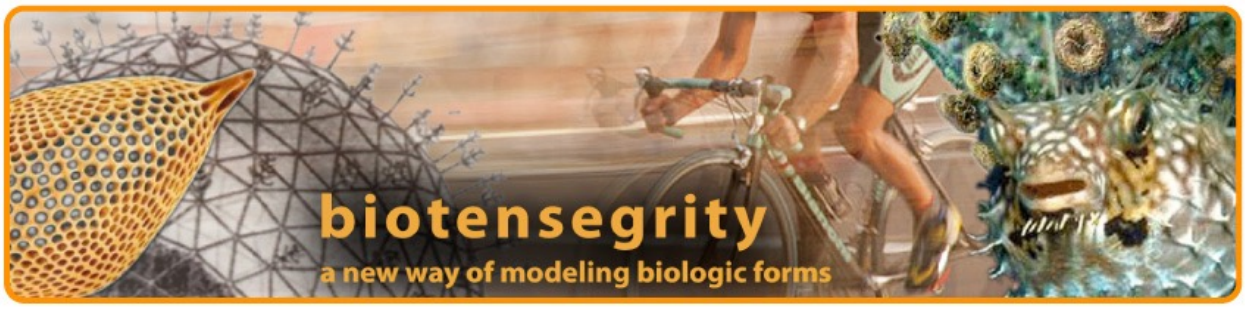

Ring Around a Rosie:
on the Force of Gravity That Pulls Us to the Center of the Earth

A technical note to accompany the presentation on the BIOTENSEGRITY DVD

The center of gravity (COG) of a human body is accelerating to the center of the earth at 9m/sec2. The resistance of the surface of the earth under our feet stops it. A plumb line dropped from the COG of a body must lie within its base otherwise it will continue its descent until it is stopped by the earth's surface. When the COG lies above the supporting base, with each rotation of the body the COG will leave the plumb line through the supporting point and take a lower position. It will tend to fall further and further unless an external force is applied to bring it back to its initial level. It cannot come back to its initial position by itself (Braune and Fisher 1985). As soon as it leaves the plumb line, a moment is created and the COG will continue to fall until it reaches its lowest position. A key word in this paragraph is external. The force cannot come from within itself, as that would be akin to pulling oneself up by one's own bootstraps.

Figure 1. Porch of the Caryatids, Athens.

Biomechanists since the days of Borrelli (Borelli 1680-1681) and even earlier, by the Greeks with their vision of Atlas as a 'column' holding up the universe and the caryatids as columns in their temples [Fig. 1], have modeled the human body as a rigid column. This 'column' is itself a stacking of loosely connected rigid segments delicately balanced on one another and connected by near-frictionless joints. The segments are like the building blocks of columns [fig.2] but with a much more tenuous support of one another as they have narrow bases for their length and rest on extremely slippery platforms. The joints are more slippery than a banana peel underfoot and, just like on a banana peel, the forces always have to be directed perpendicular to the surface of the platform or it will shear. Each rigid segment has its own COG and, therefore, will follow the same rules. Once the center of gravity of any segment leaves its plumb line, it will fall until some external force stops it.

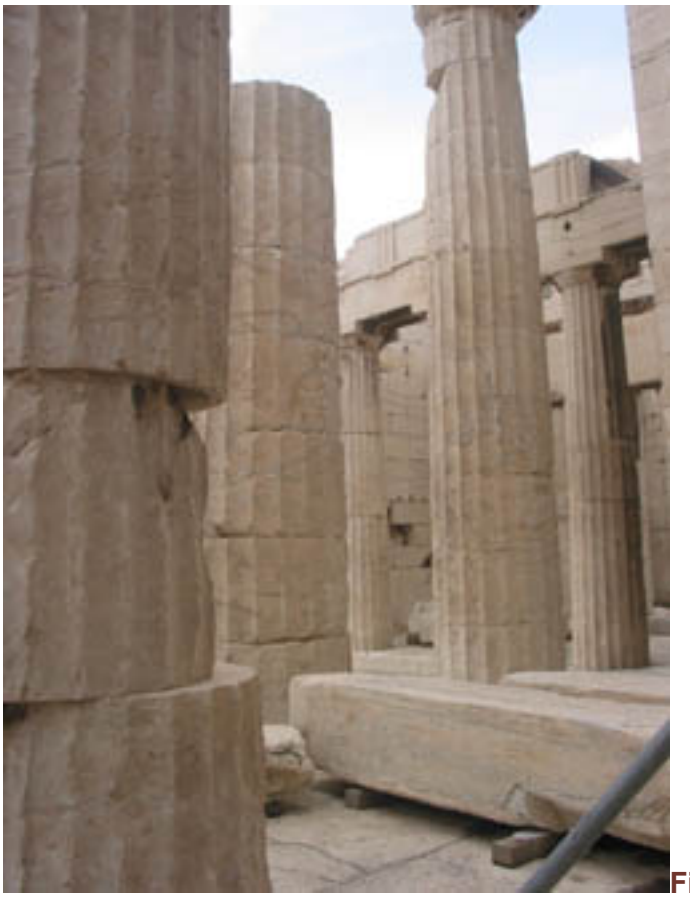

Figure 2. Greek Columns

As a body segment is falling, what is needed is a force to pull 'up' against the accelerating force of gravity and that force must be equal to the force of gravity and then some. The 'external' forces usually considered to stop this tumble, are expected to come from the muscles and ligaments attached to the other body segments. Since the muscles above the falling segment become part of the falling segment, they are internal forces and, therefore, useless. The tension muscles and ligaments below the COG of the falling mass can only pull it towards the center of the earth, over its near-frictionless joints that offer no resistance, and would accelerate its fall.

It is counterintuitive to think that muscles pull us down, not up. We have always used our muscles to lift us from lying to sitting and from sitting to standing but in the column-lever model of Borelli and modern-day biomechanists that would be contrary to Newtonian mechanical laws. Muscles do not lift, they merely approximate the two ends of the muscle as for every action there is an equal and opposite reaction. The ends of the muscle pull towards each other. In a gravity field, they must pull us into a heap as the inferior attachment is anchored, by gravity, to the earth. 'Anti-gravity' muscles are misnomers. Muscles can only accentuate

the force of gravity, they cannot oppose it, there are no sky-hooks pulling us into the air.

The column-lever model has been the plush carpet under our feet that we have stood on for hundreds of years. It is difficult to pull the rug out from someone, particularly if there is no floor underneath. Other models have been suggested that could model the musculoskeletal system and avoid the pitfalls of the column model (Ingber 1998), (Levin 2002).

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