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

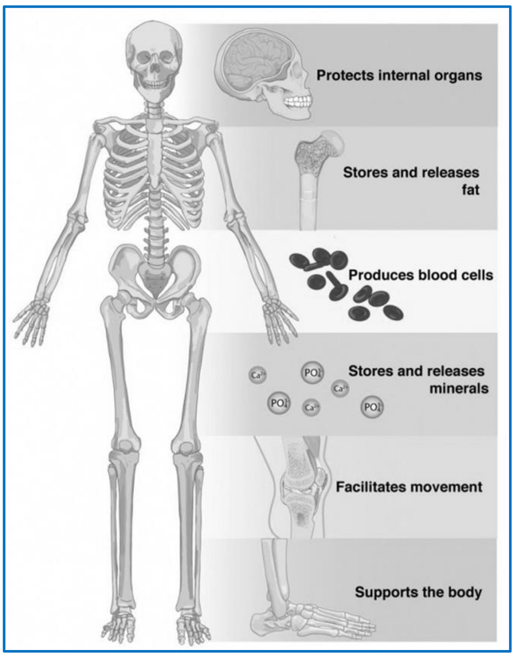

Figure 1

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.