Structure, Function, Integration.

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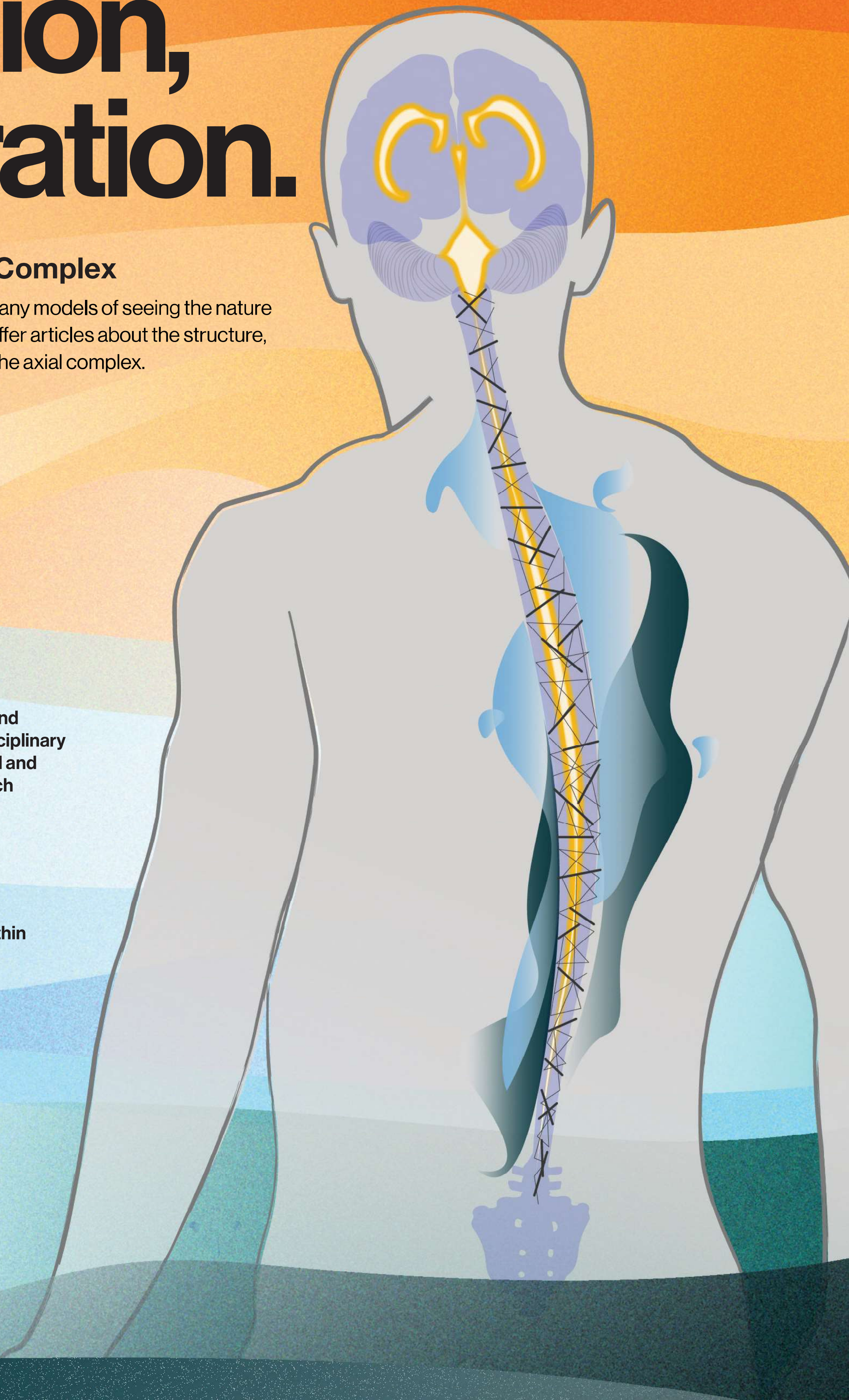

Enlightening the Axial Complex

Rolfing® Structural Integration has many models of seeing the nature of the human body; in this issue, we offer articles about the structure, movement, and wholistic context of the axial complex.

