INTRODUCTION TO EXERCISE PHYSIOLOGY

Author

S. Archana Mani Malathi,

Assistant Professor, Department of Physical Education,
Avinashilingam Institute for Home Science and Higher Education for Women, Avinashilingam University, Coimbatore-641043,
Tamil Nadu, India.

First Edition [2019]
Printed in India
ISBN: [978-93-89128-0-55]

Published by

IOR PRESS INTERNATIONAL,
5/11, Perumal Kovil Street,
Naickenpalayam,
Coimbatore - 641020,
Tamil Nadu, India.
Ph: +91 97917 48838
Email: editor@books.iorpress.org
Website: www.books.iorpress.org

Price: ₹ 850.00

Preface

Introduction to exercise Physiology is intended for students interested in exercise physiology, clinical exercise physiology, human performance, kinesiology, sports and exercise science, physical therapy and physical education. The overall objective of this text is to provide the student with an up-to-date understanding of the physiology of exercise. While the core concepts of exercise physiology remain constant across the world, this local edition has allowed us to make the text more relevant and engaging for students those studying Physical Education. Physical activity, along with proper nutrition, is beneficial to people of all ages, backgrounds, and abilities. Staying active is one of the best ways to keep our bodies healthy and it is important that everyone gets active. After this content, the student is now ready to apply this learning of the fundamentals to more applied exercise physiology knowledge and skills.

Foreward

This text is a welcome new addition to some vintage resources that have not addressed the needs of present-day students and professionals. The author of this book **Ms. S. Archana Mani Malathi,** aspiring Physical Educationist possess ten years of teaching experience in the university has methodically incorporated the contemporary aspects of Exercise Physiology, The book titled **"Introduction to Exercise Physiology**" is designed for the Physical Education Students to enrich knowledge in the field of Exercise Physiology. Its primary purpose is to clarify the latest information in the field. The purpose of this book is to make explicit the various aspects that are inherent in Exercise Physiology, and to offer the reader some tools to deal with them.

The book has six-section structure. The first is focused on showing the context of history and scope of exercise physiology. The second defines the structure and functions. The third contains the effects of exercises in which the PE trainees can be properly implemented. The fourth chapter describes the human performance and importance of exercises. The fifth focused on ergonomics and postures. Finally, the sixth chapter defines diet and performances.

All of this combined will truly capture the interest of the exercise physiology student and hopefully inspire her or him to read and learn with a passion to understand.

Dr. R. Saravana Prabha
Head, Department of Physical Education,
Avinashilingam Institute, Coimbatore,
Tamil Nadu, India.

Learning objectives

1. Describe the general scope of the field of exercise and sport physiology.

2. Describe the general history and major events of the field of exercise physiology in the United States.

3. Describe the importance of exercise physiology as a component of the kinesiology educational curriculum.

4. Define key terminology within exercise physiology.

5. Explain the general principles that form the basis of exercise physiology.

6. Describe and provide examples of the health- and skill-related components of physical fitness.

7. List and explain the principles of exercise training.

8. Identify careers related to exercise physiology.

Key words

Aerobic Exercise - is any physical activity that uses large muscle groups and causes the body to use more oxygen than it would while resting.

Anaerobic Exercise - is a physical exercise intense enough to cause lactate to form. It is used by athletes in non-endurance sports to promote strength, speed and power.

Athlete (American English) or sportsman/ sportswoman (British English) - is a person who is good at a sport and competes in one or more sports that involve physical strength, speed or endurance. The terms apply to those who participate in other activities, such as horse riding or driving, is somewhat controversial.

Barbell - is a piece of exercise equipment used in weight training, bodybuilding, weightlifting and powerlifting, consisting of a long bar, usually with weights attached at each end.

Bench Press - is an upper body strength training exercise that consists of pressing a weight upwards from a supine position.

Bridge-is a grappling move performed from a supine position, lying down face-up. It involves lifting the pelvis off the ground so that the body weight is supported on the shoulders (or head) at one end and on the feet at the other

Callisthenics - are exercises consisting of a variety of gross motor movements—running, standing, grasping, pushing, etc. to increase body strength, body fitness, and flexibility.

Concentric Contraction - muscle tension is sufficient to overcome the load, and the muscle shortens as it contracts. This occurs when the force generated by the muscle exceeds the load opposing its contraction.

Cycling – Riding a bicycle typically involves longer distances than walking or jogging. This is another low stress exercise on the joints and is great for improving leg strength.

Eccentric Contractions - normally occur as a braking force in opposition to a concentric contraction to protect joints from damage.

Elliptical Training – This is a stationary exercise machine used to perform walking, or running without causing excessive stress on the joints. This form of exercise is perfect for people with achy hips, knees and ankles.

Flexibility - refers to the range of movement in a joint or series of joints, and length in muscles that cross the joints to induce a bending movement or motion

Isometrics - are a type of strength training in which the joint angle and muscle length do not change during contraction (compared to concentric or eccentric contractions, called dynamic/isotonic movements). Isometrics are done in static positions, rather than being dynamic through a range of motion.

Jogging - straight's in steady and gentle pace. This form of exercise is great for maintaining weight.

Physical Exercise - is any bodily activity that enhances or maintains physical fitness and overall health and wellness.

Plank - is an isometric core strength exercise that involves maintaining a position similar to a push-up for the maximum possible time.

Plyometrics - also known as "jump training" or "plyos", are exercises in which muscles exert maximum force in short intervals of time, with the goal of increasing power (speed-strength).

Sprinting – retaining the whole body weight in air for few seconds or running short distances as fast as possible

Swimming – Using the arms and legs to keep oneself afloat and moving either forwards or backwards. This is a good full body exercise for those who are looking to strengthen their core while improving cardiovascular endurance.

Treadmill Training – Many treadmills have programs set up that offer numerous different workout plans. One effective cardiovascular activity would be to switch between running and walking. Typically, warm up first by walking and then switch off between walking for three minutes and running for three minutes.

Walking – Maintain anyone foot contact on floor or platform. Moving at a fairly regular pace for a short, medium or long distance.

Weight Plate- is a flat, heavy object, usually made of cast iron, that is used in combination with barbells or dumbbells to produce a bar with a desired total weight for the purpose of physical exercise.

CONTENTS

CHAPTER 1

1.1 History

Exercise has been regarded as important to human health for thousands of years, beginning with ancient cultures. The Greek physician Hippocrates is one of the earliest-recorded and most well-known proponents of exercise. He recommended moderate exercise in order to stay healthy and even improve health. Other prominent ancient scholars throughout history followed suit, including Plato, Aristotle, and the Roman physician Galen, who believed that exercise improved general health, metabolism, and muscle tone, and even led to better bowel movements. Later, the Persian physician Avicenna also wrote in support of Galen in the medical text Canon of Medicine. Avicenna believed that exercise balanced the four body humors (an idea that was popular at the time and had been passed down from Ancient Greece). Importantly, he also recognized that too much exercise could have negative effects on the body.

In the 16th Century, around the twitch of Scientific Revolution, physicians began to write books on exercise. One of the earliest known books on exercise was Book of Bodily Exercise, written by the Spanish physician Cristobal Mendez. In his book, Mendez discussed benefits, types, and values of exercise, along with common exercises and why they were important to perform. In the 19th Century, some medical textbooks began to include chapters on exercise. The negative effects of lack of exercise, including poor circulation, weakness, and increased likelihood of disease, became more well-known. As the importance of physical activity became additional and more important, schools also began to offer physical education classes, which required students to perform exercises for a set period each day.

The first true exercise physiology textbook, Exercise in Education and Medicine by Dr. R. Tait McKenzie, was published in 1910. Laboratories devoted to the study of exercise physiology were also established in the 20th Century. These included the Harvard Fatigue Laboratory, opened in 1927, and the Physical Fitness Research Laboratory at University of Illinois, opened in 1944. These schools conducted numerous on such topics as fatigue, cardiovascular changes during exercise, oxygen uptake by the body, and the effects of training. In 1948, the Journal of Applied Physiology started to be published. This journal publishes peer-reviewed research in exercise physiology and still exists today. While contributing greatly to our understanding of exercise's effects, exercise physiology labs also trained numerous scientists who would go on to find their own exercise physiology laboratories in universities and medical schools all over the world.

Types of Exercise Physiology

The two types of exercise physiology are sport and clinical.

i. Sport exercise physiology is, as its name suggests, related to athletes. Sport physiologists use knowledge of the body's response to exercise in order to develop training regimens for athletes. Such regimens include fitness conditioning, which is the process of training to become more physically fit through periods of exercising certain muscles and resting. Exercise physiology is also sometimes regarded as being either non-clinical or clinical; "non-clinical" is very similar to sport physiology, but the scope is widened to include healthy non-athletes who are looking to lose weight and/or gain fitness.

ii. Clinical exercise physiology is the use of physical activity for therapy, treatment, and prevention of chronic diseases. One disease that can be aided by exercise is diabetes. Exercise uses the body's stored glucose, so a diabetic may use exercise to help keep their blood sugar levels down. Another disease treated with exercise therapy is osteoporosis, the loss of bone tissue that commonly occurs in old age. Osteoporosis may cause joint pain and limit movement. Clinical exercise physiologists work with affected individuals to demonstrate them how to exercise in a safe way that minimizes pain and may recommend activities such as swimming that are easier on the joints. Exercise is also sometimes used as part of a treatment for anxiety and depression, either as a standalone condition or as a result of a physical disease, because it raises serotonin levels and reduces stress.

Scope of Exercise Physiology

1. To apply anatomical, physiological and biomechanical concepts to exercise testing, health and fitness.
2. Identify critical elements of the bones and muscles involved in human movement and combine the concepts related to anatomy and physiology.
3. Competent knowledge in areas of exercise physiology.
4. Understanding of the physiological systems stimulated during exercise
5. Physiological responses to a bout of physical activity
6. Influence of health problems on the capacity to perform exercise

7. Role of regular physical activity in the maintenance of health and physical fitness
8. Principles of exercise training and the various types of exercise training programs
9. Physiological adaptations to regular exercise training
10. need for specific types of exercise programs for people with different health problems
11. Skills in conducting basic fitness physical assessments and exercise tests
12. The role of pre-exercise screening

To understand

1. The basics of the cellular energy systems and how they influence performance
2. How the energy systems acclimate to various exercise training programs
3. Key aspects of the neuromuscular system
4. The role of skeletal muscle and motor units in the control of movement
5. How hormones impact exercise metabolism, substrate utilization and performance
6. The functioning of the heart and circulatory system during acute exercise and how it adapts to exercise training
7. The functioning of the cardio-respiratory system and oxygen transport during exercise

8. The basic aspects of thermoregulation and the impact of various environmental conditions
9. The basic principles of exercise training and how to use them in designing exercise training programs for fitness and athletic performance
10. The general causes of fatigue for various exercise modes and intensities
11. The basic physiological differences between males and females that might impact exercise performance
12. The impact of nutrition on exercise performance and recovery
13. The effect of ergogenic aids on exercise performance and have an appreciation for the ethical use of such aids
14. The influence of exercise training on body composition and weight
15. The health benefits of exercise throughout the life span.

1.2 Exercise physiology

Exercise Physiology is the study of how the body responds and adapts to physical stress. Sport physiology is the application of exercise physiology principles to guide training and enhance sport performance. Exercise and sport physiology overlap significantly, and therefore are generally considered together. For the remainder of this chapter, the term exercise physiology will be used to encompass the areas of both exercise and sport physiology. Exercise is an intentional physical stress placed upon the body, producing both acute and chronic effects that can be studied. Acute exercise effects are sudden and immediate, whereas chronic exercise effects are gradual and long term.

Exercise physiology is one of many topics traditionally taught within the core of physical education, Kinesiology, and exercise science programs. Exercise physiology is an essential part of the curriculum because knowledge and understanding of the principles of exercise physiology enable physical education teachers, athletes, coaches, dance teachers, fitness trainers, and other sport and exercise science professionals to enhance physical performance and health through the application of the principles. It is important to note that exercise physiology is not limited to the study of exercise and sport; it includes the study of the effects of any type of physical activity on the systems of the body.

Physiological training adaptations occur because the body resists stress. The adaptations do, in fact, reduce stress on the body systems, but they also have other positive side effects. As a result of training adaptations, the body becomes more efficient, which means it can perform the same amount of work with less energy. Training adaptations including better efficiency result in an increased ability to perform physical activity, which can improve an athlete's performance in his or her sport or an older adult's ability to carry his or her own groceries.

Physical Fitness

Physiological attributes that reflect the ability of the systems of the body to support physical activity.

Health Related Physical Fitness

Aerobic capacity: The ability to perform prolonged, large-muscle, dynamic exercise at moderate to high levels of intensity

Body composition: The proportion of total body weight made up of fat mass and fat-free mass

Flexibility: The ability of the joints to move freely through their normal range of motion

Muscular endurance: The ability of skeletal muscles to repeatedly generate force

Muscular strength: The ability of skeletal muscles to generate force.

Skill Relate Physical Fitness

Agility: The ability to change body position quickly and accurately

Balance: The ability to maintain steady body posture

Coordination: The ability to perform physical tasks smoothly and accurately

Power: The ability of the muscles to generate force quickly

Reaction time: The ability to respond to a stimulus quickly

Speed: The ability to move quickly

Principles of Exercise Physiology

The primary, overarching principle of exercise and physiology is the principle of overload, which states that the body must be stressed to a level beyond which it is normally accustomed in order to stimulate physiological training adaptations. Overload is essentially the stress that we discussed earlier. The body is stressed when it is forced to do something that it is not accustomed to. When the body and its systems are stressed regularly, the body detects the pattern of stress and responds by making physiological changes (adaptations) to resist the stress. For each fitness component, tests can be used to measure physiological adaptations to exercise. For example, one test of cardiorespiratory endurance is the step test. During the step test, we measure the heart rate response to stepping up and down for 3 minutes. When start jogging program, the cardiovascular system is overloaded because it is forced to deliver oxygen at a rate that is higher than it is accustomed to. Part of the overload in this situation is that the heart must contract (beat) faster. The high heart rate puts stress on the heart, and if the heart rate is raised long and often enough, the cardiovascular system will respond with physiological adaptations that result in a lower heart rate when jogging at the same intensity. This training adaptation can be measured by performing the step test again, after several weeks of training. It is important to note that not all physical activity causes overload, because body is "accustomed" to activities do often. For example, if walking 1–2 miles around campus every day, walking this distance will not overload the body and stimulate physiological changes. However, if some-one is sedentary and moves around very little each day, walking 1–2 miles will likely cause an overload, and if done regularly will result in adaptations. If anyone want the exercise program to result in training adaptations, it must consist of physical activity that body is not accustomed to. In addition, as exercise regularly over time, body adapts, plateaus, and eventually becomes "accustomed" to the exercise. When that occurs must increase the intensity of the exercise stress such that it, again, becomes a physical activity that body is not accustomed to. This is called the principle of progression. They must progress the overload as body adapts. For example, the stress of jogging can be increased many ways, including increasing the speed, grade (run up hills), duration (more minutes per session), or frequency (more sessions per week). Just as the body recognizes a pattern of stress and subsequently adapts, it also recognizes when that stress has been removed. Jogging regularly for over time, adapt, lowering exercise heart rate, and then stop jogging routine, body will reverse its adaptations. As mentioned earlier, the body adapts to resist tress, but if the stress is no longer present, the physiological systems no longer maintain the adaptations, and there-fore they are lost. Because it strives for efficiency, the body will not exert its energy and resources to maintain an unnecessary physiological adaptation. This is called the principle of reversibility, which is sometimes mentioned to by the saying "use it or lose it." Other exercise training principles exist, but they are beyond the scope of this chapter.

1.3 Physiology of a Human

Maintaining a stable system requires the body to continuously monitor its internal conditions. Though certain physiological systems operate within frequently larger ranges, certain body parameters are tightly controlled homeostatically. For example, body temperature and blood pressure are controlled within a very narrow range. A set point is the physiological value around which the normal range fluctuates. For example, the set point for typical human body temperature is approximately 37°C (98.6°F). Physiological parameters, such as body temperature and blood pressure, tend to fluctuate within a range of a few degrees above and below that point. Humans have a similar temperature regulation feedback system that works by promoting either heat loss or heat gain. When the brain's temperature regulation centre receives data from the sensors indicating that the body's temperature exceeds its normal range, it stimulates a cluster of brain cells referred to as the "heat-loss centre." This stimulation has three major effects:

Blood vessels in the skin begin to dilate allowing more blood from the body core to flow to the surface of the skin allowing the heat to radiate into the environment.

As blood flow to the skin increases, sweat glands are activated to increase their output. As the sweat evaporates from the skin surface into the surrounding air, it takes heat with it.

The depth of respiration increases, and a person may breathe through an open mouth instead of through the nasal passageways. This further increase heat loss from the lungs.

a. Skeletal

The skeletal system is the body system composed of bones, cartilages, ligaments and other tissues that perform essential functions for the human body. Bone tissue, or **osseous tissue**, is a hard, dense connective tissue that forms most of the adult skeleton, the internal support structure of the

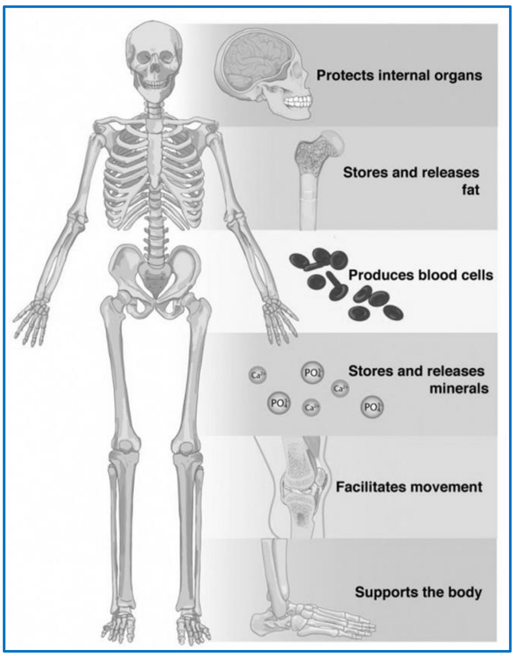

Figure 1

body. In the areas of the skeleton where whole bones move against each other (for example, joints like the shoulder or between the bones of the spine), cartilages, a semi-rigid form of connective tissue, provide flexibility and smooth surfaces for movement. Additionally, ligaments composed of dense connective tissue surround these joints, tying skeletal elements together (a **ligament** is the dense connective tissue that connect bones to other bones).

Anatomical Position

The human body is shown in anatomical position in an (a) anterior view and a (b) posterior view. The regions of the body are labelled in boldface.

A body that is lying down is described as either prone or supine. Prone describes a face-down orientation, and supine describes a face up orientation. These terms are sometimes used in describing the position of the body during specific physical examinations or surgical procedures.

Regional Terms

The human body's numerous regions have specific terms to help increase precision. The term "brachium" or "arm" is reserved for the "upper arm" and "antebrachium" or "forearm" is used rather than "lower arm." Similarly, "femur" or "thigh" is correct, and "leg" or "crus" is reserved for the portion of the lower limb between the knee and the ankle. It will be able to describe the body's regions using the terms from the figure.

Directional Terms

The terms are essential for describing the relative locations of different body structures. For instance, an anatomist might describe one band of tissue as “inferior to” another or a physician might describe a tumour as “superficial to” a deeper body structure. Commit these terms to memory to avoid confusion when studying or describing the locations of particular body parts.

