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HYPOTHESIS

The contractile field—A new model of human movement—Part 3

Phillip Beach, DO, DAc, OsNZ*

Orthodox Mews, 3-70 Webb Street, Te Aro, Wellington 6011, New Zealand

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Summary A new model, conceptually informed by the embryology and evolutionary biomechanics of vertebrate movement patterns, describes fields of interacting contractility. Each contractile field is modelled as embedding a primary sense organ. Contractile fields are whole organism in scope and are drawn from core mammalian movement patterns such as flexing/extending, lateral flexing, twisting left/right, sucking/squeezing, pulsating and peristaltic movements. Fields of contractility are textile-like in that they warp and weft, river-like in that they widen and narrow. Contractile fields converge to nodes and decussative (crossed) lines, from which they again reradiate.

Tuning between muscles within a contractile field, and tuning between fields, shapes movement patterns. An assessment methodology called 'archetypal postures' offers insight to the body's state of biomechanical tune.

Introduction

'The subdivision of the embryonic body into fields precedes the formation of specific organs or structures' (O'Rahilly and Müller, 1996).

This article, the final in a series of three, extends the contractile field (CF) model of human movement to the deep muscles of the body wall and the visceral musculature. The first article in the series described a lateral CF (L-CF) and a dorso/ventral CF (D/V-CF). Lateral flexion of the body wall is an archetypal movement pattern that Devonian fish employed. Extending and flexing the body wall is a movement pattern that was developed by vertebrates in response to the new challenges of a terrestrial environment. The second article explored the interaction of the L-CF and the D/V-CF to create twisting movements of the body wall, called the helical CF (H-CF). Limbs are modelled as power amplifiers of the H-CF with dorsal and ventral muscle groups described.

Each CF is modelled as having a sense organ embedded in the field. Traditionally, each muscle

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*Tel.: +64 4 8018781.
E-mail address: phillipbeach@runbox.com

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that is dissected out of the whole is assigned a nerve supply that enlivens it. When dozens of muscles, from the cephalic to the caudal pole of a vertebrate are considered as a functional field of contractility, it becomes meaningless to assign a nerve supply that will span the cranial nerves to the coccygeal nerves. A supra-segmental form of innervation is appropriate for this level of the biological hierarchy. The D/V-CF is modelled as embedding the nose, the L-CF embeds the ears, the H-CF embeds the eyes, and the limbs express themselves via the hands/feet. Part 1 and Part 2 of the series explored aspects of the evolutionary and embryological processes that have informed the modelling process.

Schematically:

- A *lateral CF* (otic),
- A *dorso/ventral CF* (olfactory),
- An emergent *helical CF* (optic)
  - *Limb fields* that emerge from and empower the helical field of the mammalian body wall, with a ventral/flexor/adductor/depressor moiety, and a dorsal/extensor/abductor/elevator muscle moiety (fingers/toes),
- A *radial CF* (external oral/anal sphincter),
- Coelom (a fluid filled cavity),
- *Chiralic CFs* with pulsatile and peristaltic functions (vagal).

The radial CF (R-CF)

The fields of contractility described in the previous two articles will laterally flex, flex/extend, and twist the body. These archetypal movement patterns, if carried too far, will shorten and buckle the body. On a daily basis people present to our clinics unable to flex or extend normally, fixed with a lateral shift of the pelvis, or a combination thereof that painfully twists the torso. Preserving the longitudinal integrity of the spinal system is a functional priority. The R-CF is a field of contractility that has as a prime function the squeezing of the body wall to thus preserve longitudinal integrity. When a field of torso encircling muscle contracts intra-thoracic and intra-abdominal compartmental pressures rise. The interaction of compartmental pressures determines much of the fundamental body-shape, and the ability to squeeze and suck.

