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Health -related physical fitness

Sports nutrition is a topic of constant change and has grown as a dynamic field of clinical study. Research continues to advise improved nutritional guidelines and support for both active adults and competitive athletes.[1] Science recognizes sports nutrition and energy intake as the *"cornerstone of the athlete's diet."*

What Is Sports Nutrition?

Sports nutrition is the foundation of athletic success. It is a well-designed nutrition plan that allows active adults and athletes to perform at their best.

It supplies the right food type, energy, nutrients, and fluids to keep the body well hydrated and functioning at peak levels. A sports nutrition diet may vary day to day, depending on specific energy demands.

Sports nutrition is unique to each person and is planned according to individual goals.

Sports Nutrition Basics

The energy required for living and physical activity comes from the food we eat and fluid intake. Macronutrients in the following food groups supply the energy essential to optimal body function.

Carbohydrates

Carbohydrates are either simple or complex, and the most important energy source for the human body. Simple carbs include sugars naturally occurring in foods like fruits, vegetables, and milk.

Whole grain bread, potatoes, most vegetables, and oats are examples of healthy complex carbs. Your digestive system breaks down carbohydrates into glucose or blood sugar which feeds energy to your cells, tissues, and organs.

Proteins

Proteins are made up of a chain of amino acids and are essential to every cell of the human body. Protein can either be complete or incomplete. A complete protein contains all the amino acids needed by the body, and include animal sources like meat, fish, poultry, and milk.

Incomplete protein sources (typically plant-based proteins) often lack one or more of the essential amino acids. Essential amino acids can't be made by the body and must be supplied by food. Protein plays an important role in muscle recovery and growth.

Fats

Fats can be saturated or unsaturated, and they play a vital role in the human body. Unsaturated fats are considered healthy and come from plant sources like olive oil and nuts.

Saturated fats are found in animal products like red meats and high-fat dairy, which are indicated to increase the risk of disease.

Healthy fats provide energy, help with body development, protect our organs, and maintain cell membranes.

The Goal of Sports Nutrition

Active adults and competitive athletes turn to sports nutrition to help them achieve their goals. Examples of individual goals could include gaining lean mass, improving body composition, or enhancing athletic performance.

These sport-specific scenarios require different nutritional programs. Research findings indicate the right food type, caloric intake, nutrient timing, fluids, and supplementation are essential and specific to each individual.[٢] The following are different states of training and competitive sport benefiting from sports nutrition.

Eating for Exercise/Athletic Performance

Training programs require a well-designed diet for active adults and competitive athletes. Research shows a balanced nutrition plan should include sufficient calories and healthy macronutrients to optimize athletic performance.[١]

The body will use carbohydrates or fats as the main energy source, depending on exercise intensity and duration. Inadequate caloric intake can impede athletic training and performance.

Active adults exercising three to four times weekly can usually meet nutritional needs through a normal healthy diet. Moderate to elite athletes performing intense training five to six times weekly will require significantly more nutrients to support energy demands.

For example, and according to research, energy expenditure for extreme cyclists competing in the *Tour de France* is approximately ١٢,٠٠٠ calories per day.[١]

- **Carbohydrates** are the main fuel source for an active adult or competitive athlete. General guidelines for carbohydrate intake are based on body size and training characteristics. Carbohydrate needs in a daily diet can range from ٤٥ to ٦٥٪ of total food intake depending on physical demands.[٣]
- **Proteins** are responsible for muscle growth and recovery in the active adult or athlete. Sufficient amounts of protein per individual help maintain a positive nitrogen balance in the body, which is vital to muscle tissue. Protein requirements can vary significantly ranging from .٨g to ٢g per kilogram of body weight per day.[٤]
- **Fats** help maintain energy balance, regulate hormones, and restore muscle tissue. Omega-٣ and omega-٦ are essential fatty acids that are especially important to a sports nutrition diet. Research findings recommend an athlete consume approximately ٣٠٪ of their total daily caloric intake as a healthy fat.[١]

Eating for Endurance

Endurance programs are defined as one to three hours per day of moderate to high-intensity exercise. High-energy intake in the form of carbohydrates is essential. According to research, target carbohydrate consumption for endurance athletes ranges from ٦g to ١٠g per kilogram of body weight per day.[٥]

Fat is a secondary source of energy used during long-duration training sessions. Endurance athletes are more at risk for dehydration. Replacing fluids and electrolytes lost through sweat are necessary for peak performance.

Marathon Training and Race Day Diet and Fluids

Eating for Strength

Resistance training programs are designed to gradually build the strength of skeletal muscle. Strength training is high-intensity work. It requires sufficient amounts of all macronutrients for muscle development.

Protein intake is especially vital to increase and maintain lean body mass. Research indicates protein requirements can vary from ١.٢g to ٣.١g per kilogram of body weight per day.[٥]

How to Eat to Gain Muscle

Eating for Competition

Preparing for a competitive sport will vary in sports nutrition requirements. For example, strength athletes strive to increase lean mass and body size for their sport. Endurance runners focus on reduced body weight/fat for peak body function during their event.

Athletic goals will determine the best sports nutrition strategy. Pre and post-workout meal planning are unique for each athlete and essential for optimal performance.

Hydration and Sports Performance

Adequate hydration and electrolytes are essential for health and athletic performance. We all lose water throughout the day, but active adults and athletes lose additional body water (and a significant amount of sodium) sweating during intense workouts.

