LEARNING OBJECTIVES

• Learn to differentiate physical activity and exercise.
• Describe the scope of exercise physiology as a branch of physiology.
• Learn to differentiate exercise physiology and sport physiology, and exercise physiologist and sport physiologist.
• Become familiar with the evolution of exercise physiology and its early scholars.
• Note the differences between acute responses to exercise and chronic adaptations to training.
How do you define Exercise?

What is Physical Activity?
Any body movement produced by muscle action that increases energy expenditure.

Examples:
Activities of daily living such as shopping, gardening, housekeeping, child rearing, work-related activities, etc

What is Exercise?
Planned, structured, repetitive, and purposeful physical activity

Examples:
Training for or performing athletics, sports, or recreational activities such as jogging, roller-blading, ice skating, swimming, etc.
What is physical fitness?

Attributes related to how well one performs physical activity.

• Muscular strength
• Muscular endurance
• Flexibility
• Body composition
• Cardiorespiratory endurance
• Power
• Agility
Exercise physiology as a branch of physiology

- **Physiology**
  - The study of the function of tissues, organs, and systems
    - e.g. muscle, nerve, heart, lungs, cardiovascular system

- **Exercise physiology**
  - The study of exercise on the function of these tissues, organs, and systems
    - Single bout of exercise (acute exercise)
    - Repeated bouts of exercise (training)
  - Responses to environmental factors
    - Heat, humidity and altitude
  - Effects in specific populations
    - Young and old, healthy individuals and those with disease
What is Exercise Physiology?

**Definition:**
The study of how the body (cell, tissue, organ, system) responds in function and structure to (1) acute exercise stress, and (2) chronic physical activity.
What is Exercise Physiology?

- Consider the physiological systems:
  - Cardiovascular, Respiratory, Nervous, Urinary, Gastrointestinal (GI, Digestive), Temperature Regulation, Endocrine, Muscle, Bone, Skin, Immune, Metabolism
  - Exercise tends to disturb homeostasis
  - Adaptations of physiological systems tend to minimize this disturbance

![Diagram showing Exercise: A Challenge to Homeostasis](image)
Homeostasis & Exercise

- **Homeostasis**: maintenance of a constant, unchanging internal environment by the physiological systems; normally only possible at rest; typically operate by negative feedback.
What is Exercise Training?

The repeated use of exercise to improve physical fitness.

**Adaptations to Exercise**

**Acute adaptations**  
The changes in human physiology that occur during exercise or physical activity.

**Chronic Adaptations**  
The alterations in the structure and functions of the body that occur in response to the regular completion of physical activity and exercise.
What does training do?

• Permits adaptations within the physiological systems to minimize the disturbance to homeostasis resulting from exercise

• This means exercise intensity can be increased for a given distance or duration, or a given intensity can be sustained longer
Physiological Interactions with Training

- Oxygen delivery
- Heat dissipation
- Motor control
- Substrate delivery
- Endurance
- Power output
- Hormonal responses
Why is Exercise Physiology relevant in understanding performance capabilities?

• Physiological determinants of performance
  – Rate at which energy can be transformed
  – Quantity of energy which can be available
  – Energy cost of performing a given task

• Some athletic events are more relevant
  – Individual rather than team
    • Running, cycling, swimming, rowing, x-country ski

• But the principles apply to all.....
  – Shouldn’t all exercise science majors be required to take an exercise physiology course?
Exercise Physiology vs. Sport Physiology

- **Exercise physiologists** study how the body’s structures and functions are altered when exposed to acute and chronic bouts (i.e., training) of exercise using human or animal subjects.

- **Sport physiologists** apply exercise physiology concepts to an athlete's training and performance.
What is Clinical Exercise Physiology?

• A sub-component of exercise physiology that involves the application of exercise physiology principles, knowledge and skills for purposes of the prevention, rehabilitation or diagnosis of disease or disability in humans.
## Applications of Exercise Physiology To Other Disciplines and Professions

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<th>Discipline</th>
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<td>Metabolic adaptations to muscle contraction and exercise training</td>
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<td>Cardiology</td>
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<td>Reversal of risk factors for heart disease</td>
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<td>Macro-nutrient &amp; micro-nutrient needs during exercise, and exercise training</td>
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<td>Pulmonology</td>
<td>Training/conditioning of muscles used in ventilation</td>
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Historical Note on Exercise Physiology

The earliest written record referring to the physiology of exercise:

• “Eating alone will not keep a man well; he must also take exercise. For food and exercise, while possessing opposite qualities, yet work together to produce health. For it is the nature of exercise to use up material, but of food and drink to make good deficiencies. And it is necessary, as it appears, do discern the power of the various exercises, both natural exercises and artificial, to know which of them tends to increase flesh and which to lessen it.”

