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ABSTRACT

Biomechanics involves the biological human beings interacting with his/her mechanical environment. Biomechanics research is being done in connection with sport, physical education, and general motor behavior, and concerns mechanics independent of implements. Biomechanics research falls in the following two general categories: (1) that specific research which contributes to the body of knowledge of motor behavior based on biomechanical type problems, and (2) the service components biomechanics provides to other subdisciplines for delineation of movement. The methods and general instrumentation techniques utilized in biomechanics research include (1) cinematography or high speed film (to record and analyze movement); (2) electronic transducers (to convert mechanical displacement, velocity, or acceleration into electrical voltage); (3) electrogoniometers (used to measure joint displacement); (4) anthropometry (technique of measuring length, girths, and widths of various part of the human body); and (5) electromyography (EMG) technique of investigating electrical activity associated with muscular contraction). (BD)

# Abstract
## Research Techniques in Biomechanics

Terry Ward, Ph.D.



This presentation was given at the Southern District AAHPER meeting in San Antonio, Texas. Introductory statements are made developing a rationale for Biomechanics research in sport, physical education and general motor behavior. Also, the methods and general instrumentation techniques utilized in this type of research are discussed.

# RESEARCH TECHNIQUES IN BIOMECHANICS

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Biomechanics as such is a relative newcomer to the research scene in physical education, sport and general human movements. However, biomechanics has been around for a long time, and all of us have experience with biomechanical type problems. In any situations where the biological human being interacts with its environment some sort of mechanical outcome occurs.

Early study of the human body strove to explain how it functioned via known mechanical terminology. And, for the most part, mechanical theory has precisely described the movements of people. You probably didn't notice that biomechanics was involved in your sitting here today. When you walked in and sat down you didn't worry about the height of the chair seat from the floor: that is because of a biomechanical determination (18" - 19") of seat height for average people. The same thing is true with regard to table height (29" - 30"). These are very applied biomechanical problems, that is, the biological human being interacting with his mechanical environment.

In physical education and sport activities we have the same sort of biomechanical problems but perhaps not as evident. Why are most tennis rackets approximately 30 inches long? Some of us would say because that is the way it is! That's the way it is supposed to be! And, of course, the rules only allow for rackets to be a certain length. Well, how were these lengths and widths and masses determined? Maybe by trial and error with no particular insight into biomechanics? Or maybe a great deal of insight into biomechanics just not calling it biomechanics.

I often fantasize about a 60" tennis racket as my only hope for covering the court. But biomechanically I know that there are many other factors which will influence my performance if I use a 60" tennis racket. The added mass will increase inertia of the racket and require larger torques from me to start and stop the racket. Hence, we discover the biomechanical limitations which govern the human movement in sport and other physical activities. This kind of interaction with our environment and implements determines how we move efficiently and effectively in biomechanical terms.

What are some of the questions a researcher in biomechanics might ask? Biomechanics research is interested in gross mechanics; that is, independent of implements. For example, walking, running, sprinting, and jumping are all activities which require no implement but do consist of specialized techniques for maximum performance. An example of an investigation involving gross body mechanics in the sprint start might use the distance between the bunch start and the elongated start, one might estimate the velocity

of the center of mass and its component velocities in the horizontal and vertical direction. Also, of interest to the biomechanics researcher may be the angle which the accelerating center of mass makes with the horizontal, as indicating whether the athletes are standing up too soon or staying low as they leave the blocks. Many times this kind of precise scientific investigation is necessary to distinguish subtle differences between high levels of performance.

Biomechanics research falls into two general categories. That specific research which contributes to the body of knowledge of motor behavior based with biomechanical type problems and the service components biomechanics provides to other subdisciplines for delineation of movement.

Biomechanics are also interested in the contribution of individual segments in human motor behavior. In discussing this topic let me introduce the inter-disciplinary approach biomechanics can make with many subdisciplines. In a unique throwing task the motor learning researcher might be interested in the number of baskets the subject could make using different types of practice. The motor learning researcher might be interested in practice "A" where the subject scored 2/10 whereas, with practice "B" the subject scored 8/10. Under investigation, here are the effects of the two different types of practice. The biomechanics researcher would attack this situation in another way. He would be interested in the components of the skilled movement which produced a score of 8/10 as compared with the less skilled movements which produced a score of 2/10. When two disciplines investigate human motor behavior, estimation of the "real situation," that is the complete person is more likely than when only one discipline is used in research. Cooperative research between disciplines is common practice at Florida State University where explaining motor behavior and the effects of physical activity on the human being is the charge of the Movement Sciences Program.

These are some of the types of questions one might ask in biomechanics research. Let me now describe the type of equipment used to answer these questions.

Cinematography or high speed film is the foremost tool used in biomechanics research at this time. High speed cameras are used to record movement, then frame by frame film analysis is carried out by various means. Film analysis is done in several ways from graphic analysis of stick figures from the film, to the trend towards computerized data acquisition systems. Presently, we of the Biomechanics laboratory at Florida State University are involved in the refining of just such a computerized analysis system to serve all subdisciplines in Movement Sciences in addition to Biomechanics.

Another method of recording the characteristics of motor behavior is by the use of electronic transducers. A transducer is a device which converts mechanical displacement, velocity or acceleration into electrical voltage for output onto a recorder or input into a computer for analysis. For example, a device which measures acceleration can be placed within a striking implement, e.g., baseball bat, tennis racket, golf club.

After the transducer placement the implement is used in its usual way and electronic output described the movement of the implement. Similar types of transducers are placed in force platforms in the ground of supporting surfaces to investigate the reaction forces of a subject moving over the force platform.

Joint displacement is measured by an electronic device called an electrogoniometer which is a fancy name for potentiometer. The electrogoniometer gives a specific electrical output indicative of the angle between two body segments. When time is a factor, this displacement can estimate velocity of movement.

Anthropometry is a technique of measuring the lengths, girths and widths of the various parts of the human body to investigate possible body types being indicative of performance. The size and shape of athletes contributes to the understanding of how they perform the way they do or perhaps why they are participating in a particular sport or event. The equipment used in anthropometry are sophisticated rulers and tapes; however, an excellent working knowledge of superficial human anatomy is essential.

Electromyography (EMG) is another research medium used in biomechanics to investigate movement. EMG refers to the electrical activity which is associated with muscular contraction. Electrodes are placed over or in the muscles under investigation and the potential which causes contraction is amplified several thousand times before it is recorded or analyzed. EMG analysis includes investigating the magnitude of electrical potential, the sequence of muscle activation in reflex responses and voluntary movements.