Also in this issue

Fascia-Oriented Images and Fascia Recoil

Our Rolfing colleagues Dr. Bertolucci and Dr. Patterson elaborate on the multidisciplinary work presented by Dr. Jaap van der Wal and Dr. Gunnar Spohr at the Fascia Research Summer School in 2016.

Cultural Humility

'Cultural humility' replaces 'cultural competence' to increase sensitivity within the therapeutic relationship.

Human Locomotion, Persistence Hunting, and Gracovetsky's Spinal Engine Theory

By Per Haaland, Basic Rolfing® Instructor and
Rolf Movement® Instructor

Per Haaland

ABSTRACT *Faculty member Per Haaland explores the role of the axial complex in human locomotion. Haaland discusses the importance of persistence hunting in human evolution and how Serge Gracovetsky's spinal engine theory posits the spine's centrality to human locomotion. Hubert Godard's tonic function model further describes the sophisticated interplay between tonic and phasic muscles in human locomotion. A deeper understanding of these theories and models will help our work in structural integration and movement education.*

Human beings have a distinct style of locomotion. We walk upright on two feet. Over the last decades, research and inquiry into the biomechanics of human gait have dramatically increased our understanding of human locomotion. Serge Gracovetsky, PhD, with his *spinal engine theory*, has been one of the most significant contributors to this inquiry (1988). Assessing the presence and expression of contralateral gait, a fundamental tenet of the spinal engine theory, is an important part of the training of structural integration (SI) practitioners. All manual therapists and somatic educators can benefit from a deepening of our understanding of the spinal engine model. In this paper, I aim to explain and expound on Gracovetsky's theory in a way that I hope to be useful for other SI practitioners and movement educators. I believe that deepening our understanding of the biomechanics of human gait can help us better understand what makes our work so effective in changing posture and improving coordination.

To begin understanding human gait, it is helpful to examine an important theory regarding our uniquely human style of locomotion.

Humans: Long Distance Persistence Hunters

It has been hypothesized that early humans, after having evolved bipedality, specialized as long-distance runners for their survival, practicing what has been termed *persistence hunting*. As explained by Christopher McDougall in his book *Born to Run*, this type of persistence hunting was, until recently, still being practiced among certain tribes in sub-Saharan Africa (2011). Upon encountering a herd of animals, say, antelopes, a band of humans would identify a weak member of the herd and then attempt to separate it from the rest of the animals. At that point several members of the group would start running after the animal. When the hunters had chased their prey for some time, the animal would eventually get exhausted and collapse, at which point the hunters would kill it. Thus, persistence hunting ensured an essential supply of animal protein and fat, satisfying our bodies' general nutritional needs as well as our expanding brain's need for fuel.

Features that Humans Evolved for Efficient Locomotion

What makes humans such exceptionally good long-distance runners?

Sweat Glands

An important factor in hominid evolutionary development had to do with temperature regulation. According to *Scientific American:* "The transition to naked skin and an eccrine-based sweating system . . . offset the greater heat loads that accompanied our predecessors' newly strenuous way of life" (Jablonski 2012, 23). Sweating allows for *efficient temperature regulation* as the sweat, perspiring onto the surfaces of the body, cools the skin. An antelope, like most other mammals, would regulate its body temperature (cool off) through intensified breathing. Compared to sweating, this is a much less efficient way of cooling the body. Inevitably, after some time running, the antelope would collapse from overheating, at which point the hunters would kill the animal with little risk of injury to themselves.

Uncoupling the Breathing Rhythm from the Stride Pattern

Another important feature in hominid evolution was the capacity to *uncouple the breathing rhythm from the stride pattern*. For most animals there is one breath per stride. So, to run faster and farther requires animals to both breathe more heavily and attempt to cool themselves through panting. Humans, on the other hand, having uncoupled the breathing rhythm from the stride pattern, are able to regulate their breathing freely according to the moment-to-moment, ever-changing, need for oxygen.

Morphological Changes Related to Running

Comparing the dominant modes of locomotion in different mammals, McDougall references the work of Harvard paleoanthropologist Dan Lieberman, PhD, and Dennis Bramble, PhD, professor emeritus of biology who posits that, based on morphology, there are two main categories, *walkers* and *runners*.