• Hippocrates, *Regimen in Health*, ~400 B.C.
Historical Note on Exercise Physiology

• The earliest published use of the specific term, “physiology of exercise”:

• William Byford, On the Physiology of Exercise, *American Journal of Medical Sciences*, 1855
What was the first exercise physiology laboratory?

- George Wells Fitz
  - Helped establish the Dept. of Anatomy, Physiology, and Physical Training at Harvard University in 1891.
What was the first exercise physiology laboratory?

- **Harvard Fatigue Laboratory**
  - David Bruce Dill established a fatigue laboratory at Harvard University, 1927
  - Refocused his efforts from biochemistry to experimental physiology
  - Pioneered studies that resulted in an explosion of interest in exercise physiology
  - Closed in 1947
Active Research Areas in the Harvard Fatigue Laboratory

- **Metabolism**
  - Maximal oxygen uptake
  - Oxygen debt
  - Carbohydrate and fat metabolism during long-term work

- **Environmental physiology**
  - Altitude
  - Dry and moist heat
  - Cold

- **Clinical physiology**
  - Gout
  - Schizophrenia
  - Diabetes

- **Aging**
  - Basal metabolic rate
  - Maximal oxygen uptake
  - Maximal heart rate

- **Blood**
  - Acid-base balance
  - $O_2$ saturation: role of $PO_2$, $PCO_2$, and carbon monoxide
  - Nutrition
  - Nutritional assessment techniques
  - Vitamins
  - Foods

- **Physical fitness**
  - Harvard Step Test
Nobel Prize Winners

Archibald V. Hill  August Krogh  Otto F. Meyerhof

These scientists received the Nobel Prize for work related to muscle or muscular exercise.
Physical Activity and Health

- Physical activity has been shown to:
  - Lower the risk of dying prematurely and from heart disease
  - Reduce the risk of developing diabetes and high blood pressure
  - Help maintain healthy bones, muscles, and joints
  - Help lower blood pressure in those with high blood pressure
  - Promote psychological well-being
  - Help achieve and maintain a healthy body weight
Physical Activity Guidelines

- 2013 Turkish Physical Activity Guidelines
  http://www.saglik.gov.tr/
- 2012 Canadian Physical Activity Guidelines
  http://www.csep.ca/english/view.asp?x=804
- 2011 UK Physical activity guidelines
- 2010 Global Recommendations on Physical activity for Health
- Physical Activity Guidelines
- 2008 Physical Activity Guidelines for Americans
  http://www.cdc.gov/physicalactivity/everyone/guidelines/index.html
  Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory, Musculoskeletal, and Neuromotor Fitness in Apparently Healthy Adults: Guidance for Prescribing Exercise. Medicine & Science in Sports & Exercise: July 2011 - Volume 43 - Issue 7 - pp 1334-1359
• How much physical activity is needed to improve health and cardiorespiratory fitness?
• What is the effect of exercise training on cardiorespiratory fitness and cardiovascular and metabolic disease (cardiometabolic) risk factors?
• What are the benefits of improving muscular fitness?
• How can exercise improve and maintain muscular fitness?
• How does the exercise training response vary between individuals?
• How much exercise is needed to maintain the beneficial effects of exercise training?
• What are risks associated with exercise and how can they be reduced?
Cycle Ergometer

Makes it easier to assess blood pressure and collect blood because upper body is relatively immobile.

Results are not greatly affected by body weight or changes in body weight.
Treadmill

Results in generally higher maximal physiological values—heart rate, ventilation, and oxygen uptake—than cycle ergometer
Swimming Flume

- Allows swimmers to closely simulate their natural swimming strokes while researchers collect data
Figure 5.4  The exergonic process of cellular respiration. Exergonic reactions, such as the burning of gasoline or the oxidation of glucose, release potential energy. This results in a negative standard free energy change, that is, a reduction in total energy available for work, or $\Delta G$. In this illustration, cellular respiration harvests the potential energy in food to form adenosine triphosphate (ATP). Subsequently, the energy in ATP powers all forms of biologic work.
Figure 5.7 Adenosine triphosphate (ATP) represents the energy currency that powers all forms of biologic work.
Figure 6.1  Blood lactate concentration for trained and untrained subjects at different levels of exercise expressed as a percentage of maximal oxygen consumption (VO₂max).
Figure 6.4  Oxygen uptake and oxygen deficit for trained and untrained individual during submaximum cycle ergometer exercise. Both individuals reach the same steady rate VO₂, but the trained person reaches it at a faster rate, reducing the oxygen deficit
Figure 6.5 Attainment of maximal oxygen uptake (VO₂) while running up hills of increasing slope. This occurs in the region where a further increase in exercise intensity does not produce an additional or the expected increase in oxygen uptake. Yellow and orange dots represent measured values for oxygen uptake during the run up each hill.
Figure 7.2  Three energy systems and their percentage contribution to total energy output during all-out exercise of different durations.
Six commonly used treadmill procedures.