Chapter 7
Biomechanics

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ABSTRACT

Biomechanics is a vast discipline within the field of Biomedical Engineering. It explores the underlying mechanics of how biological and physiological systems move. It encompasses important clinical applications to address questions related to medicine using engineering mechanics principles. Biomechanics includes interdisciplinary concepts from engineers, physicians, therapists, biologists, physicists, and mathematicians. Through their collaborative efforts, biomechanics research is ever changing and expanding, explaining new mechanisms and principles for dynamic human systems. Biomechanics is used to describe how the human body moves, walks, and breathes, in addition to how it responds to injury and rehabilitation. Advanced biomechanical modeling methods, such as inverse dynamics, finite element analysis, and musculoskeletal modeling are used to simulate and investigate human situations in regard to movement and injury. Biomechanical technologies are progressing to answer contemporary medical questions. The future of biomechanics is dependent on interdisciplinary research efforts and the education of tomorrow's scientists.

7.1. CHAPTER OBJECTIVES

This chapter on biomechanics aims to introduce the reader to the specialty area of biomechanics, the study of human and biological movement mechanics. The topic of biomechanics is broad by nature due to the complex and variety of biological organisms and systems; thus, this chapter presents a subset of biomechanics topics and principles, including motion analysis, postural stability, rehabilitation, trauma, and biomechanical modeling. It further identifies the biomechanics professional societies and organizations.

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7.2. INTRODUCTION

Biomechanics is a vast discipline within the field of Biomedical Engineering. It dates back to the fifteenth century, when Leonardo da Vinci (1452-1519), during his biological studies, noted the importance of mechanics. The field encompasses biology, basic sciences, engineering, and important clinical applications to address questions related to medicine, using principles of engineering mechanics. Biomechanics has improved our understanding and knowledge within numerous areas, such as clinical pathologies, neuromuscular control, the cardiovascular system, tissue mechanics, and imaging. It encompasses expanding interdisciplinary concepts from various fields of specialization, namely engineering, medicine, therapy, biology, physics, and mathematics.

Biomechanics is used to describe how the human body walks, stands still, and breathes; in addition to studying the body's response to injury. Advanced biomechanical modeling methods, such as inverse dynamics, finite element analysis, and musculoskeletal modeling are used to simulate and investigate human situations when in movement and/or in injury. New technologies brought on by the field of Biomechanics are endless; they are ever progressing to answer new medical questions. The future of biomechanics is dependent on interdisciplinary research efforts and the education of tomorrow's scientists.

7.3. A COMPREHENSIVE DEFINITION OF BIOMECHANICS

Biomechanics is the application of the principles of engineering and life science mechanics on living systems. It is an interdisciplinary field based on knowledge of physics, chemistry, mathematics, physiology and anatomy. Therefore, this branch of science is very broad, covering a range of topics from the cellular level to the whole organ; it includes disciplines such as biomaterials, biofluids, cardiovascular biomechanics, bioelectronics, respiratory biomechanics, motion analysis, rehabilitation, posturography, trauma, occupational biomechanics, and sports biomechanics.

The study of Biomechanics requires a thorough understanding of basic terminology and concepts, which are delineated herein.

Anatomical locations and motions are often described in terms of planes. The *midsagittal plane* divides the body into two symmetric halves along the midline. *Sagittal planes* are parallel to the midsagittal plane, but do not divide the body into symmetric halves. The *frontal* or *coronal plane* is perpendicular to the midsagittal plane and divides the body into anterior and posterior sections. Planes that are perpendicular to the midsagittal and frontal planes are *transverse planes* (Enderle, Bronzino, & Blanchard, 2005).

Stress is a force divided by the cross-sectional area. *Strain* is defined as the amount of elongation divided by the original length of the specimen in the direction of elongation (Özkaya & Nordin, 1999).

Springs and dashpots are often used to model viscoelastic system: springs account for the elastic solid behavior, while dashpots define the viscous fluid behavior. In a spring, a constantly applied force, or stress, produces a constant deformation or strain, which is recoverable. Whereas, in a dashpot, the force produces a constant rate of deformation or strain rate which is permanent. The *Maxwell model* is a system formed by connecting a spring and a dashpot in series. The *Kelvin-Voigt model* is a system comprising of a spring and a dashpot connected in a parallel arrangement (Özkaya & Nordin, 1999).

Kinematics is defined by time-dependent aspects of motion in terms of displacement, velocity, and acceleration. Linear kinematics describes translational motion from a net force applied to an object. Angular kinematics is the rotational motion resulting from a net torque. Articular kinematics describes motions that pertain to the joints of the body (Özkaya & Nordin, 1999).