Humans are categorized as runners. In contrast, chimpanzees, who are our closest primate relatives, are categorized as walkers. In chimpanzees the toes are long and splayed out, which means they are well suited for grasping and walking. In humans, the toes are short and stubby, a feature that suggests better efficiency for propulsion and running. Three other morphological features found in humans further support the *running human hypothesis* (McDougall 2011). The features linked to running as the main mode of locomotion are:

- The *nuchal ligament*.
- Well-developed *hip extensors (Gluteus maximus).*
- The *Achilles tendon* and associated plantar flexion muscles.

The human cranium, weighing twelve to fifteen pounds, must be balanced on top of the bipedal upright human frame. To balance and stabilize our large cranium, the long and powerful nuchal ligament developed in humans. Such a powerful stabilizing structure, spanning from the thoracic spine to the occiput, is not found in mammals whose gait is characterized by walking. Thus, the presence of the nuchal ligament suggests that early humans spent significant periods of time running.

Human bipedal locomotion relies on full hip extension, which requires large and powerful gluteal musculature. In contrast, in the case of the chimpanzee's facultative bipedality[1], the knees always remain bent, with their small gluteus maximus taking on the function of an abductor as opposed to a hip extensor.

The presence of the Achilles tendon and powerful plantar flexion muscles are other indicators that human beings are specialized for running. Chimpanzees, who are poor bipedal runners, lack an elastic tendon (the Achilles tendon) and instead have calf muscles that attach directly to the heel bone.

Gracovetsky, Controlled Instability, and the Spinal Engine Theory

The human locomotor system utilizes a phenomenon that has come to be known as *controlled instability*, a term coined by gait analyst Serge Gracovetsky (1988). Gracovetsky, a Canadian engineer, was led into the study of spinal functioning and the biomechanics of gait as a result of seeking help for a back problem. After having sought the counsel of seven different medical practitioners, he was given seven different explanations and seven different approaches for remedying his situation. He decided to do his own research and ended up proposing a new model for understanding human gait, the spinal engine theory. In his theory, Gracovetsky posits that human locomotion is characterized by what he calls controlled instability. He points to the fact that the unsupported spine will collapse under a mass of approximately

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two kilograms. By virtue of this inherent instability, he says, the components and segments of the skeletal system are designed to be displaced easily, allowing for easy and smooth shape changes and moment-to-moment adjustments, such as flexion, extension, and rotation of the spine. This controlled instability offers our species evolutionary advantages.

What Drives Human Gait?

In Gracovetsky's 2001 paper "Analysis and Interpretation of Gait in Relation to Lumbo Pelvic Function," he addressed the question of what drives human gait. Before Gracovetsky's contribution to the debate, starting in the mid-1980s, the common view held by the gait analysis community was that the legs are the driving force in human locomotion. In this view, walking is simply a motion of the legs carrying its passive passenger, the trunk.

Countering this narrative, Gracovetsky points to the fact that to achieve human gait, the pelvis needs to rotate in the horizontal plane (the 'table' plane; see Figure 1).

If the force needed to rotate (torque) the pelvis originates in the legs, he says, then a counter-torque would be observed at the level of the feet, as required by the physical law related to the conservation of angular momentum. Force plate data indicates that very little torque is applied to the ground during walking. This suggests, argues Gracovetsky, that no torque is transmitted from the legs to the pelvis. What, then, is responsible for pelvic rotation in the horizontal plane?

Features of the Human Spine

The spine, says Gracovetsky, is a curved, flexible rod (Gracovetsky 2001). In such a structure, a lateral bend induces an axial torque. Translated into terms we use as manual therapists, lateral flexion of the spine toward the right, i.e., a *right sidebend*, induces a *left rotation* of the spine; a *left sidebend* induces a *right rotation* of the spine (see Figure 2).

This mechanism is referred to as *coupled motion*. As the spine sidebends to one side and rotates to the other, this motion is transmitted into the pelvis through the sacroiliac juncture. In this way, spinal movement powers pelvic rotation in the horizontal plane. This is the 'engine' that fundamentally drives walking, according to Gracovetsky. The spinal engine theory predicts that an individual without legs would be able to 'walk' on their ischia by means of this coupled motion between spine and pelvis.