Dehydration is the process of losing body water, and fluid deficits greater than ٢ percent of body weight can compromise the athletic performance and cognitive function. Athletes are recommended to use fluid replacement strategies as part of their sports nutrition to maintain optimal body functioning.

Rehydration with water and sports drinks containing sodium are often consumed depending on the athlete and sporting event. Lack of sufficient hydration for athletes may lead to the following:[٦]

- Hypohydration (dehydration)

- Hypovolemia (decreased plasma/blood volume)
- Hyponatremia (low blood sodium levels/water intoxication)

Supplements in Sports Nutrition

Sports supplements and foods are unregulated products marketed to enhance athletic performance. According to the *Academy of Sports Medicine*, "the ethical use of sports supplements is a personal choice and remains controversial."

There are limited supplements backed by clinical research. The *Australian Institute of Sport* has provided a general guide ranking sports performance supplements and foods according to the significance of scientific evidence:[٧]

- **Sports food:** sports drinks, bars, and gels, electrolyte supplements, protein supplements, liquid meal supplements
- **Medical supplements:** iron, calcium, vitamin D, multi-vitamin/mineral, omega-٣ fatty acids
- **Performance supplements:** creatine, caffeine, sodium bicarbonate, beta-alanine, nitrate

Special Circumstances

Sports nutrition covers a wide spectrum of needs for athletes. Certain populations and environments require additional guidelines and information to enhance athletic performance.

Vegetarian Athlete

A vegetarian diet contains high intakes of plant proteins, fruits, vegetables, whole grains, and nuts. It can be nutritionally adequate, but insufficient evidence exists on long-term vegetarianism and athletic performance.

Dietary assessments are recommended to avoid deficiencies and to ensure adequate nutrients to support athletic demands.

High Altitude

Specialized training and nutrition are required for athletes training at high altitude. Increasing red blood cells to carry more oxygen is essential. Iron-rich foods are an important component of this athlete as well.

Increased risk of illness is indicated with chronic high altitude exposure. Foods high in antioxidants and protein are essential. Fluid requirements will vary per athlete, and hydration status should be individually monitored.

Hot Environments

Athletes competing in hot conditions are at greater risk of heat illness. Heat illness can have adverse health complications. Fluid and electrolyte balance is crucial for these athletes.

Hydration strategies are required to maintain peak performance while exercising in the heat.

Cold Environments

Primary concerns for athletes exercising in the cold are adequate hydration and body temperature. Leaner athletes are at higher risk of hypothermia. Modifying caloric and carbohydrate intake is important for this athlete. Appropriate foods and fluids that withstand cold temperatures will promote optimal athletic performance.

Eating Disorders and Deficiencies

Eating disorders in athletes are not uncommon. Many athletes are required to maintain lean bodies and low body weight and exhibit muscular development. Chronic competitive pressure can create psychological and physical stress of the athlete leading to disordered eating habits.

Without proper counseling, adverse health effects may eventually develop. The most common eating disorders among athletes may include:[٨]

- Anorexia nervosa
- Bulimia
- Compulsive exercise disorder
- Orthorexia[٩]

Obviously, the nutritional needs of these individuals greatly differ from that of other active adults or athletes. Until someone with an eating disorder is considered well again, the primary focus should be put on treating and managing the eating disorder and consuming the nutrition needed to achieve and maintain good health, rather than athletic performance.

Micronutrient deficiencies are a concern for active adults and athletes. Exercise stresses important body functions where micronutrients are required.

Additionally, athletes often restrict calories and certain food groups, which may potentially lead to deficiencies of essential micronutrients. Research indicates the most common micronutrient deficiencies include:[١٠]

- **Iron deficiency** can impair muscle function and compromise athletic performance
- **Vitamin D deficiency** can result in decreased bone strength and reduced muscle metabolic function
- **Calcium deficiency** can impair the repair of bone tissue, decrease regulation of muscle contraction, and reduce nerve conduction

Roles of a Sports Dietitian

Athletes and active adults are seeking guidance from sports professionals to enhance their athletic performance. Sports dietitians are increasingly hired to develop nutrition and fluid programs catered to the individual athlete or teams.

A unique credential has been created for sports nutrition professionals: *Board Certified Specialist in Sports Dietetics* (CSSD). Sports dietitians should have knowledge in the following areas:[١١]

- Clinical nutrition
- Counseling for health and athletic performance
- Design and management of effective nutrition strategies
- Effective nutrition programming for health, fitness, and optimal physical performance
- Evidence-based research
- Exercise physiology
- Medical nutrition therapy
- Nutrition science
- Safe and effective nutrition assessments
- Sports nutrition guidance

Looking for a sports nutritionist? The International Society of Sports Nutrition offers a reputable online directory.

The History of Doping

The term “doping” refers to the use of prohibited medications, drugs, or treatments by athletes with the intention of improving athletic performance. The practice of doping by athletes dates back centuries. However it has recently received increased attention due to a wide variety of potential performance enhancing drugs that are now available, and also due to prominent cases of doping by elite athletes that have been reported in the media.

The idea of performance enhancement through drug therapies and diet can be traced back centuries to the time of the invention of sports. Individuals chosen to be athletes were fed specific diets and certain herbs and plants thought to improve physical power and performance. In ١٩٠٤, doping was first noted at the Olympic Games in a runner who was injected with strychnine to assist with speed, and purportedly giving him the strength to finish the race.