- Anterior (or ventral) describes the front or direction toward the front of the body. The toes are anterior to the foot.
- Posterior (or dorsal) describes the back or direction toward the back of the body. The popliteus is posterior to the patella.
- Superior (or cranial) describes a position above or higher than another part of the body proper. The orbits are superior to the oris.
- Inferior (or caudal) describes a position below or lower than another part of the body proper; near or toward the tail (in humans, the coccyx, or lowest part of the spinal column). The pelvis is inferior to the abdomen.
- Lateral describes the side or direction toward the side of the body. The thumb (pollex) is lateral to the digits.
- Medial describes the middle or direction toward the middle of the body. The hallux is the medial toe.
- Proximal describes a position in a limb that is nearer to the point of attachment or the trunk of the body. The brachium is proximal to the antebrachium.
- Distal describes a position in a limb that is farther from the point of attachment or the trunk of the body. The crus are distal

to the femur.

- Superficial describes a position closer to the surface of the body. The skin is superficial to the bones.
- Deep describes a position farther from the surface of the body. The brain is deep to the skull.

Body Planes

A section is a two-dimensional surface of a three-dimensional structure that has been cut. Modern medical imaging devices enable clinicians to obtain "virtual sections" of living bodies. We call these scans. Body sections and scans can be correctly interpreted, only if the viewer understands the plane along which the section was made. A plane is an imaginary, two-dimensional surface that passes through the body. There are three planes commonly referred to in anatomy and medicine.

- The sagittal plane divides the body or an organ vertically into right and left sides. If this vertical plane runs directly down the middle of the body, it is called the midsagittal or median plane. If it divides the body into unequal right and left sides, it is called a parasagittal plane or less commonly a longitudinal section.
- The frontal plane divides the body or an organ into an anterior (front) portion and a posterior (rear) portion. The frontal plane is often referred to as a coronal plane. ("Corona" is Latin for "crown.")
- The transverse (or horizontal) plane divides the body or organ horizontally into upper and lower portions. Transverse planes produce images referred to as cross sections.

Human Physique

1. Circulatory system
    i. Circulates blood around the body via the heart, arteries and veins, delivering oxygen and nutrients to organs and cells and carrying their waste products away.
2. Digestive system / Excretory system
    i. Mechanical and chemical processes that provide nutrients via the mouth, esophagus, stomach and intestines.
    ii. Eliminates waste from the body.
3. Endocrine system
    i. Provides chemical communications within the body using hormones.
4. Integumentary system/ Exocrine system
    i. Skin, hair, nails, sweat and other exocrine glands.
5. Lymphatic system / Immune system
    i. The system comprising a network of lymphatic vessels that carry a clear fluid called lymph.
    ii. Defends the body against pathogenic viruses that may endanger the body.
6. Muscular system
    i. Enables the body to move using muscles.
7. Nervous system
    i. Collects and processes information from the senses via nerves and the brain and tells the muscles to contract to cause physical actions.

8. *Renal system / Urinary system*

    i. The system where the kidneys filter blood.

9. Reproductive system

    i. The sex organs required for the production of offspring.

10. Respiratory system

    i. The lungs and the trachea that bring air into and out of the body.

11. Skeletal system

    i. Bones supporting the body and its organs.

CHAPTER 2

2.1 Structure and functions of Heart

The heart made up of three layers of tissue in the heart wall. The outer layer of the heart wall is the epicardium, the middle layer is the myocardium, and the inner layer is the endocardium. Two-thirds of the Heart mass is located to the left side of midline. The heart is enclosed in a pericardial sac that is lined with the parietal layers of a serous membrane. There are four chambers in the heart Right atrium, Right ventricle, Left atrium and Left ventricle. The two atria are thin-walled chambers that receive blood from the veins. The two ventricles are thick-walled chambers that forcefully pump blood out of the heart. Differences in thickness of the heart chamber walls are due to variations in the amount of myocardium present. Pumps need a set of valves to keep the fluid flowing in one direction. The right atrioventricular valve is the tricuspid valve. The left atrioventricular valve is the bicuspid, or mitral, valve. The valve between the right ventricle and pulmonary trunk is the pulmonary semilunar valve. The valve between the left ventricle and the aorta is the aortic semilunar valve. When the ventricles contract, atrioventricular valves close to prevent blood from flowing back into the atria. When the ventricles relax, semilunar valves close to prevent blood from flowing back into the ventricles. The heart works as two pumps, one on the right and one on the left, working simultaneously. Blood flows from the right atrium to the right ventricle, and then is pumped to the lungs to receive oxygen. From the lungs, the blood flows to the left atrium, then to the left ventricle. From there it is pumped to the systemic circulation. The systole is a short period that occurs when the tricuspid and mitral valves close;

the diastole is a relatively longer period when the aortic and pulmonary valves close. The systole-diastole relationship is the reference in measuring blood pressure. The normal function of a heart is 72 bpm.

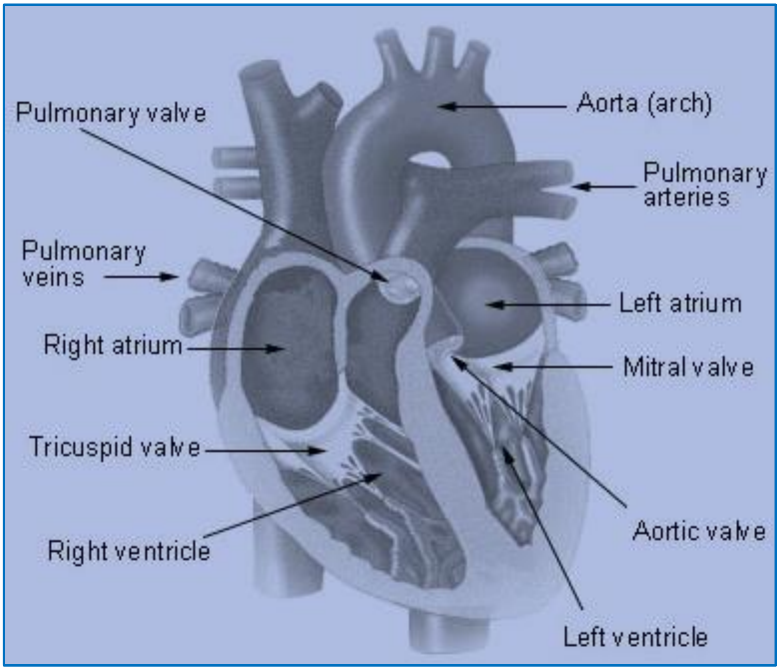

Figure 2

Effects and functions of cardiac muscle

Cardiac output is the product of the heart rate (HR), or the number of heart beats per minute (bpm), and the stroke volume (SV), which is the volume of blood pumped from the ventricle per beat; thus, CO = HR × SV. Values for cardiac output are usually denoted as L/min. A normal adult has a cardiac output of 4.7 litters

Heart rate, also known as pulse, is the number of times a person's heart beats per minute. Normal heart rate varies from person to person, but for a normal adult is 72bpm.

Cardiac Pressure: The amount of pressure in arteries during the contraction of heart muscle. This is called systolic pressure. The bottom number refers to your blood pressure when your heart muscle is between beats. This is called diastolic pressure. A normal adult has a pressure of 120/80 mm Hg

Blood cholesterol: Total cholesterol levels less than 200 milligrams per decilitre (mg/dL) are considered desirable for adults (LDL cholesterol levels should be less than 100 mg/dL).

Blood Glucose: A fasting blood sugar level less than 100 mg/dL (5.6 mmol/L) is normal. A person needs to keep blood sugar levels within a safe range to reduce the risk of diabetes and heart disease. Blood glucose monitoring measures the amount of sugar that the blood is transporting during a single instant.

Hemoglobin (Hb or Hgb): is a protein in red blood cells that carries oxygen throughout the body. The normal range for hemoglobin is: For men, 13.5 to 17.5 grams per decilitre. For women, 12.0 to 15.5 grams per decilitre.

2.2 Structure and Functions of Lungs

The lungs are a pair of organs located in the either side of the thorax. The lungs are covered by a thin tissue layer called the pleura. A thin layer of fluid acts as a lubricant allowing the lungs to slip smoothly as they expand and contract with each breath. Primarily responsible for the exchange of oxygen and carbon dioxide between the air we breathe and the blood. The lungs are separated into sections called lobes, two on the left and three on the right. The air passages continue to divide into ever smaller tubes, which finally connect with tiny air sacs called alveoli. Pulmonary artery splits in two for the left and right lungs and then continues to branch much like the tracheobronchial tree. These vessels branch into a fine network of very tiny tubes called capillaries.

The act of breathing (involuntary action)

1. Inhalation – the intake of air into the lungs through expansion of chest volume. Air passes from the high pressure outside the lungs to the low pressure inside the lungs. Contraction of the diaphragm muscle, Contraction of the rib muscles & chest cavity expands

2. Exhalation – the expulsion of air from the lungs through contraction of chest volume. Air passes from the high pressure in the lungs to the low pressure in the upper respiratory tract. Diaphragm muscles are no longer contracting, curves and rises to the position

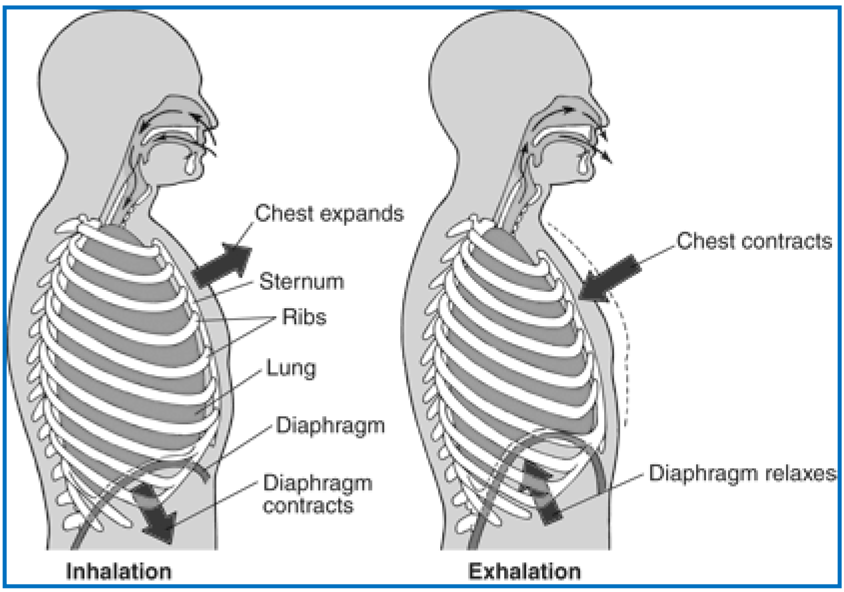

Figure 3

Lung Volume

Sum of all **volume** compartments or **volume** of air in **lungs** after maximum inspiration. The **normal** value is about 6,000mL (4-6 L). And it can be sub divided into four volumes:

a. Tidal Volume- is the amount of air that can be inhaled and exhaled during one normal (quiet) breathing cycle (about 500 ml for men & women).

b. Inspiratory reserve volume (IRV) is the amount of air that can be forcibly inhaled beyond a tidal inhalation (about 3,000 ml for men & 2,000 ml for women).

c. Expiratory reserve volume (ERV) is the amount of air that can be forcibly exhaled beyond a tidal exhalation (about 1200 ml for men & 700 ml for women).

d. **Residual Volume** (RV) is the amount of air remaining in the lungs after an ERV (= about 1,200 ml in men & women).

e. **So that** Functional reserve capacity = ERV + RV & Total lung capacity = RV + VC.

f. Vital Capacity is maximum amount of air that can be moved in or out of the lungs in a single respiratory cycle, ie. Vital capacity = TV + IRV + ERV (about 4.8ml for men & women)

2.3 Structure and Functions of Skeletal Muscle

Skeletal muscle is comprised of a series of muscle fibers made of muscle cells. These muscle cells are long and multinucleated. At the ends of each skeletal muscle a tendon connects the muscle to bone. This tendon connects directly to the epimysium, or collagenous outer covering of skeletal muscle. Underneath the epimysium, muscle fibers are grouped into bundles called fascicles. The perimysium, as it is called, allows nerve and blood vessels to make their way through the muscle. Each fascicle is formed from tens to hundreds of bundled muscle fibers. Each muscle fiber is formed from a chain of multinucleated muscle cells. These fibers are then protected by another layer called the endomysium as they are bundled into fascicles. Sarcomeres are formed from *actin* and myosin, as well as a number of proteins (The two most important are troponin and tropomyosin. Tropomyosin surrounds the actin filament and stops the heads of myosin from attaching. Troponin locks tropomyosin in place until receiving the signal to contract)

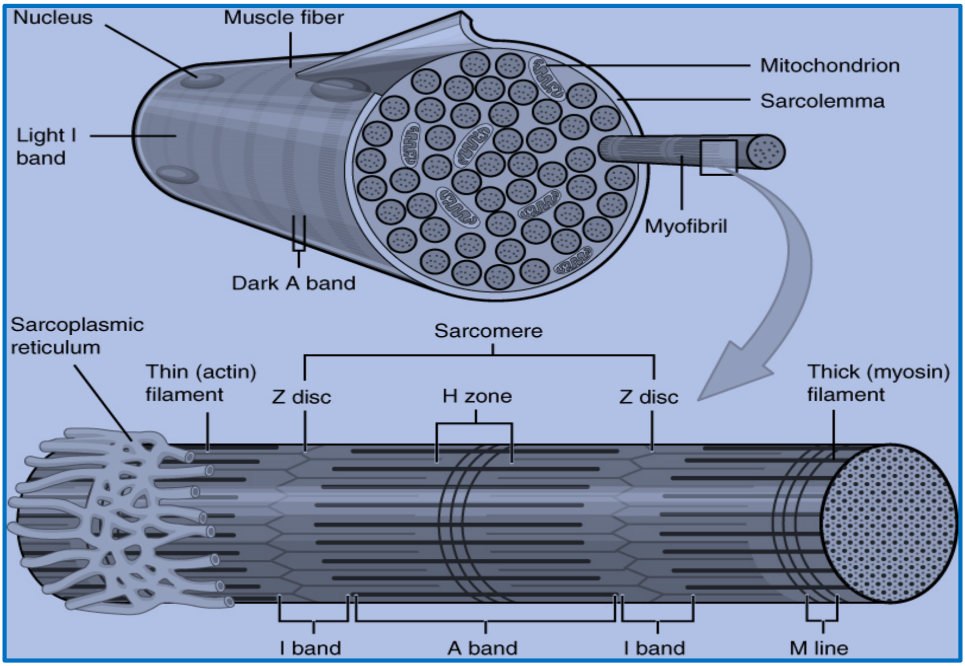

Figure 4

- ➢ The filaments seen between the dark bands are actin and myosin filaments. The **thick** filaments made up of myosin and **thin** filaments made up of actin compose structures called sarcomeres.
- ➢ **Z-line** can refer to: the borders that separate and link sarcomeres within a skeletal muscle. A sarcomere is defined as the segment

between two neighbouring Z-lines

- **H zone** The region of a striated muscle fibre that contains only thick (myosin) filaments. The **H zone** appears as a lighter band in the middle of the dark A band at the centre of a sarcomere.
- In striated muscle sarcomere, the **M line** is the attachment site for the thick filaments. The **M line** is in the center of the A band and sarcomere.
- The **I band** is the region of a striated muscle sarcomere that contains thin filaments.
- Thick filaments will happen only in **A band**

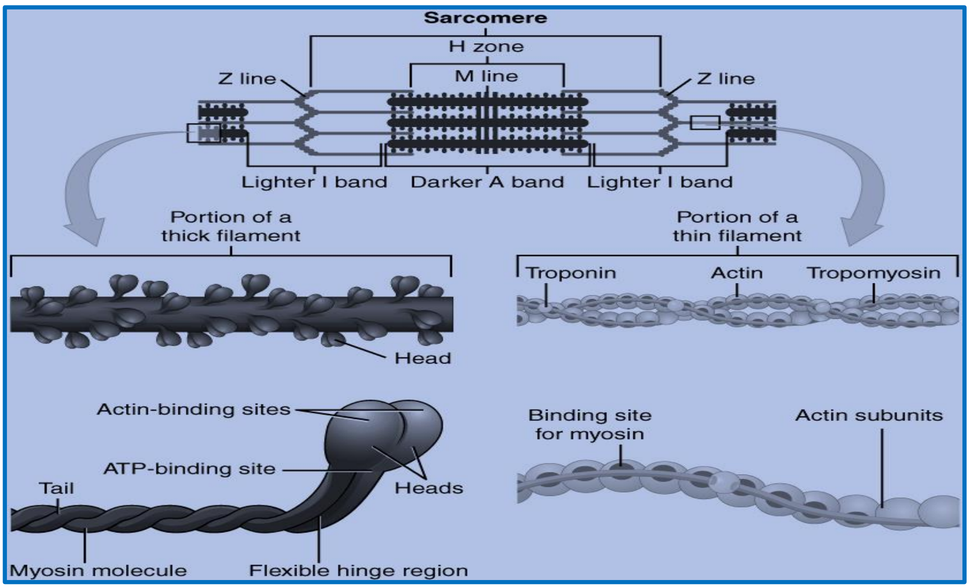

Figure 5

Effects of Skeletal Muscle

a. **Muscle Tone**- Degree of muscle tension or resistance during rest or in response to stretching. Physical exercises that are used with the aim of developing a physique with a large emphasis on musculature. In this context, the term toned implies leanness in the body.

b. Muscle **hypertrophy** involves an increase in size of skeletal muscle through a growth in size of its component cells. Two factors contribute to hypertrophy: *sarcoplasmic hypertrophy*, it focuses more on increased muscle glycogen storage; and *myofibrillar hypertrophy*, it focuses more on increased myofibril size.

CHAPTER 3

3.1 Effect of Exercise

Physical exercise is important for maintaining physical fitness and can contribute to maintaining a healthy weight, regulating digestive health, building and maintaining healthy bone density, muscle strength, and joint mobility, promoting physiological well-being, reducing surgical risks, and strengthening the immune system. Some studies indicate that exercise may increase life expectancy and the overall quality of life. People who participate in moderate to high levels of physical exercise have a lower mortality rate compared to individuals who by comparison are not physically active. Moderate levels of exercise have been correlated with preventing aging by reducing inflammatory potential. The majority of the benefits from exercise are achieved with around 3500 metabolic equivalent (MET) minutes per week. For example, climbing stairs 10 minutes, vacuuming 15 minutes, gardening 20 minutes, running 20 minutes, and walking or bicycling for transportation 25 minutes on a daily basis would together achieve about 3000 MET minutes a week. A lack of physical activity causes approximately 6% of the burden of disease from coronary heart disease, 7% of type 2 diabetes, 10% of breast cancer and 10% of colon cancer worldwide. Overall, physical inactivity causes 9% of premature mortality worldwide.

3.2 Exercise and Systems of Human Body

1. Muscular System

a. Types of Muscles

- **Skeletal muscle**

Skeletal Muscles are those which attach to bones and have the main function of contracting to facilitate movement of our skeletons. They are also sometimes known as striated muscles due to their appearance. The cause of this 'stripy' appearance is the bands of Actin and Myosin which form the Sarcomere, found within the Myofibrils.