In an experiment conducted with a legless individual as a subject, kinematics and electromyography studies were both able to demonstrate that this individual's pattern of movement was strikingly similar to that seen in bipedal gait (see Figure 3). Having thus demonstrated that the driving force for human locomotion is the spine, Gracovetsky further explains the role of the legs and the upper extremities.

The Role of the Legs

While it has been demonstrated that human bipedal locomotion can be achieved without legs, efficient locomotion, especially at high velocity, is dependent on increasing the power available to the organism. Increasing power means increasing muscular mass. As the expansion of the spinal extensor muscles in humans is restricted by the contents of the abdominal cavity, the increase in muscle mass must be located outside the trunk, such as with the hip extensors. The power that gets generated and temporarily stored within the hip extensors, primarily the gluteus maximus, is returned to the spinal engine via the ligamentous structures surrounding the sacroiliac joint. The legs greatly amplify the power of locomotion generated by the spinal engine.

The Role of the Arms

As we noted earlier, human gait is characterized by near-zero torque at the foot/ground interface. To prevent the foot from transferring torque to the ground, the pelvic girdle and the shoulder girdle counter-rotate to conserve the angular momentum. We call this contralateral motion. From the rotating thorax, the ipsilateral shoulder extends and furthers this spiraling motion, transmitting it through to the arms. The arms, through their pendular action, extend and amplify this rotation/counter-rotation energy transfer system, originally initiated in the lumbopelvic area.

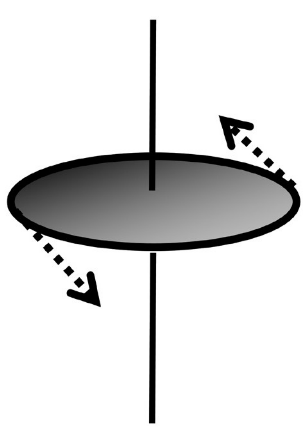

Figure 1: Axial rotation in the horizontal plane.

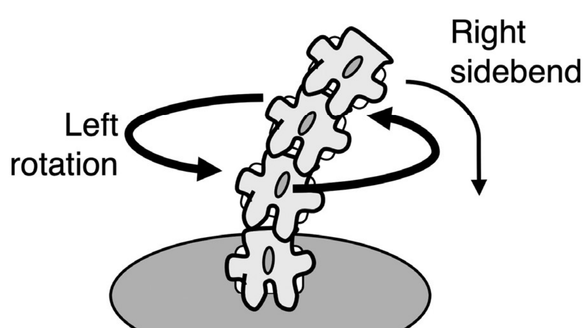

Figure 2: The spine is a curved, flexible rod. Motion is coupled, when the spine right sidebends, it is paired with left rotation.

Figure 3: Posterior view of the axial complex of a person sitting on a deck. Imagine this person walking their sit bones to the edge of the deck, they could do this by only moving their axial complex. Photo by Danie Franco on Unsplash.

Pathways of Muscle Power Transmission

As shown in Figure 1, for human contralateral gait to happen, the pelvis needs to rotate in the horizontal plane. Specific pathways of muscle power transmission ensure that this rotation/counter-rotation mechanism continues to propel our bodies forward in space.

During walking (and running), hip extensors fire as the toes push the ground. The muscle power thus generated is directly transmitted to the spine and trunk via two distinct but complementary pathways: the biceps femoris pathway (see Figure 4) and the gluteus maximus pathway (see Figure 5).

Chemical Energy Transformed from Kinetic to Potential and Back to Kinetic

When the toes of one foot push the ground, the hip extensors are triggered to fire. As a result of this muscular activation, the trunk is extended and raised (lifted up) in the sagittal plane. The chemical energy generated by the activated muscles is now converted – through the raising/lifting of the trunk – into potential energy which temporarily gets stored in the gravitational field. With the body mass thus elevated, the spine rearranges its geometry as the body readies itself to 'land' on the opposite foot. As the opposite foot lands, bringing the mass of the body back toward the ground, the potential energy, temporarily stored in the gravity field, is liberated and becomes kinetic energy. This kinetic energy is then transformed and redirected as needed to initiate another cycle of rotation and counter-rotation of the upper girdle (rib cage/shoulders/arms) with respect to the lower girdle (pelvis and legs) and vice versa. In this way, energy continues to be efficiently exchanged and transferred between the different components of the locomotor system.

