Core stability and the unstable platform device

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Summary  A popular form of exercise training and rehabilitation involves using labile surfaces upon which movement tasks are performed. The intent of such programs is to restore a preferred motor control response primarily involving multi-segmental stability. This paper describes the similarities between the goal of multi-segmental stability training and infant motor development. Next, a novel labile surface exercise device will be described together with its unique training features.

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Introduction

Exercise rehabilitation and training can provide many positive health outcomes. For clients suffering pain from an acute musculo-skeletal injury, tolerable activity can improve tissue nutrition, reduce the incidence of further injuries due to immobility and lead to early reactivation.1,2 In sub-acute cases specific exercises can be prescribed to address particular motor control dysfunctions involving segmental and multi-segmental musculo-skeletal structures. The intent of specific exercise prescriptions is to restore normal neurologic, energetic, biomechanic and cognitive function, leading to quicker return to activities of daily living.2-4

The chronic pain sufferer can often gain temporary and/or long-term pain relief through the use of regular gentle and specifically prescribed exercise routines. Exercise for these clients may also lead to improved confidence in locomotion which may also reduce the psychological effects of chronic pain.5

There is an increasing body of evidence that trunk muscle function plays a primary role in the management of low back pain.3,6,7 Measures aimed at reversing movement impairments by specific exercise training most often leads to improved physical capacity, functional outcomes and pain relief.6 For the sufferer of low back pain in particular, studies have implied that muscle strength, coordination, endurance and response time insufficiency may induce biomechanic dysfunction leading to the development of low back pain.8-10

Exercising for rehabilitation purposes, personal fitness or athletic performance may provide many positive body function enhancements, such as improvements in:

- Muscular strength, endurance and coordination.
- Flexibility.
- Motor control leading to efficient segmental and multi-segmental stability.
- Cardio-vascular efficiency.
- Confidence and improved psycho-social ratings.

An increasingly popular form of exercise training involves the use of labile (unstable) surfaces upon which an individual performs specific movement routines.11-13 This type of exercise program is also known as sensory-motor training.14 Examples of labile exercise tools include the Swiss ball, wobble/rocker boards, foam rollers and balance discs. These tools are often used in rehabilitation settings, social exercise environments and professional fitness centers and are used for a wide variety of individual specific health goals.

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There is a growing body of recent scientific evidence to strongly support the use of labile surfaces in training and rehabilitating human motor control functions and involves the activation of muscular sling contraction strategies.\textsuperscript{15,16}

Exercise tools such as swiss balls have been clearly shown to activate muscular contraction strategies differently than on flat earth surfaces. Using swiss balls during exercise improves the speed and intensity of muscular sling responses involved in a specific movement act and increases the demand on the motor control system.\textsuperscript{15} Therefore, a primary goal of labile surface exercise training and rehabilitation is to restore and improve the functional pattern of muscular sling responses involved in multi-segmental stability and orientation.

Labile surfaces have been shown to provide effective training outcomes for individuals suffering from low back, knee, shoulder and ankle injuries.\textsuperscript{17–19} Dynamic movement training on labile surfaces is believed to restore and improve the involved sensory-motor feedback arc leading to activation of preferred motor control strategies.\textsuperscript{12,14,20}

The intention of this paper is to take an alternate view of labile exercise training. Following a theme developed during this series, the author will explore the similarities and differences between labile surface training for core stability and infant motor development during the acquisition of progressively more complex motor skills. The comparison will then lead us to the principals behind the development of a new labile surface device, the DuraBoard.

**Motor control strategies for spinal stability**

There are two primary muscular recruitment strategies involved in whole body stability and orientation. These cooperative strategies are enacted in response to goal directed movement tasks. The two primary strategies are:

- Segmental muscular stiffness.
- Multi-segmental stability and orientation.

**Spinal segmental muscular stiffness**

Local, deep segmentally related muscles provide stiffness to a motion segment, in turn providing a safe and stable environment for the larger global musculature to influence joint position during movement tasks. See "Rolling exercises designed to activate the deep spinal muscles"\textsuperscript{21} for a full description of segmental stability.

**Multi-segmental stability and orientation**

Labile surface exercise training, when applied appropriately, is thought to train the preferred muscular sling contraction strategies designed to efficiently and effectively control whole body stability and orientation.\textsuperscript{15} It is therefore important to understand this aspect of motor control.

