Alphabetical Glossary

Alphabetical glossary of terms

Aerobic literally means 'with oxygen.' Aerobic metabolism is the supply of energy for long, submaximal work by chemical reactions between oxygen and fuels like glucose and fats that are carried by the blood. When a person walks, jogs, bikes, or swims for many minutes (or even hours) the heart, lungs, and blood vessels supply oxygen fast enough to keep up with the pace. Dissipation of heat and removal of waste products like CO_2 and water are also functions of the heart, lungs, blood, and sweat glands.

A high **aerobic capacity** helps a hockey player compete or practice at a higher intensity without relying heavily on anaerobic metabolism. Aerobic capacity can be raised by distance work or by interval training, but interval training is too stressful to maintain over the entire twelve months.

Aerobic capacity is highly related to endurance for distance events. In the laboratory, this can be measured in several ways:

VO_2 Max is the maximum volume of oxygen a person is capable of using in one minute of exercise. Usually, during a progressive treadmill or bicycle test, a subject will reach this maximum before having to stop. Often the subject continues to higher levels of work while oxygen consumption levels off. For this reason, VO_2 max is easily identified as the peak point and is a reliable (and somewhat valid) indicator of a person's endurance capacity.

Anaerobic threshold is the point during progressive work where lactic acid starts to build up disproportionately fast in the muscles. Another way to describe it is the level of work above which lactic acid accumulates rapidly, and below which lactic acid does not accumulate substantially in the blood. It is often associated with increased blood lactate, hyperventilation, and perceived discomfort.

Oxygen uptake kinetics is the exponential rate at which oxygen uptake adjusts to a sudden workload. Note: at the beginning of exercise (and often in anticipation) the heart and breathing rates increase immediately, because of input from the nervous system. However, the metabolic machinery is not as responsive, because these chemical reactions are driven by the heat from exercise, by concentrations of accumulating end products (like CO_2, ADP, lactic acid, or many other intermediates), or by deficits in chemicals like ATP or oxygen. Furthermore, enzymes are 'turned on' by these same factors and by other circulating hormones released during exercise. Therefore, the utilization of oxygen at the tissue level (measured by the amount of oxygen taken out of the air as you breathe) rises gradually (in 40-80 seconds) to equal the demand of the given workload.

Oxygen deficit: Since the metabolic adjustment at the beginning of work is not immediate, but the energy demand is, there is an energy deficit being built up which must be repaid later as an oxygen debt. Like any debt, the cost at a later time is greater than the actual expenditure.

Oxygen debt is the repayment (after exercise ends) of the energy deficit built up during exercise. From the discussion on anaerobic metabolism, it is observed, that the workload is met only partially by aerobic processes, but also by the breakdown of **ATP, CP,** and **glycogen** and results in the buildup of creatine and lactic acid. These fuels must be returned to pre-exercise levels, and this process requires energy, usually keeping the oxygen uptake levels above the basal rate for 10-30 minutes.

Anaerobic literally means 'without oxygen.' When a player exercises nearly all out (above his anaerobic threshold), the heart lungs, and blood vessels can no longer supply oxygen or remove waste products fast enough for the energy demands. The energy (over and above that supplied aerobically) comes from chemical conversion (without oxygen) of fuels stored in the muscle.

Alactic anaerobic metabolism is the conversion of **high energy phosphates** for a very brief, explosive workload, such as a 5-10 second sprint or strength effort. **ATP** (adenosine triphosphate) supplies the energy for muscular contraction and all other cell activities by splitting off one of its phosphates in a chemical reaction which liberates a great deal of energy. Since ATP levels must be (and generally are) kept constant, creatine phosphate (**CP**) will donate its phosphate to adenosine **di**phosphate. The measurement of this ability is sometimes called **anaerobic power** and is determined by how explosively an athlete can perform for a short effort.

