Class: Second
Subject: Mechanics of Muscleskeletal System
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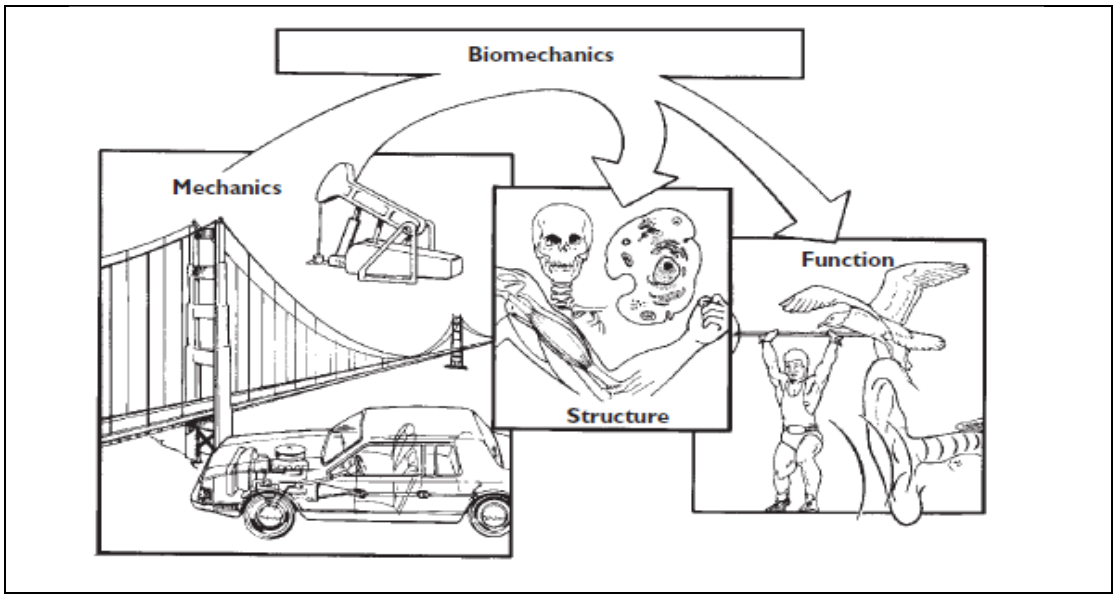
Lecture # 1

Biomechanics

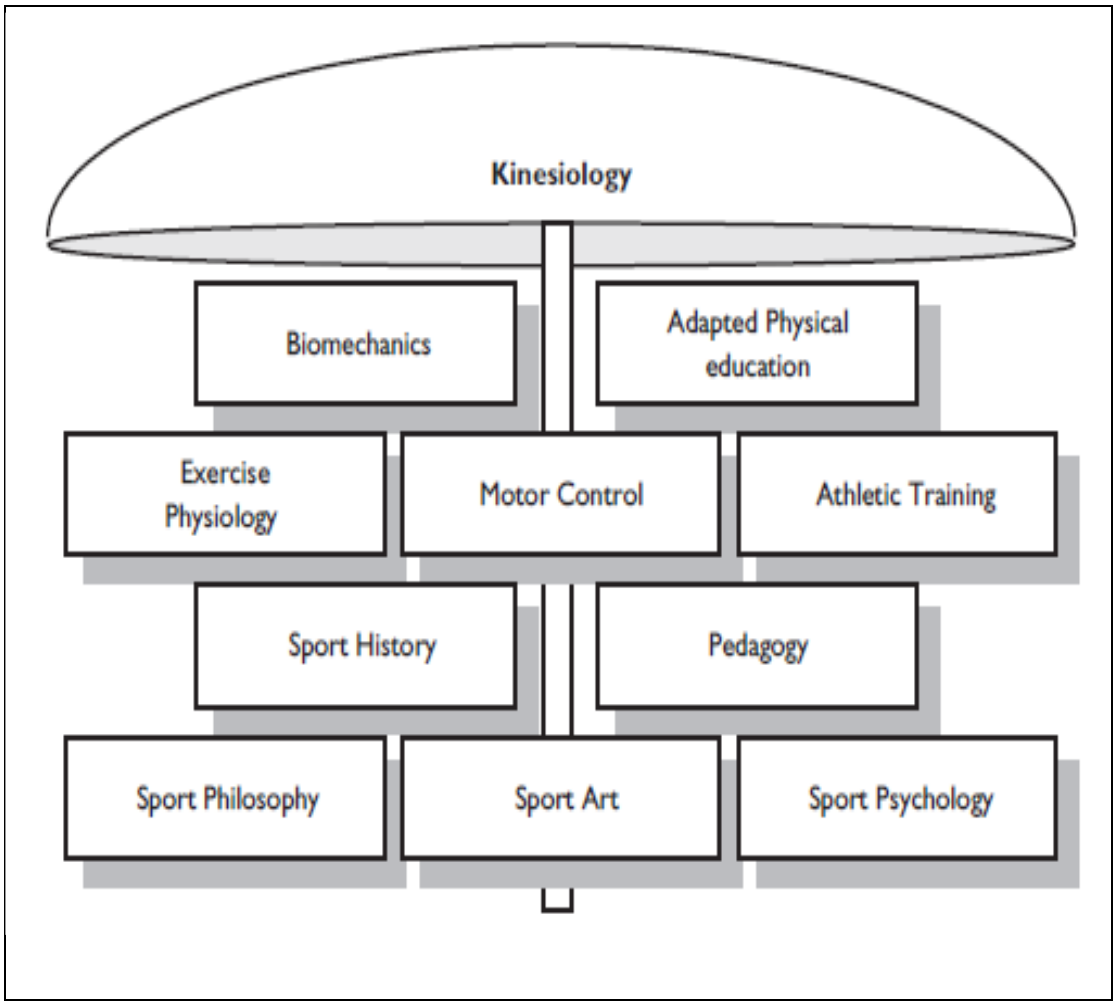
BIOMECHANICS: DEFINITION AND PERSPECTIVE