Multi-segmental stability and orientation is designed to maintain body balance and equilibrium and can be activated by anticipatory stimulus or via feedback mechanisms.\textsuperscript{22,23} The contraction strategy is generally stimulated by direction specific perturbations to the body. When stable and safe multi-segmental orientation of the body within the field of gravity is threatened by predicted or unpredicted challenges, specific pre-trained muscular recruitment synergies, adapted to a specific task related event, will be activated.\textsuperscript{23}

A muscle synergy that is activated in response to a multi-segmental stability task occurs through a discharge of a small number of individual neurons in the primary motor cortex.\textsuperscript{24}

**Body support zones**

Body support zones include the body's contact surfaces with the ground support and the primary articular and muscular zones that are key linkages for multi-segmental stability strategies enacted during a movement task. For example the contact surface support zones in a quadruped position are the hands, feet and ankles. The primary articular and muscular support zones are the scapula with its fixed position to the thorax by the action of the lower scapula stabilizing muscles, the contra lateral lumbo-pelvic area and the mid thorax.

Support zones are then stabilized and controlled during a movement by the activity of muscular slings reacting to control body orientation and stability in response to body weight shifts during movement.

Dynamic motor actions cannot be performed without first stabilizing sections of the body that act as anchoring points for associated moving parts.\textsuperscript{25} Kolar describes these anchor points as the pointum fixum.\textsuperscript{26}

A support zones' functional alignment, the activity of predictive muscle contraction sling strategies including the deep local muscles to control the centrated orientation of motion segments and the intentional process of producing a movement ultimately rely on the awareness and control of body weight shifts. The efficient and
5 Motor responses to perturbations

If a perturbation is anticipated muscle synergies are activated prior to the load being felt by the body.27,28 If a load applied to the body is not predicted, then the feed back mechanisms such as stretching of a muscle caused by the perturbation will activate a muscular reaction.29 The reactive muscular contraction synergy aims to neutralize the destabilizing forces upon the body by an equal but opposite force.

A failure to provide skillful and efficient multi-segmental stability and orientation for task specific events can lead to either the activation of alternative muscular recruitment strategies that are less sophisticated both neurologically and biomechanically,30 or a loss of balance resulting in a fall.22 The net result of either non-preferred response is often direction specific increased in visco-elastic load on pain sensitive structures that may eventually lead to pain.31,32

A primary goal of labile surface exercise training and rehabilitation is to train the safe functional speed, endurance, strength and coordination of neuromuscular reflexes, reactions and responses during movements.2 This is designed to improve the coordinated and integrated segmental and multi-segmental “articulated” stability strategies, to control the degrees of freedom available to single and multiple joints during tasks involving locomotion.

As well, the precise training programs integrated in multi-segmental functional restoration aims to alter the abstract temporal and spatial perception of the body’s reference frame with regard to one body segment to another and the body with regard to the external environment. This reference frame is stored in the “body schema” within the CNS. Perturbations produce error signals which instigate a pre-designed muscle synergy to bring the body back into alignment as perceived by the internal reference map stored in the body schema.28,33

The primary egocentric reference frames involved in acts of locomotion are the feet and ankle, the pelvis and the head and neck.34,35 Multi-segmental movement exercise training and rehabilitation programs provide an increased sensory activation of the peripheral receptors. It is hypothesized that the sensory feedback is then integrated into various central neural modulating areas to alter the body schema leading to more efficient movement outcomes.36 Balance training develops and refines a perceptual neural analogue (body schema).28,33 The control of the abundance of options of degrees of freedom in the neurologic, energetic, biomechanic and cognitive sub-systems available to fulfill a movement task is simplified and efficiently activated when muscular synergies involving a skillful and mature body schema is employed.37 Therefore, individuals suffering musculo-skeletal pain/dysfunction disorders often have altered motor control repertoires which are inefficient and costly both metabolically and biomechanically.10,38 The speed and intensity of muscle contractions is altered,9 deep segmentally related muscles lose contraction speed and intensity39,40 whilst the larger multi-segmental muscles tend to become over active and contract tonically. As well the way low back pain patients move is different than healthy individuals.41 This leads to changes in muscle length relationships, altered postures, muscle imbalances, altered location of the center of mass and changed position of the center of pressure31,32 (see Box 1). It is the belief of this author that labile surface exercise rehabilitation can address these motor control dysfunctions by restoring, through precise movement training, preferred motor control patterns.