Embryological perspective

The radial field represents the deep layer of the torso tri-laminar body wall. However, the CF model expects muscle tissue to emerge from a deep tissue plane to a more superficial plane, to cross from left to right, and to twist/counter-twist as it courses about the body. As mesoderm is drawn laterally/ventrally with embryonic folding during the fourth week, it enters morphogenic fields that split it into three muscle layers that exert different fibre direction imperatives on the precursive muscle tissue. The transversus abdominis undergoes the most extreme fibre orientation change, from longitudinal like the erector spinae to roughly transverse, dorsal to ventral. The transversus abdominis is part of the same deep muscle tissue layer as the anterior scalene, the intercostal intimi, the quadratus lumborum, the diaphragm, and the levator ani (Fitzgerald and Fitzgerald, 1994).

During the fourth week the precursor of the diaphragm, the septum transversum, originates in the neck region (C3–5) but with rostral folding it is drawn down towards the sacral region. With subsequent development the muscle is peeled away from the back of the body and the attachment point is drawn up to the L2–3 region. As the ribs migrate ventrally they drag the muscle with it. The majority of the muscular portion of the diaphragm is probably derived from the migration of cervical myotomes and the intercostal intimi, a muscle that is described as ‘patchy’ in appearance as it has donated muscle fibre to the descending diaphragm (O’Rahilly and Müller, 1996).

Evolutionary perspective

Activities such as singing, shouting, foot stomping, hopping, jumping, lifting and pushing employ the radial field (Figure 1). These activities are amongst the core suite of functional evolutionary activities, and these are activities that our desk bound society neglects. Many current exercise programs are analogous to junk food in that they bulk up individual muscles but do little towards a whole organism, functional integration, of the musculature. The cadaveric approach to anatomy has been used for devising ingenious gym machines that will isolate a named muscle and work it until exhaustion—analogous to calories without complex nutrients. For example, gym bicycle riding will not require or contribute to a robust and neurologically complex radial field. Nor will sitting whilst exercising (often wearing a weight belt that further distorts radial field recruitment) on an expensive piece of gym equipment, functionally facilitate the radial field. Free weights and Swiss balls are a great challenge to the radial field, for stabilization, and for the neurological software that drives the

Figure. 1 Lifting activates the R-CF. Carrying weight with a forehead harness or across the shoulders is biomechanically efficient.

system. However, the current trend in the personal training world of isolating the core muscles is misguided. Isolation training of named muscles is not the way to develop a functionally tuned human physique. The concept of musculoskeletal 'tune' in this context is a whole organism emergent property, where the archetypal postures described below represent keynotes in whole organism function.

The radial field compresses the viscera. If the intestines are inflamed they are able to over-ride and inhibit the squeezing muscles (Chek, 2001). One is unable to develop a strong bracing of the torso because of the pain signals fed into the neurological system from the visceral inflammation.

Field description

The R-CF, in a similar way to the CFs previously described, moves through the body wall from deep to superficial, as it courses about the body from dorsal to ventral (Figure 2).

Muscles participating in this field are:

Transversus abdominis—traditionally described as the deep muscle of the trilaminar body wall that however gradually surfaces through the aponeurosis of the internal and external oblique, to become superficial to them in the lower abdominal wall (Rizk, 1980). The emergence of the transversus abdominis as a superficial layer of the body wall in the lower abdomen enables it to compress the viscera to exert a maximum push upwards towards the dome of the diaphragm. When toothpaste is squeezed from a tube it is not a good idea to compress the middle of the tube—the gel will exert a force on the lower seam, possibly leading to a mess. Better to squeeze the bottom of the tube, thereby protecting the lower seam. Likewise, the muscular system is configured to protect the anal/urogenital orifices from herniating pressures.

The Chinese exercise/martial-art culture has for thousands of years stressed the importance of the lower abdomen in movement patterns. The Hara or Dantien region is located below the navel, about level with the iliac crests. This is the region where the transversus abdominis, as it courses from the sternum and ribs towards the pubis, emerges from a deep fascial layer to become, briefly, a superficial muscle. The body's centre of gravity is here and from a CF perspective the L-CF, the D/V-CF and the H-CF, meet and inter-penetrate in this region.

Pelvic floor—the levator ani complex and the external anal sphincter muscles are modelled as part of this field.

Diaphragm—the transversus abdominis is continuous with the costal origin of the diaphragm. It is likewise a deep muscle and both are functionless without the other. For example, if the pelvic organs have prolapsed one's ability to lift weights or develop a powerful Valsalva manoeuvre is compromised. When the radial field is compromised the spine is not adequately hoop braced in movement and is liable to buckling injury.

