient to meet the "aerobic" system demands this produces a back log and pyruvate must be converted to lactate this is an unlikely scenario as oxygen delivery and utilization is quite efficient Potential Contributors to the Lactate Threshold
- **Accelerated glycolysis** as the increasing energy demands of intense work cannot be met by "aerobic" glycolysis-Krebs alone, glycolysis is accelerated in order to produce a little more energy (ATP)
- **Failure of the hydrogen shuttle to keep pace can increase lactate concentration**:- with recruitment of fast twitch fibers for hi intensity "anaerobic" activities will accumulate Lactate by coverting pyruvate to lactate whereas slow twitch fibers used for low intensity "aerobic" activities readily convert lactate back to pyruvate.
- RER = VCO2/VO2 that is the ratio of CO2 produced to O2 consumed Fuel Utilization During Exercise can be Determined by Gas Exchange
- CO2 production is an estimate of the relative contribution of glycolysis to energy production glucose >> pyruvate >> acetic acid + CO2 >>>> Krebs >>> O2 + H20 when fat enters Krebs as acetyl coA no CO2 is produced, BUT CO2 is formed in Krebs
- Percentage of fat and carbohydrate metabolized as determined by a non-protein Respiratory Exchange Ratio (RER)
- at higher intensity workloads, carbohydrate will become the primary fuel source conversely, at lower workloads, fats will predominate Intensity vs Fuel Source

Exercise Fuel

- The crossover concept of metabolism vs. intensity
- **for short duration or during the early stages of prolonged**exercise, carbohydrates will be the primary fuel source for longer duration fat will become the predominate source Duration vs Fuel Source
- Fuel shifts from CHO to fat during prolonged exercise
- **Sources of Fuel During Exercise**
- **Carbohydrate** :- Blood glucose/Muscle glycogen
- **Fat :-** Plasma FFA (from adipose tissue lipolysis) and Intramuscular triglycerides
- **Protein** :- Only a small contribution to total energy production (only ~2%) which May increase to 5-15% late in prolonged exercise
- **Blood lactate** :- Gluconeogenesis via the Cori cycle

Muscle fuel sources in highly trained endurance athletes

- Fuel Sources in Highly Trained Athletes
- Low Intensity :- Primary source plasma FFA (from fat stores)
- Middle Intensity :- Equal from plasma FFA and muscle glycogen
- High Intensity :-Muscle glycogen predominate source
- Contributions of four energy sources over prolonged time in endurance athletes
- Prolonged Exercise in Trained Endurance Athletes (70 % VO2max) • Less than 1 hour glycogen is primary single source
- FFA and muscle triglycerides comprise 50 %
- As exercise progresses Contribution from glycogen reduced Muscle triglycerides (intramuscular fat) also reduced also
- FFA and plasma glucose increase -Must feed to maintain plasma glucose
- The Cori cycle: lactate as a fuel source