The Oscillatory Properties of the Structural Body

By John Smith, Certified Advanced Rolfer

Editor's Note: *This paper is based largely on themes discussed in Smith's recently published book:* Structural Bodywork: An Introduction for Students and Practitioners *(Elsevier, Edinburgh, 2005). A preliminary version of this article was published in the 2006 Yearbook of Structural Integration, [International Association of Structural Integration(IASI)]; reprinted with permission from IASI and Elsevier.*

"All this metaphysics is fine, but be mighty sure you've got physics under the metaphysics."
Dr. Ida P. Rolf (Feitis 1978)

When looking at the grace of a gazelle in flight, the poise of a hovering eagle, the stupendous leap of a cat, or the accomplished performance of an athlete or dancer, an extraordinary efficiency of movement may be witnessed. It may be seen in the poise of many traditional peoples, perhaps carrying heavy loads upon their heads, displaying an extraordinary mastery of such an everyday movement. It is also seen in the delicate mouldings of a master potter, the deftness of a skilled chef, the command of a skilled artist "breathing" lines onto paper.... or in the focussed action of an accomplished martial artist totally committing herself to the execution of a technique. In all of these actions there is no unnecessary muscular activity; neither too much nor too little energy is spent; nothing detracts from the coordinated action of the whole. Encouraging this functional efficiency and harmony in movement is surely one of the chief aims of our work as Rolfers.

Research is beginning to reveal that one vital aspect of this functional efficiency is the ability of an organism to utilize the inherent rhythmicity of its body in a very energy efficient way. This paper will explore the idea of the inherent rhythmicity of bodies and how insight into this fundamental level of our functionality can help in framing certain aspects of movement education. Dr. Rolf may well have referred to this aspect of human functionality as the "physics under the metaphysics."

For context, it will be necessary to clarify some of the central concepts of Rolfing Structural Integration, particularly structure, plus some more recent inclusions such as tensegrity and hydraulics. Various movement/embodiment techniques that traditionally belong to the Rolfer's art will also be touched upon. Such movement/embodiment approaches are absolutely central to the Rolfing process; they help the practitioner to draw out new postural or movement possibilities from clients—possibilities which have emerged from the prior structural intervention. It will be suggested that, along with the traditional repertoire of movement techniques available to Rolfing practitioners, various "rocking" or oscillatory techniques that are usually associated with the Trager tradition can be used to kinaesthetically sensitize clients to these oscillatory patterns that are inherent in their very structure.

A number of important premises will be expanded:

- When evaluating the many dimensions of the human structure, Rolfers will find it useful to be able to "see" what might be called the "structural body"—an abstract (and relatively low) level in our overall somatic organization—a level that is most appropriately described through Newtonian mechanics.
- The "structural body" is that aspect of the entire human being that structural integrators attempt to integrate.
- The "structural body" is composed of connective tissues that are organized into a unified fascial-skeletal-hydraulic tensegrity complex.
- The "structural body" has static attributes; it bears within it the complex three-dimensional network of fascial planes and "lines," which when compromised, will affect the efficiency of the standing posture in gravity.
- However, the "structural body" also has dynamic attributes; it has the potential for certain rhythmic or oscillatory movement patterns that arise from its elastic, hydraulic, tensegrity and other physical properties; these patterns too will be disturbed if the fascial network is compromised.
- These rhythmic movement patterns are independent of muscle activity and arise more from the elastic behavior of the connective tissues.

However:

- These inherent rhythmic movement patterns may be either reinforced or inhibited by muscle action.
- If reinforced, the resulting movement will be efficient and elegant.
- If inhibited, the resulting movement will be inefficient, constrained and inelegant.

Therefore, if clients do not naturally exhibit these rhythmic movement patterns, then they are probably being dampened or inhibited by some form of "higher order" neuromuscular control—perhaps a generalized condition of excessive tonus or through specific, learned patterns of co-contraction, conditions usually referred to as "holding patterns."

As a practical illustration of these basic ideas it may be useful to consider two styles of dance—Brazilian and traditional Irish. There is a sensual undulating quality to much Brazilian dance and a certain stately rigidity in traditional Irish dance. You may have enjoyed that Irish dance spectacular Riverdance; I found it exciting as a spectacle, yet did wonder what damage the dancers were doing to their bodies by maintaining such rigidly-held trunks—possibly a lot of unnecessary wear and tear to the joints in the longer term. This kind of wear and tear would certainly not arise from Brazilian dance, which allows the essential undulations of the hips to emerge easily, whereas in Irish dance these natural undulations are suppressed, probably through a controlled co-contraction of the trunk flexors and extensors along with the hip abductors and adductors. I believe that it would take more energy to suppress these natural undulations than to allow them to be freely expressed.

In order to explore more deeply the rhythmic or undulatory movement patterns that are inherent in our structure, it will be helpful first to clarify within the Rolfing context what is meant by structure, and to examine both its static and oscillatory properties.

WHAT IS STRUCTURE?

This is an absolutely essential question for structural integration practitioners; exactly what is it that is being integrated? Rolf discussed structure a great deal, sometimes suggesting that it is the spatial relationship between the body's major segments as seen in "the little boy logo" (see Figure 1), and sometimes suggesting that it is the unified wholeness of the connective tissue network defined in part by the presence of collagen (Rolf 1978); and of course the concept of structure is large enough to accommodate both of these attributes, and others besides. She certainly wished to differentiate structure from posture, implying that posture is the functional response of the sensory-motor intelligence attempting to stabilize the structure within the field of gravity. In her own words:

> It's rare to find a person with structural integrity, a body stacked properly with respect to gravity, free to move ...Mind. I'm not talking about posture. I'm talking about structure. Posture is holding your structure as well as you can. When the structure is properly balanced, good posture is natural. A man slouches not because he has a bad habit but because his structure doesn't make it easy for him not to slouch. Structure implies the relationship of parts and it implies gravity ... We know about gravity in architecture. We know that buildings show strain to the degree that they deviate from an optimal relation to gravitational pulls. In buildings we recognize the origins of these strains but in bodies we don't. (Gustaitis 1975)

This implies that standing posture is a function that can be more or less efficient depending on the overall pattern of structural imbalances—imbalances that must be countered continuously through muscular activity. It is now a basic premise of Rolfing that the more the segments of the body deviate from a central gravity line in standing ("the Line"), the more energy will be required to maintain an upright posture (Flury 1991).