Skeletal muscles are also sometimes called voluntary muscles, because we have direct control over them through nervous impulses from our brains sending messages to the muscle. Contractions can vary to produce powerful, fast movements or small precision actions. Skeletal muscles also have the ability to stretch or contract and still return to their original shape.

- **Skeletal muscle fibre type**

Not all fibres within Skeletal muscles are the same. Different fibre types contract at different speeds, are suited to different types of activity and vary in colour depending on their Myoglobin (an oxygen carrying protein) content.

- **Smooth muscle**

Smooth muscle is also sometimes known as Involuntary muscle due to our inability to control its movements, or unstriated as it does not have the stripy appearance of Skeletal muscle. Smooth muscle is found in the walls of hollow organs such as the Stomach, Oesophagus, Bronchi and in the walls of blood vessels. This muscle type is stimulated by involuntary neurogenic impulses and has slow, rhythmical contractions used in controlling internal organs, for example, moving food along the Oesophagus or contracting blood vessels during Vasoconstriction.

- **Cardiac muscle (heart muscle)**

This type of muscle is found solely in the walls of the heart. It has similarities with skeletal muscles in that it is striated and with smooth muscles in that its contractions are not under conscious control. However, this type of muscle is highly specialised. It is under the control of the autonomic nervous system, however, even without a nervous impute contractions can occur due to cells called pacemaker cells. Cardiac muscle is highly resistant to fatigue due to the presence of many mitochondria, myoglobin and a good blood supply allowing continuous aerobic metabolism.

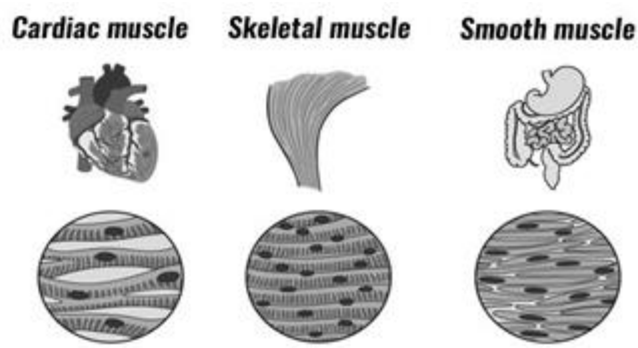

Figure 6

b. Functions of the Muscular System

- *Voluntary and Reflexive Movement*

Gross movement refers to large coordinated movements such as walking, running, jumping, sitting down, standing up, lifting large objects, swimming, and swinging a bat or racket. Gross movements rely primarily on large skeletal muscles. Fine motor skills refer to smaller, more intricate body movements. Examples include speaking, writing and playing a musical instrument. Fine motor skills typically involve small skeletal muscles of hands, face or feet. Although most skeletal muscles are under voluntary control, they can also contract reflexively – such as blinking when an insect flies toward face or pulling hand away from a hot surface.

- *Skeletal Stability and Organ Protection*

Bones provide the frame for body. Skeleton, however, lacks structural stability without the skeletal muscles and their associated tendons that hold bones together and keep them in place. Even in a static posture, such as when we're standing still, numerous skeletal muscles of the trunk, neck and legs must remain in a contracted state to support body and head. The axial skeletal muscles are particularly important for maintaining an upright position and enabling to twist head and body.

- *Blood Circulation*

Smooth muscle cells in the walls of arteries and veins also contribute to blood circulation by altering the diameter of these blood vessels in different situations. For example, arteries supplying exercising skeletal muscles relax to enable increased blood flow to meet the increased metabolic demand. Conversely, if we're dehydrated or suffer a significant blood loss, the smooth muscle of blood vessels contracts to help maintain blood pressure and ensure continued circulation to brain and other vital organs.

- *Internal Organ Function*

Several internal organs contain smooth muscle tissue, which contracts automatically to support their normal function. For example, smooth muscle tissue in the walls of esophagus, stomach, and small and large intestines produce rhythmic contractions that propel food through digestive tract. Similarly, smooth muscle in the wall of bladder enables to expel urine. Uterine smooth muscle tissue, called the myometrium, proliferates during pregnancy and provides the strong propulsive force that enables a vaginal delivery. Other internal organs and structures that rely on smooth muscle to support some of their functions include the gallbladder, male reproductive ducts and glands, and the irises of the eyes.

- *Body Temperature Regulation*

A normal body temperature of roughly 98.6 F is generally lower than the environmental temperature. Since body heat is lost to the environment in typical conditions, body must generate heat to maintain a normal temperature. Most of this needed heat is generated by skeletal muscles. When body temperature decreases, skeletal muscle activity automatically increases to generate heat. Shivering is the most obvious manifestation of this response. Smooth muscle in the blood vessels supplying skin also automatically constricts in cold conditions to conserve heat by limiting loss at body surface. The opposite effect occurs when exercising or otherwise overheated. Smooth muscle cells in surface blood vessels relax, increasing blood flow and heat release through skin.

c. Types of Muscle Fibers

The body's diverse requirements of its skeletal muscles, e.g. to generate rapid movements in some cases but to maintain high levels of tension (without fatigue) in the cases of other muscles, are such that the muscle fibres forming some muscles have different properties than muscle fibres forming other muscles whose main function and activity is significantly different.

Muscles that need to be able to perform effectively in both respects consist of a combination of both slow- *and* fast-contracting muscle fibres.

Slow-contracting muscle fibres are called **Type I**. Fast-contracting muscle fibres are called **Type II**.

There are two main types of fast-contracting muscle fibres (that is, **Type II** muscle fibres are divided into **Type IIa** and **Type IIb**), which have **different resistance to fatigue**. This relates to how effectively the muscle fibres can access the energy they need to contract. As explained on supply of energy for muscle contraction, the immediate source of (chemical) energy for muscle contraction is the molecule adenosine triphosphate (ATP), which releases energy when it breaks down: ATP $\rightarrow$ ADP + P_i + Energy. As ATP is used-up by muscles as they contract, an important aspect of the supply of energy for muscle contraction is *how* the muscle fibres produce ATP.

In order to describe and compare the different types of skeletal muscle fibres it is useful to know that:

- In general, the myosin heads (within the thick filaments of muscle fibres) include an enzyme called **ATPase** that **catalyzes**, i.e. it acts as a catalyst for (=increases the rate of) the reaction ATP $\rightarrow$ ADP + P_i + Energy, in which ATP decomposes into ADP and a free phosphate ion.

- **Oxidative phosphorylation** is the final series of chemical reactions in the synthesis of ATP by **aerobic cellular respiration**, which is a very efficient method of production of ATP and a method of ATP production that can be sustained for long periods of time, e.g. when running a race that takes several hours to complete. However, this process of ATP synthesis requires oxygen.

Oxidative phosphorylation takes place in the mitochondria within cells, so cells that contain many mitochondria are better adapted for production of ATP *via aerobic cellular respiration*, of which the final steps that yield most of the ATP are known as **oxidative phosphorylation**, than cells that contain fewer mitochondria.

Properties	Properties	Red / Fast (Type II a)	White / Fast (Type II b)
Another Name	Slow twitch fibers	Fast oxidative fibers	Fast glycolytic fibers
Colour	Red - due to the respiratory pigment myoglobin which, in common with the haemoglobin (Am.Sp. hemoglobin) in red blood cells, stores O_2 by loosely binding it.	Red - due to the respiratory pigment myoglobin which, in common with the haemoglobin (Am.Sp. hemoglobin) in red blood cells, stores O_2 by loosely binding it.	White - due to the absence of pigmentation, e.g. the respiratory pigment myoglobin or hemoglobin (as present in red blood cells)
Contraction time	Slow	Fast	Very Fast
Oxidative capacity	High	High	Low
Resistance to fatigue	High	Medium (Intermediate)	Low
Diameter (of muscle fibre)	Small	Medium (Intermediate)	Large

Capillary density	High	Medium (Intermediate)	Low
Mitochondrial density	High	High	Low
Glycogen reserves	Low	Intermediate	High
Main (metabolic) pathway for production of ATP	Aerobic cellular respiration - final stage: oxidative phosphorylation	Both aerobic and anaerobic metabolic pathways	Only anaerobic metabolism, esp. anaerobic glycosis
Force production (i.e. force produced by muscle)	Low	Medium-High	Very High
Example of typical use	Repeated low-level contractions e.g. walking or low intensity cycling for 30 mins.	Activities involving speed, strength and power, e.g. moderately weight training and fast running e.g. 400 metres.	Short, fast, bursts of power (but rapid fatigue) e.g. heavy weight training, power lifting, and 100 metre sprints

Examples of muscles or locations of skeletal muscles with this type of fibre	Postural muscles, e.g. of the neck and spine, & leg muscles (which have Type I & Type II a fibres).	Leg muscles have large quantities of both Type I and Type II a fibres.	*Arm muscles.* *N.B. Type IIb fibres can be converted into II a fibres by resistance training.*

a. The Effects of Exercise on Muscular System

Exercise involves a series of sustained muscle contractions, of either long or short duration, depending on the nature of the physical activity. Effects of exercise on muscles can be considered short-term or immediate, both during and shortly after exercise; as well as long-term, lasting effects.

✓ **Short term effects such as**

- **Blood flow** – after exercise muscle tissue (warm muscle) is bigger than cold muscle, because of blood flow into them. It can increase by up to 25 times, because muscle requires more energy and oxygen.
- **Muscle fatigue** – is the decline in ability of a muscle to generate force. It can be a result of intense exercise, but abnormal fatigue may be caused by barriers to or interference with the different stages of muscle contraction. There are two main causes of muscle fatigue. The limitations of a nerve's ability to generate a sustained signal (neural fatigue) and the reduced ability of the muscle fibre to contract (metabolic fatigue).

- **Muscle exhaustion –** general exhaustion often occurs after have done too much activity at one time, such as by taking an extra-long hike. It may feel weak and tired, or the muscles may be sore. These sensations usually go away within a few days. In rare cases, generalized muscle weakness may be caused by another health problem, such as problems with body regulating the distribution of energy to muscles and organs.
- **Muscle damage –** any effort beyond muscle ability level or accident can tear the fibres and cause muscle damage. When a muscle fibre is damaged, the body immediately starts to repair it at the cellular level. Muscles most of the time repairs by themselves (if body is functioning properly) through time. If damage or injury is critical, surgery might be needed.
- **Cramp –** because of over-exercise, lack of nutrients like magnesium or bad blood circulation when muscles don't receive enough oxygen. It is very painful and can be dangerous if doing exercise that involves heavy weights alone.

✓ **Long-term effects of exercise**

- **Muscle size** – is mostly determined by persons genetics but can be affected with life choices like anabolic steroids, exercise, and healthy food. Exercising specific muscles regularly can increase their size by up to 60%. This increase in muscle size is mainly due to increased diameter of individual muscle fibres.
- **Muscle coordination** – It trains muscles to work more

efficient and effectively by working together. E.g.: when the prime mover contracts more rapidly the antagonist (muscle) must also relax as quickly to prevent blocking the movement.

- **Blood supply** – As a result of frequent exercise over a sustained period of time both the quantity of blood vessels and the extent of the capillary beds increases.
- Effects of exercise on muscular system would benefit by increasing size and number of mitochondria, improved perception of muscle tone and also overall improved.

- Coordination
- Power
- Balance
- Speed
- Agility
- Body composition
- Reaction time
- Muscular endurance
- Flexibility

2. Effect of Exercise on Nervous System

The nervous system is largely comprised of nerves and the brain. The brain is the control centre for the system and resides inside the skull. In addition, the spinal column which contains the most imperative nerves resides in the spine.

The nervous system consists of brain, spinal cord, nerve fibers that transmit messages from the brain throughout the body

Function

The nervous system is responsible for all physical reactions and telling each body part to move when and where. The nerves are also responsible for feeling pain and reaction time to stimuli. Additionally, the brain is responsible for all emotions and feelings.

System Importance

The nervous system is important for proper functioning of the body in that it ensures that reactions occur efficiently and directs signals through the body that result in every bodily function.

Potential Health Issues

Some of the many potential health issues associated with the nervous system are paralysis due to nerve damage, all psychological disorders, and epilepsy.

a. Exercise can affect the Nervous System

Short Term Effects

The immediate effects of exercise are on the neurotransmitters. It causes complex signals to pass through the neurons in the brain. This alerts the brain for learning and makes information easier to retain.

Long Term Effects

Exercise stresses the muscles which creates growth factors. This contributes to brand new brain cells and it increases the number of pathways for oxygen, energy, and to remove waste from the brain.

Aerobic Exercise

Aerobic exercise is the more beneficial type of exercise on the nervous system. It improves cognition for all people, but the cognitive abilities of aerobically active children particularly stand out against those who are not aerobically active.

Anaerobic Exercise

Anaerobic exercise has no proven effect on the nervous system, but it still is a very important part of a balanced exercise plan and positively affects other body systems.

Inactivity's Effect

Inactivity makes the nerve cells reduce growth, as depicted. It reduces the effectiveness of the areas of the brain associated with motor skills and learning.

3. **Circulatory system**

Exercise places an increased demand on the cardiovascular system. Oxygen demand by the muscles increases sharply. Metabolic processes speed up and more waste is created. More nutrients are used and body temperature rises.

- ✓ Delivers oxygen to working muscles
- ✓ Oxygenates blood by returning it to the lungs
- ✓ Transports heat (a by-product of activity) from the core to the skin
- ✓ Delivers nutrients and fuel to active tissues
- ✓ Transports hormones
- ✓ Reduction in bad (LDL and total) cholesterol

- ✓ Increase in good (HDL) cholesterol

To perform as efficiently as possible the cardiovascular system must regulate these changes and meet the body increasing demands.

The acute or immediate response to exercise and the long-term adaptations that take place in the cardiovascular system with repeated exercise. The most important aspects of the cardiovascular system to examine include:

- Heart rate
- Stroke volume
- Cardiac output
- Blood flow
- Blood pressure
- Blood

4. Digestive system

Digestive system is responsible for breaking down food and providing energy to the rest of the body. The digestive system is made up of the esophagus, the stomach, the pancreas, liver, gallbladder, small intestine and the large intestine. Exercise can help to improve the efficiency of the digestive process and helps to maintain a healthy weight. Regular exercise and conscious breathing (pranayama), which works on the digestive system as a gentle massage, have a favourable effect on the digestion. They activate the digestive enzymes and the bowel movement. Regular exercise is good for circulation, and it stimulates and energizes the nervous, endocrine, and muscular systems.

- ✓ **Increased Metabolism**
- ✓ **Internal Massage**
- ✓ **Strengthens the Muscles**
- ✓ **Increased Blood Flow**

5. Endocrine system

Endorphins can help reduce tension and anxiety and facilitate the proverbial "runner's high." endocrine response to exercise can increase organ function, physical appearance and state of mind. Conversely, low testosterone levels might inhibit motivation, self-confidence, concentration and memory. Pituitary gland may produce a large increase in blood endorphin levels shortly after exercise begins. Endorphins block sensitivity to pain and can reduce tension or anxiety by inducing a sense of euphoria.

- ✓ **Pituitary Gland-**During exercise, the pituitary gland releases human growth hormone, which tells the body to increase bone, muscle and tissue production.
- ✓ **Thyroid Gland-** sends out hormones that regulate the body's temperature, heart rate and blood pressure. It also regulates the alertness and focus that are needed to work at a high intensity.
- ✓ **Adrenal Gland -** Located at the top of the kidneys, the adrenal glands are responsible for the release of cortisol into the bloodstream. Cortisol levels control blood pressure, glucose and acts as an anti-inflammatory agent. The adrenal glands also release aldosterone, a hormone that regulates hydration levels, the speed of the heart and the strength of contractions.

It also turns stored carbohydrates into energy.

- ✓ **Pancreas -** Insulin regulates glucose, or blood sugar, by transporting it to the muscles and tissue that use glucose for energy. Excessive insulin in the blood reduces sensitivity to insulin and can cause diabetes, which is also connected to overweight and obesity. Exercise improves insulin sensitivity and reduces the reliance on insulin injections.

6. Exocrine system

The Exocrine System is a system of glands that produce and secrete substances that may either protect or lubricate the body. Combining exercise with proper amounts of sleep, relaxation techniques, and positive thinking will help reduce stress and keep hormone levels balanced. One of the main functions of some glands is to secrete hormones which will help the body respond to stressful situations; however, that is intended to be short-term. When stress lasts longer than a few hours, higher energy demands are placed on the body. They tend to weaken the body's defences, leaving the body open to infection.

Exocrine glands include:

- **Sweat:** secretes sweat and is in the dermis of the skin
- **salivary**: discharges a fluid secretion into the mouth cavity
- **mammary**: the milk-producing gland of women
- **prostate**: the semen-producing gland of men
- **gastric**: produces acids in the stomach to help with digestion
- **bile-producing glands of the liver**

- **ceruminous**: a special kind of sweat gland
- **lacrimal**: secretes tears
- **sebaceous**: a small gland in the skin which secretes an oily substance to lubricate the skin and hair
- **Mucous**: a slimy substance used for lubrication and protection.

These are all travel through ducts. They usually deposit their substances onto epithelial surfaces which line the cavities and surfaces of blood vessels and organs throughout the body. They are in three distinct shapes:

- squamous (very thin and flat)
- columnar (like a column)
- cuboidal (many sides)

2.3 Muscular Contraction

For voluntary muscles, all contraction (excluding reflexes) occurs as a result of conscious effort originating in the brain. The brain sends signals, in the form of action potentials, through the nervous system to the motor neuron that innervates several muscle fibers. In the case of some reflexes, the signal to contract can originate in the spinal cord through a feedback loop with the grey matter. Involuntary muscles such as the heart or smooth muscles in the gut and vascular system contract as a result of non-conscious brain activity or stimuli endogenous to the muscle itself. Other actions such as locomotion, breathing, and chewing have a reflex aspect to them: the contractions can be initiated either consciously or unconsciously.

There are three general types of muscle tissues:

- Skeletal muscle responsible for movement
- Cardiac muscle responsible for pumping blood
- Smooth muscle responsible for sustained contractions in the vascular system, gastrointestinal tract, and other areas in the body.

Skeletal and cardiac muscles are called striated muscle because of their striped appearance under a microscope, which is due to the highly organized alternating pattern of A band and I band.

While nerve impulse profiles are, for the most part, always the same, skeletal muscles can produce varying levels of contractile force. This phenomenon can be best explained by Force Summation. Force precis describes the addition of individual twitch contractions to increase the intensity of overall muscle contraction. This can be achieved in two ways: by increasing the number and size of contractile units simultaneously, called *multiple fibres summation*, and by increasing the frequency at which action potentials are sent to muscle fibers called *frequency summation*.

- **Multiple fiber summation** – When a weak signal is sent by the CNS to contract a muscle, the smaller motor units, being more excitable than the larger ones, are stimulated first. As the strength of the signal increases, more motor units are excited in addition to larger ones, with the largest motor units having as much as 50 times the contractile strength as the smaller ones. As more and larger motor units are activated, the force of muscle contraction becomes progressively stronger. A concept known as the size principle, allows for a gradation of muscle force during weak contraction to occur in small steps, which then become progressively larger when greater amounts of force are required.