Respiration involves a patterned interplay between the thoracic muscles and the abdominal muscles. Both share a common innervation (ventral rami) and both are embryologically derived from the same fascial layers (Fitzgerald and Fitzgerald, 1994).

Rostrally the anterior scalene (embryologically the deepest of the 3 scalenes) is the continuation of the field, as are the muscles that are involved in bracing the throat before a heavy lift. Other endothoracic muscles in this field are the sternocostalis and the subcostals.

Muscles of the pharynx and larynx

Platysma—is a superficial muscle that blends with the orbicularis oris that rings the mouth. It fires with sudden inhalations and in straining lifts.

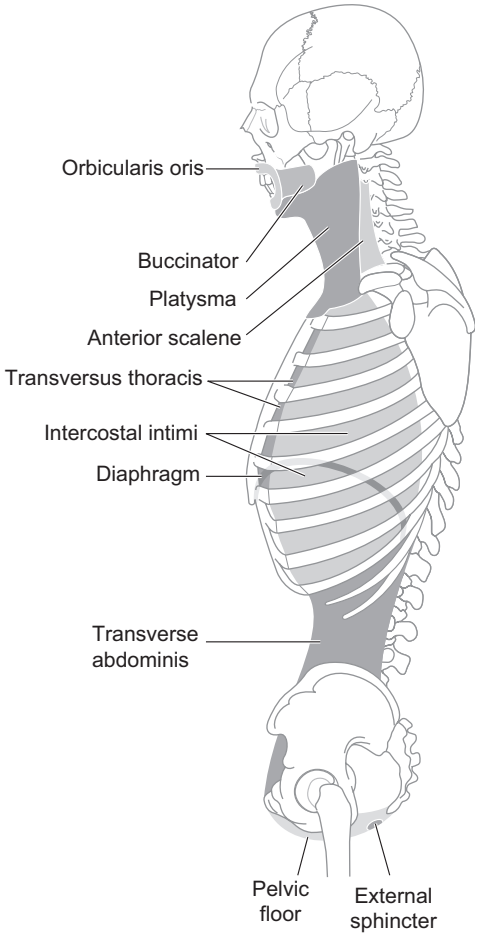

Figure. 2 The radial contractile field (R-CF).

Here is an example of a muscle that is superficial but is functionally linked with the deeper muscles of core stabilization.

Buccinator—Latin for the trumpeter as it expels air in blowing and acts during mastication of food.

Orbicularis oris.

The coelom

Figure 3 below depicts the outer embryonic layer—the ectoderm (skin/brain); the middle embryonic layer—the mesoderm (muscle, bone, blood, kidney); and the deep layer—the endoderm (gut lining). By day 25 of the fourth week the mesoderm has been drawn ventrally, and in the lateral region has split into two layers, the somatic and splanchnic layers of what is called the lateral plate. All the muscles that contribute to the CFs described to this point are derived from the spinal somites and the outer layer of mesodermal migration, i.e. the somatic mesoderm (O'Rahilly and Müller, 1996). The splanchnic layer of the mesoderm contributes to the formation of the visceral musculature. Between these two muscle layers a fluid filled cavity comes to be created. When reading embryology the coelom appears to be an uninteresting structure that with further development compartmentalises into the pericardial cavity, the pleural cavity and the peritoneal cavity.

However, from an evolution of movement perspective, the advent of a coelom marked a key stage in the development of animals that could volitionally move. Our bodyplan is termed triploblastic (ectoderm, endoderm and mesoderm), with a coelom that forms within the mesodermal layer (Erwin et al., 1997). In effect, this creates a visceral tube within an encircling external bodywall tube, the two separated by the coelom and its fluid. The outside body wall became partially decoupled from the inner, gas food absorptive layer of the animal. When a primitive animal without a coelom changed shape to move food was pushed about within the animal. Without a coelom if we ate a baguette and ran for a bus we would have an embarrassing moment as the semi-digested baguette got pushed towards the mouth or anus. Without the pericardial cavity derived from the coelom we would all oscillate 80 times per minute with our cardiac pulse.

