Biomechanics: A Neural Control Perspective
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PHYS THER. 1984; 64:1810-1811.

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When asked to define biomechanics, my first thought was to describe biomechanics as a measurement tool for the investigator interested in the neural control of movement. The use of biomechanics, however, in clinical assessment schemes is just as important as laboratory investigations. What must be kept in mind is that a traditional biomechanical description of movement will only generate a list of kinetic and kinematic variables. Biomechanics is traditionally defined as the science of structure and function of the biological system by use of mechanics and biophysics. Therefore, biomechanics of human movement is the science of the musculoskeletal system as it pertains to a movement skill. This limited view translates the end results of motor acts into a description of mechanical units. If, however, a goal in the study of human movement is to restore function after injury, we must ask why the behavior occurs and how the behavior is elaborated in addition to describing what the motor output is. The biomechanical assessment of human movement should be approached with specific questions in mind if the results are to be most useful.

The importance of combining traditional biomechanics and neurophysiology to study functional movement is emphasized in the more recent studies of the neural control of movement. Until the 1970s, the function of the nervous system was primarily inferred from a molecular view of the nervous system. In the 1970s, investigators of neural control moved from the study of reflex-induced neural activity in supine, decerebrated, and anesthetized cats to the study of the activity of neuronal assemblies in cats performing locomotor acts. The examination of the nervous system during movement and careful biomechanical descriptions of the nervous system output have led investigators to postulate why and how the walking pattern is elaborated and have challenged the hierarchical model of neural control. Such studies have also emphasized the need to focus on the manner in which the entire body participates in posture and motion rather than the activity of a single neuron, single muscle, or single limb. The attempt to develop a tie between the elaborated movement patterns and the responsible units of neuronal activity has also encouraged investigators of human movement to examine biomechanical variables with new questions in mind. For example, gastrocnemius-soleus muscle activity at the time the limb contacts a step during stair descent has been described as serving a "shock-absorber" role. When these data are examined with an expanded view of the study of human movement, the other interesting finding is that the EMG activity precedes ground contact. The presence of this anticipatory EMG suggests that the movement is not elaborated by a chain of reflexes as was traditionally proposed. Therefore, a biomechanical description of human movement can provide data that require the development of an alternate neural control hypothesis to account for actual functional events. Similarly, the finding that the pattern of reciprocal arm swing observed during free-speed walking is changed to a synchronous bilateral arm swing during very slow walking raises neural control questions. Running and walking have been distinguished as two distinct motor patterns; perhaps slow walking is yet another form of locomotion that requires a different set of motor commands. If this is true, the current concepts of ambulation training will have to be evaluated.

The use of biomechanical variables as a tool to assist in answering nonbiomechanical questions is not limited to laboratory investigations of neural control theory. In fact, the clinical use of such an approach has developed quite rapidly. A result of combining biomechanical and clinical approaches is that assessment of the neuromusculoskeletal system is being performed during dynamic functional tasks rather than static conditions. For example, an evaluation of the contribution of muscle to the generation and control of joint moments and forward progression is a more meaningful indicator of that muscle's ability to assist in ambulatory function than is an isolated test of muscle strength and active joint range of motion. Perhaps this statement is best illustrated by considering the appearance of genu recurvatum in a hemiplegic lower extremity. Static testing may reveal a patient's ability to isolate active knee flexion and extension. A static evaluation, however, may not assess the patient's ability to control the knee when the knee extension moment is posterior to the knee joint. The dynamic event, therefore, bears little resemblance to the static test. Knutsson and Richards took the dynamic assessment one step further and classified the abnormal gait of patients with spastic hemiparesis based on one of three distinct types of EMG patterns produced during walking. In this case, the biomechanical evaluation of walking served to classify or segregate three different motor problems in a sample of patients with the same diagnosis—spastic hemiparesis. Therefore, a combination of biomechanics with questions of why or how the behavior is produced may more effectively assist in treatment planning than traditional testing has.

The work of Nashner et al serves as another excellent example of applying biomechanical principles to problems of motor control. Rather than limiting the assessment of sensory systems to classical clinical testing, a system has been developed to test functionally the integrity of the sensory systems; the normal role of the visual, vestibular, and proprioceptive systems in maintaining human upright posture has been described through the use of a posture platform and measurement of biomechanical variables. The control model that was de-

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veloped is now being examined with a variety of patients to determine whether the approach is clinically useful. For example, the test paradigm has been able to detect vestibular dysfunction in patients who do not show abnormal findings with such classic tests of the vestibular apparatus as caloric testing. Because classic tests had not revealed nervous system dysfunction, many of these patients were receiving psychological treatment for their symptoms until they were assessed on the posture platform. Therefore, biomechanical variables can serve as useful measurement tools.

In summary, biomechanics can provide sensitive measures of motor performance. When this approach of description is combined with questions of how and why the behavior is produced, we will gain fresh insight into the neural control of movement and suggestions for treatment intervention.

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