- **Frequency summation** – For skeletal muscles, the force exerted by the muscle is controlled by varying the frequency at which action potentials are sent to muscle fibers. Action potentials do not arrive at muscles synchronously, and, during a contraction, some fraction of the fibers in the muscle will be firing at any given time. In a typical circumstance, when a human is exerting a muscle as hard as he/she is deliberately able to roughly one-third of the fibers in that muscle will be firing at once, though this ratio can be affected by various physiological and psychological factors (including Golgi tendon organs and Renshaw cells). This 'low' level of contraction is a protective mechanism to prevent avulsion of the tendon the force generated by a 95% contraction of all fibers is sufficient to damage the body.

A. Types of Muscular Contraction

Muscle fiber generates tension through the action of actin and myosin cross-bridge cycling. While under tension, the muscle may lengthen, shorten, or remain the same. Although the term contraction implies shortening, when referring to the muscular system, it means muscle fibers generating tension with the help of motor neurons. Several types of muscle contractions occur, they are defined by the changes in the length of the muscle during contraction.

1. Isotonic Contractions

Isotonic contractions maintain constant tension in the muscle as the muscle changes length. This can occur only when a muscle's maximal force of contraction exceeds the total load on the muscle. Isotonic muscle contractions can be either concentric (muscle shortens) or eccentric (muscle lengthens).

i. Concentric Contractions

A concentric contraction is a type of muscle contraction in which the muscles shorten while generating force. This is typical of muscles that contract due to the sliding filament mechanism, and it occurs throughout the muscle. Such contractions also alter the angle of the joints to which the muscles are attached, as they are stimulated to contract according to the sliding filament mechanism.

This occurs throughout the length of the muscle, generating force at the musculo-tendinous junction; causing the muscle to shorten and the angle of the joint to change. For instance, a concentric contraction of the biceps would cause the arm to bend at the elbow as the hand moves from near to the leg to close to the shoulder (a biceps curl). A concentric contraction of the triceps would change the angle of the joint in the opposite direction, straightening the arm and moving the hand toward the leg.

ii. Eccentric Contractions

An eccentric contraction results in the elongation of a muscle. Such contractions decelerate the muscle joints (acting as "brakes" to concentric contractions) and can alter the position of the load force. These contractions can be both voluntary and involuntary. During an eccentric contraction, the muscle elongates while under tension due to an opposing force which is greater than the force generated by the muscle. Rather than working to pull a joint in the direction of the muscle contraction, the muscle acts to decelerate the joint at the end of a movement or otherwise control the repositioning of a load.

This can occur involuntarily (when attempting to move a weight too heavy for the muscle to lift) or voluntarily (when the muscle is "smoothing out" a movement). Over the short-term, strength training involving both eccentric and concentric contractions appear to increase muscular strength more than training with concentric contractions alone.

2. Isometric Contractions

In contrast to isotonic contractions, isometric contractions generate force without changing the length of the muscle. This is typical of muscles found in the hands and forearm: the muscles do not change length, and joints are not moved, so force for grip is sufficient. An example is when the muscles of the hand and forearm grip an object; the joints of the hand do not move, but muscles generate enough force to prevent the object from being dropped.

3. Isokinetic Contractions

Isokinetic contractions are like Isotonic in that the muscle changes length during the contraction, where they differ is that Isokinetic contractions produce movements of a constant speed. To measure this a special piece of equipment known as an Isokinetic dynamometer is required. Examples of using Isokinetic contractions in day-to-day and sporting activities are rare. The best is breaststroke in swimming, where the water provides a constant, even resistance to the movement of adduction.

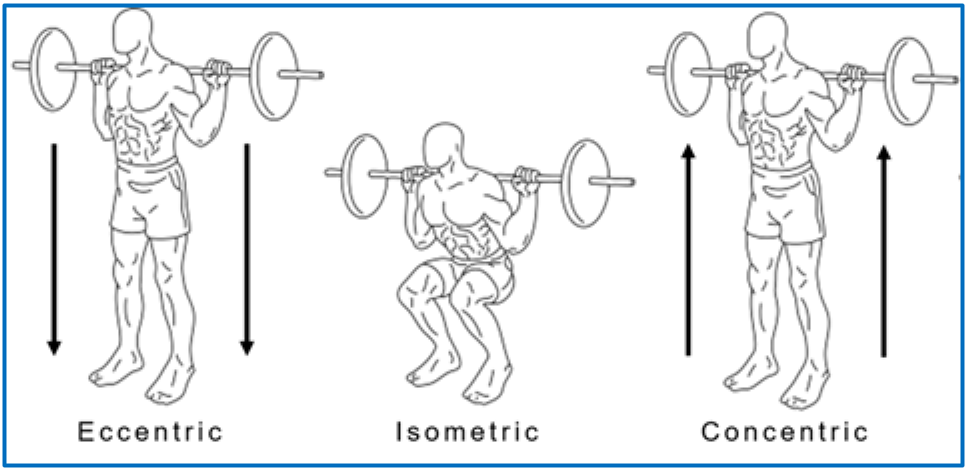

Figure 7

CHAPTER 4

4.1 Ergonomics

Ergonomics is a relatively new branch of science which celebrated its 50th anniversary in 1999 but relies on research carried out in many other older, established scientific areas, such as engineering, physiology and psychology. Ergonomics is a branch of science that aims to learn about human abilities and limitations, and then apply this learning to improve people's interaction with products, systems and environments.

To achieve best practice design, Ergonomists use the data and techniques of several disciplines:

- anthropometry: body sizes, shapes; populations and variations
- biomechanics: muscles, levers, forces, strength
- environmental physics: noise, light, heat, cold, radiation, vibration body systems: hearing, vision, sensations
- Applied psychology: skill, learning, errors, differences
- Social psychology: groups, communication, learning, behaviours.

Ergonomics aims to create safe, comfortable and productive workspaces by bringing human abilities and limitations into the design of a workspace, including the individual's body size, strength, skill, speed, sensory abilities (vision, hearing), and even attitudes.

4.2 Posture

Posture is a term used to describe a position of the body or the arrangements of body parts relative to one another. Ideal postures are those assumed to perform an activity in the most efficient manner utilizing the least amount of energy. All activity begins with a posture and ends with a posture. The relationships between body parts can be controlled voluntarily but to do this would require too much concentration. During normal functioning one's postures and adjustments to postures are automatic and occur quickly.

- Posture is Dynamic - it is usually during these transitions from one posture to another that injury occurs.
- Posture requires Coordination - The movement between one static posture and another requires the coordinated timing and recruitment of muscles specific to the task at hand. It is a programmed pattern of muscle activity that the body counts on to maintain stability.
- Poor movement patterns can result from any of the following: Joint dysfunction, Pain, Stress, Central nervous system disorder/injury, Overwork or overtraining and prolonged postures or repetition of the same activity.

A. Postural Mechanism

Sitting Posture

- When sitting on an office chair at a desk, arms should be flexed at a 75 to 90-degree angle at the elbows. If this is not the case, the office chair should be adjusted accordingly.

- Be sure the back is aligned against the back of the office chair. Avoid slouching or leaning forward, especially when tired from sitting in the office chair for long periods
- For long term sitting, such as in an office chair, be sure the chair is ergonomically designed to properly support the back and that it is a custom fit
- Knees should be even with the hips, or slightly higher when sitting in the office chair
- Keep both feet flat on the floor. If there's a problem with feet reaching the floor comfortably, a footrest can be used along with the office chair
- Sit in the office chair with shoulders straight
- Don't sit in one place for too long, even in ergonomic office chairs that have good back support. Get up and walk around and stretch as needed

Standing Posture

- Stand with weight mostly on the balls of the feet, not with weight on the heels
- Keep feet slightly apart, about shoulder-width
- Let arms hang naturally down the sides of the body
- Avoid locking the knees
- Tuck the chin in a little to keep the head level
- Be sure the head is square on top of the spine, not pushed out forward
- Stand straight and tall, with shoulders upright

- If standing for a long period of time, shift weight from one foot to the other, or rock from heels to toes.
- Stand against a wall with shoulders and bottom touching wall. In this position, the back of the head should also touch the wall - if it does not, the head is carried to far forward (anterior head carriage).

Walking Posture

- Keep the head up and eyes looking straight ahead
- Avoid pushing the head forward
- Keep shoulders properly aligned with the rest of the body

Driving Posture

- Sit with the back firmly beside the seat for proper back support
- The seat should be a proper distance from the pedals and steering wheel to avoid leaning forward or reaching
- The headrest should support the middle of the head to keep it upright. Tilt the headrest forward if possible, to make sure that the head-to-headrest distance is not more than four inches.

Posture and Ergonomics While Lifting and Carrying

- Always bend at the knees, not the waist
- Use the large leg and stomach muscles for lifting, not the lower back
- If necessary, get a supportive belt to help maintain good posture while lifting

- When carrying what a heavy or large object, keep it close to the chest
- If carrying something with one arm, switch arms frequently
- When carrying a backpack or purse, keep it as light as possible, and balance the weight on both sides as much as possible, or alternate from side to side
- When carrying a backpack, avoid leaning forward or rounding the shoulders. If the weight feels like too much, consider using a rolling backpack with wheels.

Sleeping Posture with Mattresses and Pillows

- A relatively firm mattress is generally best for proper back support, although individual preference is very important
- Sleeping on the side or back is usually more comfortable for the back than sleeping on the stomach
- Use a pillow to provide proper support and alignment for the head and shoulders
- Consider putting a rolled-up towel under the neck and a pillow under the knees to better support the spine
- If sleeping on the side, a relatively flat pillow placed between the legs will help keep the spine aligned and straight.

B. Types of Postural Deformities

✓ ***Kyphosis*** (Greek -kyphos, a hump) is also called round back or Kelso's hunch back, is a condition of over-curvature of the thoracic vertebrae (upper back). It can be either the result of degenerative diseases (such as arthritis), developmental problems, osteoporosis with compression fractures of the vertebrae, and/or trauma.

Causes

- Habitual Bad Posture
- Underdevelopment/ Weakness of Longitudinal Back Muscle
- Rickets
- Mental/Physical Fatigue
- Injury/Disease of Spine
- Arthritis

Symptoms

- Appearance of poor posture with a hump appearance of the back or "hunchback," backpain, muscle fatigue, and stiffness in the back.
- In rare cases, this can lead to compression of the spinal cord with neurologic symptoms including weakness, loss of sensation, or loss of bowel and bladder control.
- Thoracic kyphosis can also limit the amount of space in the chest and cause cardiac and pulmonary problems leading to chest pain and shortness of breath.

Remedial Exercise

- Mobilizing exercises are given for whole spine.
- Strengthening exercises are given for abdominal muscles and back extensors.
- There may be associated tightening in hamstring muscles. Hence stretching of hamstring is done.

✓ ***Scoliosis*** is an abnormal curving of the spine. The spine is backbone. It runs straight down to back. Everyone's spine naturally curves a tiny bit. But people with scoliosis have a spine that curves too much. The spine might look like the letter "C" or "S".

Causes

- In most cases (85%), the cause of scoliosis is unknown (what doctors call idiopathic). The other 15% of cases fall into two groups:
- Non-structural (functional): This type of scoliosis is a temporary condition when the spine is then normal. The curvature occurs as the result of another problem. Examples include one leg being shorter than another from muscle spasms or from appendicitis.
- Structural: In this type of scoliosis, the spine is not normal. The curvature is caused by another disease process such as a birth defect, muscular dystrophy, metabolic diseases, connective tissue disorders, or Marfan's syndrome.

Symptoms

- One shoulder is higher than the other
- One shoulder blade sticks out
- One side of the rib cage appears higher
- One hip appears higher or more prominent
- The waist appears uneven
- The body tilts to one side
- One leg may appear shorter than the other one

Remedial Exercise

Bracing - Braces will help control any worsening of a spine curvature but do little to correct an existing deformity. Bracing is most effective for scoliosis treatment when used in children that are rapidly growing and have worsening scoliosis curves.

Surgery- Surgery is often the best options for more severe curves. Depending on the site of the curve and the degree of curvature, the surgeon will fuse vertebrae in a more normal anatomic position.

- ✓ ***Lordosis*** is a medical term used to describe an inward curvature of apportion of the lumbar and cervical vertebral column. Excessive or hyper lordosis is commonly referred to as swayback or saddle back.

Causes

- Imbalances in muscle strength and length are also a cause, such as weak hamstrings, or tight hip flexors(psoas).
- Tight low back muscles.
- Excessive visceral fat.

Symptoms

- The major clinical feature of lordosis is a prominence of the buttocks.
- Symptoms will vary depending if lordosis occurs with other defects, such as muscular dystrophy, developmental dysplasia of the hip, or neuro muscular disorders.

Treatment

- Physical Therapy- Exercises may be used to strengthen muscles and increase range of motion. It may also be taught how to maintain a correct posture.
- Medications- Non-steroidal anti-inflammatory drugs (NSAIDs) may be given for discomfort or to decrease swelling.
- Back Brace- Braces are sometimes used with children. The brace can make sure the curve doesn't worsen as they grow.
- Surgery- Surgery is reserved for severe cases. In this case the spine is straightened by using a metal rod, hooks, or screws in the back bones. Surgeons also use a bone graft to promote new growth and stability.

✓ **Bowlegs** is a condition in which the knees stay wide apart when a person stands with the feet and ankles together.

Causes

Bowlegs may be caused by illnesses such as:

- Bone disease
- Bone dysplasia (abnormal development)
- Fractures that do not heal correctly Lead or fluoride poisoning
- Rickets, which is caused by a vitamin D deficiency.

Symptoms

- Knees do not touch when standing with feet together (ankles touching)

- Bowing of legs is same on both side of the body (symmetrical)
- Bowed legs continue beyond age 3

Treatment

- If the condition is severe or the child also has another disease, special shoes, braces, or casts can be tried. It is unclear how well these works.
- At times, surgery is performed to correct the deformity in an adolescent with severe bowlegs.

✓ **Knock Knee** is a deformity of the legs in which the knees are abnormally close together and the ankles are spread widely apart.

Causes

- Rickets- Rickets are the result of a vitamin D deficiency. Vitamin D helps regulate the calcium and phosphate in the blood.
- Injury- An injury to the knee affecting the anterior cruciate ligament or ACL causes instability to the knee in children or young adults.

Symptoms

- A large difference between the angle of one leg and the other when standing straight,
- An excessive inward or outward knee angle, pain linked to the angle of their knee, and
- Difficulty walking or an awkward way of walking.

Treatment

- A change of diet, if knock knee is caused by a condition such as rickets or scurvy,
- Wearing special heel supports inside shoes to correct the line of the legs,
- Wearing braces or splints to correct the line of the legs, and surgery, although this is only considered in severe cases.

✓ **Flat Foot** is a medical condition in which the arch of the foot collapses, with the entire sole of the foot coming into complete or near-complete contact with the ground.

Causes

- Family history - experts say fallen arches can run in families.
- Weak arch - the arch of the foot may be there when no weight is placed on it, for example, when the person is sitting. But as soon as they stand up the foot flattens (falls) onto the ground.
- Injury
- Arthritis
- Nervous system or muscle diseases

Symptoms

- Foot pain, particularly in the heel or arch area
- Difficulty standing on tip toe
- Swelling along the inside of the ankle

Treatment

- Pain in the foot that is caused by flat feet may be alleviated if the patient wears supportive well-fitted shoes.
- Fitted insoles or orthotics (custom-designed arch supports)

may relieve pressure from the arch and reduce pain if the patient's feet roll or over-pronate.

- Wearing an ankle brace may help patients with posterior tibial tendinitis, until the inflammation comes down.
- Bodyweight management - if the patients obese the doctor may advise him/her to lose weight. A significant number of obese patients with flat feet who successfully lose weight experience considerable improvement of symptoms.

4.3 Exercise and Postural Mechanism

Proper posture and breathing may sound like simple things to remember during exercise but all too often injuries like muscle strains and even falling can occur when we fail to maintain good posture and inadvertently holding breath during exertion. Good posture helps the body to function effectively and will minimize muscle strain and injury. During exercise, whether sitting or standing, the body will potentially be in several different positions. If weights added, such as dumbbells used for strength training, or increasing exercise intensity to a vigorous level remember to maintain proper form and posture. If there are lax on posture or physic can easily sustain an injury and be side lined. Take the time to learn proper body alignment and be mindful about how the body is feeling is better. Pain could be an indicator of incorrect form or posture.

Some of

- Keep neck in line with spine
- Chin aligned with neck, ears over shoulders

- Back straight
- Shoulders back, relaxed and down
- Keep knees relaxed do not lock them
- Pelvis slightly tucked under; belly button pulled back towards spine

CHAPTER 5

5.1 Diet and Performance

A. Diet

In nutrition, diet is the sum of food consumed by a person or other organism. The word diet often implies the use of specific intake of nutrition for health or weight-management reasons.

A particular diet may be chosen to seek weight loss or weight gain. Changing a subject's dietary intake, or "going on a diet", can change the energy balance and increase or decrease the amount of fat stored by the body. Some foods are specifically recommended, or even altered, for conformity to the requirements of a particular diet.

Planning the food pattern and making the action plan for nutritional way can make a healthy lifestyle. Many of them wrongly understand the word diet, it means reducing the calorie intake; actually, it's wrong. Diet means planned and controlled food consumption according the need of a person. It may be falls under in different categories.

a. Maintaining the proper weight
b. Increasing/ decreasing the calories intake
c. Diet for health issues

In any occasion, the person should not disturb their BMR bcoz, it will cause severe health problems in later stages while planning for diet concentrate on few points are must for better result.

- Calorie need of a person
- Nature of lifestyle

- Food alternate
- Number of servings and time management
- Adequate varieties to avoid boredom
- Must avoid appetite after consuming it.

And another category is consuming food for sports performance. In this category the mode or nature of sports will decide the food chart preparation. Maximum depends on duration/distance covering event of sports and energy release by working muscles. Mainly it divides into following types: Blood glucose – short distance/ Short time, Glucose and Glycogen – Middle Distance/ Speed Endurance, Fat metabolism – Long Distance/ Pure Endurance, Kerbs Cycle- Strength based activity/ Strength or Strength Endurance effects of each nutrient is explained with its benefits detailed.

B. Balanced Diet

A balanced diet needs to contain foods from all the main food groups in the correct proportions to provide the body with optimum nutrition. Components of a healthy balanced diet:

1. Dairy - This includes cheese, milk and yogurt. Dairy foods are usually high in saturated fat so to reduce fat and calories it is best to choose low fat or fat free varieties. Dairy is essential in the diet to provide calcium for strong bones as well as protein and vitamin D.

2. Protein - This is the main protein containing food group and includes lean meat and poultry with visible fat and skin removed, as well as fish, beans, lentils, peas, nuts and seeds, eggs and soy proteins such as tofu and tempeh. Meat and poultry are high in iron, whilst legumes are a rich source of fibre and eggs provide a multitude of vitamins and minerals. Fish should be included regularly, particularly oily fish high in omega three fatty acids such as salmon and sardines. Cooking methods should be low fat such as grilling, poaching, dry frying or steaming to minimize extra fat added during the cooking process.

3. Fruit - Fruit is virtually fat free, low in calories, high in fibre and very nutritious. Aim to include a variety of fruits to get a wide range of vitamins and minerals.

4. Vegetables - These generally contain the least calories and the most vitamins and minerals, hence they are an excellent option for filling up on. Make sure to include a wide variety in meals as different vegetables are rich in different vitamins.