> *What is the relevance of persistence hunting ancestors and Gracovetsky's spinal engine model to our evolution as humans and to the practice of structural integration and somatic education?*

The running human hypothesis offers an understanding of one of our early ancestors' survival adaptations. Our locomotor system is characterized by the capacity for long-distance persistence hunting. Important features of this capacity include: the development of sweat glands; uncoupling breathing from stride pattern; and morphological developments related to running. Gracovetsky's spinal engine theory explains how our unique bipedal locomotor system, by exploiting the laws of physics and kinetics, is primed to take advantage of properties such as inertia, momentum, and viscoelasticity. His theory shows how humans can efficiently recycle, redirect, and transform kinetic energy, minimizing the need for excess muscular effort. But what does this have to do with our work as SI practitioners and somatic educators? And how can we help contemporary humans, often presenting with pain, movement restrictions, and less-than-optimal coordination patterns? How can we help our clients re-embody the elegant, energy efficient functional patterns of our ancestors?

Sensorimotor Amnesia

The average modern human can be said to have become afflicted by sensorimotor amnesia, a term coined by Thomas Hanna (2004) from his work with Moshe Feldenkrais. As infants and children, we explore our physicality with curiosity, joy, and excitement. We crawl, we roll, we twist, and we turn, flexing and extending as we curiously explore our environment. Infant movement exploration, from supine and prone through to quadrupedal, gradually helps the infant acquaint itself with its own spinal engine. Playing with sidebends and twists, we find joy in stretching and contracting, extending and flexing the muscles and fasciae surrounding the spine. The pride and mastery we feel as we take our first few steps upright is well earned. We slowly and painstakingly had to develop the coordination patterns, stabilization skills, and balancing capabilities that enabled us to master our own spinal engine.

Fast forward to school age, when our agile, flexible, and excitable bodies are forced into restrictive chairs and desks,

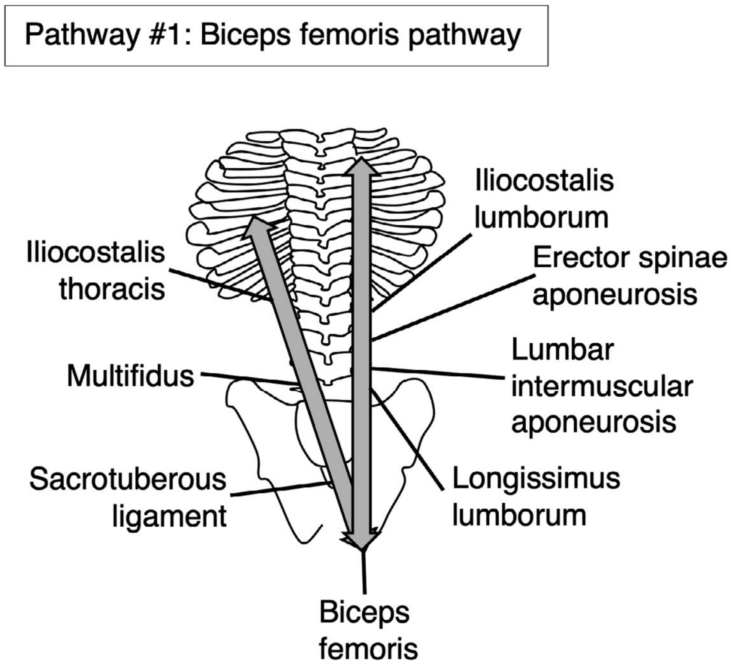

Figure 4: Biceps femoris pathway: Biceps femoris to sacrotuberous ligament to lumbar intermuscular aponeurosis (LIA). LIA is linked directly with the lumbar transverse processes via iliocostalis lumborum and longissimus lumborum and to spinous process vis multifidus (Gracovetsky 1988).