The term biomechanics combines the prefix bio, meaning “life,” with the field of mechanics, which is the study of the actions of forces. The international community of scientists adopted the term biomechanics during the early 1970s to describe the science involving the study of the mechanical aspects of living organisms. The forces studied include both the internal forces produced by muscles and the external forces that act on the body.

Biomechanists use the tools of mechanics, the branch of physics involving analysis of the actions of forces, to study the anatomical and functional aspects of living organisms .Statics and dynamics are two major sub branches of mechanics. Statics is the study of systems that are in a state of constant motion, that is, at either rest (with no motion) or moving with a constant velocity. Dynamics is the study of systems in which acceleration is present.



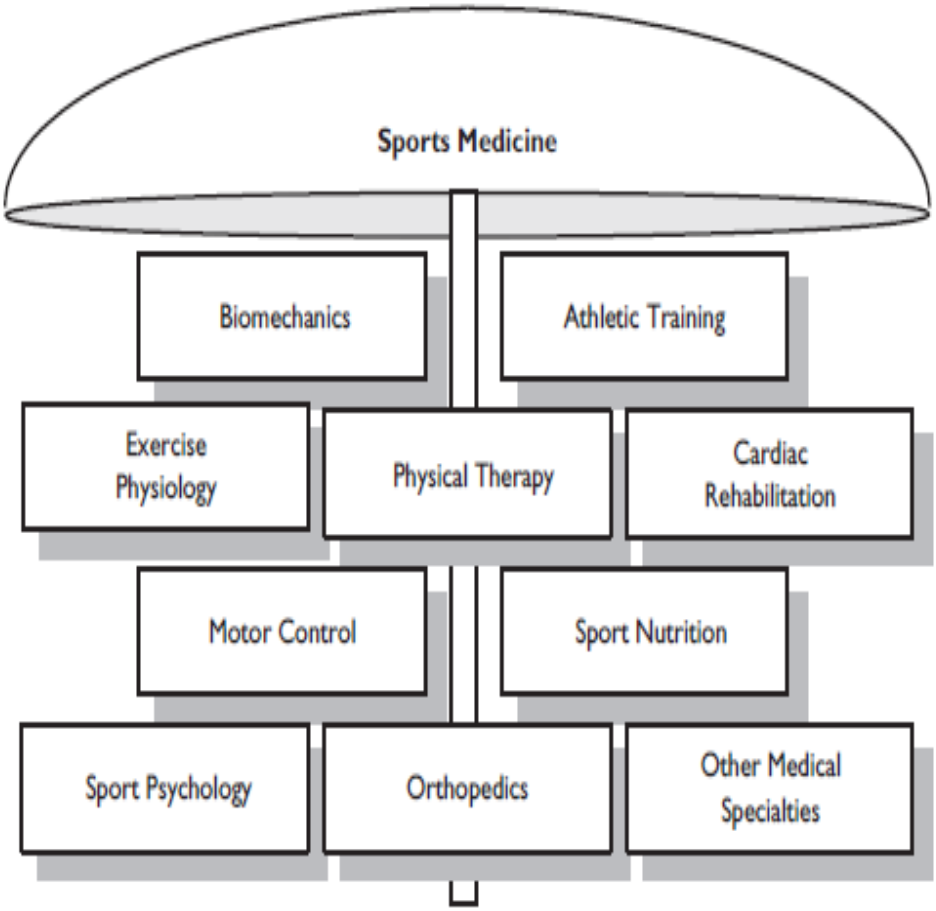
Kinematics and kinetics are further subdivisions of biomechanical study. What we are able to observe visually when watching a body in motion is termed the kinematics of the movement. Kinematics involves the study of the size, sequencing, and timing of movement, without reference to the forces that cause or result from the motion. The kinematics of an exercise or a sport skill execution is also known, more commonly, as form or technique. Whereas kinematics describes the appearance of motion, kinetics is the study of the forces associated with motion. Force can be thought of as a push or pull acting on a body. The study of human biomechanics may include questions such as whether the amount of force the muscles are producing is optimal for the intended purpose of the movement.



