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FrameWork

by Nicholas A. DiNubile, MD

Dr. DiNubile will appear November 18th at the YRS Conference

The skeleton protects our internal organs; provides a scaffold to support the muscles, skin, organs, blood vessels, and nerves; and gives rigidity and leverage to the muscular action that allows us to move. Because of the way our muscles and bones are joined, and the way the joints that link bones together are articulated, the skeleton is not only rigid, but also flexible.

Bones are also every bit as alive as are the tissues in your muscle or skin. Yes, bones have a high content of inorganic materials, namely minerals, mostly in the form of calcium phosphate, but bones are surrounded by a dense connective tissue membrane, called the periosteum, that contains nerve fibers that pass into the bone cortex. The periosteum also contains blood vessels that keep bone supplied with the oxygen and nutrients it needs.

The organic part of bone consists of millions of living cells, but also a matrix called osteoid, made from a tough, fibrous protein called collagen.

When we are still embryos in the womb, we develop a soft skeleton consisting of cartilage, a highly elastic form of collagen. Later, that rubbery cartilage is invaded by builder cells (called osteoblasts) that replace the soft tissue with new osteoid (the organic matrix) that eventually mineralizes into bone. This process is called ossification.

Motion is lotion.

Even after we're fully grown, though, our bones are constantly being remodeled. They change and renew themselves, replacing obsolete components to preserve structural integrity and prolong normal function. In order to make room for new bone, the old bone—especially bone that has been damaged—is eaten away by cells dedicated to just that purpose. Cells that tear down are called osteoclasts; the cells that build your bones back up are called osteoblasts, and the interplay and balance between the two types of cells is key to your ability to "keep on truckin".

Your hormones, your nutrition, and your level and type of exercise have a direct effect on the balance between building up and tearing down that goes on continuously in your bones.

One of the fundamental rules of orthopaedics is called Wolff's Law, which states that bone is laid down where needed (by way of the osteoblasts) and reabsorbed where not needed

(by way of the osteoclasts) in response to the mechanical demands or stresses placed on it.

Wolff's Law is why astronauts who spend a long time in the weightlessness of outer space can barely stand when they return.

Their free ride away from the laws of gravity (weightlessness means no heavy lifting) has weakened their bones. Even after a short space flight of 1 or 2 weeks, astronauts, who are amazing athletes in their own right, can lose the same massive amounts of calcium from their bones that elderly patients lose when kept at complete bed rest for 4 to 6 months. On extended space flights of 6 months to a year, astronauts lose not only calcium but up to a fourth of their muscle mass—even with creative in-flight exercise routines designed to combat the zero-gravity environment. A word to the wise: The same thing happens (over a much longer period of time) to people who don't exercise.

Partnering to give our bodies structural integrity are connective tissues that lack the rigid mineral content of bone. They derive their strength and flexibility from the tough, fibrous, rubbery, and elastic substance we introduced earlier—collagen. While it is a featured player in bone, collagen is a star in the world of soft tissue. It provides not only scaffolding but tensile strength, holding things tightly together, while allowing enough flexibility to move.

We've already mentioned cartilage, the form of collagen that gave us structure before our bones fully mineralized. Cartilage continues to give structure to the nose, ears, and other nonrigid parts of the body. In sports medicine, its most vital role is as a friction plate to prevent wear and tear on our joints. Cartilage is a smooth, glistening coating for the ends of articulated bones that also provides support, flexibility, and elasticity. It is your joint surface or cushion that, when functioning normally, glides effortlessly as you bend and straighten your joints. With just a single drop of synovial fluid acting as a lubricant, the gliding action of our joints has a coefficient of friction 20 to 30 times that of ice gliding on ice. Now that's what I call a smooth ride.

Articular cartilage does not have a blood supply, so it, along with the chondrocytes (cartilage cells), derives its nourishment from the synovial fluid, a process that is enhanced by movement, especially rhythmic movement like exercise. Motion is lotion. Injured or inflamed joints (synovitis) tend to produce excess synovial fluid, creating a painful swelling with stiffness, as well as loss of strength and motion.

When cartilage becomes damaged, wears thin, or wears out, however, you have the number one medical complaint in the Western World—osteoarthritis. It afflicts almost 30 million (and rapidly rising) people in the United States alone. If you want to have any chance of avoiding this almost inevitable bane of the human condition, you have to start taking care of those bones and joints!

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Water accounts for 65 to 80 percent of the wet weight of articular cartilage, and it is this moisture that allows for cartilage to change shape in response to stress, resisting compression. When you squeeze a baby's cheek, or the skin on the back of a child's hand, the skin bounces right back—that's healthy collagen with plenty of moisture. Squeeze the back of an elderly person's hand, and the pressure leaves its mark—a fold of skin that only gradually resumes its shape. Unfortunately this change is not just skin deep.

"Drying out" affects your muscles, tendons, ligaments, joint surfaces, and more. As we get older, collagen also undergoes a process called maturational stabilization, in which the molecules become more tightly round. Up to a point, this actually enhances connective tissue strength, but in the later part of life, the increasing rigidity of collagen fibers brings stiffness and a greater vulnerability to injury.

Loss of water content in collagen—and therefore in articular cartilage—also affects the disks between the vertebrae in your spine. These shock absorbers should be plump like grapes, but, as they lose water, they become more like raisins. Drying out reduces flexibility, increases wear and tear, and makes everything more vulnerable to injury. This is why you'll hear me say again and again that you have to drink more water than you ever think you'll need.

Just as bone renews itself, so do the cell populations and extra-curricular matrix of soft tissue. In connective tissues, especially in the musculoskeletal system, there is continual turnover of collagen, primarily in response to tissue loading, both through repeated movement and through the accumulation of load over time.

But just as with bone, either excessive load or prolonged immobilization can trigger breakdown. Our bodies adapt favorably to graduated increases in physical demand. The lesson from Wolff's Law is that manageable stress on your bones, muscles, and connective tissues is a good thing. But "manageable" is the key word.

excerpted from
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