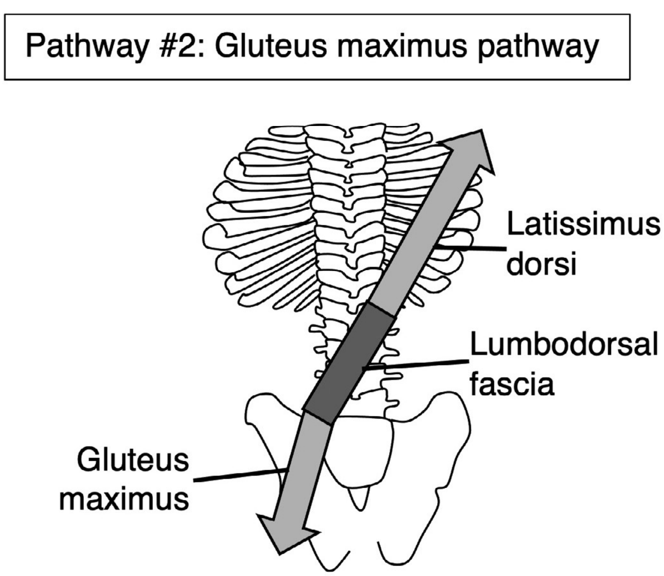

Figure 5: Gluteus maximus pathway: Gluteus maximus to lumbodorsal fascia to latissimus dorsi to upper extremities (Gracovetsky 1988).

our frames expected to spend extended periods of time sitting still, bodies growing tense and restricted. As we grow into adults, further cultural and societal forces, such as gender stereotypes and fear of being sexually provocative, may make us subdued, minimizing freedom of movement, toning down the external appearance of pleasure and sensuality, to portray ourselves as responsible, well-adjusted adults. We become more cerebral, less embodied. We develop sensorimotor amnesia. Adult sensorimotor amnesia shows itself as a lack of adaptability, movement restriction, and lack of spontaneity. This diminishment of movement and flexibility results in inefficient coordination, greater wear on our joints, potential pain, and even tissue damage.

Reclaiming Our Birthright – Gravity, Evolution, and Human Potential

Observing the predicament of modern humans alienated from our own somatic awareness, Ida P. Rolf, PhD, offered structural integration as a means to further human potential through refining our relationship with gravity. The benefits of structural integration, as we know, include improved structure/posture, enhanced coordination, and a fuller sense of self-expression.

Hubert Godard: The Tonic Function Model

Hubert Godard, a French Rolfer®, Rolf Movement Practitioner, dancer, and faculty member for the European Rolfing® Association, has given us many tools to be able to apply what Rolf was pointing to. Godard has helped update the SI community regarding research in perception, coordination, and body mechanics. His contributions have improved our understanding of how and why structural integration is effective and therefore helping us help our clients achieve the benefits of our work. Godard's most important contribution may be the *tonic function model*. In the article "Tonic Function: A Gravity Response Model for Rolfing Structural and Movement Integration," written by Advanced Rolfer and Rolf Movement instructor Kevin Frank (1995), the main premises of Godard's model are laid out, including the model's

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relationship to Gracovetsky's spinal engine theory. Gracovetsky's 'controlled instability' (1988) is shown to offer humans evolutionary advantages and has important ramifications for us as body therapists. Human development, Frank notes, is closely linked to our relationship to gravity. He explains how we, as gravity-sensitive creatures, evolved structures and body systems specifically dedicated to ensure our capacity to balance and stay upright in the gravitational field.

Tonic Function: The Interplay Between Tonic and Phasic Muscles

Expounding on Godard's tonic function model, Frank explains how a body designed for instability can move quickly and efficiently by *letting go* (1995). We can change our position in space more quickly and efficiently when we let go, release and lengthen, as compared to initiating movement through muscle effort. For humans to manage and take advantage of this controlled instability, there have been parallel improvements in the complex body systems designed to assure our stability and uprightness in the gravitational field. These body systems are known collectively as our *gravity response system*. Humans' sophisticated gravity response system enables us to maintain upright balance and coordination without conscious control. Our controlled instability allows us to harness, convert, and redirect physical and kinetic forces with a minimum of energy expenditure. An important feature of this system is the subtle interplay between two types of muscles: *tonic muscles* and *phasic muscles*.

Tonic muscles (stabilizer muscles) are engaged in the continuous, moment-to-moment negotiations required to stay upright in the gravity field. These muscles have a way of metabolizing oxygen which gives them great endurance and allows them to be 'on' for long periods of time.

Phasic muscles are action muscles, muscles, they are responsible for our movements, actions, and gestures in the world. These muscles are designed for brief bursts of activation and are not meant to stay 'on' for long periods of time.