Rolf further offers a "blocks in a sack" model of structure, which portrays the body as an organization of segments enclosed within an elastic, investing envelope (see Figure 2). This model emphasizes the structural importance of the superficial and deep fascial layers, and seems to anticipate the concept of tensegrity as an essential aspect of structure—an idea that lately has been quite extensively explored by the structural integration community (Bell 2005, Sommer 2005).

SOME THOUGHT EXPERIMENTS ABOUT STRUCTURE

Many thinkers in the field of structural integration have devised thought experiments to clarify various aspects of our somatic reality. Myers in his Anatomy Trains makes one such thought experiment by asking what kinds of everyday materials could be used to create something that behaves like a human body—PVC piping, rubber tubing, cling-wrap, plastic bags and duct tape were some of the materials he suggests as having close similarities to actual materials within the human body (Myers 2001). He also suggests servo-motors in place of muscles and a computer to provide the intelligent coordination of the whole. This thought experiment can be expanded further; it is suggested that in order to create something that behaves passively like a human body only three basic ingredients would be needed:

- An elastic membranous material that is strong in tension to model fascia, ligaments, capsules, tendons etc,
- Struts that are strong in compression to model bones, and
- A thick gelatinous material to model the semi-liquid contents of organs and cavities.

These three basic materials are all that would be needed to model something that behaves passively like a body at rest—something that behaves like what I have called the "unified fascial-skeletal-hydraulic tensegrity complex" that com-

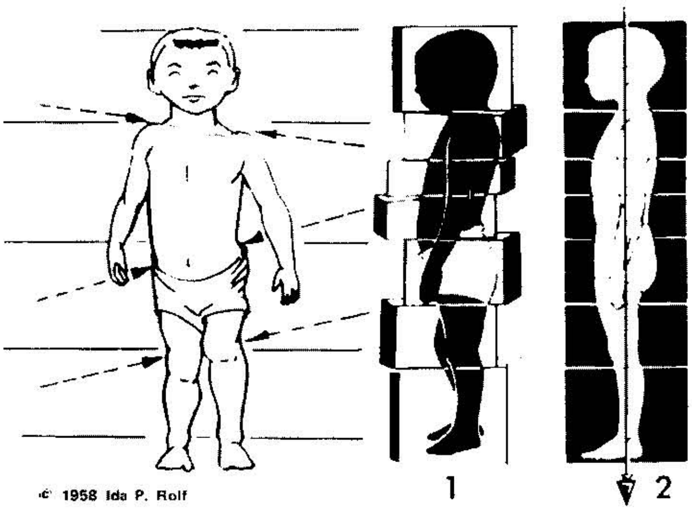

Figure 1 The "little boy" logo showing segmental organization around the "Line"

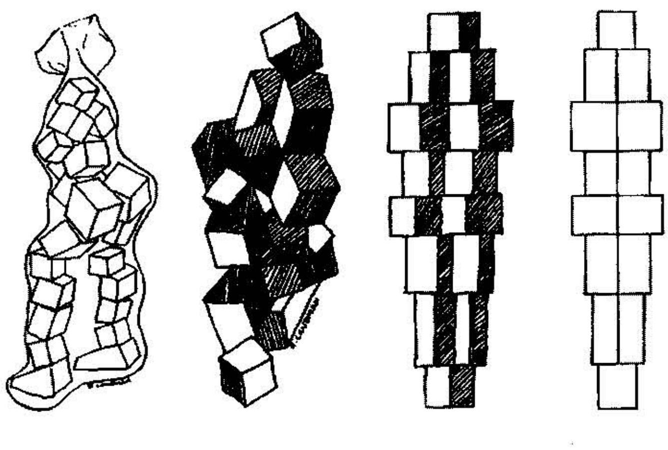

Figure 2 The "blocks in a sack" model (from Rolf 1978)

prises the human structure. This is a body with its neuromuscular system turned off, and a body that would have many of the attributes of a tensegrity structure. Such a modeled body would have structural integrity but would be inert—unable to move of itself. To move it would need to be animated by the equivalent of a neuromuscular system—and in the realm of robotics, this would be various kinds of sensors and computer-controlled servo-motors.

This thought experiment immediately emphasizes two abstract levels within the overall somatic organization: a structural level that has mechanical properties, and a functional level required to animate the more passive structural level.

THE STRUCTURAL BODY

The concept of structure will now be refined by introducing what is perhaps a much more useful concept, the "structural body," and by examining its static and dynamic properties. Certified Advanced Rolfer, Dr. Hans Flury has been one of the foremost thinkers in helping to clarify the meaning of many of the central concepts in the field of structural integration; of structure he says (Flury 1997):

> Structure is the spatial arrangement of all the parts of the body, determined primarily by the fascial net, as it manifests in the absence of any muscle activity in the body and with no outside forces acting on the body. This spatial arrangement can be called the "structural body." It is evident that we can never see the structural body directly because there always exists muscle activity in the body, and outside forces are always acting on the body.

However, even with this definition of structure, the structural body could be "seen" provided the two chief forces that act upon it, gravity and muscular tonus, could be eliminated, but it would be under the somewhat unusual set of conditions of floating around in outer space under general anaesthesia! This is not in fact a fanciful suggestion; a human body under such conditions would necessarily "give in" to all its internal structural tensions and would assume a form that reflected its true structure (see Figure 3). How would all the articulations respond under these conditions? Surely the body would fold at every articulation to balance out all of the internal "pulls" or fascial tensions within its structure—pulls that would need to be countered by muscular tension when this body is returned to gravity and stands erect.