Regulations

Despite the visible improvement in performance noted in countless athletes throughout several centuries, it was also noted that the athletes would often suffer adverse health effects and even premature death that seemed to be associated with the doping practices. These adverse outcomes and deaths lead to the first ban on doping by the International Association of Athletics Federation in ١٩٢٨. This ban proved to be inadequate however, as the ability to test for banned substances was quite limited at that time. In ١٩٦٧ the International Olympic Committee (IOC) banned doping, and in ١٩٩٩ the IOC led the initiative to form the World Anti-Doping Agency (WADA). Today WADA forms the backbone of anti-doping laws and testing worldwide, and assists in setting the standard for other agencies and sports. WADA’s main activities include education of the health risks of doping, scientific research of doping practices, development of anti-doping capabilities, and development of testing methods for doping detection.

According to the World Anti-Doping Code, which was established by WADA in ٢٠٠٨, a substance or treatment constitutes doping if it meets two of the three following criteria:

- It enhances performance
- It presents a risk to the athlete’s health
- It is contrary to the spirit of the sport

This code consists of a yearly-published list of prohibited substances and treatment methods that athletes are not allowed to use. Various penalties can be enforced upon athletes found to be in violation of the Anti-Doping Code. Many athletes found in violation of the code have previously suffered punishments ranging from being stripped of Olympic medals or sports titles to lifetime bans from future competition in sport.

Methods and Goals of Doping

The goals of doping practices typically fall into four broad categories. These are substances that increase muscle mass, substances that decrease recovery time, substances that increase energy and/or endurance, and substances that mask the presence of other drugs. A few examples of substances and methods used in doping are noted below.

Anabolic Drugs (Anabolic Steroids)

Anabolic steroids have been prevalent in professional sports since they were first used in the ١٩٥٠s in weight lifters. They have been used extensively in strength-based sports such as weight lifting, football, baseball and many other sports. Anabolic steroids are typically synthetic derivatives of testosterone. The goal of their use in doping is to increase muscle mass and lean body weight. These medications can be taken either orally or by injection, and many different forms are often taken simultaneously to maximize their desired effects. Users often take these drugs for their desired effects such as increased muscle strength and size, however many major and minor adverse health effects are related to their use. Relatively minor health effects such as skin infections, acne, irreversible gynecomastia (male development of breast tissue), and testicular shrinkage are well described with anabolic steroid use. Additionally severe and potentially life-threatening effects such as psychosis, bleeding around the liver, increased risk of heart attack, and sudden death has been associated with anabolic steroid use. Due to the many adverse health effects associated with anabolic steroid use, they are listed as controlled substances in the United States, are permanently listed on the World Anti-Doping Code, and are routinely tested for in elite athletes.

Stimulants

Stimulant drugs are composed of a large and diverse group of drugs, which when used for doping purposes have the intent to increase an athlete's stamina, decrease their sensation of fatigue and pain, and improve their mental function and behavior. The most common stimulants detected in anti-doping tests include amphetamines, cocaine, ecstasy and methylphenidate (Ritalin). The actual effects vary according to the drug and its method of ingestion—drugs that are snorted or injected will produce more immediate results than those that are taken in pill form. Amphetamines were initially desirable in athletes as they decreased the sensation of pain and fatigue. Amphetamines have been documented to have been used in many sports such as cycling, soccer and track and field, and were first noted in the Olympics of ١٩٣٦. However, despite their widespread use, amphetamines were quickly found to be associated with many undesirable and sometimes life-threatening effects. Amphetamines have been linked with increased risk of seizures, heart attacks and sudden death along with many other effects, and therefore have been banned for use both in sport and also are illegal for personal use as well. Stimulant drugs are the second largest class of banned drugs on the WADA Anti-Doping Code, and are also routinely tested for in elite athletes

Stimulants are drugs that directly affect the central nervous system. They work to speed up parts of the brain and body, increasing the heart rate, blood pressure, metabolism and body

temperature of the user. They are used by athletes to reduce tiredness and fatigue, and to increase alertness, competitiveness and aggressiveness.

Nicotine and caffeine are also frequently used as stimulants but they are not banned in sports. However, both substances are currently on the WADA Monitoring Program for ٢٠١٨. WADA is observing them in order to detect potential patterns of misuse in sport.

The risks of using stimulants vary for each drug, but in general are high. For example, cocaine use can cause panic attacks and paranoia, lead to the loss of smell and problems swallowing, become addictive and, in rare cases, lead to heart attack. Amphetamines can cause damage to the liver, kidneys and cardiovascular system, and cause hallucinations and violent behaviour, while long term use can change the structures of the brain involved with memory and emotion.

Hormones

The endocrine system is the system in the human body that produces and regulates hormones. Hormones are responsible for almost every bodily function including muscle development and growth. Several hormones have been discovered which function to increase protein production and therefore are involved in increasing muscle mass. Hormones such as insulin and human growth hormone (hGH) have been used by athletes in an attempt to increase muscle mass and definition. While some of these therapies have been successful previously, they are also associated with severe health effects such as low blood sugar, fluid overload and limb swelling, overgrowth of bone and heart attacks. Due to these and many other dangerous health effects, these substances are also listed on the Anti-Doping Code.

Oxygen Transport (“Blood Doping”)

Lastly, athletes may try to improve their performance in sport by increasing the amount of oxygen in their bloodstream. As oxygen one of the basic nutrients for all cells, increased oxygen delivery to tissues can improve endurance and athletic performance. Athletes have attempted to achieve this goal in many ways. Some athletes will have their own blood drawn months in advance of a competition, only to be re-transfused into the same athlete just prior to the competition to increase their blood volume and the amount of oxygen in that blood during the competition. Other athletes have used certain medications such as erythropoietin, that work to increase the body’s production of red blood cells, which carry oxygen to the cells. Overall, increased red blood cell volume ensures increased oxygen delivery to cells, and likely improved endurance. However, the body is quite sensitive to such changes, and as the volume of blood increases, the blood thickens, increasing the risk of high blood pressure, strokes, heart attacks, and sudden death.