Infant motor milestones imitate core stability training

Infant motor milestones provide a progressive training pathway to prepare the child to eventually exhibit mature and sophisticated movement and stability strategies that can be easily adapted to a wide variety of tasks.42,43 Examples of these progressions are seen in the infant postures from rolling, supine kicking, creeping and crawling, sitting up, sit to stand, squat, lunge, standing and balancing, walking then walking and carrying and running (see Box 2).

The movement pattern progressions seen in the developing infant, in many ways, mimic the exercises we prescribe in multi-segmental orientation and stability (core) training i.e. supine bridge, dead bug, Side Bridge, quadruped cross crawl, abdominal cross crawl, lunge, squat etc. The functional goals in infant motor development also appear to be similar to those of core stability training. So, to move efficiently, infants and toddlers must undertake extensive, intensive and intuitively guided exercise programs to actively stabilize with mobility, a pathway that is similar to the goals of training or rehabilitating adult (see Box 3).
Differences between infant motor learning and core stability training

The infant develops awareness of motion through reflexive and spontaneous movement activities. When a child is born, it carries with it certain pre-designed movement reflexes and reactions called primitive reflexes. These reflexes provide the infrastructure for building of body awareness and normal joint bone and muscle function. As the child grows it differentiates these movement patterns into nonspecific movement activities which build general postural reactions and intention guided activities which activates the conscious control movement activities i.e. grasping a toy. This allows online programming of central mechanisms to allow awareness of the basic feel of limbs, muscles and movement.

The first stabilizing programs are rehearsed by an infant as it combines sensory awareness, improved motor function and increased levels of cognition to progress from a lying position to eventual upright locomotion. During this time a child starts to explore its environment, motivated by pleasurable experi-

Box 1 Multi-segmental instability is characterized by multiple body segments possessing alterations in the preferred way a task related movement is performed. These altered motor control characteristics include:

- Areas of segmental instability including single or multiple vertebral articulations that have an increased neutral zone or articular "give".
- Altered muscle-length tension relationships and speed of muscular responses.
- Vertebral and peripheral motion segments that have compensatory direction specific loss of viscoelastic extensibility resulting in a loss of direction specific range of motion to multiple consecutive motion segments.
- Loss of coordinated expression of a functional movement pattern (altered muscular recruitment strategy), illustrated for example by the hip abduction and hip extension tests.
- Loss of control of balance and locus of control in task specific environments.
- Reduced anticipatory muscular responses and higher reliance on feedback mechanisms.
- Muscle imbalances.

The primary goal in the treatment of multi-segmental instability is to simultaneously:

1. Reduce the neuro-muscular neutral zone in segmentally unstable motion segments during a movement pattern by activating muscular contraction strategies involving segmental stabilizing muscles, whilst performing range of motion exercises.
2. Improve muscle-fascial extensibility and joint range of motion in the direction of the pathologic barrier during a movement pattern.
3. Activate and train the orientation and equilibrium of the whole body during a movement task using multi-segmentally related muscle synergies.
4. Restore and integrate the preferred muscle firing patterns in movement activities.
5. Improve balance and locus of control in task specific environments.
6. Restore the preferred motor control strategy.

The author believes that the goals for treatment outlined above can be most effectively addressed by the correct use of labile surface training devices and most specifically by the unique properties of the DuraBoard. Treatment of multi-segmental instability requires precise movement skills to be regularly practiced to stimulate the restoration of preferred motor control strategies. The treatment of multi-segmental instability is the last step in the musculo-skeletal approach to functional restoration of locomotor skills. It must be emphasized that the end phase of a functional restoration program can only be properly accomplished after first addressing segmental restrictions, segmental instability and multi-segmental restrictions. The treatment of multi-segmental instability functionally ties together all the gains from the other treatment modalities and will lead to goal-oriented functional restoration.
### Box 2 Infant motor milestones

Infant motor milestone progressions and their functional relevance:

(a) Rotational movements, beginning with head and neck turning towards or away from a stimulus. Progression of this locomotion pattern leads to first upper limb, then lower limb involvement in the act of full body rolling locomotion (1–9 months). The author believes intersegmental vertebral motion control for the whole spine develops from these rolling activities.21

(b) Sensory stimulation of the body support zones i.e. hands, anterior pelvis and legs when the child lifts its body for visual orientation, creating cervical and lumbar lordosis and activating the cervico-thoracic and scapulo-humeral muscular stabilizers (3–6 months).