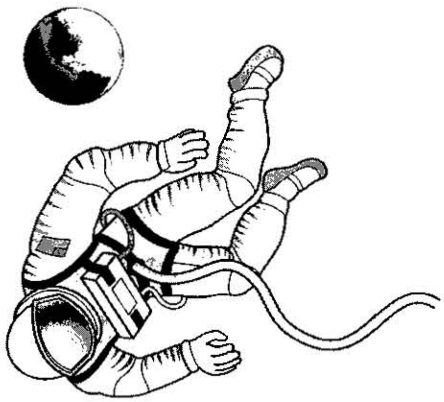

Figure 3 An anaesthetized spaceman (from Smith 2005)

However, Flury's definition could be expanded to include two other important aspects of structure: tensegrity dynamics and fluid mechanics (or hydraulics).

TENSEGRITY: CONTINUOUS TENSION AND LOCAL COMPRESSION

The renowned architect Buckminster Fuller used the word tensegrity (from "tensional integrity") to describe a design principle for creating integrated lightweight structures of great stability. Tensegrity structures are different in principle from the traditional columnar structures that employ a "ground up" stacking of compressive elements, instead relying on strategically spaced compressional struts suspended within a web of tensile cables or sheets—islands of compression within an ocean of tension. Tensegrity structures combine these two kinds of structural element such that they mutually balance their tensile and compressive forces, thereby producing a highly stable structure (see Figure 4).

Some aspects of the human structure can perhaps be best understood as conforming to the tensegrity dynamic. Bones can act as compressional elements, while the fascial sheaths, tendons and ligaments can act as the tensional elements. Together they ensure the structural integrity of the whole. Taut fascia serves to maintain appropriate spatial relationships between the skeletal elements. If the activity of muscle fibers could be entirely eliminated then what would remain would be a tensegrity structure—bones organized into a skeleton by its spanning fascia.

Another series of thought experiments will now be quoted at length to illustrate the "tensegritous" nature of the human body. I acknowledge that the following is not original; many Rolfing® practitioners have used similar imagery to express the unitary nature of the connective-tissue network.

> Imagine that by some miraculous intervention we could dissolve away all materials from the human body except the fascia; what would remain would be a perfect representation of the human form—with spaces to represent all the muscles, bones, organs and cavities of the body. However, this fascial spectre could not last a moment—the relentless force of gravity would instantly act, and like a tent without poles, it would slump to the floor in a random heap. (Here we are using the word fascia in its broadest sense to mean all of the binding connective tissues: myofascia, aponeuroses and tendons, ligaments, synovial capsules

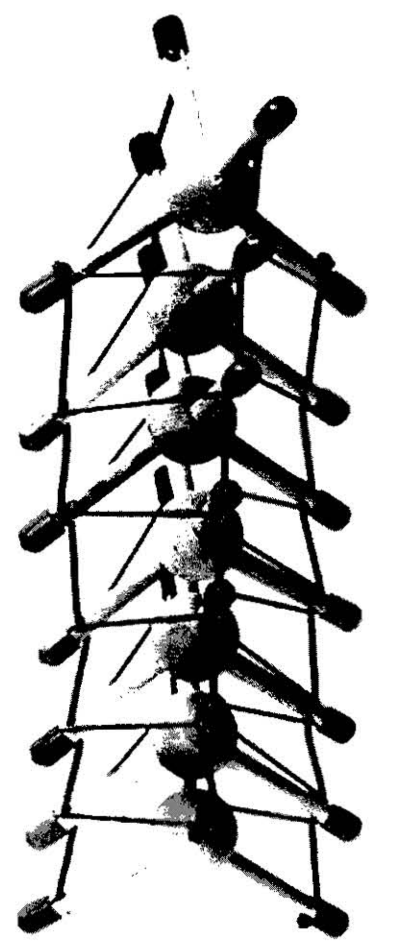

Figure 4 A tensegrity structure – "Tetrahedral Vertebral Mast" (Tom Flemons)

and even the periosteum of bones.)

If we could repeat the experiment, but this time dissolving away everything except the bones, then what would momentarily remain would be a skeleton, followed by the clattering of a disarticulated and jumbled heap of bones—there being nothing to bind the bones together or maintain their normal spatial configuration.

But if in a third experiment, we could dissolve away all the materials except the fascia AND the bones, then what would remain would still retain a recognizably human form—would still remain an integrated and coherent whole—and this despite the fact that it would be collapsed and unresponsive. Like the fabric of the tent, it is the fascia, ligaments and other connective tissues that maintain the appropriate relationship between the bones—maintaining an appropriate spacing and span. It is fascia that creates the unified skeleton. It takes the integrated properties of the fascial and skeletal systems to create a true tensegrity structure. But like all tensegrity structures it would be relatively inert, relatively static; it would be internally stable but would respond only to externally applied forces, particularly gravity, and would be unable to initiate movement from within itself—a body with structural integrity but which cannot move of itself—a body with its neuromuscular system turned off. (Smith 2005)

The tensegrity principle is thus vital to our understanding of structure; however the hydraulic aspects of our material reality must also be included.

FLUID MECHANICS

Bodies are composed mostly of water, and much of their structure consists of hydraulic bags—fascial bags filled with gels or with semi-liquid masses that behave like gels: the mass of the abdominal viscera within the peritoneum, individual visceral organs such as the liver and kidneys within their fibrous capsules, the brain within its meninges, the heart within its fibrous pericardium, and even muscles (in a relaxed state) within their endomyseal sheaths [an "electrogel" according to Deane Juhan (1987]. Indeed, the entire organism is enclosed within the embrace of the superficial and deep fasciae. Human beings are indeed "bags inside bags inside bags." And as Flury has noted, some of these bags have hard fillings (the bones enclosed within their periosteum) and some have soft fillings (all the rest).

The structural integrity of a hydraulic bag arises from the interaction between the compressive tendency of the surrounding sheath and the equal but opposite tendency for the fluid contents to resist compression. Can a hydraulic bag be seen as another kind of tensegrity structure? After all it does have both tensile and compressive elements—the elastic skin under tension compressing the fluid contents, which with equal force resist that compression; indeed Buckminster Fuller himself regarded the balloon as the mathematical limit of the class of tensegrity structures. However a hydraulic bag does not behave like a true tensegrity structure, particularly in how it responds to externally applied pressure (Levin 2005). Such pressure will cause a displacement of the fluid contents away from where the pressure is applied. For instance, the abdominal cavity is essentially a balloon—the viscera contained within a fascial bag, the peritoneum. A contraction of the transversus abdominis will both reshape and firm up the peritoneal bag in a way that can actually lift the thorax above, and stiffen the spine—an action which recently has been called "core stabilization." Some tonus in the abdominals is also necessary under certain circumstances to prevent the semi-liquid viscera from "sloshing around" too much during strong activity.