5. Grains - This group is the major carbohydrate source in a balanced diet and includes bread, cereals, pasta and rice. Try to choose whole-grain varieties as these are higher in fibre and contain more B vitamins than white versions. Enriched cereals and breads, for example with iron, calcium or omega 3 can also be a good way to add some extra nutrition in diet.

6. Fats and Oils- Whilst some fat is necessary in our diets for the body to function correctly, it is important that these are the right types of fats. Saturated and trans fats should be minimized as these are unhealthy for the heart. Other good sources of unsaturated fats include nuts, avocado and fish.

How to achieve Balanced Diet

- At the core of a balanced diet are foods that are low in unnecessary fats and sugars and high in vitamins, minerals, and other nutrients. The following food groups are essential parts of a balanced diet.
- Food should also be made up of the correct number of calories to maintain a healthy weight and be low in processed foods.
- Calorie intake should also be balanced with physical activity and sedentary activities such as watching TV should be reduced.

C. Types of Diet

The word **diet** comes from Old French *diete* and Medieval Latin *dieta* meaning "a daily food allowance". The Latin word *diaeta* and Greek word *diaita* mean "a way of life, a regimen". A diet can be described as a set course of eating and drinking in which the kind and amount of food one should eat is been planned out.

i . The Zone Diet

The Zone Diet aims for a nutritional balance of 40% carbohydrates, 30% fats, and 30% protein each time we eat. The focus is also on controlling insulin levels, which result in more successful weight loss and **body weight** control.

The Zone Diet encourages the consumption of good quality carbohydrates - unrefined carbohydrates, and fats, such as olive oil, avocado, and nuts.

ii. Atkins Diet

The Atkins Diet, or Atkins Nutritional Approach, focuses on controlling the levels of insulin in our bodies through diet. In case of consuming large amounts of refined carbohydrates our insulin levels will rise rapidly, and then fall rapidly. Rising insulin levels will trigger our bodies to store as much of the energy we eat as possible - it will also make it less likely that our bodies use stored fat as a source of energy.

Most people on the Atkins Diet will consume a higher proportion of proteins than they normally do.

iii. Vegetarian Diet

There are various types of vegetarian: Lacto vegetarian, Fruitarian vegetarian, Lacto- vegetarian, Living food diet vegetarian and Semi-vegetarian.

The majority of vegetarians are lacto vegetarians, in other words they do not eat animal-based foods, except for eggs, dairy, and honey.

Studies over the last few years have shown that vegetarians have a lower body weight, suffer less from diseases, and generally have a longer life expectancy than people who eat meat.

iv. Vegan Diet

Veganism is more of a way of life and a philosophy than a diet. A vegan does not eat anything that is animal based, including eggs, dairy, and honey. Vegans do not generally adopt veganism just for health reasons, but also for environmental and ethical/compassionate reasons.

Vegans believe that modern intensive farming methods are bad for our environment and unsustainable in the long term. If all our food were plant based our environment would benefit, animals would suffer less, more food would be produced, and people would generally enjoy better physical and **mental health**, vegans say.

v. Raw Food Diet

The Raw Food Diet involves consuming foods and drinks which are not processed, are completely plant-based, and ideally organic. Raw foodists generally say that at least three-quarters of food intake should consist of uncooked food. A significant number of raw foodists are also vegans - they do not eat or drink anything which is animal based.

There are four main types of raw foodists: raw vegetarians, raw vegans, raw omnivores (both animal and vegetable foods are eaten), and raw carnivores (contains animal flesh).

vi. Mediterranean Diet

The Mediterranean Diet is Southern European, and more specifically focuses on the nutritional habits of the people of Crete, Greece, and southern Italy.

The emphasis is on lots of plant foods, fresh fruits as dessert, beans, nuts, cereals, seeds, olive oil as the main source of dietary fats, cheese and yogurts are the main dairy foods, moderate amounts of fish and poultry, up to about four eggs per week, small amounts of red meat, and low/moderate amounts of wine

D. Nutrient Recommendations

- children 2 to 8 years: 1,000 to 1,400 calories
- active women 14 to 30 years: 2,400 calories
- sedentary women 14 to 30 years: 1,800 to 2,000 calories
- active men 14 to 30 years: 2,800 to 3,000 calories
- sedentary men 14 to 30 years: 2,000 to 2,600 calories
- active men and women over 30 years: 2,200 to 3,000 calories
- sedentary men and women over 30 years: 1,800 to 2,200 calories

5. 2 Dietary Supplements

Manufacturers are responsible for ensuring their products are reasonably safe and not misleading, however, they are not required to prove a supplement works before marketing it, or even that it contains what it says it does. Some organizations test supplements to verify what is inside of them. An alternative to taking some of these supplements is to get the nutrients they provide in food.

Types

- Natural supplements are extracted from plants, animal tissues or inorganic material, such as seawater and rocks.
- Semi-synthetic supplements are extracted from natural sources and then chemically changed.
- Synthetic supplements are completely artificially produced.

a. Energy Production

A variety of vitamins are needed in metabolism. These vitamins help to break down food from bigger nutrients, such as carbohydrates and fatty acids, into smaller units that the body can use to turn food into fuel.

1. Thiamin

Thiamin is important to several metabolic pathways, such as the breakdown of carbohydrates and branched-chain amino acids.

- Good sources: Whole or fortified grain products, pork, peanuts and black beans

2. Niacin

Having too little or too much niacin can result in unpleasant and even dangerous side effects such as diarrhea, dementia, rashes and liver damage. Choose food sources before supplements.

- Good sources: Poultry, peanuts, fish, brown rice and whole grains

3. Vitamin B6

Involved in nearly 100 metabolic pathways, vitamin B6 is essential to the breakdown of foods, particularly carbohydrates.

- Good sources: Poultry, pistachios, chickpeas, lentils, pork, bananas and tuna

b. Performance Enhancement

The following vitamins and minerals often are taken for performance enhancement or to make up for missed nutrients of a restricted diet. Try focusing on food sources first, as high doses of some supplements may result in side effects such as constipation, bone damage and kidney stones.

1. Vitamin B12

B12 is found only in animal products, putting vegan and vegetarian athletes at risk for a deficiency. Fortified foods including breakfast cereals, nutritional yeast and plant-based meat alternatives provide vitamin B12. Be sure to read the food label as not all these foods are fortified. Taking a B12 supplement may also be needed but check with a health care provider first.

- Food sources: Seafood, meats, milk and cheese, eggs and fortified breakfast cereals

2. Iron

Iron is essential for oxygen transportation, traveling in blood throughout the body. Not having enough iron in the body may cause fatigue and impact physical performance. Exercise may cause some iron losses or decreased absorption.

- Food Sources: Clams, turkey breast, fortified breakfast cereals, beef, beans, spinach and oats

3. Vitamin A

Well-known for its role in vision, vitamin A also may act as an antioxidant, particularly during endurance training. Excess amounts from supplements can have toxic effects, though, so check with a health care provider before taking.

- Food Sources: Sweet potato, carrot, pumpkin, collard greens, spinach and cheese

c. Bone Health

Running, jumping and acrobatics – intense physical activity puts stress on bones and joints. Some vitamins and minerals promote bone health.

1. Vitamin D

Vitamin D can be absorbed from exposure to sunlight, however, an individual's weight, geographic location and skin color all can affect how well vitamin D is absorbed from ultraviolet light.

- Food sources: Fortified milk and soymilk, cod-liver oil, seafood and eggs

2. Calcium

In addition to bone health, calcium is important for nerve function and the release of hormones.

- Food sources: Milk, cheese, fortified orange juice and soymilk, and collard greens

d. Builds Muscle

1. The Best Protein Sources

Bodybuilding supplements are dietary supplements commonly used by those involved in bodybuilding, weightlifting, mixed martial arts, and athletics for the purpose of facilitating an increase in lean body mass. The intent is to increase muscle, increase body weight, improve athletic performance, and for some sports, to simultaneously decrease percent body fat so as to create better muscle definition. Among the most widely used are high protein drinks, branched-chain amino acids (BCAA), glutamine, arginine, essential fatty acids, creatine, HMB and weight loss products.

Supplements are sold either as single ingredient preparations or in the form of "stacks" – proprietary blends of various supplements marketed as offering synergistic advantages. While many bodybuilding supplements are also consumed by the general public the frequency of use will differ when used specifically by bodybuilders

Food	Serving Size	Grams of Protein
Chicken breast, cooked	4 ounces	33
Fish, salmon, cooked	4 ounces	29
Ground beef, cooked	4 ounces	26
Greek yogurt	1 cup	18 to 22
Yogurt	1 cup	12 to 14
Tofu, firm	½ cup	11
Milk	1 cup	8
Beans	½ cup	7 to 9
Nut butters	2 tablespoons	7 to 8
Cheese	1 ounce	7
Nuts	1 ounce	6
Egg	1 large	6
Quinoa, cooked	½ cup	4

2. Creatine

Found in food sources such as meat and fish, creatine also is produced naturally in our muscles for energy production. Creatine supplements claim to improve strength and exercise performance. However, more research is needed as results vary greatly depending on the study and athletic event.

5.3 Nutrients and its performance

Sportsman/ Sportswoman are very special. Some play for their passion and some play for the country. Being a sports person is not an easy task. Apart from being physically active they also have to look very deep into the amount and quality of calories they eat. It is true that they need more energy, calories, proteins, fats, carbohydrates than the regular person but right amount and quality of calories, protein, carbohydrates and fats are very important.

The guidance and the timely facts about the required nutrients will even make a sportsperson fall in line with his or her routine. An appropriate nutritional diet for a sports person consists of a minimum of 2000 calories per day, in which the division from different nutrients are as follows:

- **Carbohydrates –** 55% – 65%
- **Proteins** - 15% – 20% &
- 20–30% from **Fats**

Athletes who exercise strenuously for more than 60 to 90 minutes every day may need to increase the amount of energy they get from carbohydrates to between 65 and 70 per cent.
More recent advice also provides guidelines for carbohydrate and protein based on grams per kilogram (g/kg) of body weight. The current recommendations for fat intake are for most athletes to follow similar recommendations to those given for the general community, with the preference for fats coming from olive oils,

nuts, avocado, nuts and seeds. Athletes should also aim to minimise intake of high-fat foods such as biscuits, cakes, pastries, chips and fried foods.

Diet of sports person is crucial because their energy requirement varies. It intensifies when they are playing sports. So body store of nutrition should be such that help them to meet up those requirements during their optimum activity.

On an average a healthy young sports man in the age group of 19-30 yrs requires 3000 Kcals whereas beyond 30 years it varies from 2800-3000 Kcals. Still the requirement remains high as compared to regular person.

While talk about a mixture of carbohydrates, Proteins and fats, we cannot forget the importance of multi vitamins in the diet. They are also as important as other food groups.

Sports nutrition requires emphasis in three areas:

- Pre Event Meal
- Eating during Exercise
- Post Event Nutrition

1. Pre Event Meal

The pre-competition meal provides a final opportunity to top up the muscle and liver fuel stores. A high-carbohydrate, low fat meal is the best choice. The pre-event meal is an important part of the athlete's pre-exercise preparation. A high-carbohydrate meal three to four hours before exercise is thought to have a positive effect on performance. A small snack one to two hours before exercise may also benefit performance.

Some people may experience a negative response to eating close to exercise. A meal high in fat or protein is likely to increase the risk of digestive discomfort. It is recommended that meals just before exercise should be high in carbohydrates and known not to cause gastrointestinal upset.

Examples of appropriate pre-exercise meals and snacks include cereal and low-fat milk, toast/muffins/crumpets, fruit salad and yoghurt, pasta with tomato-based sauce, a low-fat breakfast or muesli bar, or low-fat creamed rice.

2. Eating during exercise

During exercise lasting more than 60 minutes, an intake of carbohydrate is required to top up blood glucose levels and delay fatigue. Eating or drinking carbohydrate becomes to maintain the blood glucose levels and improve performance.

Carbohydrate can be used as a fuel is 60 grams of carbohydrate per hour of exercise (approximately 0.7 gm carbohydrate/kg body weight/hour). This is the reason why sports drinks that contain 6 grams of carbohydrate per 100 ml. It is important to start intake early in exercise and to consume regular amounts throughout the exercise period. It is also important to consume regular fluid during prolonged exercise to avoid dehydration. Sports drinks, diluted fruit juice and water are suitable choices. For people exercising for more than four hours, up to 90 grams of carbohydrate per hour is recommended. For athletes who have not carbohydrate loaded, consumed a pre-exercise meal or are dieting to lose fat weight, taking in carbohydrates during exercise is even more important.

3. Post Event Nutrition

Rapid replacement of glycogen is important following exercise. Carbohydrate foods and fluids should be consumed after exercise, particularly in the first one to two hours after exercise. To top up glycogen stores after exercise, eat carbohydrates with a moderate to high GI in the first half hour or so after exercise. This must be continued until the normal meal pattern resumes. Suitable choices to start refuelling include sports drinks, juices, cereal and low-fat milk, low-fat flavoured milk, sandwiches, pasta, muffin/crumpets, fruit and yoghurt.

Carbohydrates and exercise

During digestion, all carbohydrates are broken down into sugar (glucose), which is the body's primary energy source. Glucose can be converted into glycogen and stored in the liver and muscle tissue. It can then be used as a key energy source during exercise to fuel exercising muscle tissue and other body systems. Athletes can increase their stores of glycogen by regularly eating high-carbohydrate foods.

If carbohydrate in the diet is restricted, a person's ability to exercise is compromised because there is not enough glycogen kept in storage to fuel the body. This can result in a loss of protein (muscle) tissue, because the body will start to break down muscle tissue to meet its energy needs and may increase the risk of infections and illness.

Carbohydrates are essential for fuel and recovery

Current recommendations for carbohydrate requirements vary depending on the duration, frequency and intensity of exercise. Foods rich in unrefined carbohydrates, like wholegrain breads and cereals, should form the basis of the athlete's diet. More refined carbohydrate foods (such as white bread, jams and lollies) are useful to boost the total intake of carbohydrate, particularly for very active people.

Athletes are advised to adjust the amount of carbohydrate they consume for fuelling and recovery to suit their exercise level. For example:

- Light intensity exercise (30 mins/day): 3–5 g/kg/day
- Moderate intensity exercise (60 mins/day): 5–7 g/kg/day
- Endurance exercise (1–3 hrs/day): 6–10 g/kg/day
- Extreme endurance exercise (more than 4 hrs/day): 8–12 g/kg/day

Importance of Carbohydrates: Carbs are the first nutrient to give energy to the body. Brain cells, cornea of eye and nervous tissues are majorly dependant on carbs as a source of energy. So for any sports person it is very important to undergo carb counting of the day as per the intensity and duration of his exercise. If exercise is for a short duration then the glycogen (form of carbs) stored in the body will be used up but if the exercise continues for a long time than constant supply of carbs to the body is important.

Choice of carbohydrates: Whole grains and fruits are better choice over refined carbs which will raise the glucose rapidly which causes overeating. Good amount of fiber should also be included in the diet.

Protein and sporting performance

Protein is an important part of a training diet and plays a key role in post-exercise recovery and repair. Protein needs are generally met by following a high-carbohydrate diet, because many foods, especially cereal-based foods, are a combination of carbohydrate and protein.

The **amount of protein recommended for sporting people** is only slightly higher than that recommended for the general public. For example:

- General public and active people – the daily recommended amount of protein is 0.8–1.0 g/kg of body weight (a 60 kg person should eat around 45–60 g of protein daily).
- Sports people involved in non-endurance events – people who exercise daily for 45–60 minutes should consume between 1.0–1.2 g/kg of body weight per day.
- Sports people involved in endurance events and strength events – people who exercise for longer periods (more than one hour) or who are involved in strength exercise, such as weight lifting, should consume between 1.2–1.7 g/kg of protein of body weight per day.

Dietary surveys have found that most athletic groups comfortably reach and often exceed their protein requirements by consuming a high-energy diet. Protein supplements are therefore unlikely to improving sport performance.

While more research is required, other concerns associated with very high-protein diets include:

- Increased cost
- A potential negative impact on kidney function
- Increased weight if protein choices are also high in fat
- A lack of other nutritious foods in the diet, such as bread, cereal, fruit and vegetables.

Importance of Proteins: As we know proteins are building blocks of the body so they become important for sportsman but apart from its function of body building it helps in building up immunity and increase the body stamina to sustain that high intensity of activity for a longer period of time. So to build up optimum stamina required by the sport it's essential to supply body with adequate protein on regular basis. 30-35% of total calories should come from protein.

Choice of Proteins: Choose lean meat proteins like chicken, lean fish, egg whites. These are first class proteins. For vegetarians proteins would include skimmed milk, yoghurts, beans etc but the quality of protein is low. So for a vegetarian it is recommended to include a protein supplement in the diet.

Fats: Fats are also required by the body for proper lubrication of bones. Fats help in absorption and transportation of fat soluble vitamins. Vitamin D required for bone strengthening requires fat for its absorption. Recommended amount is 25-30% of total calories.

Choices of Fats: Choose saturated fats over trans fats. Trans fats are harmful to the body. They increase the oxidative stress in the body and thereby cause cell destruction and reduce the immunity of the athlete. So avoid fried foods and junk foods. Include nuts olive oils, fatty fish, low fat milk, and low fat dairy products to meet up the requirements.

Water and Fluids: Hydrating body for an athlete is equally important with other nutrients. It increases the functionality of the sportsman. As proteins tend to induce constipation, adequate supply of water and fluids become necessary.

Fiber: With everything else is the diet fiber also plays an equally important part. It helps to keep the bowel movement regular. But before exercise fiber can be avoided.

Sodium: Major source of sodium in the diet is salt. So, observed amount of salt intake is recommended.

5.4 Water Mechanism

Heat Disorders

Thermoregulation

Body heat may be transferred by 4 mechanisms: (1) conduction, which refers to heat that flows from a cooler to a warmer object by direct contact; (2) convection, which involves heat transfer via air circulation at the body surface; (3) radiation, which arises through the transmission of electromagnetic waves; and (4) evaporation, which occurs via sweat at the skin surface.

Physiological changes include increases in plasma volume, sweat rates, cutaneous vasodilatation and decreases in urinary sodium excretion, sweating threshold, sweat electrolyte content, and heart rate at a given workload.

Factors of Heat

Environment

- Temperature

- Humidity and direct sunlight
- Presence or absence of wind
- Onset of a heat wave

The Individual

- Individual differences in strength and physical constitution
- General Health condition
- The person's physical health and level of fatigue
- The degree to which the person is acclimated to the heat
- Clothing etc.

Exercise

- Intensity, nature, and duration of exercise
- Rehydration
- Rest break regimen

Heat Disorder

- Heat stroke - Defined by a body temperature of greater than 40 °C (104 °F) due to environmental heat exposure with lack of thermoregulation. Symptoms include dry skin, rapid, strong pulse and dizziness.(High body temperature, Disturbance of consciousness, Slow reaction to calls and stimuli, Unusual speech and behaviour and Wobbly)
- Heat exhaustion - Can be a precursor of heatstroke; the symptoms include heavy sweating, rapid breathing and a

fast, weak pulse.(General feeling of malaise, Nausea/ vomiting, Headache and Decreased ability to concentrate or make decisions)

- Heat syncope - Fainting or dizziness as a result of overheating.(Dizziness, Fainting, Facial pallor, Quickening and weakening of the pulse)
- Heat cramps - Muscle pains that happen during heavy exercise in hot weather.(Muscle pain, Cramps and Muscle convulsions)
- Heat rash - Skin irritation from excessive sweating.

