Physical exercise

- It is any bodily activity that enhances or maintains physical fitness and overall health & wellness.
- It is performed for various reasons including:
  - strengthening muscles
  - cardiovascular system,
  - athletic skills,
  - weight loss or maintenance
  - Purpose of enjoyment.
- Frequent and regular physical exercise boosts the immune system, & helps prevent diseases such as heart disease, cardiovascular disease, Type 2 diabetes and obesity.
- Exercise physiology is the study of the acute responses and chronic adaptations to a wide range of physical exercise conditions. In addition, study the effect of exercise on pathology, and the mechanisms by which exercise can reduce or reverse disease progression.

Classification (Types of exercise)

Physical exercises are generally grouped into three types, depending on the overall effect they have on the human body:

- Flexibility exercises, such as stretching, improve range of motion of muscles and joints.
- Aerobic exercises, such as cycling, swimming, walking, skipping rope, running, or playing tennis, focus on increasing cardiovascular endurance.
- Anaerobic exercises, such as weight training, eccentric training or sprinting and high-intensity interval training, increase short-term muscle strength.

Categories of physical exercise

- Strength training - Agility training
- Eccentric training - Interval training
- Continuous training
- Sometimes the terms 'dynamic' and 'static' are used.
- 'Dynamic' exercises such as steady running tend to produce a lowering of diastolic blood pressure during exercise, due to the improved blood flow.
- While, static exercise (weight-lifting) can cause systolic pressure to rise significantly during exercise.

General Health effects of physical exercise

- Generally, It is important for maintaining physical fitness & can contribute positively to maintain a healthy weight, promot physiological well-being, reduce surgical risks, and strengthen the immune system.
- It reduces levels of cortisol, which causes many health problems (physical & mental).
- Endurance exercise before meals lowers blood glucose more than the same exercise after meals.
- Studies show that vigorous exercise (not moderate exercise) executed by healthy individuals can:
  i. Increase opioid peptides (endorphins, naturally occurring opioids ((natural pain reliever) that in conjunction with other neurotransmitters are responsible for exercise-induced euphoria.
  ii. Increase testosterone and growth hormone,
- There is variation in individual response to training (inherent) ; where most people will see a moderate ↑ in endurance from aerobic exercise, while others can never augment endurance.
- Muscle hypertrophy from resistance training is primarily determined by diet & testosterone.
- Exercising in middle age leads to better physical ability later in life.


Exercise & musculoskeletal system

- It maintains building & maintaining healthy bone density, muscle strength, & joint mobility.
- Many of benefits of exercise are mediated through the role of skeletal muscle. That is, contracting muscles release multiple substances (myokines) which promote growth of new tissue, tissue repair, and multiple anti-inflammatory functions.

Exercise & Cardiovascular system

- There is a direct relation between physical inactivity and cardiovascular mortality.
- Most beneficial effects of physical activity on CVS disease mortality can be attained through moderate-intensity activity.
- Both aerobic & anaerobic exercise work to ↑ mechanical efficiency of heart by ↑ cardiac volume (aerobic exercise), or myocardial thickness (strength training).

Exercise & Immune system

- The immune systems of athletes and nonathletes are generally similar.
- Athletes may have slightly elevated natural killer cell count & cytolytic action.
- Biomarkers of inflammation e.g. C-reactive protein, are reduced in active individual relative to sedentary individuals, & +ve effects of exercise due to its anti-inflammatory effects.

Exercise & Brain function

- Physical activity, aerobic exercise in particular, enhances older adults' cognitive function.
- It had been shown to be neuroprotective in many neurodegenerative and neuromuscular diseases. So, it reduces the risk of developing dementia.
- It is suggested that frequent exercise may reverse alcohol-induced brain damage.

There are several possibilities for why exercise is beneficial for the brain:

- Increase the blood and oxygen flow to the brain.
- Increase growth factors that promote synaptic plasticity.
- Increase chemicals in brain that help cognition, e.g. dopamine, glutamate, norepinephrine, & serotonin.

Exercise & psychological health (especially Depression)

- It improves mental health, helps prevent depression, helps to promote or maintain positive self-esteem, and can even augment an individual's sex appeal or body image.
- When a person exercises, levels of both circulating serotonin & endorphins are ↑ed. They stay elevated even several days after exercise is discontinued, possibly contributing to improvement in mood, ↑ed self-esteem, & weight management. (Endorphins act as a natural pain reliever and antidepressant in the body).
- Exercise alone is a potential prevention method and/or treatment for mild forms of depression, especially when done in the presence of other people (familiar or not).

Exercise & Sleep

- Exercise improves sleep for most people, and helps sleep disorders such as insomnia.
- Exercise is the most recommended alternative to sleeping pills for resolving insomnia.
Excessive exercise

- Too much exercise can be harmful. Without proper rest→↑ chance of stroke or other circulation problems.
- Extremely intense, long-term cardiovascular exercise, as can be seen in athletes who train for multiple marathons, associated with scarring of heart & heart rhythm abnormalities.
- Unaccustomed overexertion of muscles leads to rhabdomyolysis (damage to muscle).
- Too much exercise can also cause a woman to miss her period (amenorrhea).
- Stopping excessive exercise suddenly can create a change in mood. Feelings of depression & agitation (withdrawal from the natural endorphins produced by exercise occurs).