(c) Infant crawling is associated with stability and orientation using visual, vestibular and somatosensory feedback from hands, knees and foot. Crawling helps establish repertoires of automatic muscular sling responses for weight shift control. Also coordination and strength development evolves for both global and local musculature when crawling. The previously mentioned strategies are integrated with thoraco-lumbar fascial tension and reciprocal activation of contralateral arm and leg (an essential element in upright gait), with co-contraction of transversus abdominis and multifidus (4–9 months). It is also proposed that crawling promotes psychological development and the development of body schema.55

(d) Progression from crawling position to activity involving both hand and plantar foot pressure by having knee and hip in extended position—the "spider-man" walking position in preparation for assisted standing, strengthening the above-mentioned strategies. Both crawling and "spider-man" walking develop intra-abdominal pressure, inter-compartment pressure and thoraco-lumbar fascial tension.

(e) Development of effective balance and orientation through sophisticated integration of previously mentioned strategies during lunge and squat to assisted standing position.

(f) A child develops mature postural responses and control of gait dynamics at around 7 years of age.34

(g) Also, the carried position provides "erect" visual orientation, tactile stimulation and improved body kinaesthetic awareness of the body in relation to space.

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### Box 3 Similarities between infant motor learning and core stability training

Both infant motor learning and core stability training:

- Have a primary function to design and neurologically fix the most efficient motor control pattern during a specific motor learning task.
- Are designed to allow the motor pattern to be adapted to a specific task requirement focusing on the individual's intent, level of skill and the environment in which the task is performed.
- Aim to provide the most efficient movement outcome for a wide variety of similar motor requirements.
- Have cognitive factors influencing the skillful production of a movement outcome i.e. alertness, intentions and cultural factors.
- Require a focused goal specific task to motivate the production of the most skillful motor training outcomes. Movement training without goal intentions may lead to poor training outcomes.
- Need regular motor control training to develop the most efficient movement outcomes and allow progression towards more demanding movement tasks.
- Initially produce a high level of muscular agonist and antagonist co-contracture, leading to higher than necessary muscular loading on articular segments, a stiffening of the multiple motion segments involved in the movement, using large multi attached muscles in a lock down or en bloc strategy (reducing the degrees of freedom available to those motion segments during a movement task) and producing a higher metabolic cost, when performing a new or novel movement tasks.27

This feature of both infant and adult motor control can be termed a motor learning program based on multiple feedback mechanisms used to train and focus the most efficient motor program and to quantify and store all the spatial and temporal characteristics of that movement pattern.
Box 3 (continued).

- With training and experience of a new or novel movement task the muscular co-contraction strategy intensity is reduced without compromising stability. As well the lock down strategy is replaced by the more neurologically sophisticated articulated strategy allowing a freeing up of the consecutive motion segments.
- A mature and sophisticated motor control pattern eventually emerges from the motor learning program. This features anticipatory muscular responses is reliant on the so-called motor schema that has stored the vital characteristics of the new or novel motor task.
- Are designed to develop, over time and with experience, control over the range of motion (flexibility) of multiple articular segments. Control over the range of motion of a functional task is termed the functional range.
- Adaptation to novel movement tasks allows motor control progressions to explore more complex and dynamic motion equations.
- The training mechanism involves developing appropriate support zones so that skillful and efficient movement patterns can be conducted.

Environments. To do this a child begins to activate stabilization strategies, i.e. head rotation, rolling, push away responses and co-contraction of stabilizer muscles which will provide stabilization strategies against gravity allowing the propulsion muscles to be integrated into these movement programs (see Box 2).

When an infant first assumes a new movement posture, for example the quadruped position, it does it without previous experiences of any aspect of the task i.e. the body’s position in relation to other body parts and to the support surface, the effects of gravity and the reactive forces through the whole body as a limb position is shifted—these are new and demanding challenges. In this environment the infant feels unsteady and unstable as it has yet to form a body schema for this task, posture or environment. The infant is learning to move in an environment that it perceives as labile.

As well, compare the infant to an adult attempting the same movement. The infant with its smaller lever arms, lower surface area for weight bearing contact, lower muscle strength and naïve motor control patterns (compared to an adult) leads to a much greater instability in a quadruped position.