The biomechanics of human movement is one of the sub disciplines of kinesiology, the study of human movement (Figure Above). Although some biomechanics study topics such as ostrich locomotion, blood flow through constricted arteries, or micro mapping of dental cavities, this course focuses primarily on the biomechanics of human movement from the perspective of the movement analyst.

As shown in Figure below, biomechanics is also a scientific branch of sports medicine. Sports medicine is an umbrella term that encompasses both clinical and scientific aspects of exercise and sport. The American College of Sports Medicine is an example of an organization that promotes

interaction between scientists and clinicians with interests in sports medicine–related topics.



What Problems Are Studied by Biomechanics?

As expected given the different scientific and professional fields represented, bio mechanists study questions or problems that are topically diverse. For example, zoologists have examined the locomotion patterns of dozens of species of animals walking, running, trotting, and galloping at controlled speeds on a treadmill to determine why animals choose a particular stride length and stride rate at a given speed. They have found that running actually consumes less energy than walking in small animals

up to the size of dogs, but running is more costly than walking for larger animals such as horses . One of the challenges of this type of research is determining how to persuade a cat, a dog, or a turkey to run on a treadmill

The U.S. National Aeronautics and Space Administration (NASA) sponsors another multidisciplinary line of biomechanics research to promote understanding of the effects of microgravity on the human musculoskeletal system. Of concern is the fact that astronauts who have been out of the earth's gravitational field for just a few days have returned with muscle atrophy, cardiovascular and immune system changes, and reduced bone density, mineralization, and strength, especially in the lower extremities. The issue of bone loss, in particular, is currently a limiting factor for long-term space flights, with bone lost at a rate of about 1% per month from the lumbar spine and 1.5% per month from the hips. Both increased bone resorption (the process by which osteoclasts break down the tissue in bones and release the minerals, resulting in a transfer of calcium from bone tissue to the blood.) and decreased calcium absorption appear to be responsible.

Since those early days of space flight, bio mechanists have designed and built a number of exercise devices for use in space to take the place of normal bone-maintaining activities on earth. Some of this research has focused on the design of treadmills for use in space that load the bones of the lower extremity with deformations and strain rates that are optimal for stimulating new bone formation. Another approach involves combining voluntary muscle contraction with electrical stimulation of the muscles to maintain muscle mass and tone. So far, however, no adequate substitute

has been found for weight bearing for the prevention of bone and muscle loss in space.

Maintaining sufficient bone-mineral density is also a topic of concern here on earth. Osteoporosis is a condition in which bone mineral mass and strength are so severely compromised that daily activities can cause bone pain and fracturing. This condition is found in most elderly individuals, with earlier onset in women, and is becoming increasingly prevalent throughout the world with the increasing mean age of the population. Approximately 40% of women experience one or more osteoporotic fractures after age 50, and after age 60, about 90% of all fractures in both men and women are osteoporosis-related. The most common fracture site is the vertebrae, with the presence of one fracture indicating increased risk for future vertebral and hip fractures.

Another problem area challenging bio mechanists who study the elderly is mobility impairment. Age is associated with decreased ability to balance, and older adults both sway more and fall more than young adults, although the reasons for these changes are not well understood. Falls, and particularly fall-related hip fractures, are extremely serious, common, and costly medical problems among the elderly. Each year, falls cause large percentages of the wrist fractures, head injuries, vertebral fractures, and lacerations, as well as over 90% of the hip fractures, occurring in the United States. Biomechanical research teams are investigating the biomechanical factors that enable individuals to avoid falling, the characteristics of safe landings from falls, the forces sustained by different parts of the body during falls, and the ability of protective clothing, and floors to prevent falling injuries. Promising work in the development of intervention

strategies has shown that the key to preventing falls may be the ability to limit trunk motion. Older adults can quickly learn strategies for limiting trunk motion through task-specific training combined with whole-body exercise.

This field covers many other problems such as-

- The gait analysis of the cerebral palsy individual.
- Improved gait for children and adults with below-knee amputations.
- Occupational biomechanics is a field that focuses on the prevention of work-related injuries and the improvement of working conditions and worker performance.
- Improvements in selected sports through the design of innovative equipment.