It should be stressed that the fascia, which in synergy with the skeleton creates a tensegrity structure, is the selfsame fascia that also encases the hydraulic balloons within the body; it is all "the one fascia."

THE STRUCTURAL BODY – THE FUNCTIONAL BODY

The characteristics of the structural body may now be summarized:

The structural body is an abstract level of the entire somatic organization, composed of connective tissues that are organized into a unified fascial-skeletal-hydraulic tensegrity complex. This complex both:

- Determines the efficiency of the erect posture; and
- Forms the basis of oscillatory movement patterns.

The structural body is thus just one aspect of our material reality—a relatively low level in our overall somatic organization. Yet it is a level that has its own set of laws—it being responsive in a mechanical and elastic sense. Of course the structural body works with the neuromuscular system; it has to be coordinated and directed. So it is perhaps more accurate to say that the structural body is worked by the neuromuscular system.

Thus, within the context of gravity:

The Functional Body = The Structural Body + Neuromuscular Coordination

This formula defines the central focus of structural integrators who work on the structural body to improve function, while functional integrators such as Feldenkrais practitioners take neuromuscular coordination as the central focus in their work to improve function.

All movements are ultimately initiated and ruled by the central nervous system (CNS), but our somatic organization is hierarchical in nature: the higher organizing functions of the cortex are at the "top" while the structural body is "below." Movement patterns initiated at the "top" are necessarily conditioned by what is "below"—by what the structural body will allow in real time. The structural body is highly innervated and densely populated with many kinds of mechanoreceptor, and this provides the CNS with a great deal of information about its current state. Fed by this flood of proprioceptive information, the sensory-motor intelligence is constantly making choices about what is economical in movement, and will usually take the path of least resistance. And the path of least resistance is defined to a great extent by the structural body; it has a major influence on what is economical in movement and will greatly condition and temper the nature of movement; it is a constant, underlying, unconscious determinant of all movement patterns.

Therefore it is vital that therapists be aware of this fundamental aspect of our functionality, since it underlies both our postural efficiency as well as all undulatory or rhythmic movement patterns.

SEEING THE STRUCTURAL BODY

Rolfers traditionally assess their clients by looking at:

- How they stand (how they are segmentally organized around the "Line");

- How they walk (the "Line" in motion);
- How their bodies feel when palpated

The standing posture is inspected to get some idea of the tensile structure of the structural body – which areas are short and need to be opened. In the Rolfing® community we have the work of Certified Advanced Rolfers Jan Sultan (1986), Dr. Hans Flury (1991) and Liz Gaggini to assist us in gaining a perspective on the static organization of body segments around the "Line"—the internal/external model. This model can give precise information about where to work by indicating which tissues have adaptively shortened around a habitual postural pattern.

Then clients are observed walking, again to uncover which areas of the structure do not move or do not transmit movement well. But perhaps what Rolfing practitioners are really doing when assessing gait is to note the presence or absence of key oscillatory patterns within the structural body. As was said earlier, the structural body has both static and dynamic qualities. A stationary body is examined to see the pattern of fascial tensions which determine the efficiency of its standing posture. But a body in movement has an inherent tendency to move in an oscillatory manner. It embodies rhythm, and these rhythmic qualities can be qualitatively assessed by observing the client's gait. The inherent rhythmic qualities of the structural body will now be examined in more detail.

FASCIA AS AN ANTAGONIST

Early biomechanical research tended to view movement purely in terms of the coordinated action of synergistic muscle groups. The elastic behaviour of its component fascia was ignored (just as earlier anatomists tended to ignore fascia in their dissections). But fascia now is seen as an elastic antagonist to muscular action, and movement is seen less as the coordinated action of synergistic muscles and more in terms of the elastic and oscillatory properties of the myofascial network as a whole. In this view of rhythmic movement, muscular action works primarily to maintain oscillatory patterns with an occasional and timely input of energy each movement cycle (Gracovetsky 1988, Novacheck 1998).

Vertebrate biomechanics has demonstrated the many ways in which animals employ the springiness of their connective tissues in hopping, walking, running, swimming and respiration. Animals have found some very efficient ways of recycling some of the energy of movement through their connective tissues in a cyclic dance of exchanging potential and kinetic energies (McNeill 1975 1988). Vertebrate structures employ a host of elastic, self-correcting mechanisms; for instance the ligamentous/fascial environment of joints act such that any deviation from a neutral position will normally result in an elastic response that will bring it back towards neutral, independent of muscle action (Flury 1990).

All elastic structures have their own resonant frequencies—even such complex entities as the human structural body. Recall the anaesthetized spaceman (Figure 3); this is the pure structural body, a body with no muscular activity and with no external forces acting on it. A body in this unusual condition could be induced to undulate in various ways—flexion/extension, lateral flexion and transverse undulation around the long axis of the body—and the actual frequency of these undulations would be quite specific to the mass and proportions of the body segments as well as the tensile structure of the fasciae of that body. Of course this would change as the body is brought into gravity and even then would be quite variable depending on the added continuously shifting tensions arising from muscle activity; however it may be surmised that if an organism could "tune in" to the inherent rhythmic qualities of its own body, then this would greatly enhance its movement efficiency. This may be seen in champion distance runners for example: once they have accelerated to cruising speed, many of their muscles merely flicker each gait cycle. The whole fascial tensegrity complex has its own natural frequency of oscillation and once the rhythm is established it only takes a small input of energy each cycle to keep it going (Huat et al 2004).