Consequences of Doping

We know that the majority of athletes are clean and abide by the Anti-Doping Rules. We work hard to help protect your reputation and sporting achievements.

We also know that some athletes will choose to cheat - and we work hard to detect doping behaviour and remove those doing so from sport.

We also know that some athletes may be more vulnerable to a doping decision.

Remember, not knowing is not an excuse - and there is limited sympathy for carelessness in anti-doping.

If you're found doping and face a ban from sport that is only the beginning. The consequences of doping to your health, psychological and mental wellbeing - as well as the social and financial consequences - are far reaching and damaging.

The facts - what you need to know

For Anti-Doping Rule Violations of presence or use of a prohibited substance, the basic rules are as follows:

- If you intended to cheat, whatever the substance, the period of ineligibility is four years
- Otherwise, it is two years – unless you can show you had no significant fault or negligence, in which case ineligibility may be reduced by up to a maximum of one year (that is, to a minimum ineligibility of one year)
- If the violation involved a specified substance or a contaminated product, and you can demonstrate you had no significant fault, ineligibility may range from two years to a reprimand (depending on your level of fault)

You should also be aware that multiple Anti-Doping Rule Violations, or the presence of multiple substances may increase the sanction you face beyond four years.

For some Anti-Doping Rule Violations the penalty can be a life ban from sport.

What that means for you

It is not simply the detection of a banned substance in a sample that can result in an Anti-Doping Rule Violation (ADRV). There are ١٠ ADRVs that can result in a sanction, and these are not only applicable to athletes, six also apply to a coach or athlete support personnel.

If you believe you have inadvertently doped then you must be able to prove that fact, demonstrating that you were either not at fault or intending to cheat. That is not always easy to do.

There is also a potential for a reduced sanction if an athlete admits guilt promptly following an ADRV, or provides useful and reliable information which results in UKAD (or any other

Anti-Doping Organisation) discovering or bringing forward an ADRV by any other person. This is known as 'substantial assistance'.

What you should do

- Make sure you stay up to date with anti-doping matters to prevent inadvertent doping and keep records of any enquiries you make about any supplements you may take.
- Seek help when you feel under pressure or unable to cope with the demands of training and competing – there are always alternatives to doping that will not damage your health, reputation and sporting career
- Develop your resilience over your sporting career - working with your coach, wider support team, parents and other athletes
- Remember that the majority of athletes are clean – doping athletes are not the majority

Doping Tests

Doping testing is an activity that is strictly specified in the International Standard for Testing and Investigations. Urine, blood or both are collected as test samples. Doping testing takes place both at competitions and outside of them.

Doping test types

There are two types of doping tests: in-competition tests and out-of-competition tests. An athlete can be summoned to testing at any time and anywhere, either in their home country or abroad. The athlete is invited in person.

In-competition tests

In-competition tests refer to doping tests performed in connection with a competition event. Unless otherwise specified in the rules of the international or another relevant antidoping organisation, this refers to a period starting ١٢ hours prior to the competition and ending at the end of the competition and the related collection of samples.

All known doping substances and methods and any manipulation of the sample are tested from samples collected in connection with competitions.

The athletes are drawn or ordered to undergo testing based on ranking, for example, or chosen for it as specified in the competition rules of the sport. The athletes can also be ordered to take the test by name in the in-competition tests.

In some sports, a record result (Finnish record, European record, world record) cannot be officially approved until the athlete in question has produced a negative sample. After breaking a record, the athlete must attend the doping control in a manner provided by the rules of the sport. The athlete can acquire further information from his or her sports federation.

Out-of-competition tests

Targeted doping tests are also carried out outside of competitions. Out-of-competition samples are tested for non-approved substances, anabolic agents, peptide hormones, growth factors and similar substances, ß٢-agonists, hormone and metabolism modulators, diuretics and other masking agents as well as all prohibited methods.

International sports federations may have rules of their own regarding the substances to be tested. It is the athletes responsibility to be aware of the relevant rules.

Athletes are chosen for out-of-competition tests in a targeted manner or by drawing the athletes to be tested during the training of a certain group or athletes on a camp. In targeted tests, FINCIS or another antidoping organisation that has ordered the test has named the athlete in advance for the test.

Targeted tests are mainly carried out for testing pool and national team athletes. FINCIS can, however, target any athlete bound by the antidoping code for testing, both in-competition and out-of-competition.

Out-of-competition tests also include follow-up tests made to clarify the results of previous tests and tests carried out during a period of ineligibility due to antidoping rule violations.

Sample types

Doping tests consist of taking a urine sample or a blood sample or both. A blood sample does not replace a urine test, because it concerns primarily different substances and different methods.

Urine tests

Doping control is most often carried out based on urine tests. The urine sample is used in analysing the use of prohibited substances and methods.

Blood tests

Blood samples may be taken for identifying prohibited substances and methods, for screening or as a part of long-term monitoring in order to create an athlete's personal profile.

Blood samples are collected according to the instructions of the International Standard for Testing and Investigations. They are taken by a person who, in addition to training and authorisation provided by FINCIS, has vocational training in health care and is qualified to take blood samples. Blood tests are carried out, for example, in order to detect growth hormone and the use of various artificial substances and methods related to the manipulation of blood.