Symptoms

1. Symptoms of heat exhaustion include:
2. Heavy sweating
3. Extreme weakness or fatigue
4. Dizziness, confusion
5. Nausea
6. Clammy, moist skin
7. Pale or flushed complexion
8. Muscle cramps
9. Slightly elevated body temperature
10. Fast and shallow breathing

Water inhuman Body

The human body can last weeks without food, but only days without water. The body is made up of 50 to 75 per cent water. Water forms the basis of blood, digestive juices, urine and perspiration, and is contained in lean muscle, fat and bones. As the body can't store water, we need fresh supplies every day to make up for losses from the lungs, skin, urine and faeces (poo). The amount we need depends on our body size, metabolism, the weather, the food we eat and our activity levels.

Water in our bodies

Some facts about our internal water supply include:

- Body water content is higher in men than in women and falls in both with age.
- Most mature adults lose about 2.5 to 3 litres of water per day. Water loss may increase in hot weather and with prolonged exercise.
- Elderly people lose about two litres per day.
- An air traveller can lose approximately 1.5 litres of water during a three-hour flight.
- Water loss needs to be replaced.

Importance of water

Water is needed for most body functions, including to:

- maintain the health and integrity of every cell in the body
- keep the bloodstream liquid enough to flow through blood vessels
- help eliminate the by products of the body's metabolism,

excess electrolytes (for example, sodium and potassium), and urea, which is a waste product formed through the processing of dietary protein

- regulate body temperature through sweating
- moisten mucous membranes such as those of the lungs and mouth
- lubricate and cushion joints
- reduce the risk of cystitis by keeping the bladder clear of bacteria
- aid digestion and prevent constipation
- moisturise the skin to maintain its texture and appearance
- carry nutrients and oxygen to cells
- serve as a shock absorber inside the eyes, spinal cord and in the amniotic sac surrounding the fetus in pregnancy.

Water content in food

Most foods, even those that look hard and dry, contain water. The body can get approximately 20 per cent of its total water requirements from solid foods alone. The digestion process also produces water as a byproduct and can provide around 10 per cent of the body's water requirements. The rest must come from liquids.

Recommended daily fluid intake

Approximate adequate daily intakes of fluids (including plain water, milk and other drinks) in litres per day include:

- infants 0–6 months – 0.7 l (from breast milk or formula)

- infants 7–12 months – 0.9 l (from breast milk, formula and other foods and drinks)
- children 1–3 years – 1.0 l (about 4 cups)
- children 4–8 years – 1.2 l (about 5 cups)
- girls 9–13 years – 1.4 l (about 5-6 cups)
- boys 9–13 years – 1.6 l (about 6 cups)
- girls 14–18 years – 1.6 l (about 6 cups)
- boys 14–18 years – 1.9 l (about 7-8 cups)
- women – 2.1 l (about 8 cups)
- men – 2.6 l (about 10 cups).

These adequate intakes include all fluids, but it is preferable that the majority of intake is from plain water (except for infants where fluid intake is met by breast milk or infant formula). Sedentary people, people in cold environments, or people who eat a lot of high-water content foods (such as fruits and vegetables) may need less water.

Some people need higher fluid intake

People need to increase their fluid intake when they are:

- on a high-protein diet
- on a high-fibre diet, as fluids help prevent constipation
- pregnant or breastfeeding (the fluid need is 750-1,000 ml a day above basic needs)
- vomiting or have diarrhoea
- physically active
- exposed to warm or hot conditions.

Sports drinks

For optimal performance, athletes should be hydrated and adequately fuelled during exercise. Although there are a wide range of beverages marketed with reference to sport or performance; sports drinks are specifically designed to provide the right balance of carbohydrate, electrolytes and fluid to adequately fuel exercise and provide fluid for hydration. When used appropriately they can result in performance benefits.

Sports drinks are beverages whose stated purpose is to help athletes replace water, electrolytes, and energy before and after training or competition, though their efficiency for that purpose has been questioned, particularly after exercise.

Sports drinks can be split into three major types:

- Isotonic sport drinks contain similar concentrations of salt and sugar as in the human body.
- Hypertonic sport drinks contain a higher concentration of salt and sugar than the human body.
- Hypotonic sport drinks contain a lower concentration of salt and sugar than the human body.

Most sports drinks are approximately isotonic, having between 4 and 5 heaped teaspoons of sugar per eight ounce (13 and 19 grams per 250ml) serving.

Electrolytes

Besides water, electrolytes are the major component of sweat. Sodium and chloride comprise the largest proportion of electrolytes in sweat, along with smaller amounts of potassium, magnesium, calcium, iron, copper and zinc. Sodium stimulates thirst and enhances the absorption of carbohydrate and water by the small intestine. Sports drinks typically contain 20-60mg sodium/100mL and may or may not contain small amounts of other electrolytes. Although higher levels of sodium would result in better fluid retention, the palatability of the drink would be compromised. During ultra-endurance events such as adventure racing and Ironman triathlons, inadequate repletion of sodium can lead to a dangerous condition known as hyponatremia, however for most athletes engaged in prolonged exercise, the danger of this condition is relatively low if they remain well fuelled and hydrated.

Practical applications

1. Before exercise

Sports drinks may be useful before an event to fine tune fluid and fuel (carbohydrate) intake. The carbohydrate in sports drinks can increase carbohydrate availability, while the added sodium may reduce urine losses before exercise begins.

2. During exercise

Sports drinks are primarily designed for use during exercise lasting more than 90 minutes by providing optimal fluid and fuel delivery. Sports drinks may allow athletes to perform for longer and more effectively in training and competition by providing energy to working muscles and the brain.

3. Recovery

Sports drinks can help meet nutrition recovery goals by replacing fluids and electrolytes lost in sweat and helping to replenish glycogen stores. If there is limited time between training sessions or competition, drinks with higher sodium content may promote more effective rehydration. To meet all recovery goals, the ingestion of sports drinks should be complimented with foods and fluids that provide adequate carbohydrate, protein, and other nutrients essential for recovery.

Natural Home-made Recipe

Coconut water is often referred to as "Nature's Gatorade." It contains 13 times more potassium – an electrolyte needed for proper cell function – than Gatorade, plus twice the amount of another electrolyte (sodium). (source) (This brand doesn't have any additives/preservatives)

Raw honey is rich in minerals and easily digestible sugars, which can be used for energy. Sugar "signals the body to down-regulate the production of stress hormones like cortisol. Cortisol levels spike during exercise and particularly during anaerobic (when get breathless) exercise." (source)

Sea salt is full of electrolytes and minerals. Plus it "plays an important role of balancing the stress hormones during exercise. Salt reduces adrenaline levels and supports overall metabolic health." (source)

Trace mineral drops add to the electrolyte content of the drink. Due to soil depletion many of us do not get enough trace minerals in our diet, so I supplement with this regularly.

Freshly pressed juices such as lemon, lime, and orange contain vitamins, enzymes and easily digestible sugars that help maintain energy during a workout, then help speed recovery afterwards.

5.5 Ergogenic Aids

In the context of sport, an ergogenic aid can be broadly defined as a technique or substance used for the purpose of enhancing performance. A performance enhancer, or ergogenic aid, is anything that gives a mental or physical edge while exercising or competing. This can range from caffeine and sports drinks to illegal substances.

As competition in athletics grows and becomes more beneficial, so does the temptation to use chemical performance enhancers. The use of drugs and supplements to enhance performance is almost universal across athletic competition. The use of ergogenic aids stretches from the professional athlete to adolescent competitors without regard to gender. This large prevalence suggests education and monitoring is required at all levels.

I. Types of Ergogenic Aids

It includes Chemical or Pharmacological, Physiological, Nutritional, Psychological and Mechanical product introduced into the body for the specific purpose of enhancing athletic performance

1. Pharmacological Aids

Pharmacological ergogenic aids can be described as drugs, both legal and illegal, that are used to enhance physical performance. Pharmacological aids are commonly used by athletes of various sports competitions in order to gain a more competitive edge. They should be used with caution as pharmacological aids can have harmful side-effects and can potentially be dangerous or life threatening when abused. Before taking a pharmacological aid, it is important to conduct research to find out the effectiveness of the drug, any possible side effects, and if the drug is legal.

Common examples of pharmacological ergogenic aids include:

- Amphetamines – Improves concentration, decreases fatigue and appetite
- Anabolic steroids – Increases training time and intensity of workouts, as well as reduces recovery time.
- Beta-hydroxy methyl butyrate (HMB) – Improves strength and muscle mass
- Creatine – Increases muscle energy, short term endurance, strength, and lean muscle mass
- Caffeine – Stimulates the central nervous system, increases focus and alertness.
- Carnitine – Claimed to increase fat metabolism
- Chromium picolinate – Falsely promoted to build muscle, enhance energy, and burn fat
- Dehydroepiandrosterone (DHEA) – Increases endogenous steroid production
- Human growth hormone (HGH) – Hormone naturally produced in the pituitary gland that regulates growth and development.

2. Physiological Aids

Natural substances like herbal tea and things like acupuncture are physiological ergogenic aids and can be used to aid performance. Most of these aids are safe and effective.

a. Legal

1. Oxygen - is essential for the production of energy by aerobic processes. The greater the body's capacity to supply oxygen to the muscles during exercise, the greater the ability to maintain aerobic activity without fatigue. If a person can improve their capacity to utilize oxygen they are likely to improve their performance in endurance events.

2. Sports Massage - Massage is the most effective therapy for releasing muscle tension and restoring balance to the musculoskeletal system. Received regularly this may help athletes prevent injuries, which might otherwise be caused by overuse.

a. Illegal

1. Blood Doping - involves putting extra blood into the body which increases the level of hemoglobin thereby providing an increased oxygen carrying capacity for delivery to the working muscles.

2. EPO - EPO (erythropoietin) stimulates red blood cell production. It causes an increase in the total number of circulating red bloods cells.

3. Nutritional Ergogenic Aids

Products that may enhance energy production to improve strength, speed, power, or endurance (such as: carbohydrates, fat, protein, fluid, vitamins, minerals, and/or herbs). Products that may enhance performance by changing body composition (such as protein, energy, chromium). Products that may enhance recovery (such as fluids, carbohydrates, vitamins, minerals, and/or herbal products).

Aid	Possible Effect	Possible Side Effect	Legality
Caffeine	Increases use of fat as fuel Stimulates the central nervous system (CNS)	Dehydration Elevated heart rate and blood pressure	Legal up to 15 micrograms/ml (the equivalent of drinking 10 cups of coffee in 1 hour)
Anabolic steroids	Increases protein synthesis and muscle mass Accelerates recovery from heavy exercise	Possible disorders of the heart, liver, and kidney Reduction in size and function of testes Increased risk of heart disease	Controlled substance Prescribed for individuals with low testosterone, HIV, and sexual dysfunction Detected levels above normal are illegal in sports that test for it
Carbohydrates	Increase exercise performance Accelerate recovery from heavy exercise Essential for fat burning and most high-	Can add non-nutritious calories to the diet and promote fat storage, if the carbs eaten are simple sugars	Legal Strive to get 40–60% of calories from complex carbs that have fiber and nutrients.

	intensity activities		
Erythropoietin	Stimulates the production of red blood cells Increases oxygen transport capacity of the blood, thereby improving performance in aerobic activities	Thickens the blood, increasing blood clot risk May damage kidneys and blood vessels Is a danger to pregnant women and fetuses	Is prescribed by doctors for patients with anemia (low red blood cell count) Can be naturally increased through exposure to altitude, but supplementation is Illegal in sports
Creatine	May increase muscle stores of creatine phosphate, a high-energy source of ATP in the muscle May result in improved performance for short duration, high-intensity activities	According to most studies, safe in doses of 5–20g/day May be dangerous to those with kidney disease Other side effects possible, so caution is advised	Legal

4. Psychological Aids

Techniques that support the athlete's mental state are psychological ergogenic aids and can aid performance. Most of these aids are safe and effective. Psychological aid techniques are easy to learn and can be done anywhere.

a. Hypnosis - a very effective tool to distract the mind from negative thought before an event. It is a good idea to consult a professional for help.

b. Cheering - having affirmation from friends and family can improve the mental state of the athlete resulting in an improved performance.

c. Imagery - Involves positive visualization including seeing the winning an event, mastering a challenge, relieve feeling of stress, seeing perform a specific skill and planning game strategy.

d. Music - soothing music can calm pre-game jitters while energetic music can pump up before an event.

e. Psychology - techniques which athletes can use in the competitive situation to maintain control and optimize their performance. These include relaxation and imagery. Once learned, these techniques allow the athlete to relax and to focus his/her attention in a positive manner on the task of preparing for and participating in competition.

f. Relaxation - involves breathing techniques and muscle manipulation to help ease stress.

g. Yoga - can help relax tense muscles and calm the mind with breathing exercises

5. Mechanical Ergogenic Aids

Mechanical forms of ergogenic aids include specially-designed clothing, enhanced forms of sports equipment, and/or physical devices in contact with a person's body.

Here are a few examples of some mechanical aids:

- Altitude Training
- Heart Rate Monitors
- Computers - Used to analyze VO2 max, technique, test results etc.
- Video recorders - Used to analyze technique
- Weights
- Parachutes
- Downhill running
- Elastic cord (pulling and resisting)
- Uphill running
- Treadmills
- Weighted vests
- Sports clothing, footwear and equipment
- Timing equipment
- Nasal Strip

Aid	Possible Effect	Possible Effect
Wicking clothing	Transfers moisture from the skin through clothing, to be evaporated Aids in cooling the skin for	Legal and sold at most sporting goods stores

	temperature regulation during exercise	
Compression garments	May prevent post-exercise tissue swelling (edema) and aid in recovery from exercise Limited information on performance enhancement potential	Legal
Clap skates (a type of speed skate designed to keep more surface area of the skate on the ice)	Provides added acceleration and speed during the push-offphase	Legal and widely used in speed skating
Aerodynamic cycle and helmet	Reduces drag and allows for greater race speed	Legal
Drag-resistant swimsuits (specially designed compression suits)	Increases buoyancy and reduces drag, greatly improving speed in the water	Regulated by the International Swimming Federation for international competition
Specially designed running shoes (many varieties are available, depending on the activity)	Improves running speed due to improved traction and better foot support Reduces injury	Legal

World Anti-Doping Agency (WADA)

Multinational organization created to develop standards, definitions, testing, and regulations with regards to doping control on a worldwide basis for athletic competition.

The WADA stance on the presence of a prohibited substance or its metabolite(s) or marker(s) in an athlete's bodily specimen(s) or sample is clear: it is each athlete's personal duty to ensure that no prohibited substance enters his or her body. WADA also informs athletes about drug testing programs and provides a prohibited drug list, information about drug use, drug actions, adverse drug actions, side effects, and ethics. Different compounds may represent banned substances in different competitive sports and, thus, prohibitive lists are sport specific.

TERMINOLOGIES

A

Abdomen

That part of the body containing the viscera, ie the kidneys, liver, stomach, and intestines; separated from the thorax by the diaphragm.

Acetylcholine

A chemical (neurohormone) released from presynaptic nerve endings, which diffuses across the synapse (gap between the neurones) and stimulates the initiation of an impulse in the post-synaptic membrane. Is rapidly broken down by the enzyme cholinesterase.

Acid

A chemical which dissociates ("splits up") in solution to give hydrogen ions (H+). Have a Ph less than 7. Neutralised by alkalis (bases).

Adenosine Triphosphate (ATP)

A compound formed from ADP + P with energy released from Phosphocreatine (PC) and/or the breakdown (oxidation – either aerobic or anaerobic) of energy rich substrates e.g. glucose. Stored in all cells, especially muscle fibres. When it is broken down by enzyme action back into ADP + P the stored energy is made available for chemical or mechanical work. All the body"s energy use is via ATP, which is continually broken down and resynthesised (average daily turn-over = body weight).

Adipose tissue

Special tissue within which fat is stored. Found mainly under the skin (sub-cutaneous) and around the major organs.

Adolescence

The period in which a second growth spurt occurs and sexual maturity is achieved.

Adrenal glands

Literally "on top of the kidneys". Composed of two distinct regions, an outer cortex, and an inner medulla. The cortex secretes adrenal cortical hormones, e.g. sex hormones, aldosterone, cortisol; the medulla secretes adrenaline and noradrenaline, and is closely linked to the sympathetic nervous system.

Adrenaline

A hormone (chemical transmitter substance) released from the medulla of the adrenal glands and from sympathetic nerve endings, which prepares the body for "fight or flight"as a result of a "fright".

Aerobic Exercise

Exercise during which the energy needed is supplied by aerobic respiration (oxidation) of energy rich substrates e.g. glucose, using the oxygen that is breathed in (fats can only be broken down aerobically). Such exercise can be continued for long periods.

Affinity

Attraction to, "liking" for; e.g. haemoglobin has an affinity for oxygen, with which it forms oxyhaemoglobin.

Alactacid (alactate) Oxygen Debt (alactic recovery oxygen consumption)

The oxygen necessary after exercise to replenish the ATP-PC energy stores, and to resaturate the myoglobin and tissue fluids with oxygen.

Alkali (or base)

A chemical which accepts hydrogen ions, thus neutralising acids. Have a Ph greater than 7.

Amino Acids

Organic acids containing nitrogen. Proteins are made up of long chains of amino acids joined by peptide bonds. The body must be supplied with amino acids in the diet. There are 20 different types of amino acids in proteins of living origin. "Non-essential" amino acids are necessary for body function but can be produced in the body by interconversions (trans-amination) of other amino acids; about 11 so called "essential" amino acids are not produced by conversion in the body (at least not at a fast enough rate to satisfy demand) and must be obtained via the diet. Amino acids excess to the body's needs cannot be stored and are converted into glucose which is used as an energy source, and urea which is excreted in the urine, and incidentally in the sweat (especially during exercise when the kidneys have a reduced blood supply.

Amphetamine

A synthetic central nervous system stimulant related to adrenaline.

Anabolic Steroids

A group of ergogenic aids (related to the male hormone testosterone) that have an anabolic (protein building) effect, and to a greater or lesser extent an androgenic (development of male characteristics) effect on the body.

Anabolism

That aspect of metabolism involved in the building up (synthesis) of complex substances (e.g. proteins) from simpler substances (e.g. amino acids). Requires energy in the form of ATP.

Anaerobic Exercise (respiration)

Exercise that demands more oxygen than can be supplied at the time, and which therefore results in the depletion of ATP-PC stores, and the incomplete oxidation of glucose with the accumulation of lactic acid.

Anaerobic Glycolysis

The initial stages in the oxidative breakdown of glucose in the cytoplasm of cells and muscle fibres, which does not directly involve oxygen, generates a relatively small amount of ATP from each glucose molecule very rapidly, and which in the shortage of oxygen leads to the accumulation of lactic acid.

Anaerobic Threshold

The "point" at which, during exercise, the oxygen supply becomes insufficient to maintain aerobic respiration, so that anaerobic respiration becomes predominant, with the accumulation of lactic acid in the blood. Less used than previously, as always overlap between aerobic and anaerobic respiration systems in all types of exercise complicate the idea of a simple "threshold".

Analgesic

Pain killer e.g. aspirin.

Anoxia

Lack of oxygen in tissues.