This view has been further supported by some interesting research into Kenyan female porters which demonstrated their extraordinary efficiency in carrying weight on their heads, while barely increasing their oxygen uptake (Samuel 2001). Samuel concludes that this ability arises not through muscular strength but through the women's use of the inherent periodicity of walking, the pendular motion of their hips in the frontal plane. Interestingly Samuel compares the energy-saving principle of this kind of gait to that of the old-fashioned pendulum clock—once the initial momentum is given to the pendulum, it only takes a tiny tweak each swing cycle (supplied by a pre-wound spring) to maintain the motion and to overcome the slight loss of energy through friction. Several computer modeling and experimental studies support this view (Zajak et al 2003, Kuo et al 2005). It should be remarked that these ideas are not new to the Rolfing community; Certified Advanced Rolfers Gael Ohlgren and David Clark clearly articulated such ideas as far back as 1995, based on their clinical observations, and discussed in their article "Natural Walking" (*Rolf Lines*, March 1995).

These undulatory movement patterns are independent of muscular activity. Once these undulatory patterns are set in motion by an initial impulse of energy, then the system will continue oscillating; however the amplitude of this oscillation will gradually decrease as internal friction dissipates some of the kinetic energy. So in order to maintain a constant amplitude, a small input of energy is required each cycle to replace that lost through friction. In an organism, this energy is supplied by appropriate muscle activity.

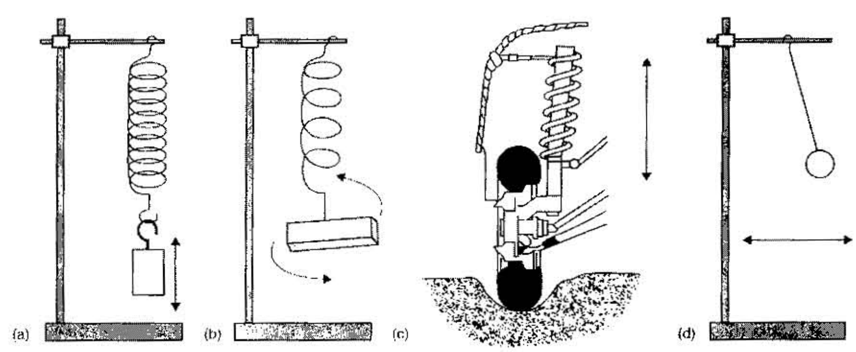

Figure 5 The oscillatory properties of elastic structures that have close parallels with the human structural body: a) a spring in tension; b) a torsional pendulum; c) a spring in compression; and d) a pendulum (from Smith 2005)

Some of the oscillatory movement patterns that are inherent in the structural body will now be examined. Figure 5 shows just a few oscillatory systems that have very close parallels to the behavior of the structural body. It can be seen that during gait, arms and the swinging leg act as compound pendulums, while the counter-rotation of the shoulder girdle against the pelvic girdle during gait is a kind of torsional pendulum. It may also be seen that the primary and secondary curves of the spine act as a spring to dampen the wave of compression that sweeps through the skeleton during heel strike. In each of these cases the momentum of one phase of the movement is conserved as potential or elastic energy in the connective tissues, and is then recycled into the following movement. Very little muscle energy is needed each cycle to maintain the rhythm.

THE SPINAL ENGINE

In his book *The Spinal Engine*, Serge Gracovetsky suggests that the spine, not the legs, is the major motivating force for powering our gait. The spine coupled with the pelvis has a complex motion that has elements of flexion/extension, side flexion/extension and rotation; these elements are not independent but are integrated into a complex motion that actually forms the basis of efficient walking, even partly driving the action of the legs (Gracovetsky 1988). Gracovetsky cites Lovett's discovery that the cadaver spine, divested of the entire vertebral arch, has the same mechanical properties as other kinds of flexible rod. And these properties may be simply summarized; three kinds of distorting forces can be applied to a rod: front/back flexion, left/right flexion and axial torsion (twisting through the length of the rod); any two of these distortions applied simultaneously to a rod will automatically induce the third, a phenomenon termed *coupled motion*.

This logic may then be applied to the lumbar spine. The lumbar lordosis provides a pre-existing curvature in the sagittal plane; then if to this lordosis is added a side flexion (as occurs naturally when weight shifts from leg to leg each gait cycle), then a rotational tendency in the transverse plane will automatically be induced in the pelvis. Lovett found this property of the human spine to be present even after the vertebral arch (pedicles, facets, etc.) was removed—showing that this reaction of the spine was independent of the orientation of the facet joints.

Gracovetsky later (2001) suggested that this rotational tendency of the pelvic segment in walking needed to be matched in torque by the counterrotation of the thoracic segment, and a further counterrotation of the head against the thorax. So here is an example of an undulatory movement pattern that is built into the very core of our structure, while the ligamentous and fascial layers that surround the spine have evolved, it seems, to further support this undulation. At every level of the structure there is a criss-crossing helical "grain" in how the component fibres are arranged. Thus the head/thorax/pelvis complex can be seen as a torsional pendulum system that is supported at many levels within the structure:

- Within the vertebral column itself; this is the "Lovett effect" as just discussed, assisted no doubt by the criss-crossing, spiralling orientation of collagen fibres in successive laminae of the annulus;
- Within the organization of the facet joints of the thoracic and cervical regions, which guide the axial rotation of one vertebral segment against the next;
- At a ligamentous level—in the organization of the short and long spinal ligaments and the facet joint capsules, which are put in tension through rotation and which then assist the vertebrae back to neutral; and
- In the many layerings of the myofasciae surrounding the spine.

Looking more closely at these myofascial layerings, it can be seen that at the deepest level the local muscles, the rotatores and multifidi, are oriented to assist rotation, while at the most superficial level there are global myofascial continuities that support the helical oscillation of the trunk during gait, particularly what Myers (2001) has called the "spiral line" and "functional line." Even the internal and external intercostals seem to contribute to the general helical "grain" of the fascicles within the sleeve myofasciae.

OSCILLATORY PATTERNS IN GAIT

Rather than trying to present an exhaustive account of every oscillatory pattern available to the structural body, just a few associated with gait will now be explored. There are three main kinds of pelvic undulation that are inherent in efficient walking:

- A rocking in the sagittal plane around an acetabular axis (see Figure 6);
- The lateral sway of the pelvis in the frontal plane (see Figures 7a and 7b); and
- The counterrotation of the shoulder and pelvic girdles in the transverse plane—a slight twisting and untwisting through the longitudinal axis of the body (see Figure 8).