Chiralic CFs (C-CFs)

The fields of contractility described above are all derived from the somites and the outer leaf of mesodermal migration, the somatic mesoderm. As introduced above mesoderm forms another, deeper leaf that forms the musculature of the cardiovascular system (CVS) and the gut/lung tube.

This layer, the splanchnopleure, is essentially different from the external body wall in that it contributes to contractile structures that are not bilaterally symmetrical. All the muscles of the external body wall are left/right counter-parted, that is not so for the visceral and cardiac musculature. Rather splanchnopleuric musculature is selectively handed as found in the heart tube that is left loop biased, or intestines that coil counter-clockwise 270° in development (Larsen, 1993). The relationship between symmetry and asymmetry is a major preoccupation of scientific cosmology—
a relationship that each of us has embodied.

Chiral means a three-dimensional form that is not superposable on its mirror image (Figure 4). The chiralic field is modelled as having pulsatile and peristaltic functions. Organs shape the body wall before the development of ribs or abdominal

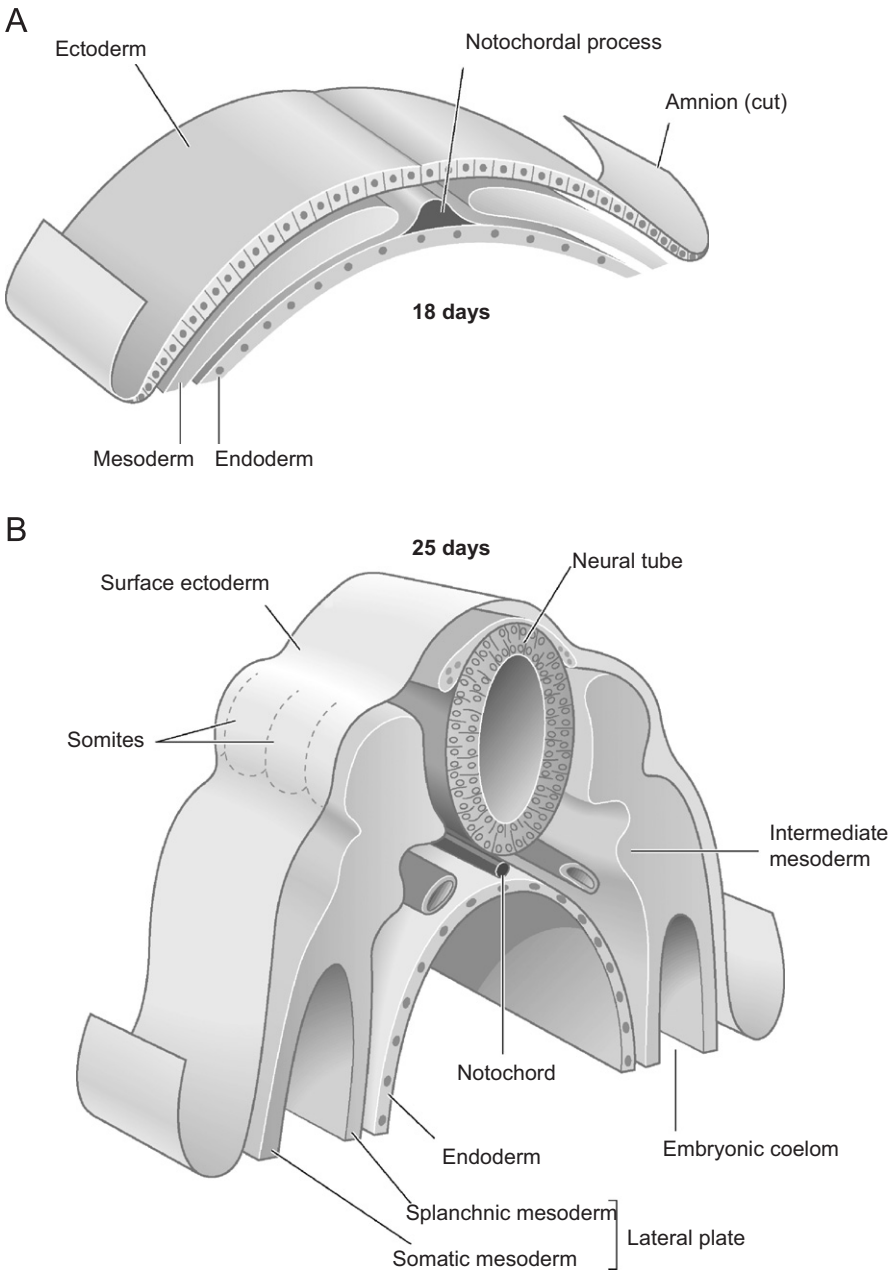

Figure. 3 Mesoderm at 25 days. Early differentiation of the mesoderm. The somites will differentiate to form the spinal region; the intermediate mesoderm will drop away to form aspects of the urogenital system; the lateral plate mesoderm forms the external body wall whilst the inner leaf forms the visceral musculature. The coelom is the potential space between the two layers.

musculature, and organ health has a profound affect on external body movement. An example from the pulsatile function is that of high blood pressure. During much of embryogenesis the pressurised blood vessels are a major constraining factor in growth (Blechsmidt and Gasser, 1978). Stiff arteries will tend to flex the body as the vertebrate bodyplan features a cardiovascular system placed ventral to the gut tube (Figure 5). An experienced weight lifter during a double-leg press was recorded as having a blood pressure in excess of 480/350 mmHG! (MacDougall et al., 1985). The same study recorded mouth pressures of 30–50 Torr during a single maximum lift. Modelling movement without conceptually encompassing the pulsatile and the pulmonary/peristaltic systems is just inadequate. Blood and visceral muscle is as mesodermal as the biceps and erector spinae.