For the body to move efficiently and fluidly, an intricate orchestration takes place in which tonic muscles provide the underlying, subconscious stabilization needed for the phasic muscles to perform voluntary actions. Our *gravity response system* functions optimally when moment-to-moment stabilization is left to the muscles that are best suited for this purpose, the tonic muscles or stabilizers. Tonic muscle coordination creates the underlying stabilization needed to enable phasic muscles to freely move, act and express in the world.

Understanding the Significance of Tonic Function – Structural Integration and Somatic Education as Antidote to Sensorimotor Amnesia

When tonic and phasic muscles function together in a balanced and differentiated manner, good stabilization patterns are developed and sustained. Stabilization patterns can, however, become disorganized, sometimes leading to a dysfunctional situation where phasic muscles habitually take on the role of tonic muscles. Stabilizing the body in unnatural positions – such as when driving a car or sitting for long hours at a desk in front of a computer – may contribute to our shifting into unhealthy postures and suboptimal coordination patterns. Flattened lumbar curves, muscle tightness, and movement restrictions can ensue. "Our coordinative code has been corrupted, leading to a system-wide deterioration of function" (Frank 2014, 53).

In structural integration, we use fascial mobilization techniques, visualization, and guided movement to re-structure the body by talking to the "movement brain" (Frank 2014, 53). Frank suggests that our work in structural integration may be due in part to our capacity to affect coordinative change, as we facilitate "a system-wide restoring of stability" (Frank 2014, 55). By actively differentiating muscle groups, restoring and clarifying the differentiation between body parts (i.e., pelvis and thorax), we can help fine-tune the interplay between tonic and phasic muscles. By restoring the optimal balance between tonic and phasic muscle effort, we help restore healthy posture and graceful, efficient coordination. As we educate our clients through manual touch, movement prompts, and attention to sensation, we can help them optimize the efficiency of their spinal engine, evoking efficient contralateral gait.

The legacy from our persistence hunter ancestors is a high level of coordination and efficiency. Let's use our skill sets as structural integrators and movement educators to help our clients experience it.

Endnote

1. "Animals, including chimpanzees and gorillas, that assume bipedalism on a temporary basis in order to perform a particular function practice a form of locomotion called facultative bipedalism" (The University of Texas 2022).

Per Haaland is a Certified Advanced Rolfer, Rolfing Instructor, and Rolf Movement Instructor. Per received his Basic Rolfing Training in 1989 and completed his Advanced Training in 1994. Studies with Hubert Godard and Kevin Frank shaped his understanding of

SI as an interactive somatic education, highlighting perceptual and coordinative processes. Haaland's inclusive teaching style enables Rolfers to easily and confidently expand their SI skills into Rolf Movement applications. Per lives and practices in Santa Cruz, CA.

Per Haaland's next webinar class is "Embodying Rolf's Structural Integration Recipe" starting Sunday April 10th. Email Per for more information (perhaaland@baymoon.com), details available at rolf.org, continuing education calendar.

References

Frank, Kevin. March 1995. Tonic function: A gravity response model for Rolfing structural and movement integration. *Rolf Lines* 23(1):12-20.

———. 2014. Structural integration psoas intervention considered in terms of normal stability response for hip and trunk flexion: A perceptive-coordinative view. *IASI Yearbook of Structural Integration:* 52-68.

Gracovetsky, Serge. 1988. *The spinal engine*. New York, NY: Springer-Verlag.

———. 2001. Analysis and Interpretation of Gait in Relation to Lumbopelvic Function. 4th Interdisciplinary World Congress on Low Back and Pelvic Pain, Montreal, Canada.

Hanna, Thomas. 2004. Somatics: *Reawakening the mind's control of movement, flexibility, and health*. Cambridge, MA: Da Capo Press.

Jablonski, Nina G. December 2012. The naked truth. *Scientific American* 22:22-29.

McDougall, Christopher. 2011. Born to run: *A hidden tribe, superathletes, and the greatest race the world has never seen*. New York, NY: Vintage Books.

The University of Texas, Department of Anthropology, eFossils Production Credits. "What is bipedalism?" Available from: http://efossils.org/book/what-bipedalism. Accessed January 15, 2022.