Glycolytic metabolism (glycolysis) is the conversion of muscle glycogen (glucose) to **lactic acid** in the absence of oxygen. This releases energy to re-supply the ATP stores. However, the increased acidity eventually prevents effective muscle contraction, limiting all-out effort to 20-40 seconds. After that point, coordination, speed, and strength are adversely effected. Interval training (eg: 40:80 seconds) would allow players to eventually function better and longer with acid buildup during a very intense shift. The measurement of this ability is called **anaerobic endurance.** Continuing these anaerobic intervals for the length of a game or practice leads to more and more lactic acid buildup and eventually depletes muscle glycogen stores.

ATP (adenosine triphosphate) is the body's energy currency. In its chemical bonds, it stores energy for all of the processes of life like muscle contraction and relaxation, and supporting cell growth, integrity, and duplication, maintaining electrical potentials, and pumping certain molecules in and out of cells. For any reaction requiring energy, one phosphate is split off from ATP. If an athlete has trained for power, his muscles will have more enzymes to make the muscle contract and use ATP faster. They should also have more enzymes to re-supply the ATP either by aerobic or anaerobic metabolism.

CP (creatine phosphate) is the most immediate source of replacement of the phosphate to ADP (adenosine diphosphate) to convert it back to ATP. Powerful sprinters or weightlifters, whose performance lasts only a few seconds, have more of the enzymes (creatine phosphokinase) that aid in this reaction.

Capillaries are the smallest blood vessels, whose diameter allows red blood cells through in single file. Capillaries are intermediate between arteries and veins, and are the place for exchange of water, oxygen, fuels, waste products, and any other molecules from the blood to other tissue (such as muscle tissue).

From training (for as little as a few days) the microscope can detect an increase in capillary density around those muscle fibers that have been working aerobically.

Cardiovascular refers to the heart and vessels. Very often this term is over-used to describe aerobic training and its benefits, but this term does not acknowledge the beneficial changes in the lungs, blood, and muscle.

Cholesterol is a ring shaped molecule manufactured in the body for vital purposes such as in the composition of cell membranes and as a building block for physiological hormones. It is also manufactured by the body to line the arteries in areas where they have been damaged by nicotine, high blood pressure, or other trauma. This is where cholesterol gets its bad reputation, because it is part of the plaque which builds up and narrows the arteries over time. Don't be fooled by advertisements which claim that a food product has no cholesterol. If the food is rich in saturated fats, it leads to an increase in blood cholesterol, and this is one of the potent risk factors for future vascular disease.

Enzymes are the large proteins which facilitate chemical reactions within the body. Enzymes are not 'used up' or 'broken down' in the process, and are therefore, not part of the chemical reaction as either a product or reactant. However, they speed up the reaction by bringing the reactants (fuels) together, repositioning them, even changing their shape, so the chemicals will react more readily.

Fat as a fuel in the body is in the form of **tri-glyceride**, a molecule that contains glycerin and three long carbon chains called fatty acids.

Glucose is the six carbon sugar of the blood. It is used for energy supply to the brain, to muscles, and to other active organs.

Glycogen is the storage form of glucose within cells (like the liver and muscles). Many molecules of glucose are chemically bonded together to form glycogen, and when the cell needs energy, the first step is to split each glucose molecule away from glycogen.

Metabolism is the conversion of chemicals within the body to supply energy. See also **aerobic** and **anaerobic** metabolism.

Mitochondria are small bodies (organelles) within a cell. These are often called the 'powerhouse' of the cell, because this is where aerobic energy metabolism takes place. Mitochondria contain all the enzymes of the Krebs citric acid cycle and of the electron transport chain. After several weeks of aerobic training, the slow twitch (and fast twitch intermediate) fibers contain more mitochondria, giving the muscle fiber greater capacity to exchange oxygen and fuels for energy.

Muscle fibers are long, thin muscle cells which have the ability to contract and relax when they are electrically stimulated by nerve impulses or when they are stretched. Energy for contraction is stored in several chemical forms (each one is discussed in this glossary): ATP, CP, fat, protein, glucose, and glycogen.

Any muscle is composed of several fibers, up to thousands of fibers in the large muscles of the leg. Fibers contract all-out when stimulated by the nerve. That is, no fiber is capable of making progressively stronger contractions. The two ways a muscle can contract with varying strength is to either fire more of these fibers or have each one contract more often.