Different individuals will of course exhibit a different "mix" of these three basic undulations, while certain cultures seem to have a characteristic bias towards one or another form: many native Africans for instance employ a "sagittal rock" in walking, while in Brazil a sway in the frontal plane is more evident, and these patterns are often emphasized in their traditional dance. In the West it seems there are cultural constraints regarding what is acceptable in pelvic movement, hence the "brick on legs" syndrome, a gait pattern in which there is little or no differentiated movement between the head, thoracic and pelvic segments.

From my experience, the absence of any of these undulations in gait correlates well with fibrotic restrictions in specific fascial "lines" or "planes"; therefore the presence or absence of any of these undulations can be used as a crude diagnostic to indicate where fascial lines are likely to be compromised. This point will now be illustrated using Myers' classification of the longitudinal myofascial meridians or lines.

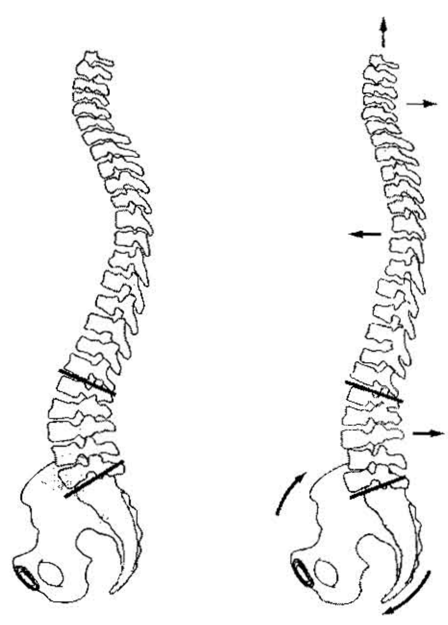

Figure 6 Sagittal undulation (from Smith 2005)

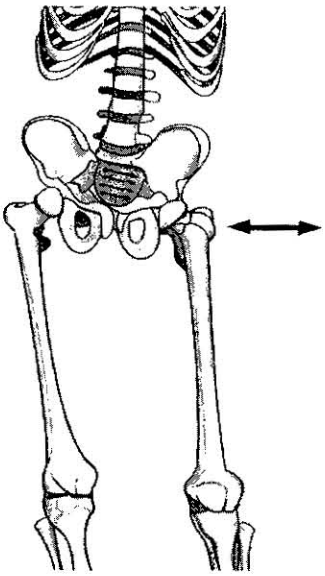

Figure 7a Lateral sway of the pelvis in gait in the frontal plane (from Smith 2005)

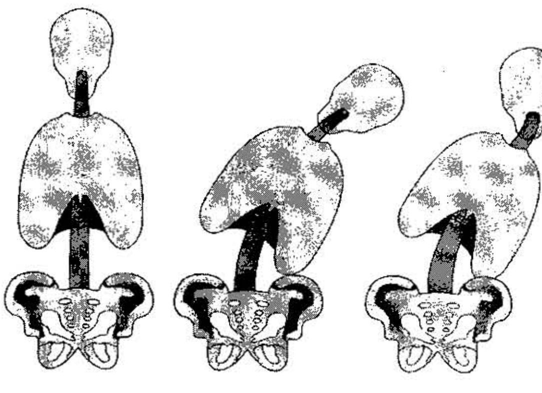

Figure 7b Lateral undulation in the frontal plane (from Smith 2005)

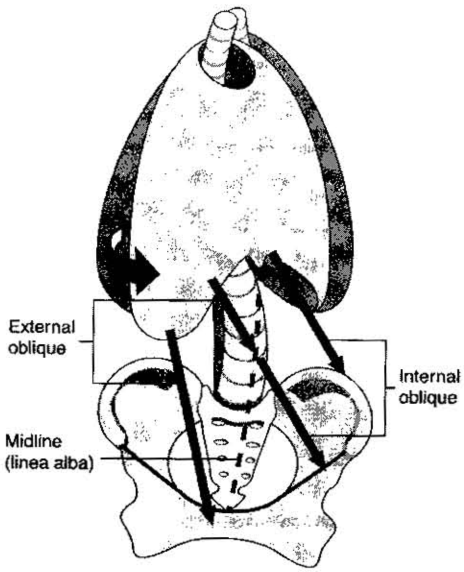

Figure 8 Torsional undulation in the transverse plane (from Smith 2005)

If there is an absence of a lateral sway of the pelvis in gait (see Figure 7a), then it is probably being suppressed by co-contraction somewhere within the "lateral lines." In such cases it is common to find a densely fibrotic iliotibial band (ITB), and it seems as though this increased fibrosis arises from the increased stress imposed on the ITB by overactive hip abductors as they attempt to oppose or inhibit the lateral sway of the pelvis during gait.

Similarly an absence of a sagittal rocking of the pelvis in gait would indicate restrictions located somewhere within the "superficial front line" and "back line," and probably also the deep front line.

While if a torsional undulation were lacking in gait, then it would be sensible to look for restrictions in the "spiral line" and "functional line." However, if the habit of suppressing the counter-rotation of the girdles had been long-standing then it might be suspected that restrictions would also be found at a deeper, even ligamentous level of the thoracic spine.

INTEGRATION INTO THE TRADITIONAL TEN-SERIES

I have noticed anecdotally that pelvic undulations of different kinds tend to emerge spontaneously at different stages of the Rolfing® process. The traditional 3rd hour focuses on lengthening and balancing the lateral lines of the client and the effects of this work are generally most evident in the frontal plane as an increased lateral translation of the pelvic segment in gait (and this will be explored in some case studies later in the paper). In the traditional 5th and 6th hours there is a definite emphasis on the superficial front and back lines and the deep front line. Many Rolfing practitioners report that during these sessions the so-called "psoas walk" emerges spontaneously—a more pronounced sagittal rocking. The 8th and 9th hours are often used to integrate the upper and lower girdles, and thus are an ideal opportunity for exploring torsional undulation between the girdles. So a kind of pedagogical logic begins to suggest itself—to follow up the traditional structural work with some kind of movement exploration of the undulation made potential by that session. It should be emphasized that this integrating movement work is not to impose a different kind of gait pattern on the client, but rather to highlight for the client a pattern that is already emerging, and to give him the option of taking it up. This principle is demonstrated in the following examples.

