

The Clinical Application of Biomechanics

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One only needs look at people in the world around them to wonder why one shows signs of degenerative changes at an early age while another demonstrates minimal degenerative change despite being much older. Consider the fate of two professional baseball pitchers: The first has a long career of comparatively injury-free play, while the second is plagued with constant shoulder or elbow problems that might be career-ending.

The explanation for this may be due, at least in part, to how an individual's bodily tissues are able to absorb the forces placed on them and how the body reacts to those forces. Normal bone alignment, adequate muscle length and tone, and the normal functioning of joints (both in motion and at rest) are important considerations in understanding and treating the above-mentioned patients.

Human biomechanics is the study of human motion and the effect forces have on those motions. Biomechanics is a diverse field, incorporating aspects of a number of different branches of science. When we think of biomechanics, we often observe stress and strain curves predicting the failure rates of tissue, or hear discussion of lever arms and moments of force. We might be reminded of Sir Isaac Newton's laws of motion, or coefficients of friction. The purpose of this article is to show the applicability and practicality of these concepts in clinical practice, as they can aid doctors in specifying their diagnosis and embellishing their treatments for the benefit of their patients.

The human skeleton is literally composed of a system of levers. All human motion revolves around this lever system. To accurately describe the direction of movement occurring at a joint, a reference system for human motion must be defined. In this way, any motion occurring in three-dimensional space can be defined.

This reference system is the three cardinal planes of motion. Each plane is perpendicular to the other two and divides the body in half. The frontal (coronal) plane is a flat vertical plane that divides the body into an anterior and posterior half. The sagittal plane also is a flat vertical plane that divides the body into right and left halves. The transverse plane is a flat horizontal plane that divides the body into an upper and lower half. All three planes pass through the body's center of gravity, located just anterior to the S2 tubercle of the sacrum.

Among the other elements of the physical examination, the doctor must examine the glenoid humeral joint for its arthrokinematics. With the patient sitting and the arm abducted to 90 degrees, have them relax the deltoid muscle and gently move the glenohumeral joint inferiorly. If the joint does not glide inferiorly, then a gentle impulse directed over the joint will help to restore the normal motion, decrease the impingement and restore the normal motion and assist the healing process.

Consider a joint limited to 60 degrees of flexion. Assume that a passive motion is manually applied to the bone containing the concave (female) surface. If a force is applied on the distal aspect of this segment and joint motion is firmly restricted, the female surface can be levered in the direction opposite to that desired in normal arthrokinematics. Under these conditions, the segment can only

move in the same direction as the required rolling. This situation is preferred because normal arthrokinematics are produced by the therapeutic effort. This concept is necessary to maintain when stretching a joint in a person who may be osteopenic or osteoporotic. Proper application of force could allow for therapeutic stretching while decreasing the chances of fracturing the joint by the application of excessive force.

The wisdom of the body does not permit a destructive process to happen easily. The body has many adaptation mechanisms. It changes muscle length, causes osseous adaptations and will compensate in a variety of ways to maintain homeostasis. A study in which individuals wore orthotic shoe inserts for four months resulted in average improvements of 5 mm in femoral head height, 3 mm in sacrovertebral angle and 3 degrees in lumbosacral disc angle. These findings are significant because they occurred without accompanying manipulative care.

The vertebral column might increase its thoracic kyphosis in response to an increase to lumbar lordosis. Osteophytes might develop over a degenerative segment of the spine in an attempt to provide stability at that level. These methods help the body to adapt to excessive and abnormal loads. Eventually, as the abnormal loads continue and stress persists, our internal stabilization methods fail. This failure results in degenerative tissue damage, disability, pain and altered function.

For example, there could be an asymmetry caused by an increase in the quadriceps (Q) angle. The Q angle is formed by the intersection of lines from the anterior superior iliac spine and the tibial tubercle as they pass through the mediolateral superior-inferior bisection of the patella. This angle influences the direction in which the quadriceps pull and affects the patella's tracking mechanism.

The angle is measured with the patient in the functional standing position. If the Q angle increases, the patient is at risk for developing anterior knee pain. As the patella is repeatedly pulled laterally over the lateral femoral condyle, the posterior aspect of the patella begins to deteriorate from the excessive friction. Over time, this friction causes irritation, swelling and anterior knee pain. The patient often has difficulty walking stairs and feels knee stiffness after sitting. As the friction continues over time, the synovium begins to wear down and degenerative changes take place. These degenerative changes can be seen on X-rays and lead to a diagnosis of chondromalecia patella.

The question is: How can we prevent the Q angle from increasing in the first place? An increased Q angle often is related to an increase in body weight, causing collapsed posture, muscle weakness and foot pronation, which causes rotation of the tibia and an increase in genu valgus. The patient often develops a short leg on the pronated foot side, resulting in pelvic unleveling. Naturally, the position of the fifth lumbar vertebrae is altered, leading to stress of the disc and dysfunction at that level. The changes continue up the kinetic chain, as does the body's attempt to compensate for these alterations.

The effect of muscle imbalance has received much attention of late. It is well-known that tight hip-flexor muscles are accompanied by tight low back muscles. Additionally, there are weak, stretched abdominal and hamstring muscles. This pattern is thought to be a contributing factor in the etiology of back pain. The resulting hyperlordosis is thought to be a factor in the development of a number of low back syndromes chiropractors treat on a regular basis. There are a number of ways to assess muscle shortening: the Thomas test to assess the length of the hip flexors or the sit-and-reach test to assess the length of the gastrocnemius group, hamstrings and low back extensor muscles. Goniometric, inclinometer and tape measurements are commonly used to assess muscle length and joint range of motion.

Overly tight muscles also cause excessive stress at the various joints they cross. For example, tight hamstrings contribute to anterior knee pain, as the tightness causes compression of the patella on the femur. Short-leg syndrome due to foot pronation causes imbalances of the hip adductors and abductors as compensation. Over time, these changes in muscle length can become difficult, if not impossible to correct with muscle-lengthening therapies. These conditions often require aggressive rehabilitation and chiropractic therapy. Therapeutic support from outside sources is frequently needed, such as shoe orthotics, braces and supports to absorb excessive force. Occasionally, when degeneration has gone untreated over a long period of time and conservative therapies fail, surgery becomes necessary.

Another example of altered biomechanics causing the development of a musculoskeletal condition is the development of shin splints. *Medial shin splints* is a term that applies to a complex of conditions leading to pain and irritation to the shin. The etiology is a posterior tibial tendonitis, secondary to abnormal subtalar joint pronation. An individual who excessively pronates will overuse the tibialis posterior muscle as it attempts to support the medial longitudinal arch. Treatment includes rest, ice, manipulation of the foot and ankle, stretching of the calf muscles, gradual resistive exercises to the anterior muscle group if weakness is noted, and functional orthotics to prevent excessive pronation of the subtalar joint. Studies have found that a viscoelastic polymer insert will reduce impact at heel strike, significantly decreasing foot and back symptoms. Heel pads will help relieve chronic degenerative back pain.

Preventive care is a responsibility physicians have to their patients. We commonly make recommendations about hypertension, hyperlipidemia, smoking and stressful lifestyles. We have no less responsibility to our patients when it comes to musculoskeletal conditions leading to chronic degenerative processes. These conditions may not be life-threatening, but they deteriorate quality of life and cause a lifetime of chronic pain and disability. If early intervention occurs, I suggest this deterioration of the human condition might be prevented or at least significantly decreased when impacted upon favorably by the astute, intelligent and proactive doctor of chiropractic.

Resources

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JUNE 2008