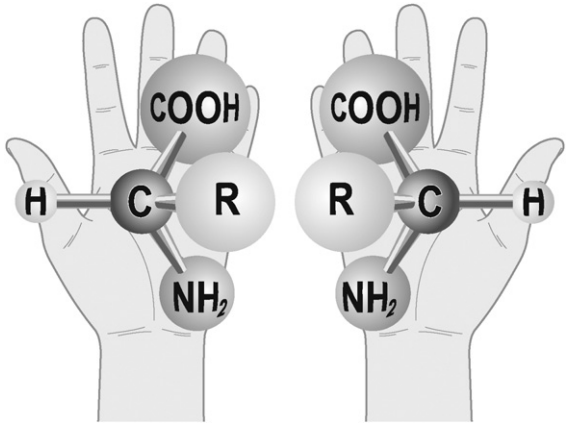

Figure. 4 Chirality. 'I call any geometrical Figure, or group of points, chiral, and say it has chirality, if its image in a plane mirror, ideally realized, cannot be brought to coincide with itself.' Lord Kelvin (1824–1907).

Discussion

Models are a simplification of large systems but if the key building blocks are carefully selected they add significantly to understanding the system. The CF model aids our understanding of how our patients move in both ease and dis-ease. A knowledge of CFs helps during all stages of the clinical encounter. Case history taking is enhanced by an appreciation of how disparate events, often separated by many years, interact to produce presenting symptoms. Treatment is given a context in which to think about how manual therapy can influence the function of our patients.

Good models are also transferable across different academic domains. The CF model has been turned to look at the world's oldest medical map, the enigmatic map of the meridians drawn by Chinese medical theorists 2000+ years ago. Bioscience has looked in vain for meridians. Without a modern understanding of what was mapped mainstream medicine tends to reject the meridial concept. By using a methodology available to the Chinese, i.e. recoil from a noxious stimulus, allied to the CF model, meridians are hypothesized to be 'emergent lines of shape control' (Beach, 2007a, b). Lines emerge on the body wall that when needled or burned trigger a similar recoil vector. A blunt needle will elicit a field of contractility that the CF model aids us to understand. In essence, it is hypothesized the Chinese mapped the minimum number of lines, in exactly the right location, to accurately/predictably control subtle human shape in three dimensions. Shape and function are profoundly related. The correlation between the CF model and the deeply detailed and nuanced