The child, when it first experiences gravity in a quadruped position has no previous awareness of the effects of gravity, muscle pulls and weight shifts. However with practice involving responses such as the automatic co-contracture and the push away responses, motor control programs will be created and stored in central control areas. With neurologic maturity, experience, growth and confidence a stable posture to build more sophisticated movement activities will naturally occur.

Again compare this posture to that of an adult. With many years of movement experience, such tasks appear to be simple. However, due to many predictable and unpredictable factors that occur during a life span, dynamic and static postures may exhibit many ‘incorrect’ or non-preferred motion repertoires. In the adult example, movement experience simplifies the task but the task may be completed inefficiently with higher muscle, joint and energy costs. A less skillful motor control repertoire may be exhibited.

So the infant has a much more difficult job of it. For the infant to complete the motor training task i.e. crawling, with no or very little previous knowledge of the skill as well as experiencing much higher reactive forces in the support limbs, it can be seen that adult quadruped exercises on the floor cannot genuinely imitate the infant learning environment.

Then add to the equation movement dysfunction due to injury, developmental or environmental factors that can lead to non-preferred motor control responses during a desired or required task. This can happen at any stage of life. Non-preferred motor control repertoires, when re-enforced through repeated movement acts will eventually become fixed by the forces of neurogenesis and neuroplasticity.

So, in the adult, with repeated movement activities the mal-adapted and inefficient program developed for a specific motor task is constantly re-enforced. By the time an individual has reached 30 years of age the non-preferred program is clearly fixed and the compensations or dysfunctions in this program are extremely hard to change.

Both the infant and the adult can contribute to the failure to develop and retain the preferred motor control strategies. The factors are briefly explored below.
Development of spinal distortions in the infant

A failure to develop sophisticated motor control in an infant can be due to many factors including the immaturity of the nervous system and poor environmental challenges that are required to stimulate and train the motor control strategies. During the early stages of life many peripheral and central nervous system processes undergo growth and development.\textsuperscript{45,47} These processes of motor and sensory maturation coincide with cognitive and self-awareness activities. An infant can fail to create normal functional motor control status for a number of environmental and biological reasons that also involves the immaturity of the infant nervous system. During this critical phase of development central and peripheral plastic changes can occur.

Sensory-motor development in an infant

In childhood motor development it is hypothesized that a failure to build a sophisticated and skilful motor control can occur from:

- Sensory-motor development under bland and non-challenging environments i.e. flat, hard surfaces with low tactile stimulation (carpet and tiles).
- Interventions that promote premature infant motor development, i.e. infant walkers.
- Hands and feet are often covered with ill-fitting devices further reducing sensitivity.
- Sitting in front of the television, "computer games" or in a classroom, further devaluing the dynamic stabilizing mechanisms.
- Pushed in pram or stroller which doesn't adequately provide "erect" posture visual orientation, body perturbation or tactile stimulation, and body kinaesthetic awareness that is associated with the erect carried position.
- Social and cultural considerations.
- Structural abnormalities.
- Nutritional health.

Sensory-motor control in the adult

The modern adult interacts within its environment vastly differently to that which, in previous centuries, would provide the necessary stimulation to train the sophisticated motor control patterns.

For example the modern adult no longer climbs trees or mountains in search of food and friends. We no longer walk long distances over difficult terrain and face widely differing and challenging obstacles. Dangerous life interactions such as hunting wild animals with primitive tools appear to be a thing of the past.

Further, as adults we spend many hours sitting at work, at the computers or in motor vehicles.

Finally, any injury in motor, sensory or central control systems leads to further functional alterations.

Our developmental motor control programs have not adapted to the sudden changes in modern lifestyle requirements. Whilst our lifestyles and life goals have radically changed, the development requirements of human motor control have not.

As a result today's adult is forced to imitate the environmental challenges that were previously part of early human existence thus enabling us to develop and secure skilful motor control. To address these fundamental motor development issues, training tools and exercise programs are available that are designed in part to replicate and replace the environmental stressors so essential to the formation of a repertoire of skilful human movements.

Training devices for multi-segmental stability

Historically, the most popular devices used in labile surface training are rocker/wobble boards, foam rollers and Swiss balls.