TWO 3RD-HOUR CASE STUDIES

Figures 9 and 10 were taken during a traditional 3rd hour. The photos show: 1) the client prior to the session; 2) after the client's left lateral line had been lengthened; and 3) after both sides had been lengthened. It will be apparent that the intelligent body, having just had one of its lateral lines lengthened, is obliged to accommodate a different tensional pattern within the overall fascial network. In client A we see the more common response—the hip laterally shifts towards the lengthened side. The response of client B (Figure 10) is atypical—this client was obviously not able to respond through the hip and was obliged therefore to use the mass of his head to maintain a balance. Both cases, however, illustrate the point—the client has been given increased access to the frontal plane. Client A now has the potential for enhanced lateral excursion of his hips during gait. It would therefore make practical sense to directly address this expanded functionality during the integration phase of this session, and this could involve exploration of an enhanced lateral pelvic sway in walking.

IMPLICATIONS FOR MOVEMENT EDUCATION

Throughout the history of Rolfing, practitioners have developed various forms of movement work to help their clients make that vital transition from structural change to a higher order of functionality. These approaches include:

- Tracking—a form of proprioceptive joint work, which allows the client to sense different patterns of coordinated movement through joints;
- Repatterning exercises—to encourage

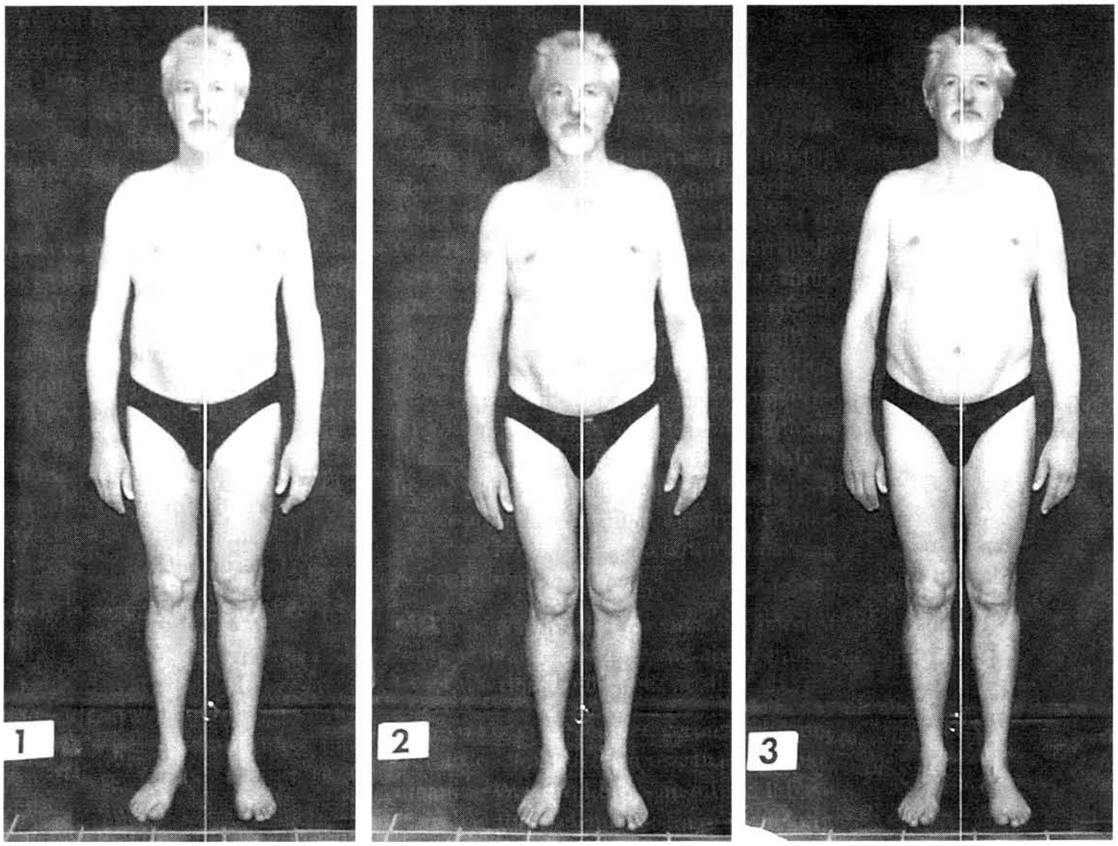

Figure 9 Client A

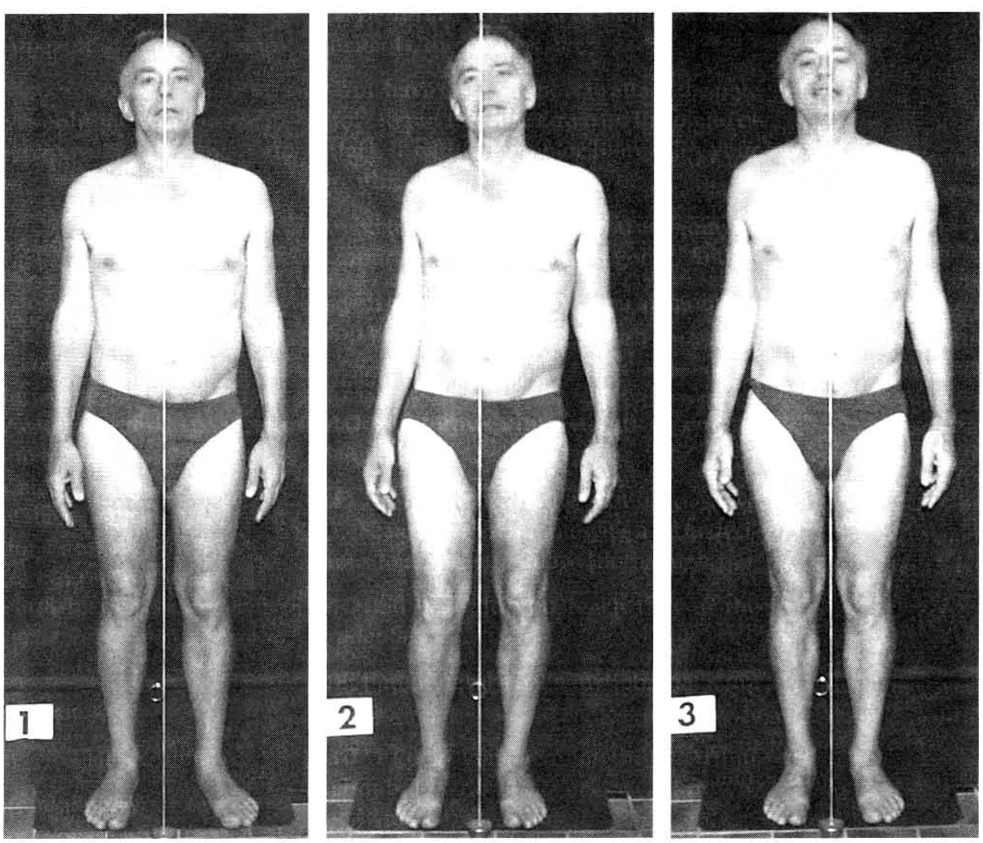

Figure 10 Client B

Figure 11 Working with lateral undulation

new patterns of neuromuscular coordination over a series of joints, the classic Rolf "foot yoga" for instance;

- Manual suggestion—using the hands to suggest qualities of movement (the approach that is most highly developed in Alexander and the Feldenkrais® method work); and
- Ideokinetic suggestion—the use of imagery to evoke a certain quality of movement or to give a sense of a vector into space, ("Allow your sitbones to be heavy and hang towards your heels while your head floats up," etc.).

Which of these approaches then could be useful in evoking these natural undulations? It has been stressed throughout this paper that if these inherent rhythmic movement patterns are not apparent in a client then it is because they are being dampened or suppressed by a form of "higher order" neuromuscular control—in other words, by a holding pattern. The pedagogical implication of this is clear: regaining these movement possibilities is a process of allowing, of giving up the tendency to over-control; it is probably not through the targeted learning of a new pattern of muscular coordination. Hence the approaches of tracking, manual and ideokinetic suggestion could play a large part, while repatterning approaches would probably not be useful. Clients need to be helped to "listen" more carefully to the inherent rhythmicity of their structure and to discover the minimum input from the muscular system necessary to maintain the movement.

Rolfing® typically proceeds first by freeing up fascial restrictions and then performing some kind of movement integration work. Working to enhance these inherent undulatory patterns is no different. First the associated fascial restrictions need to be eased and then some form of movement education needs to be performed (unless the client is one of those rare individuals who "get it" straight away, without coaching, just from structural intervention alone.)

It is suggested that this technical repertoire of movement approaches may be expanded to include certain techniques from the Trager tradition that feed directly into the inherent oscillatory properties of the "structural body"—that sensitize it and assist in allowing new, more efficient undulatory movement to emerge.