Athlete Biological Passport

FINCIS also utilises personal profiles created for athletes as well as any information that can be obtained from these profiles. Certain biological variables of an athlete will be monitored regularly throughout his/her athletic career. Changes in the athlete's profile may reveal the use of doping.

An athlete's individual profile, i.e. the so-called Athlete Biological Passport (ABP) system, is about monitoring selected biological variables (such as haemoglobin and haematocrit in the haematological profile and testosterone and epi-testosterone in the steroid profile) over an extended period of time. The results are used to create a profile which serves as an athlete's personal reference value range instead of population-based reference values used earlier.

The Athlete Biological Passport system can be used as a tool for targeting and scheduling testing. It can also be used for indirectly showing any use of doping agents or methods and therefore an antidoping rule violation.

effects of physical activity on body systems

Neural Adaptations

- Increased central drive (from the higher centers of the brain) after resistance training is partly responsible for the increase in strength
- Increased Motor Unit (MU) synchronization (several MU's firing at similar times)
- Decrease in the force threshold at which Motor Units are recruited
- Increased Motor Unit firing rate
- Decrease in the level of co-activation of antagonist muscles after training

Muscular Adaptations

Skeletal muscle will adapt to mechanical overload by increasing in muscle size. With resistance training various signaling mechanisms are activated and these initiate the creation of new proteins and the enlargement of muscle fibre and muscle cell size leading to hypertrophy with little evidence showing an increase in the number of muscle fibres (hyperplasia) taking placeVarious adaptations include:

- Increase in the cross sectional area of the muscle
- Changes in muscle architecture
    - Ultrasound studies have shown changes in the angle of fiber pennation (the angle at which fibres are aligned in regards to their insertion to the aponeuroses of the muscle). This will affect force output by determining the physiological cross sectional area (where the cross-section area is determined perpendicular to the line of pull of the muscle fibres).
- Hypertrophy of fibre types at cellular level, especially in Type II fibres:
    - Research shows a decrease in the number of Type IIx fibres, together with an increase in Type IIa fibres
    - Fast twitch muscle fibres are inherently stronger (greater force per unit area) and have a high speed of shortening, therefore "a given enlargement of a fast twitch fibre should have a proportionately greater effect on strength and power than the same growth of a slow twitch fibre.

Adaptations to Endurance Training

Endurance training is focused on increasing muscle fatigue resistance for exercise of longer duration. Fatigue is defined as: "a loss in the capacity for developing force and/or velocity of a muscle, resulting from muscular activity under load and which is reversible by rest." Performance in endurance activities is dependent on the body's ability to produce sufficient ATP through aerobic respiration. This process requires the neuromuscular, cardiovascular and respiratory systems to interact. The focus will be more on the local adaptations that happens in skeletal muscle for the purpose of this page.

Essentially, endurance training and activity enhances the oxidative capacity and metabolic efficiency of skeletal muscle. The adaptations that it achieves this through are: oxygen

utilisation (mitochondrial adaptations), oxygen delivery (angiogenesis) and local substrate availability.

Mitochondrial Adaptations (Oxygen Utilisation)

Mitochondria is the "powerhouse" of the cell. These organelles generate the majority of the cell's supply of ATP through aerobic respiration. Endurance training can:

- increase the volume and number of mitochondria and the magnitude of these changes are dependent on the frequency and intensity of training

With the increased number and size of mitochondria, the proportion of pyruvate formed during glycolysis passing into the mitochondria for oxidative phosphorylation is increased with less used for the production of lactate and its byproducts. As a result the exercise intensity, which can be sustained through relying on aerobic metabolism, is higher.

Angiogenesis (Oxygen Delivery)

The network of capillaries adjacent to the muscle fibres is responsibly for the diffusive exchange of gasses, substrates and metabolites between the circulation and the working muscle fibres. Endurance training results in:

- the growth of new capillaries (process of angiogenesis), with an increase of ~٢٠٪ being present after ٨ weeks of training in both Type I and Type II fibres

Substrate Utilisation

During submaximal exercise the main fuel sources are carbohydrates (mainly muscle glycogen) and fats (local and circulating fatty acids). Endurance training leads to a key adaptation in substrate utilisation:

- for a given level of submaximal exercise the contribution of fatty acid oxidation to the total energy requirement increases with a marked increase in the muscle's ability to utilise intramuscular triglycerides as the primary fuel source.
- Training results in more glycogen being stored in muscle fibres, in form of granules, this leads to a greater number of intramuscular lipid droplets being in contact with the mitochondria
- Endurance athletes rely on on improved fatty acid oxidation as it conserves muscle glycogen stores (these are more needed during exercise of high intensity)[١]

Neural Adaptations

With endurance training the following adaptations occur in the neural system:

- Motor unit discharge rate decreases
- Slower rate of decline in Motor unit conduction velocity during sustained contractions is found after endurance training]
- Decrease in Motor unit recruitment thresholds

Comparison of Neuromuscular Adaptations to Strength and Endurance Training

Variable	Strength Training	Endurance Training
Muscle fibre size	increase	no change
Number of muscle fibres	no change	no change
Movement speed	increase	no change
Strength	increase	no change
Aerobic capacity	no change	increase
Anaerobic capacity	increase	no change
Capillary density	no change or decrease	increase
Mitochondrial density	decrease	increase
Type II muscle fibre subtype conversion	almost all to Type IIa	with sprint interval majority to Type IIa

Short Term Effects of Exercise on Respiratory System

When your activity level changes, your body has to respond by making changes to your respiratory system. The change in activity will also affect your muscles and the circulatory system.