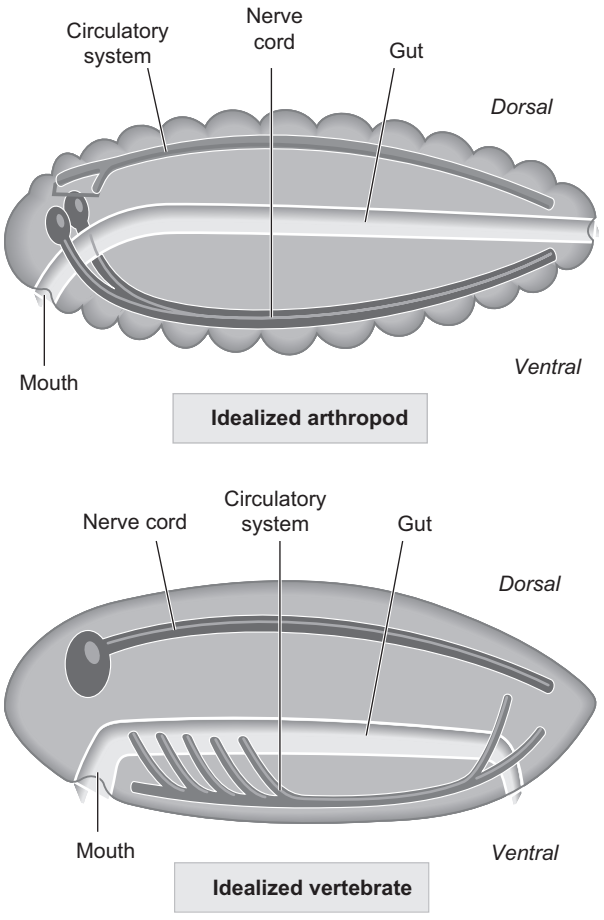

Figure. 5 Bodyplans. The difference between an idealized arthropod and vertebrate is essentially a swapping of the location of the CNS and the CVS.

Chinese meridial map is uncanny. It was the meridial map that suggested to the author the association between the sense organs and the CFs, an association that was conceptually off the radar from a conventional musculoskeletal perspective.

Summary

The CF is a model of the musculoskeletal system that functionally links muscles together via the primary movement patterns exploited by vertebrates. The vertebrate spinal system imposes constraints on movement, channelling it into deeply conserved patterns. Mammalian vertebrates lateral flex, flex and extend, twist left/right, squeeze and suck (evolved for suckling). These bilaterally symmetrical body-wall muscles act somewhat independently of the underlying visceral musculature that is not symmetrical but rather is handed. The coelom separates the symmetrical from the asymmetrical. Blood pressure and the

interaction of visceral compartmental pressures affect movement in a profound way.

Archetypal postures are a quick way to scan the tune of the musculoskeletal system. Encouraging people to sit on the floor in a variety of postures, in the author's clinical experience, helps people regain normal mobility. To then stand erect from the floor (with good technique) is an essential anti-gravity exercise that our musculoskeletal system benefits from. Fields of interacting contractility, allied with archetypal postures, can offer new insights into our clinical work.

Musculoskeletal 'tune': archetypal postures reflecting function, safety and aesthetics

Part 2 of this paper introduced archetypal postures as a self-tuning mechanism for the musculoskeletal system. They involve postures that all people, of all ages and all cultures, have used for repose. Each archetypal posture orders the body across many joints and many muscles. Learning to assess and read these postures, allied with a conventional musculoskeletal diagnosis, will help in treatment and in rehabilitation. Loss of ease in these postures, it is suggested, significantly predisposes the physique to biomechanical dis-ease.

Musculoskeletal tune is an important concept. From a whole organism perspective in-tune emerges from a profound three-dimensional interplay of the musculoskeletal system, the nervous system and the visceral system. Archetypal postures are nodal (meaning a vertex or end-point in a system, a point of rest in a standing wave system) to the musculoskeletal system. Tune is not the icing on a biomechanical cake; rather it is what function is all about. By way of an example a musician about to go on stage is handed two guitars. One is worth $100 and in tune. The other is a fine example of the instrument, worth about $10,000 but out of tune. The musician will choose the cheaper guitar, as tune is an essential emergent quality. Without tune systems produce discordance, function less efficiently and may crash unexpectedly. We experience this as pain or dysfunction.