TRAGER

The Trager® approach is a manual system of bodywork characterized in part by a huge stock of oscillatory interventions, though of course as an advanced somatic modality it is much more than a mere collection of techniques (Liskin 2004). In Trager table work the client's body is rocked or oscillated in specific ways, while the client is reminded to "allow" and not control the movement. This can be seen as a form of kinesthetic feeding—giving a "homeopathic dose" of the movement that the practitioner wishes to evoke, and which clients can later explore in standing and walking.

I have found that my cross-training in the Trager approach has been invaluable for my Rolfing®. Oscillating a body in this way gives considerable insight (or "end feel") into how a body is organized. Muscular holding patterns, joint play and ligamentous laxity for example can all be sensed very easily, providing information that is vital in a Rolfing context. But it also offers a means of giving clients a direct experience of some of the rhythms inherent in their own structure.

Figure 11 shows a working position that can be used for exploring lateral undulation. When the practitioner presses through one heel it will result in a system-wide response in the body. There will be a successive compression of joints, starting from the ankle joints, the knee, the hip joint and SI joint. Then a side flexion in the lumbar spine will be evoked along with a contrary side flexion in the thoracic spine and so on up to the head. This is the same sequence of joint compressions and undulating adaptations of the spine that is experienced through the standing leg each gait cycle.

The typical Feldenkrais® approach to working with this undulation would be to press through this line so that the client can have a gradual, incremental experience of this aspect of gait.

The Trager approach instead would alternately press and traction the heel to set up a gentle undulatory pattern through the whole system. Trager practitioners are encouraged to "feel" into the undulation to discover the most appropriate frequency—the frequency that requires the least energetic input from the practitioner to maintain the undulation. The practitioner learns to anticipate the elastic rebound and to not oppose it but to augment it instead. With experience a dramatic undulatory pattern can be evoked on the table, with very little expenditure of energy. It is all about timing. This technique could well have been applied to client A (Figure 9) following the structural work. Normal movement pedagogy would then suggest that the movement then be experienced in other orientations before finally taking it into walking. Such techniques may be woven seamlessly into the normal course of a Rolfing session.

CONCLUSION

In this paper the concept of *structure* has been explored and expanded in a way that has some very practical implications. Rolfers have all undertaken a form of perceptual training—have learned ways of discerning patterns of restriction hidden within the flesh. Some have also undertaken various movement trainings and have learned new ways of looking at bodies in motion in order to uncover movement restrictions. It is suggested that one way of looking at bodies in motion is to note the presence or absence of specific undulatory patterns that are inherent in our structure. Reduced patterns may first be addressed myofascially and then evoked in movement by using movement techniques such as those from the Rolfing and Trager traditions.

John Smith is a Certified Advanced Rolfer, Rolf Movement Practitioner, Feldenkrais Practitioner, and Anatomy Instructor for The Australian Rolfing Association.

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