۱. *Changes in Circulatory System*

The change in your activity will have an immediate effect on your heart rate. In fact, the release of adrenaline can change your heart rate even before you begin your activity. This in turn increases your cardiac output as well as venous return.

۲. *Changes in Respiratory System*

The short-term effect of exercise on respiratory system is usually quite extensive and that is mainly due to the changes in the concentration of oxygen and carbon dioxide in the blood. It is due to these changes that you will notice your breathing rate go up quickly. This also makes your intercostals muscles, diaphragm, and other muscles involved in the expansion of thoracic cavity to work harder. This in turn will make it possible for you to inhale more air to deal with the increased demand for oxygen.

Long Term Effects of Exercise on Respiratory System

Your respiratory system responds to a change in your activity level almost immediately, but there will also be some long-term effect of exercise on respiratory and circulatory system. Here is more about it.

١. Changes in Heart Rate

When you exercise, your adrenal gland becomes active and prepares you for the hard work by releasing adrenaline and noradrenaline. These hormones affect the way your heart transports carbon dioxide and oxygen throughout the body. This requires your heart to beat stronger, and this is where the hormones will help by stimulating the sympathetic nervous system. Your heart rate will increase and your cardiac output will go up to help you deal with the strenuous physical activity.

٢. Changes in Respiratory Muscles

Exercise leaves an effect on your diaphragm and intercostals muscles, and regular exercise will help strengthen the respiratory muscles. Over time, this also helps chest caving become larger.

٣. Changes in Respiratory Volume

The respiratory volume goes up immediately, and regular exercise leads to an increase in overall efficiency of your respiratory system. In fact, people who exercise regularly develop an improved ability to consume oxygen during maximal exercise. This ability is measured using a test called a VO_2 max test.

٤. Changes in the Gaseous Exchange

Studies show that regular exercise has the ability to increase the number of capillaries around the alveoli. Moreover, regular exercise can help capillaries dilate more, which in turn facilitates efficient exchange of gasses.

٥. Changes in Lung Efficiency

The overall efficiency of lungs improves through regular exercise. The benefit comes mainly due because your lungs can now deliver oxygen to the cells of the body. Regular exercise also increases blood flow, which in turn strengthens the lungs and ensures better exchange of gasses.

Effects of Exercise on the Immune System

KEY POINTS

- Regular moderate exercise reduces the risk of infection compared with a sedentary lifestyle, but very prolonged bouts of exercise and periods of intensified training or competition are associated with increased risk of infection. In athletes, a common

observation is that symptoms of respiratory illness cluster around competitions and these can impair exercise performance.

- Prolonged bouts of strenuous exercise have been shown to result in transient depression of white blood cell functions and it is suggested that such changes create an "open window" of decreased host protection, during which viruses and bacteria can gain a foothold, increasing the risk of developing an infection. Other factors such as psychological stress, lack of sleep and malnutrition can also depress immunity and lead to increased risk of infection.
- Periods of intensified training with insufficient recovery may result in a temporary state of immunodepression which should recover with a few days of relative rest.
- There are several behavioral, nutritional and training strategies that can be adopted to limit exercise-induced immunodepression and minimise the risk of infection. Athletes can limit their risk of infection by avoiding close contact with people who are showing symptoms of infection, by practising good hand, oral and food hygiene, and by avoiding the sharing of personal items such as towels and drink bottles.
- For maintaining robust immunity, getting adequate recovery and sleep is important, as is avoiding deficiencies of protein and micronutrients (particularly iron, zinc and vitamins A, D, E, B٦ and B١٢).
- Athletes are advised to ingest carbohydrate (٣٠-٦٠ g [١-٢ oz] per h) during prolonged training sessions, and consume – on a daily basis – plant polyphenol (flavonoid) containing supplements or foodstuffs and Lactobacillus probiotics. Vitamin D٣ supplementation may also be desirable for some athletes as vitamin D deficiency is common in the winter months.

Exercise and digestion can be mutually exclusive. When you exercise, your body isn't using its energy for digestion. Instead, it slows any digestion currently taking place so it can divert as much blood as it can to feed your muscles and your lungs.

If you've just eaten before exercising, you can experience gastrointestinal problems. Depending on the type of food you've eaten and the intensity of your exercise program, you may suffer from heartburn, abdominal pain, or even vomiting. (See below for pre-exercise eating tips.) Any and all symptoms should be diagnosed by your gastroenterologist for an accurate diagnosis and treatment plan.

For example, eating a complex meal that's high in fiber, protein or fat before a high-intensity workout is not a good idea and may not end well. So if you only remember one thing from this article, remember that exercise time does not coincide with digestion time.

Gastrointestinal Benefits of Exercise

That doesn't mean you should give up exercising! A regular exercise regimen — along with a positive mental outlook and a healthy, high-fiber diet — are the building blocks of a healthy lifestyle. Exercise can even help treat constipation and promote healthy digestion!

Over time, regular exercise can strengthen your digestive tract. If you're fit, the amount of blood diverted from your digestive system decreases because the need is less urgent. Your muscles are more efficient when you're in shape.

Caution When Exercising

Give your body the proper time to digest before exercising. If you eat a meal heavy in proteins and fats, you may need two or three hours for digestion. Your blood sugar rises to help you digest. Wait for it to drop back to normal so you can devote all your energy to your workout.

