SECTION

# 15

# Biomechanical Principles and Applications

# Biomechanical Principles and Applications

- Definition of biomechanics
- Scientific models reduce things to their essentials and establish a basis, not only for understanding how things work, but also for predicting how they will behave and, ultimately, for influencing them to behave in ways we want
- Example:  anatomical position
- Sir Isaac Newton's Three Laws of Motion

# Equilibrium and the Conservation of Energy

- Newton's theory (and biomechanics) rests on two assumptions: physical equilibrium and the conservation of energy. Equilibrium is posited in his First Law and the conservation of energy in his Third Law.
- Equilibrium can be thought of as kind of a **"perfect" situation** where more than one force acts on the body but, because the sum of forces is zero, no change in velocity results.

# Equilibrium and the Conservation of Energy

- The conservation of energy principle states that energy can never be created or destroyed, but can only be converted from one form to another.

# Isaac Newton's "Model Universe"

- **1. The Law of Inertia**
  - Every object in a state of uniform motion tends to remain in that state of motion unless an external force is applied to it.
- **2. The Law of Acceleration**
  - A force applied to a body causes an acceleration of that body of a magnitude proportional to the force, in the direction of the force, and inversely proportional to the body's mass.
- **3. The Law of Reaction**
  - For every action there is an equal and opposite reaction.

# Types of Motion

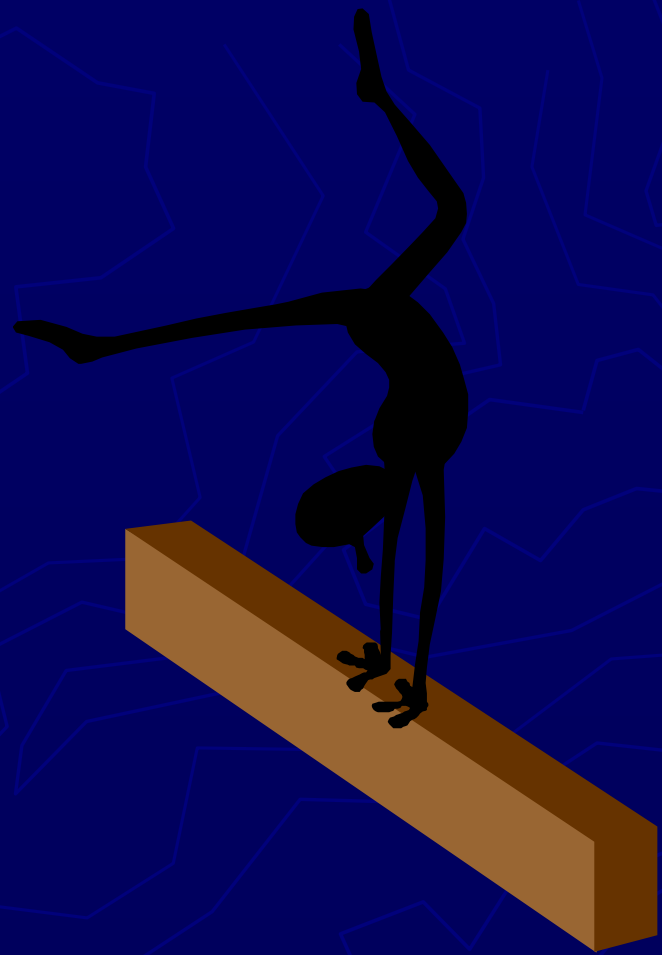
- It is important to distinguish between two types of motion:
- **Linear (or Translational) Motion**
  - Movement in particular direction (and would include the resultant of more than one linear force acting on an object). Example: a sprinter accelerating down the track.
- **Rotational Motion**
  - Movement about an axis. The force does not act through the centre of mass, but rather is "off-centre," and this results in rotation. Example: ice-skater's spin.

# Examples of Rotation Principles

- **Ice-Skating**
- The ice-skater begins to spin with arms spread apart then suddenly brings them closer to the body. The end result of tightening up is that the skater's spin (angular velocity) increases, seemingly miraculously.

# Examples of Rotation Principles

- **Gymnastics**
- Following a series of rapid somersaults in a tight position, the gymnast does a forward flip with the body positioned more or less straight. By opening up, the gymnast increases the moment of inertia, thereby resulting in a decrease in angular velocity.



# Examples of Rotation Principles

- **Diving**
- After leaving the high diving board, the diver curls tightly and then opens up just before entering the water. By opening up before entry, the diver increases the moment of inertia, thereby slowing down the angular velocity.

# Seven Principles of Biomechanical Analysis

- The Coaching Association of Canada's National Coaching Certification Program (NCCP) Level 2 Theory course sets forward seven principles that can be grouped into four broad categories:
  - (1) stability,
  - (2) maximum effort,
  - (3) linear motion, and
  - (4) angular motion.

# Seven Principles of Biomechanical Analysis

- **STABILITY**
  - **Principle 1:** The lower the centre of mass, the larger the base of support, the closer the centre of mass to the base of support, and the greater the mass, the more stability increases.
  - Four subcomponents
  - Example: Sumo wrestling

# Seven Principles of Biomechanical Analysis

- **MAXIMUM EFFORT**
  - **Principle 2:** The production of maximum force requires the use of all possible joint movements that contribute to the task's objective.
  - Examples: golf, bench press

# Seven Principles of Biomechanical Analysis

- **MAXIMUM VELOCITY**
  - **Principle 3**: The production of maximum velocity requires the use of joints in order – from largest to smallest.
  - Examples: hockey slapshot, hitting a golf ball

# Seven Principles of Biomechanical Analysis

- **LINEAR MOTION**
  - **Principle 4:** The greater the applied impulse, the greater the increase in velocity.
  - Example: slam-dunking a basketball

# Seven Principles of Biomechanical Analysis

- **LINEAR MOTION**
  - **Principle 5**: Movement usually occurs in the direction opposite that of the applied force.
  - Examples: high jumper, cyclists, runners

# Seven Principles of Biomechanical Analysis

- **ANGULAR MOTION**
  - **Principle 6:** Angular motion is produced by the application of a force acting at some distance from an axis, that is, by torque.
  - Principle is also known as the principle of the production of angular motion
  - Example: baseball pitchers

# Seven Principles of Biomechanical Analysis

- **ANGULAR MOMENTUM**
  - **Principle 7**: Angular momentum is constant when an athlete or object is free in the air.
  - This principle is also known as the principle of conservation of angular momentum, and its key component is the fact that, once an athlete is airborne, he or she will travel with constant angular momentum.
  - Example: Diver