Arterioles

Finer branches of arteries, with relatively narrow diameters, and involuntary muscle in their walls, the contraction of which leads to vasoconstriction, and the relaxation of which leads to vasodilation. When constricted (narrowed) there is a greater resistance to the flow of the blood and a raised blood pressure, and vice-versa. Lead into the capillary beds.

Arterio-venous oxygen difference (a-Vo2 diff)

The difference in oxygen content between the blood entering and that leaving the pulmonary capillaries.

Artery

Blood vessels carrying blood away from the heart, eventually dividing into arterioles.

Articulate

To connect by means of a joint.

ATP-PC System (phosphagen system)

An anaerobic energy system in which ATP is regenerated from the breakdown of phosphocreatine (PC). Muscles performing at maximal effort obtain ATP from this system.

Atrophy

Reduction in size and/or mass of cells and tissues, especially relating to muscle fibres.

Autonomic

Self-controlling; functionally independent of voluntary control.

Autonomic Nervous System

That part of the nervous system which works involuntarily (is not under voluntary control), controlling all the autonomic processes in the body, e.g. breathing rate, heart rate, peristalsis in the gut, contraction of the bladder, dilation and constriction of the pupil of the eye. Consists of two opposing (antagonistic) sub-systems, the sympathetic and parasympathetic nervous systems.

B

Basal Metabolic Rate

The rate of the metabolism, as measured by the energy output of an individual, whilst at rest in optimum conditions 12-18 hours after eating (post-absorptive period).

Biopsy

The extraction of small pieces of tissues for chemical and/or histological studies, e.g. muscle biopsy to study fibre composition, using a hollow needle.

Blood Pressure

The pressure exerted by the blood on the wall of a blood vessel, a function of cardiac output and peripheral resistance (the resistance to flow of the blood in the blood vessels, mainly the arterioles).

Bradycardia

Resting heart rate slower than average.

Buffering capacity

The capacity to prevent changes in pH.

Buffers

Substances which can prevent rapid changes in pH (acidity and alkalinity) within the body, e.g. proteins in the plasma, and haemoglobin in the red cells of the blood.

C

Calorie

A unit of heat. A thousand so-called small calories equals one large Calorie (kilocalorie or kcal), which is the type used when speaking of human nutrition. 1 Calorie = 4186 joules (4.186 kJ).

Carbohydrates

Organic compound containing only carbon, hydrogen and oxygen in a characteristic ratio, e.g. starch, sucrose (table sugar), and glucose. They are a basic source of energy, circulating as glucose in the blood stream, and being stored as glycogen in virtually all body tissues, but mainly in the liver and muscles. Bread, potatoes, fruits, honey and refined sugars are all excellent sources of carbohydrates. Carbohydrates yield about four Calories per gram when oxidised.

Cardiac Output

The amount of blood in dm3 (litres), pumped by the heart per minute, a function of heart rate and stroke volume. Generally the outputs of the right and left ventricles are the same.

Catabolism

That aspect of metabolism involved in the breakdown of complex substances into simpler substances. For example the oxidation of glucose into carbon dioxide and water (with the release of energy) in aerobic respiration.

Central nervous system

The brain and spinal cord.

Chemoreceptors

Receptors sensing changes in the chemical composition of body fluids e.g. blood glucose levels.

Complete Protein (protein of high biological value)

Protein that contains all of the essential amino acids, e.g. eggs (which contain them in the ratio closest to that of human requirements), cheese, milk, meat, whole grains, and soya beans.

Concentric contraction

Contraction of a muscle reducing its length.

Connective Tissue

Tissues that provide support and cohesion for the body, e.g. white collagen fibres which form tendons, the basis of bone, and fibrous cartilage: yellow elastic fibreswhich form ligaments, and the basis of elastic cartilage; bone and cartilage. Others form sheets or mesenteries which hold organs in place.

Core Body Temperature

The central body temperature, as opposed to that of the limbs, the temperature of which is lower due to their greater surface area to volume ratio.

Coronary

Relating to the blood vessels that supply the cardiac muscle of the heart wall (from their "crown" like arrangement around the heart).

D

Dehydration

Excessive loss of water, during exercise mainly as a result of sweating.

Diastole

Relaxation, as in relaxation of the ventricles (ventricular diastole).

Diffusion

The net movement of gases or dissolved substances, as a result of their kinetic energy, from regions of their higher concentration to regions of their lower concentration, down a concentration gradient, until equilibrium is reached.

E

Eccentric contraction

Contraction of a muscle whilst the length of the muscle increases, e.g. the contraction of the quadriceps in the front of the thigh whilst running downhill.

Electrolytes

Substances that dissociate into ions in solution (ionize). See inorganic ions/mineral salts.

"Empty" Calories

Calories obtained from foods such as sugar, which are virtually devoid of dietary essentials like amino acids, vitamins and minerals.

Endocrine glands

Ductless glands that produce and release (secrete) hormones directly into the blood, e.g. pituitary gland, adrenal glands, thyroid gland.

Energy

Energy can neither be created nor destroyed. In metabolism, energy in chemical compounds is trapped eventually in ATP, and then either used in synthetic reactions e.g. protein synthesis in growth, or in the sliding filament mechanism in contracting muscle fibres etc.; ultimately all energy is lost as heat.

Epithelium

A tissue lining a body surface, e.g. the lungs.

EPOC

Excess post exercise oxygen consumption, the oxygen taken up after the end of a period of exercise. To be preferred to "oxygen debt", as not all the extra oxygen taken up after a period of exercise excess to normal needs is "a debt" as such resulting from under supply during the period of exercise.

Ergogenic Aids

Substances, other than naturally occurring foods, that when taken orally or by injection will increase the potential for exercise performance, e.g. anabolic steroids.

Ergometer

A stationary cycle used for training or for laboratory tests to measure work performed.

F

Fast-Twitch (FT) Muscle Fibres

They have a contraction speed 2-3 times faster than slow-twitch (ST) fibres, and are capable of producing more power than ST fibres.

Fat (lipid)

Fat acts as an energy store, contains fat soluble vitamins, provides heat insulation under the skin (sub-cutaneous), and support and protection for organs. Fat supplies about nine Calories per gram when oxidised. Fat can only be oxidised aerobically.

Fatigue

A subjective experience, not amenable to objective testing, but clearly understood by all sportspersons.

Fatty acids

Long chain organic acids which are one of the end products of the digestion of fats (glycerol being the other), which can be oxidised aerobically as a source of energy, or which can be resynthesised back into fats stored in adipose tissue. Some are essential for certain key metabolic processes e.g. the proper functioning of the nervous system, and must be supplied in the diet (the essential fatty acids).

Fulcrum

The axis of rotation for a lever

Functional residual capacity (FRC)

The volume of air left in the lungs when the respiratory muscles are relaxed.

G

Glucose (blood sugar)

The simplest carbohydrate in the body (a monosaccharide or "single sugar"). It may be oxidised aerobically to carbon dioxide and water, or anaerobically to lactic acid. It is the sole source of energy for the nervous system. It may be converted into glycogen or fat.

Glycogen

The form in which carbohydrate is stored in the body, mainly in the muscles and the liver, sometimes known as "animal starch".

Glycolysis

The first stages of cellular respiration occurring with or without the presence of oxygen, in which glucose is converted to two molecules of pyruvic acid.

H

Haemoglobin

The iron-containing pigment in the red blood corpuscles (erythrocytes) that combines with oxygen to form oxyhaemoglobin.

HDL / Homeostasis

The maintenance of constant internal conditions (mainly of the body fluids) in the face of changing activity and external conditions, to provide optimum conditions for enzyme activity of metabolism. Controlled by negative feed-back loops, in which any change away from the “goal state” is opposed. The “ideal state” is never reached, and the metabolism fluctuates or “hunts” around the optimum within narrow limits, meaning that homeostasis is a dynamic equilibrium, never a static state.

Hormones

Chemical “messengers” secreted by ductless endocrine glands directly into the blood, which in small amounts stimulate specific processes of metabolism in “target” organs or tissues, usually at a distance from their site of production and secretion.

Hyperglycaemia

Higher blood glucose level than normal

Hypertension

High blood pressure.

Hypertrophy

Increase in the size and/or mass of cells and tissues, especially relating to muscle fibres.

Hyperventilation

An excessive increase in the rate of breathing, which causes a decrease in the amount of carbon dioxide in the blood, resulting in giddiness, cramps, convulsions, lowered blood pressure, and anxiety.

Hypoglycaemia

Lower blood glucose level than normal.

Hypothermia

Body temperature below normal.

Hypoxia

Low oxygen in the inspired air.

I

Incomplete Protein (protein of low biological value)

Protein that lacks one or more of the essential amino acids e.g. much vegetable protein.

Insulin

Hormone secreted by patches of endocrine cells in the pancreas. Opposes any rise in blood glucose by suppressing breakdown of liver glycogen to blood glucose, and stimulating formation of muscle glycogen from blood glucose. Also has a role in protein synthesis. The actions of insulin are opposed by the hormones glucagon and adrenaline.

Interval Training

A system of training in which intervals of hard exercise are alternated with easier recovery intervals.

Isokinetic Exercise

Contraction of a muscle at constant speed, whilst exerting maximum tension over the full range of movement at all joint angles, rarely achieved without special equipment.

Isometric Exercise

Contraction of a muscle in which shortening is prevented, e.g. when straining against an immovable resistance.

Isotonic drink

Being of the same concentration as the blood.

Isotonic Exercise

Contraction of a muscle during which the force of resistance to the movement remains constant throughout the range of motion.

J

Joint Provision

The providing of new facilities for the shared use of different groups, eg. school, and public.

Joule

A measure of energy. 4.2 joules = 1 calorie.

K

Kinaesthetic Feedback

The provision of feedback from proprioceptors (internal sense organs) about the position and movement of the body.

Kilocalorie (Kcal)

a unit of work or energy equal to the amount of heat required to raise the temperature of one kilogram of water one degree Celsius

Kinesiology

Scientific study of human movement. Includes such aspects of study as ex phys, motor learning/control, and biomechanics

Krebs cycle

A series of chemical reactions occurring in mitochondria, in which carbon dioxide is produce and hydrogen ions and electrons are removed from carbon atoms (oxidation). Also referred to as the tricarboxylic acid cycle (TCA), or citric acid cycle

L

Lactic Acid (lactate)

Formed in exercising muscles under anaerobic conditions. It causes the muscular pain associated with intense exercise. It is not a waste product, as it is oxidised as an energy source when oxygen is available. The alternative term "lactate" is strictly more accurate, as all acids exist in solution in the dissociated form, that is the molecule of lactic acid "splits up" releasing positively charged hydrogen ions, and the remainder of the molecule, which is negatively charged, is the lactate ion.

Lactic Oxygen Debt

The oxygen necessary after strenuous exercise to remove lactic acid from the blood

LDL

Low Density Lipoproteins, cholesterol is considered the "bad" cholesterol, because it contributes to fatty build ups in arteries

Ligament

Elastic tissue joining bones to bones.

Lymph

Plasma, minus plasma proteins, is exuded (pushed) through the capillary walls by the blood pressure and bathes the tissues as "tissue fluid", which is drained into the lymphatic system, where white cells known as lymphocytes are added by the lymph glands that occur throughout the system. The fluid is now known as lymph. It is returned to the circulatory system in the neck region. The lymphocytes help fight infection, if the lymph glands become infected, they become swollen and painful (hence "glandular fever").

M

Maximal Oxygen Consumption (Vo2 max)

The maximum amount of oxygen that an individual can consume in one minute. The figure may be expressed in dm3 (litres) of oxygen per minute, or more commonly in body weight bearing sports, e.g. running, in centimetres cubed (cm3) of oxygen per kilogram of body weight per minute. Remember the dot over the V represents "per minute".

Metabolism

All the chemical processes involved in maintaining life.

Minerals (inorganic ions, mineral salts, electrolytes)

Chemically simple substances that are essential constituents of all cells. Minerals play an important role in water balance (osmoregulation), regulation of blood volume, maintenance of proper acid-base balance, and all body functions eg calcium is essential for muscle contraction, and sodium and potassium are essential for nerve impulse transmission. Mineral salts are lost daily in the sweat and urine and must be replaced through the diet.

Mitochondria

Microscopic structures (from 0.001 mm – 0.4 mm) in cells and muscle fibres, just visible under the highest magnification of the light microscope. Centres of aerobic respiration using oxygen, regenerating ATP, and producing carbon dioxide and water as end products of the oxidation of glucose.

Monosaccharide

Literally "single sugar", the simplest type of sugar molecules e.g. glucose.

Motor unit

All the muscle fibres supplied (innervated) by a single motor neurone.

Myogenic contraction

Initiating contraction without nervous stimulation, although nervous stimulation and hormones are involved in co-ordination and determining rate, e.g. cardiac muscle, and involuntary muscle in the wall of the gut.

Myoglobin

"Muscle haemoglobin", an iron containing muscle pigment, that when oxygenated acts as an oxygen storage compound in Slow Twitch muscle fibres, imparting a red colour, hence red muscle fibres.

N

National Curriculum

Programmes of study and attainment targets laid down by the Government, stating what pupils must study from the time they enter primary school, to when they take GCSE in year 11. It is divided into 4 Key Stages, and Maths, English, Science are the core subjects.

Neuroticism

A personality factor (trait) which involves sensitivity, anxiety and insecurity.

Newton's Third Law

To every action there is an equal and opposite reaction.

O

OBLA

Onset of blood lactate accumulation. Although there are normally traces of lactate in the blood, it is generally agreed that a level of about 2 – 4 millimoles per dm3 (litre) represents OBLA, which correlates to the term "anaerobic threshold".

Optimum

The best possible.

Osmosis

The passage of water from regions of high water potential (pure water or more dilute solutions) to regions of low water potential (more concentrated solutions), across a partially permeable membrane (one that is more permeable to water than to dissolved substances (solutes)), down a water potential gradient until an equilibrium is reached. It is the special case of the diffusion of water. Sea water is more concentrated than blood, therefore if it is swallowed water moves from the blood and tissues by osmosis into the sea water in the gut. Fresh water is less concentrated than blood, therefore when drunk it moves by osmosis from the gut into the blood.

Oxidative potential

The ability to use oxygen in aerobic respiration.

Oxygen Debt

The amount of oxygen required to repay the oxygen deficit, by the removal of lactic acid and other metabolic products that accumulate when the supply of oxygen was below the needs of the individual during intense activity.

Oxygen Deficit

The amount of oxygen that the body is undersupplied with during a period of intense exercise, when oxygen consumption does not equal what is necessary to supply all the ATP from aerobic oxidation, during which time energy is partially supplied from anaerobic stores.

P

Parasympathetic nervous system

The part of the autonomic (involuntary) nervous system responsible for promoting normal relaxed functioning. Antagonistic to the sympathetic nervous system, e.g. the sympathetic nervous system stimulates an increase in the heart rate, and the parasympathetic nervous system decreases the rate. Partial pressureIn mixtures of gases, e.g. air, each substance exerts a partial pressure proportional to its concentration in the mixture. This pressure arises from continuous random movements that all gas particles exhibit.

pH

A measure of acidity or alkalinity, pH 7 is neutral, increasing acidity is expressed as a number less than 7; increasing alkalinity as a number greater than 7. The normal pH of blood plasma is 7.35-7.45.

Phosphagen system

The energy system involving ATP and phosphocreatine (PC). Stores of ATP and PC are exploited first in explosive exercise in what is known as the alactic anaerobic system.

Phosphocreatine (creatine phosphate)

Energy rich phosphate containing substance used as an immediate source of energy in the regeneration of ATP. Phosphocreatine itself can only be regenerated when there is an excess of ATP.

Physical Fitness

The capacity to perform physical activity with relative success and enjoyment without undue discomfort during or after. This normally involves a measure of the relative efficiency of the heart, blood vessels, lungs and muscles, in carrying out movements. In hard physical activity the enjoyment involves knowing that achieved aims.

Plyometrics

Maximum concentric effort made immediately following an eccentric phase. In simpler terms bounding, hopping, and rebound jumping.

Power

The rate of doing work; the rate of transfer of energy. It is defined in watts (W). 1 watt = 1 joule per second.

Proprioceptors

Internal sensory organs found in muscles, joints and tendons, which detect movements and position of the body.

Protein

Large molecules composed of long chains of amino acids (see also amino acids). Essential for growth and repair, but also a source of energy with one gram of protein supplying four Calories when oxidised. Excess protein (amino acids) cannot be stored as such, therefore daily intake required.

Puberty

The beginning of the development of sexual maturity.

Pulse rate

The rate of the pressure waves generated in the arteries as a result of the contraction (systole) of the left ventricle. In normal, healthy individuals, pulse rate and heart rate are identical.

Q

Quadriceps

The quadriceps femoris is a group of muscles located in the front of the thigh. The Latin translation of 'quadriceps' is 'four headed,' as the group contains four separate muscles: the vastus lateralis, vastus medialis, vastus intermedius, and the rectus femoris.

R

Racist Behaviour

This is behaviour that develops from the idea of the superiority of one race (a division of humankind whose members share certain characteristics) over another. This usually involves behaviour that is abusive, often violent, and discriminatory.

Rectus Abdominis

Muscle known as the "abdominals" or "abs", is a paired muscle running vertically on each side of the anterior wall of the human abdomen

Reaction Time

The time it takes for the brain to receive information, to decide what to do, and to send impulses to the muscles. Part of the response time.

Relaxation

A process of reducing tension, rigidity, anxiety, and intensity. Specific techniques can be developed, eg. Progressive Muscular Relaxation, the Quiet Place, Centring.

Reliability

A measure of whether a test gives repeatable results.

Residual volume (RV)

The volume of air left in the lungs after a forced maximal expiration.

Respiratory Exchange Ratio (RER)

The ratio of carbon dioxide produced and oxygen used. Indicates the type of fuel being used in the activity, e.g. aerobic oxidation of glucose (RER = 1), fats (RER = 0.7), and protein (RER = 0.8).

Respiratory Quotient (RQ)

See Respiratory Exchange Ratio.

Response Time

The time it takes to respond to some stimulus, eg. the actions of people.

Response = Reaction + Movement Time

Where the reaction time is the time it takes the brain to receive information, to decide what to do, and to send impulses to the muscles; and the movement time is the time it takes to actually move.

Reversibility (of training)

Gains in fitness as result of training are not permanent, they are easily lost (reversed) if training stops.

S

Sarcomere

The functional unit of a muscle myofibril, consisting of overlapping actin and myosin filaments between two Z discs (bands).

Slow-Twitch (ST) Muscle Fibres

Contract at a rate 2-3 times slower than fast-twitch (FT) fibres, but have greater endurance. Also known as red fibres as a result of the presence of myoglobin and large numbers of mitochondria.

Stationary Air

The air remaining in the lungs during quiet tidal breathing.

Strength

The force that a muscle can exert in one maximal effort.

Stroke volume (SV)

The volume of blood ejected by each contraction (systole) of the ventricle, is calculated by dividing the cardiac output by the heart rate.

Symbiosis

The living together of members of different species.

Sympathetic nervous system

The part of the autonomic (involuntary) nervous system responsible for preparing the body for action (see adrenaline.) Antagonistic to the parasympathetic nervous system.

Syncitium

Mass of cytoplasm in animals containing many nuclei as in striated muscle fibres.