A large meal, especially if it contains a lot of fat, can delay your digestion, which in turn should delay your exercise time. On the other hand, not eating anything before a workout will leave you feeling tired and weak. Unless it's the day before a marathon, eat a balanced meal and give yourself time to digest before you exercise.

In addition, keep hydrated while you exercise. Dehydration is one of the leading causes of exercise-related gastrointestinal problems. It can lead to constipation, acid reflux, and even microscopic death of your intestines if you don't absorb all the nutrients and oxygen from the food in your system during digestion.

Runners in particular can be subject to bouts of diarrhea. It's the combination of the physical jarring and the lack of blood to the intestines that can cause the condition. Avoid caffeine, dairy products and sugar substitutes before you exercise if you're susceptible.

Pre-Exercise Eating Tips

- Ideally, eat about three hours before you exercise. Eat less if you dine less than two hours before your workout.
- Eat food you can digest easily, like those high in carbohydrates and low in fats. Bananas, toast and oats are excellent low-fiber carbohydrate sources.
- Avoid proteins and high-fiber foods, which digest more slowly.
- Keep yourself hydrated during your exercise regimen.
- When hydrating, make sure you drink enough to support your activity.

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- SPORT INJURIES
- The term sports injury, in the broadest sense, refers to the kinds of injuries that most commonly occur during sports or exercise. Some sports injuries result from accidents, others are due to poor training practices, improper equipment, lack of conditioning, or insufficient warm-up and stretching.
- Although any part of your body can be injured during sports or exercise, the term is usually reserved for injuries that involve the musculoskeletal system, which includes the muscles, bones, and associated tissues like cartilage.
- **A strain** is an injury which occurs to a muscle in which the muscle fibers tear as a result of overstretching. Strains are also colloquially known as *pulled muscles*. The equivalent injury to a ligament is a sprain. Typical symptoms of a strain include localized pain, stiffness, swelling, inflammation, and bruising around the strained muscle.
- Strains can happen to anyone and are certainly not restricted to athletes; nevertheless, people who are involved in sports are more at risk of developing a strain.
- **A sprain** is an injury which occurs to ligaments caused by a sudden overstretching. The ligament is usually only stretched, but sometimes it can be snapped, slightly torn, or ruptured, all of which are more serious and require longer to heal.
- Sprains are graded in three degrees. Although some signs and symptoms can be used to assess the severity of a sprain, the most definitive method is with the use of *Magnetic Resonance Imaging* (MRI). A first degree sprain has only minor tearing of the ligament whereas a third degree sprain is characterized by complete **rupture**.
- The typical signs and symptoms associated with a sprain are the cardinal signs of inflammation: localized pain, swelling, and loss of function.
- Although any joint can experience a sprain, some of the more common include the ankle, knee, and fingers. Perhaps one of the more spoken about sprains is that to the Anterior Cruciate Ligament of the knee. This is a disabling sprain common to athletes, especially basketball, soccer, and judo players.
- Sprains can best be prevented by proper use of safety equipment (wrist, ankle guards), warm-ups and cool-downs (including stretching), being aware of your surroundings and maintaining strength and flexibility.
- **Achilles tendon injuries** refer to a stretch, tear, or irritation to the tendon connecting the calf muscle to the back of the heel. The most common cause of Achilles tendon tears is a problem called tendinitis, a degenerative condition caused by aging or overuse. When a tendon is weakened, trauma can cause it to rupture.
- **A bone fracture** is a medical condition in which a bone becomes cracked, splintered, or bisected as a result of physical trauma. In orthopaedic medicine, fractures are classified as *closed* or *open* (compound) and *simple* or *multi-fragmentary* (formerly comminuted).
- **Closed fractures** are those in which the skin is intact, while **open (compound) fractures** involve wounds that communicate with the fracture and may expose bone to contamination. Open injuries carry an elevated risk of infection. They require antibiotics treatment and usually urgent surgical treatment. This involves removal of all dirt, contamination, and dead tissue.
- **Simple fractures** are fractures that occur along one line, splitting the bone into two pieces, while **multi-fragmentary fractures** involve the bone splitting into multiple pieces. A simple, closed fracture is much easier to treat and has a much better prognosis than an open, contaminated fracture. Other considerations in fracture care are displacement and angulation. If angulation or displacement is large, reduction

(manipulation) of the bone may be required and, in adults, frequently requires surgical care.