The full squat is a deeply human posture. Kingdon (2003), a world authority on the mammals of Africa, wrote a book that he called 'Lowly Origin'. Kingdon (2003) is referring to the full squat in his book title. In his opinion squatting to forage with both forearms freed of weight-bearing duties, probably in the forest valleys of the eastern coastal strip of Africa, started the cascade of anatomical modification that would lead to the erect spine, standing, walking and running. From a CF perspective the squat is analogous to middle C on a piano—the reference note from which the instrument is tuned. Most Western people now find a full squat position difficult and uncomfortable, suggesting they are 'out of tune'.

A good squat calls for the heels to be on the floor, the feet should be symmetrical and pointing forwards, with the tibialis anterior muscle relaxed as the centre of gravity has moved forwards on the ankle due to adequate dorsiflexion, the spine should be erect, and the shoulders down (Figure 6). Loss of flexion at the ankle, knee, and hip, or an abdomen that is too large, will make a full squat difficult. In the authors' clinical experience, loss of the full squat is associated with knee degeneration and crepitus, and a strong tendency to develop excessive tension in the neck/shoulder region. No manipulation or soft tissue technique will keep tense neck/shoulder muscles relaxed for long when the body is out of tune.

Sitting cross-legged in a variety of ways is another key archetypal posture. Sitting with poise whilst cross-legged involves interaction of the deep hip and body-wall musculature. People who regularly sit at a desk may rarely or never sit on the floor in these postures, postures that the author has come to see as mandatory to musculoskeletal health. Learning to sit on the floor, and arise easily and gracefully from the floor, is a simple educational

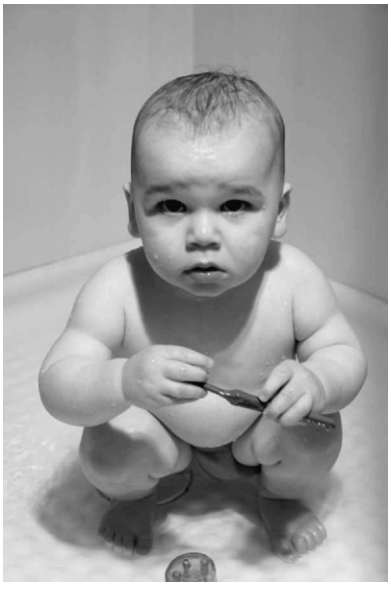

Figure. 6 A full squat is an important milestone in childhood development. The correct dorsiflexion of the ankle is established. Squatting to standing should be a life-long habit.

process that will offer benefit to people suffering from chronic musculoskeletal distress.

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References

Beach, P., 2007a. Meridians: emergent lines of shape control. Medical Acupuncture 19 (2), 79–84.

Beach, P., 2007b. Australian Journal of Acupuncture and Chinese Medicine 2 (1), 5–8.

Blechsmidt, E., Gasser, R.F., 1978. Biokinetics and Biodynamics of Human Differentiation. Thomas, Illinois.

Chek, P., 2001. Swiss Ball Workshop, Reading, UK.

Erwin, D., Valentine, J., Jablonski, D., 1997. The origin of animal body plans. American Scientist 85 (March–April), 126–137.

Fitzgerald, M.J.T., Fitzgerald, M., 1994. Human Embryology. Baillière Tindall, London.

Kingdon, J., 2003. Lowly Origin: Where, When, and Why Our Ancestors First Stood Up. Princeton University Press, Princeton, Oxford.

Larsen, W.J., 1993. Human Embryology. Churchill Livingston, New York.

MacDougall, J., Tuxen, D., Sale, D., Moroz, J., Sutton, J., 1985. Arterial blood pressure response to heavy resistance exercise. Journal of Applied Physiology 58 (3), 785–790.

O'Rahilly, R., Müller, F., 1996. Human Embryology and Teratology, second ed. Wiley-Liss, New York, p. 93.

Rizk, N., 1980. A new description of the anterior abdominal wall in man and mammals. Journal of Anatomy 131 (3), 373–385.