Energy Sources of exercise

- Energy needed to perform short lasting, high intensity bursts of activity is derived from anaerobic metabolism within the cytosol of muscle cells, as opposed to aerobic respiration which utilizes oxygen, is sustainable, and occurs in the mitochondria.
- The quick energy sources consist of:
  - Phosphocreatine (PCr) system, the most rapid source, but the most readily depleted.
  - Fast glycolysis, Glycogen is broken down into glucose during intense exercise. Glucose is then oxidized, and under anaerobic condition is reduced to lactic acid→ release H+, promoting acidosis. For this reason, fast glycolysis cannot be sustained for long periods.
  - Adenylate kinase. It catalyzes a reaction by which 2 ADP are combined to form ATP This reaction takes place during low energy situations eg extreme exercise or hypoxia, but isn’t a significant energy source.
- All of these systems re-synthesize adenosine triphosphate (ATP).

Exercise for diabetes

- Plasma glucose is maintained by an equal rate of glucose appearance (entry into the blood) and glucose disposal (removal from the blood).
- Exercise is a particularly potent tool for glucose control in diabetes mellitus.
- In the healthy individual:
  - During Moderate exercise: rate of appearance and disposal are essentially equal.
  - During prolonged or intense exercise result in an imbalance → disposal > appearance.
- In hyperglycemia, moderate exercise can induce greater glucose disposal than appearance, thereby decreasing total plasma glucose concentrations:
  - The mechanism for this glucose disposal is independent of insulin.
  - It appears to be ↑ in sensitivity to insulin for 12–24 hours post-exercise.
- During extreme hyperglycemic episodes, exercise should be avoided, due to potential complications associated with ketoacidosis.
- In Type II diabetes, weight loss from both exercise & diet ↑ insulin sensitivity in majority of people.

RESPONSES TO EXERCISE— MAINTAINING HOMEOSTASIS

- Moderate or strenuous exercise is a physiological stress situation, a change that the body must still maintain a normal internal environment, that is, homeostasis.
  - Respiratory & cardiovascular systems make essential contributions to exercise.
  - Integumentary system also has a role, since it eliminates excess body heat.
  - Nervous system also directly involved. Brain generates impulses for muscle contraction, coordinates contractions, &d regulates heart rate, breathing rate, & diameter of blood vessels.
Changes during exercise

- Plasma **catecholamine** concentrations increase 10 fold in whole body exercise.
- **Ammonia** is produced by exercised skeletal m from ADP (the precursor of ATP), this could be a factor in sensation of fatigue.
- **interleukin-6** (IL-6) ↑ in blood circulation due to its release from working skeletal ms.
  - IL-6 → secretion of arginine vasopressin→ affect Na+ absorption → exercise associated hyponatremia , which can result in encephalopathy (caused by swelling of brain).
- **Oxygen**: O2 consumption \( (VO_2) \) during exercise is best described by the Fick Equation: \( VO_2 = Q \times (a - vO_2 \text{diff}) \), which states that amount of oxygen consumed is equal to cardiac output \( (Q) \) multiplied by difference between arterial and venous oxygen concentrations.
  - Factors affecting O2 consumption:
    I. Factors affecting ability of lung to oxygenate blood.
    II. O2 carrying capacity of blood. It is often the target used in endurance sports to ↑ hematocrit, such as the use of erythropoietin.
    III. Peripheral O2 uptake is reliant on a rerouting of blood flow from inactive viscera to working skeletal muscles, & within skeletal m, capillary to muscle fiber ratio influences O2 extraction.
- **Cerebral oxygen**: Cerebral autoregulation ensures brain has priority to cardiac output, though this is impaired slightly by exhaustive exercise.
  - During submaximal exercise, ↑ cardiac output & ↑cerebral blood flow beyond brain’s O2 needs.
  - In Maximal exercise, despite the increase in capillary oxygenation [in the brain], it associated with a reduced mitochondrial O2 content during whole body exercis. So,autoregulation of brain’s blood supply is impaired.
- **Brain**: At rest, brain receives 15% of total cardiac output, & uses 20% of body's energy consumption.
  - Brain dependent for its energy expenditure upon aerobic metabolism, & it is highly sensitive to failure of its O2 supply.
  - Metabolic demands of exercise could therefore quickly disrupt brain’ functioning.
  - Brain energy consumption is ↑ during intense physical exercise due to demands in motor cognition needed to control the body.
- **Dehydration**: Exercise-induced dehydration (develops during exercise) ↓ aerobic endurance performance & results in ↑ body temperature, heart rate, exertion, & ↑ reliance on CHO as a fuel source. Hypo hydration ↓ aerobic endurance, but its effects on muscle strength & endurance are not consistent.
- **Hyperthermia**: Humans use sweat thermoregulation to remove heat produced during exercise. Moderate dehydration as a consequence of exercise & heat is reported to impair cognition. Cognitive impairment, particularly due to heat & exercise is likely to be due to loss of integrity to the blood brain barrier. Hyperthermia also can lower cerebral blood flow, & raise brain temperature.