- **Stress fractures** occur largely in the weight-bearing bones, such as the tibia or fibula (bones of the lower leg) and metatarsals (bones of the foot), and are common in sports that require repetitive impact, primarily running/jumping sports such as gymnastics or track and field. Running creates forces two to three times a person's body weight on the lower limbs.
- Stress fractures usually have a narrow list of symptoms. It could present as a generalized area of pain, tenderness, and pain with weight-bearing. Usually when running, a stress fracture has severe pain in the beginning of the run, moderate pain in the middle of the run, and severe pain at the end and after the run. X-rays usually do not show any evidence of stress fractures, so a CT scan, or MRI may be more effective in unclear cases.
- Joint **dislocation** takes place when bones in a joint become displaced or misaligned. It is often caused by a sudden impact to the joint. The ligaments almost always become damaged as a result of a dislocation. Once a joint is dislocated, it may reduce (return to its proper position) on its own, or it may require physical manipulation. Once reduction is achieved, the joint is held in place through a splint (for straight joints like fingers and toes) or a bandage (for complex joints like shoulders). Even if a dislocated joint reduces on its own, it should be immobilized and medical attention should be sought. Contact sports such as football and basketball, as well as high-impact sports and sports that can result in excessive stretching or falling, cause the majority of dislocations. The shoulders, fingers, and wrists are all common places for a dislocation to occur.
- **Menisci** are cartilaginous elements within the knee joint which serve to protect the ends of the bones from rubbing on each other and to effectively deepen the tibial sockets into which the femur attaches. There are two menisci in each knee, the medial and the lateral meniscus. Either or both may be cracked, or torn, when the knee is forcefully rotated and/or bent.
- **Overtraining** occurs when the volume and intensity of an exercise exceeds the organism’s recovery capacity. Improvements in strength and fitness occur only during the rest period following the training. This process takes at least ٣٦ hours to complete. If sufficient rest is not available then complete regeneration cannot occur. If this imbalance between excess training and inadequate rest persists then the individual's performance will eventually plateau and decline. Overtraining may be accompanied by one or more of the following symptoms: persistent muscle soreness, persistent fatigue, elevated resting heart rate, increased susceptibility to infections, increased incidence of injuries, irritability, depression and loss of motivation.
- Fortunately, most sports injuries can be treated effectively, and most people who suffer injuries can return to a satisfying level of physical activity after an injury. Even better, many sports injuries can be prevented if people take the proper precautions.
- The RICE Method

he five-step process for treating a muscle or joint injury such as an ankle sprain is called "P.R.I.C.E." which is short for **P**rotection, **R**est, **I**ce, **C**ompression, and **E**levation).

It can be used even by someone without first-aid training, and should be used immediately when an injury occurs – the **earlier, the better** – while further medical attention is being sought.

If the athlete experiences too much pain during the process, stop immediately.

"P" is for Protection

Protect the injured person and the area being treated but also protect yourself. If the injury occurs on the sports field, stop the game.

Protect the area being treated with a splint if possible.

If the athlete can move, carefully move them to a safer area using a stretcher or a crutch, but if there is any doubt, do not move the injured athlete.

"R" is for Rest

When a child is injured, the body responds in an effort to defend, localize, protect, and clean up the injured area, a response called inflammation. At the time of injury small blood vessels at the injury site rupture and cause tissue bleeding, which, in turn, can cause bruising and swelling.

There are **five warning signs** of inflammation:

- Pain
- Redness;
- Tissue hotness;
- Swelling, and
- Loss of function.

Not every injury exhibits all these signs, but if your child is in pain then it is important to stop exercising immediately to avoid further damage.

"I" is for Ice

- As soon as possible after injury, begin **applying ice continuousl**y for the first ١٥-٢٠ minutes to decrease swelling and pain.
- An ice bag can be **applied directly to the skin** (except on the outside of the knee) unless the child has a known cold allergy.
- The safest form of icing is to use a **plastic bag with ice cubes or crushed ice, or instant cold packs**. Do **not** use “blue ice” or “gel packs”.
- While icing will be uncomfortable at first, in ٢ to ٣ minutes, the skin will go numb and the ice bag will feel more comfortable.
- If the child is very uncomfortable with ice bag, then a barrier like a wet towel can be placed between the ice and skin.
- The ice bag can be secured in place using an elastic bandage, but the compression should not be too tight.
- During the application of the ice, ask the child to wiggle their fingers/toes and monitor tissue around area that is being iced to ensure that they are not experiencing a lost of sensation.

Icing for ١٥-٢٠ minutes with an ice bag is unlikely to cause nerve damage or frostbite; however, any loss of sensation and any changes in tissue coloration in areas other than the area that is being iced indicate that the application is no longer safe.

Because ice and plastic bags are so important, make sure that someone brings these to every practice and game. Better yet, to be on the safe side, bring your own!

"C" is for Compression

- After icing, to further prevent swelling, wrap the injured area with an elastic bandage or compression sleeve.
- Take the wrap and start farthest away from the injured body part to the heart.
- Continuously wrap, always making sure to cover half of the previously wrapped area.
- As you get closer to the end of the wrap, you don't need to wrap as tightly.
- You will know you have wrapped correctly when the hurt part ends up in the middle of the wrap.
- Tension should be firm but still comfortable. Tingling or pain means it's too tight.
- Incorrect application of an elastic wrap could cause further pain and damage and delay healing.

"E" is for Elevation

For both upper and lower limb injuries, it is equally important to keep the limb elevated to minimize swelling. Elevation to the level of the heart or above allows for excess fluid to be pumped back into the blood vessel system and will help prevent further swelling from occurring.

Return to play

In addition to protection, rest, ice, compression, and elevation, restoring range of motion (ROM) is an important part of the recovery process when the swelling and pain begins to subside. Active ROM of an injured joint assists in introducing new blood flow to the injury site to "flush" out any residual cellular waste and joint edema present. Motion also assists in decreasing scar tissue and adhesion formation and stimulates the nervous system to begin activating the muscles that control strength, balance, and proprioception (position-movement sensation or body awareness) when return to play occurs. An athlete experiencing pain or swelling upon return to play or during rehab prior to play should seek the advice of a physician for further evaluation and/or diagnostic testing.

Return to play should ultimately be dictated by:

- pain-free, full range of motion;
- equal strength compared to the uninjured side;
- elimination of bruising and swelling;
- equal balance compared to the uninjured side (if it is a lower body injury); and
- no residual gait deficits.

Not only is rest important in the period immediately after your child is injured, but adequate rest is necessary before your child returns to sports. Returning too soon from an injury can

cause further damage and result in a chronic, long-term condition, such as chronic ankle instability.

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