There are two distinct types of muscle fibers, categorized by the speed at which they can contract and relax.

Fast twitch fibers contract very rapidly and powerfully when stimulated. They have a high concentration of enzymes to split ATP for contraction and replace the ATP quickly through anaerobic metabolism. Because they contain fewer mitochondria, fewer enzymes of aerobic metabolism, and are surrounded by fewer capillaries, fast twitch fibers are more easily fatigued.

Fast twitch glycolytic fibers are the powerful fibers of sprinters and weight lifters. These fibers appear more pale than slow twitch fibers. In some animals, certain muscles are composed almost entirely of fast twitch fibers, like the white meat of turkeys or chickens. These are powerful muscles with little endurance, like domestic chicken breasts which are not used for long flight. Wild ducks or geese, on the other hand, have darker red breasts, because they are the muscles of endurance flights. In humans most muscles are heterogeneous, having a combination of fast and slow twitch fibers. Most physiologists think the overall percentage of each type in a human is determined genetically. However, there is evidence that different training regimes might change the relative makeup.

Fast twitch intermediate fibers have some of the best characteristics of fast and slow fibers. Probably as a result of rigorous training, these fast twitch fibers are large, powerful, and quick, but have great endurance as well. Intermediate fibers appear more reddish because they are surrounded by many capillaries and because they have more **myoglobin**, the chemical which binds or stores oxygen in the muscle and appears red (because of the combination of iron and oxygen).

Slow twitch fibers are smaller in diameter and contract more slowly and with less force than fast twitch. Long distance runners usually have a greater percentage of these than power athletes. Hockey players, and the average person have about 50% of each type. The endurance of a slow twitch fiber results from greater blood supply, more mitochondria, along with an enzyme profile opposite to fast twitch fibers. Any one nerve axon supplies several fibers, all of the same type. A nerve together with all its fibers is called a **motor unit**.

Neuromuscular refers to all the interractions between nerves and muscles.

Plyometrics are jumping or hopping exercises, whose purpose is to train with great force in an explosive manner. There are two components to train. When any muscle is stretched, it actively contracts against the stretch because of a neuromuscular reflex. This is the same stretch reflex that is observed when the doctor taps your patellar tendon, stretching the quadriceps muscle, causing it to contract quickly. The second component is the strengthening of tendons and connective tissue surrounding muscles. These function like a rubber band or spring during jumping. The more training the stronger the spring.

Sports sciences mentioned in this book:

Biomechanics deals with the physics of motion of the entire body or the relative motion of individual limbs. Two branches of physics (mechanics and kinetics) describe these motions in terms of distance-time relationships like velocity and acceleration or force-time relationships like force, torque, work, and power.

Physiology is the study of how the body works on the cellular level. On a larger scale, physiology describes the function of various organs and how they work together to support life and react to stress, such as exercise. Biochemistry includes the description of all the chemical reactions within the body, such as those dealing with energy metabolism, electro-chemical signals, or the breakdown or construction of substances involved in cell structure or regulation. Biophysics, unlike biomechanics, deals with other areas of physics such as electricity, hydrostatic and osmotic pressure, and the flow of water and particles through vessels and leaky membranes.

Statistics and abbreviations used in this text:

Correlation (Pearson product-moment correlation in this text) is simply a number, r, which expresses the degree to which two variables are related, the extent to which one could be predicted from the other variable. The value of **r is zero** if there is no relationship at all. On the other hand, **r is 1 or -1** if the value of one variable is predictable, simply by knowing the value of the other variable. In this case, the x,y graph of these two variables is a straight line.

Regression equation for two variables is the equation of the straight line which best fits the data or best describes the relationship between the two variables.

T-test (Student's t-test) in this text is an expression for the probability, p, that two group means (A and B) are truly different. For example: to say that research results showed that A was greater than B and **p<.01**, means that if we continued to randomly compare groups from A against groups from B, the probability is greater than 99% that we would continue to get the same result, that A>B.