Synthesis

Formation of complex substances from simpler ones. Requries energy.

Systemic circulation

The general circulatory system of the body, as opposed to that of the lungs (pulmonary circulation). Blood passes through the heart twice, as it flows from the systemic to the pulmonary and back to the systemic circulation.

Systole

Contraction, as in ventricular systole.

Superficial

On or near the surface, visible or palpable (able to feel with hands).

Suspension

Mixture containing solid particles that will ultimately settle our under gravity

T

Tachycardia

Resting heart rate faster than average.

Temporal summation

An increase in responsiveness of a nerve or muscle fibre, resulting from the additive effect of frequently occurring stimuli.

Tendon

Tough fibrous tissue attaching muscles to bones.

Testosterone

The male sex hormone secreted by the testes in the male, and by the adrenal cortex in both males and females. Responsible for the development of male characteristics.

Thorax

That part of the body containing the heart and the lungs, separated from the abdomen by the diaphragm.

Tidal volume

The volume of air moved during quiet breathing at rest.

Total lung capacity

Vital capacity + residual volume, difficult to measure.

Trace Decay (forgetting)

The fading away of a memory which has been learned but not practised or used.

Training (physical)

A process which is designed to improve physical capacity, fitness, skill, etc.

Transfer of Training (learning)

The influence of previously learned skills and activities on the learning of new ones. This appears to depend on the amount of similarity between the skills and activities and may be helpful (positive) or harmful (negative).

Trait Anxiety

A personality factor (trait). The tendency to become anxious in almost all or any situation.

U

Ulna

The longer bone of the forelimb between the humerus and the "wrist"

V

Validity

A measure of whether a test actually tests what it claims to test, e.g. does the Conconi test give an accurate measure of the anaerobic threshold? (Answer = No)

Vasoconstriction

A decrease in the diameter of a blood vessel (usually an arteriole) by contraction of circular involuntary muscle fibres in the walls, resulting in a reduction of blood flow to the area supplied by the vessel.

Vasodilation

An increase in the diameter of a blood vessel (usually an arteriole) resulting in an increased blood flow to the area supplied by a vessel.

Vasomotor

Relating to the control of vasoconstriction and vasodilation.

Viscosity

"Thickness" of a fluid or "ease of flow", e.g. plasma has a viscosity which allows it to be pumped rapidly around the body.

Vital Capacity

The total volume of air that can be expired following full inspiration, in other words the total volume of air that can be moved over the lungs in one "breath".

Vitamins

Complex organic substances required in the diet (NB vitamin D also produced by the action of ultra-violet light on the skin), essential for normal body functions and maintenance of health. Vitamins contribute to the regulation of metabolic processes, including a role in energy transformations.

Viviparous

Young born alive after developing on nutrients obtained from the mother rather than from egg yolk. Not separated from the maternal tissues by the egg membrane.

Voluntary Muscle

Muscle that can be controlled by the conscious decisions

W

Warm-up

A warm-up should involve a gradual increase in the heart rate and breathing rate, a slight rise in body temperature, and prepare the mind and the body for activity. Helps to reduce the risk of injury

Water potential

A special case of "chemical potential". All substances diffuse from regions of high concentration or high chemical potential to regions of low concentration or low chemical potential. With respect to water, pure water has the highest chemical or water potential, and the presence of solutes lowers the water potential of a solution. Thus in osmosis water diffuses from regions of high water potential to regions of low water potential. Water potential is measured in kPa.

Wild type

Phenotype (appearance) characteristic of the majority of a species in a natural environment.

Work

Application of a force through a distance; it is measured in joules (J, kJ, MJ).

Work rate

Work performed per unit time = power.

X

Xerophytes

Plants adapted to dry habitats.

Y

Z

Zoospores

Flagellate, motile spores found in some fungi and algae.

Zygospore

Thick-walled resistant resting spore produced by sexual reproduction in some fungi; for example Mucor, and in some algae; for example Spirogyra.

Zygote

Cell (typically diploid) formed by the fusion of two gametes (each typically haploid), eg fertilised egg in humans.

DISCUSSION

A. Objective Questions

1. During prolonged exercise, the preferred energy source for skeletal muscle is:

a. Plasma glucose

b. Plasma fatty acids

c. Muscle triglycerides

d. Muscle glycogen

2. In athletes, physical fitness is more closely correlated with

a. Maximal oxygen uptake than with resting oxygen uptake

b. Maximal pulse rate than with resting pulse rate

c. Maximal minute ventilation than with maximal cardiac output

d. Blood oxygen saturation than with blood lactate level during strenuous exercise

e. Resting vagal tone than with resting sympathetic tone to the heart

3. The muscle fibers adapted to endurance running

a. Are classified as slow rather than fast.

b. Have a relatively high myoglobin content.

c. Are red rather than white

d. Have a relatively high mitochondria content.

e. Are classified as anaerobic rather than aerobic.

4. The oxygen consumed per minute

a. Is greater than the carbon dioxide produced per minute during long distance running.

b. In the resting adult is nearer 100 than 150 ml.

c. During intense mental activity can rise to twice the resting level.

d. During brisk walking is nearer five times than twice the resting level.

e. In an Olympic athlete can rise to 50 litters.

5. The increase in blood flow to muscle in an exercising limb is related to a rise in

a. Local PCO2

b. Local H concentration

c. Local muscle temperature

d. Arterial pressure

e. Vasodilator nerve activity

6. During muscular training

a. Neural control factors improve performance before there is evidence of skeletal muscle hypertrophy.

b. Repeated stretching of skeletal muscle fibers leads to their hypertrophy.

c. There is a gradual decrease in the size of the heart in diastole.

d. There is a gradual increase in the O2 extraction rate from blood perfusing exercising skeletal muscle.

e. The increase in skeletal muscle blood flow for a given work load decreases.

7. Blood lactic acid is

a. Normally undetectable in resting subjects

b. A product of anaerobic metabolism

c. Increased by a 100-metre dash

d. Not increased during steady state running in a marathon race

e. Raised to about 5–10 moles/liter during maximal exercise

8. Isotonic (dynamic) exercise differs from isometric (static) exercise in that there is less

a. Increase in systolic arterial pressure.

b. ncrease in diastolic arterial pressure.

c. Assistance to the circulation by the muscle pump

d. Use of slow-twitch muscle fibers

e. Reliance on anaerobic glycolysis

9. Electrocardiological danger signs during incremental treadmill exercise include

a. A heart rate equal to the maximal predicted for the person's age.

b. An R-R interval of about 500 milliseconds.

c. R waves with an amplitude greater than one milliVolts.

d. Ventricular tachycardia

e. ST depression of one millimetre

10. Exercising in a hot chamber may induce

a. Fainting due to a decreased total peripheral resistance

b. Heat stroke when core temperature rises above 40° C.

c. A rise in alveolar PCO_2

d. A decrease in the osmolality of extracellular fluid

e. Heat adaptation if performed daily for several weeks

That part of the body containing the viscera, ie the kidneys, liver, stomach, and intestines; separated from the thorax by the diaphragm.

Answers

1. (b) plasma fatty acid

2.

   A. True

   B. False

   C. False

   D. False

   E. True

3.

   A. True

   B. True

   C. True

   D. True

   E. False

4.

   A. True

   B. False

   C. False

   D. True

   E. False

5.

   A. True

   B. True

C. True

D. False

E. False

6.

A. True

B. True

C. False

D. True

E. True

7.

A. False

B. True

C. True

D. False

E. False

8.

A. False

B. True

C. False

D. False

E. True

9.

A. False

B. False

C. False

D. True

E. False

10.

A. True

B. True

C. False

D. False

E. True

B. Question and Descriptive Answers

1. What is the name of the neurotransmitter in the process of muscular contraction?

Muscle contraction begins when the nervous system generates a signal. The signal, an impulse called an action potential, travels through a type of nerve cell called a motor neuron. The chemical message, a neurotransmitter called acetylcholine, binds to receptors on the outside of the muscle fiber.

2. What steps are involved in neuromuscular transmission?

Steps in neuromuscular transmission: 1) nerve action potential. 2) calcium entry into the presynaptic terminus. 3) release of Ach quanta. 4) diffusion of Ach across cleft. 5) combination of Ach with post-synaptic receptors and Ach breakdown via esterase. 6) opening of Na+/K+ channels (cation channels).

3. **During a muscular contraction, the myosin filaments pull the actin filaments closer together. This brings what closer together?**

   During muscle contraction, each sarcomere shortens, bringing the Z discs closer together. Muscle contraction thus results from an interaction between the actin and myosin filaments that generates their movement relative to one another.

4. **What is covering the binding site for the myosin head to attach on the actin filament?**

   The protein tropomyosin winds around the thin filaments and covers the myosin binding sites. At regular intervals along the tropomyosin cable sit troponin molecules. The myosin head attaches to the binding site on the actin filament. In addition, it binds ATP, acting as an enzyme to transfer energy from ATP.

5. **What energy system is used in a 100m sprint?**

   Crowder et al. (1992) estimates that during sprint events approximately 95% of energy production comes via the anaerobic system (85% phosphate, 10% lactic acid), and only 5% from aerobic oxygen. Thus, the 100m sprint is an anaerobic event relying heavily on energy supply from the ATP-PC system

6. **What energy system is used in a marathon?**

   Aerobically the body can create energy for running through the use of glucose and fats in the presence of oxygen. This is known as aerobic glycolysis. The aerobic energy system is primarily used in distance running. Typically running events such as the 10km to ultra-marathon events are run aerobically.

7. Write about Major three system of energy?

a. Anaerobic – Phosphocreatine (PCr) System (ATP; triphosphate, as in three phosphates)

The first phase is called the ATP- CPr (Adenosine Triphosphate)- (Phosphocreatine) system. ATP is stored in all cells, particularly muscles. It is the only system that doesn't require a blood supply and has no by products. As a result, the ATP-PCr system can provide a lot of energy quickly but only for immediate and short (10s) maximum intensity efforts.

b. Glycolytic or Lactic Acid System

The next major phase is called the Lactic (LA) system. After the 20 seconds of the ATP-PCr system, the body requires another ingredient– muscle glycogen (glucose) to be added to continue. his system breaks down carbohydrate, a fuel in limited supply in the body, to produce medium amounts of power for medium amounts of time. The body's stores around 500 grams worth of carbohydrate in the tissues of the liver and muscles in the form of glycogen.The energy is produced without oxygen using carbohydrate > sugar > glucose > glycogen > ATP.

Its by-product, lactic acid, comes from the breakdown of the glucose released from the muscles. Most cyclists have heard of lactate or lactic acid. Lactate is not a waste product but is actually an important part of anaerobic and aerobic metabolism.

c. **Aerobic System**

The third system is the Oxidative phase. By using oxygen to fuel the breakdown of carbohydrates first, free fatty acids second and if the exercise continues long enough - protein. Whereas, the previous systems have related to higher intensity work (or power) the aerobic system is more for moderate or low intensity work, but of longer duration. It is only able to produce a relatively small amount of energy, so cannot produce enough energy for any sprinting, but can produce power for extended periods of time.

8. What covers the myosin binding site on actin?

There are two main proteins that regulate actin and myosin interactions: tropomyosin and troponin. Tropomyosin is a long strand that loops around the actin chains in the thin filament. By covering the myosin-binding sites of the actin molecules, tropomyosin prevents muscle contraction.

9. What does an exercise physiologist do?

Exercise physiologists analyze their patients' fitness in order to help them improve their health or maintain good health. They help patients with heart disease and other chronic conditions, like diabetes or pulmonary (lung) disease, to regain their health.

A sports physiologist is a type of exercise physiologist that works strictly with athletes in order to progress or maintain overall health, fitness, performance and endurance.

10. What is ergonomics?

The study of people's efficiency in their working environment.

Book References

1. McArdle, W. D., Katch, F. I., & Katch, V. L. (2001). Exercise physiology: Energy, nutrition, and human performance. Philadelphia: Lippincott Williams & Wilkins.
2. McArdle, William D., Frank I. Katch, and Victor L. Katch. 2001. Exercise physiology: energy, nutrition, and human performance. Philadelphia: Lippincott Williams & Wilkins.
3. Cooper, Kenneth C. The New Aerobics. Eldora, Iowa: Prairie Wind.
4. Donatelle, Rebecca J. Health: The Basics. 6th ed. San Francisco: Pearson Education, Inc. 2005.
5. Aberg MA, Pedersen NL, Torén K, Svartengren M, Bäckstrand B, Johnsson T, Cooper-Kuhn CM, Aberg ND, Nilsson M, & Kuhn HG. (2009) Cardiovascular fitness is associated with cognition in young adulthood. Proceedings of the National Academy of Sciences of the United States of America.
6. Guiney, Hayley & Machado, Liana. Benefits of regular exercise for executive functioning in healthy populations. Psychon. Bull. Rev. 2013.
7. Rendi, Maria, Szabo, Atila, Szabo, Tomas, Velenczei, Attila & Kovas, Arpad. Acute psychological benefits of aerobic exercise: A field study into the effects of exercise characteristics. Psychol, Health. Med. 2008.
8. Widmaier, E.P., Raff, H., Strang, K.T. Vander's Human Physiology. 11th Edition, McGraw-Hill, 2009.
9. Marieb, E.N. Essentials of Human Anatomy and Physiology.

10th Edition, Benjamin Cummings, 2012.

10. Schmidt-Nielsen, K. Animal Physiology: Adaptation and Environment. Cambridge & New York: Cambridge University Press, 1997.
11. Withers, P.C. Comparative animal physiology. Saunders College Publishing, New York, 1992.
12. Brandon L (2009). Anatomy of Strength and Fitness Training for Speed. McGraw-Hill. ISBN 978-0-07-163363-5.
13. Berryman, Jack; Park, Roberta (1992). Sport and Exercise Science. Urbana and Chicago: University of Illinois Press. pp. 14–19. ISBN 0-252-01896-6.
14. McArdle, William; Katch, Frank; Katch, Victor (2006). Essentials of Exercise Physiology (3 ed.). United States of America: Lippincott Williams & Wilkins. p. 8. ISBN 0-7817-4991-3.
15. Sweet, William. "150 Years Ago: Amherst Established Nation's First College Health Program". amherst.edu. Amherst College.
16. McArdle, William; Katch, Frank; Katch, Victor (2006). Essentials of Exercise Physiology (3 ed.). USA: Lippincott Williams & Wilkins. p. 9. ISBN 0-7817-4991-3.
17. Astrand, Per-Olof; Rodahl, Kaare; Dahl, Hans; Stromme, Sigmund (2003). The Textbook of Work Physiology (4th ed.). USA: McGraw-Hill. pp. 260–288. ISBN 0-7360-0140-9.
18. Washburn, S. L. (1951) “The New Physical Anthropology”, *Transactions of the New York Academy of Sciences*, Series II, 13:298–304.

19. Michael A. Little and Kenneth A.R. Kennedy, eds. Histories of American Physical Anthropology in the Twentieth Century, (Lexington Books; 2010); 259 pages; essays on the field from the late 19th to the late 20th century; topics include Sherwood L. Washburn (1911–2000) and the "new physical anthropology"

References

1. Pazoki R, Dehghan A, Evangelou E, Warren H, Gao H, Caulfield M, Elliott P, Tzoulaki I. Genetic Predisposition to High Blood Pressure and Lifestyle Factors: Associations With Midlife Blood Pressure Levels and Cardiovascular Events. Circulation. 2018 Feb 13;137(7):653-661.
2. McAuley KA, Williams SM, Mann JI, Goulding A, Chisholm A, Wilson N, Story G, McLay RT, Harper MJ, Jones IE. Intensive lifestyle changes are necessary to improve insulin sensitivity: a randomized controlled trial. Diabetes Care. 2002 Mar;25(3):445-52.
3. Coffey VG, Hawley JA. The molecular bases of training adaptation. Sports Med. 2007;37(9):737-63.
4. Patel SA, Winkel M, Ali MK, Narayan KM, Mehta NK. Cardiovascular mortality associated with 5 leading risk factors: national and state preventable fractions estimated from survey data. Ann. Intern. Med. 2015 Aug 18;163(4):245-53.
5. Arkel M, Garbati P, Salis A, Damonte G, Liessi N, Adriano E, Benatti U, Balestrino M, Millo E. A Novel Method to Synthesize Phosphocreatine and Phosphocreatine Prodrugs.

Med Chem. 2018;14(4):387-393.

6. Heinonen OJ, Takala J, Kvist MH. Effect of carnitine loading on long-chain fatty acid oxidation, maximal exercise capacity, and nitrogen balance. Eur J Appl Physiol Occup Physiol. 1992;65(1):13-7.
7. Loprinzi PD, Kane CJ. Exercise and cognitive function: a randomized controlled trial examining acute exercise and free-living physical activity and sedentary effects. Mayo Clin. Proc. 2015 Apr;90(4):450-60.
8. Boyle T, Keegel T, Bull F, Heyworth J, Fritschi L. Physical activity and risks of proximal and distal colon cancers: a systematic review and meta-analysis. J. Natl. Cancer Inst. 2012 Oct 17;104(20):1548-61.
9. Mairbäurl H. Red blood cells in sports: effects of exercise and training on oxygen supply by red blood cells. Front Physiol. 2013;4:332.
10. Goldstein RE. Exercise Capacity. In: Walker HK, Hall WD, Hurst JW, editors. Clinical Methods: The History, Physical, and Laboratory Examinations. 3rd ed. Butterworths; Boston: 1990.
11. Bassett DR, Howley ET. Limiting factors for maximum oxygen uptake and determinants of endurance performance. Med Sci Sports Exerc. 2000 Jan;32(1):70-84.
12. ERS Task Force. Palange P, Ward SA, Carlsen KH, Casaburi R, Gallagher CG, Gosselink R, O'Donnell DE, Puente-Maestu L, Schols AM, Singh S, Whipp BJ. Recommendations on the use of exercise testing in clinical practice. Eur. Respir. J. 2007 Jan;29(1):185-209.

13. Herbison GJ, Jaweed MM, Ditunno JF. Muscle fiber types. Arch Phys Med Rehabil. 1982 May;63(5):227-30.

14. Yin H, Price F, Rudnicki MA. Satellite cells and the muscle stem cell niche. Physiol. Rev. 2013 Jan;93(1):23-67.

15. Hellsten Y, Nyberg M. Cardiovascular Adaptations to Exercise Training. Compr Physiol. 2015 Dec 15;6(1):1-32.

16. Holmqvist N, Secher NH, Sander-Jensen K, Knigge U, Warberg J, Schwartz TW. Sympathoadrenal and parasympathetic responses to exercise. J Sports Sci. 1986 Autumn;4(2):123-8.

17. Olson BR. Exercise-induced amenorrhea. Am Fam Physician. 1989 Feb;39(2):213-21.

18. Smith AJ, Phipps WR, Thomas W, Schmitz KH, Kurzer MS. The effects of aerobic exercise on estrogen metabolism in healthy premenopausal women. Cancer Epidemiol. Biomarkers Prev. 2013 May;22(5):756-64.

19. Kokkinos PF, Fernhall B. Physical activity and high density lipoprotein cholesterol levels: what is the relationship? Sports Med. 1999 Nov;28(5):307-14.

20. Galun E, Burstein R, Assia E, Tur-Kaspa I, Rosenblum J, Epstein Y. Changes of white blood cell count during prolonged exercise. Int J Sports Med. 1987 Aug;8(4):253-5.