These devices are widely thought to be effective in neuro-musculo-skeletal rehabilitation and are proposed to be successful in imitating environmental challenges common in previous centuries. The use of these devices is promoted by many noted clinicians\textsuperscript{11,14} and the application of these devices is taught at many exercise training and rehabilitation institutions.

The author suggests that in many ways these devices have failed to evolve with advances made in understanding the multiple complex concepts involved in stability training, characterized by:

1. Labile rehabilitation devices ideally should provide progressively demanding challenges tailored to an individual's skill. The "one size fits all" application of these devices does not match the prescription philosophy promoted by many functional restoration clinicians.

2. Progressive challenges allow quantification and documentation of start up skill and skill acquisition. Quantification and documentation provides valuable data to the client, the practitioner and third parties. Future care models will require such data for third party payment of services.
3. Non-progressive labile devices are often too difficult for the functionally impaired client to master. Personal clinical evidence suggests that if a task is too demanding for the neuromuscular system to answer, alternative strategies can be employed to compensate. If that strategy is replayed regularly the alternative synergy will become the preferred model of muscular re-recruitment. Some clients may be "rehabilitated into dysfunction".

4. The ideal environment for functional restoration should reflect those experienced in activities of daily living.

5. To create a central set of neuromuscular responses, the exerciser should reside wholly on the labile device. For example, adult person might be able to lie on some of the prior art balance boards with the middle part of the person’s body supported by the board, but will only be able to balance. When the person attempts to use arms and legs when supported on a small dimension board, e.g. to do a full body push up, either the arms or legs have to contact the floor or the exercise is inappropriately conducted with regard to the normally acceptable performance of that exercise.

6. Wobble/rocker boards train only a limited number of tasks and are most suitable for end phase rehabilitation for multi-segmental standing balance activities.

The author believes that a whole body unstable platform device (such as the DuraBoard) addresses most of the concerns discussed in the above section.

The DuraBoard has been invented and developed by the author and has a patent pending.

The DuraBoard can be thought of as an exercise environment. It is most suitably described as an adaptive locomotion device—“adaptive locomotion depends upon the match between an animal’s current capabilities and properties of the support surface.” Adolf goes further and describes adaptive locomotion requiring a continuous path for body support, large enough for the whole body, sturdy enough to support the body and strong enough to maintain weight shifts.

With variations of environmental conditions, continuous modifications of ongoing movements occur that lead to adaptive learning. Muscle activation synergies must be constantly adapted to the changing alignment of the body segments and shifting weight. This description fits well with the DuraBoard.

The DuraBoard comprises three parts:

(a) A large flat rigid surface large enough to support the whole body in a lying position. The board lies horizontal to the supporting surface, on which movement activities are performed (Fig. 1).

(b) A detachable undersurface apparatus which provides inherent instability to the platform. The undersurface mechanisms are changeable to increase, decrease or alter the degree or type of balance challenge. Various rockers, domes or elliptical devices can be incorporated (Fig. 2).

(c) Points of attachment on the superior surface of the platform for the coupling of various devices to perform specific exercises (Fig. 8). In
particular, a Swiss ball can be fixed to the superior board surface. The ball in this instance acts as a fixed apparatus on an unstable supporting surface (Fig. 5).

The requirement in most DuraBoard exercises is to hold the horizontal alignment of the board whilst conducting a movement task. As well, the client is instructed on the correct positioning of the body’s support zones for individual specific exercises (Fig. 6).

During the body positioning process and the execution of the exercise, body weight shifts constantly challenge the body’s normal and stable orientation. This leads to constant adaptations of the support zones and weight shifts by the activation a number of control strategies including reflexive and reactive muscular sling responses.

When exercising with the body frame horizontal to the support surface on the platform device, whole body muscular slings are reflexively activated to hold the horizontal alignment of the board. When there is a body weight shift when performing an exercise, the muscular sling strategy is required to rapidly adapt. This sling activity passes through the whole body from one point of board support i.e. hand to other points of board support i.e. other hand or feet. This will only occur with a full body contact on an unstable platform (Fig. 3).

In response to a DuraBoard training program, it is speculated that sophisticated motor control adaptations brought about by constant movement repetitions leads to skill acquisition. At this point, mastering of a particular DuraBoard challenge will have occurred. Following this, the board challenge can be increased by altering the undersurface mechanism. This then leads to further skill acquisitions without altering the movement task. The intention of this process then is to increase the threshold at which the complicated movement task can exhibit a preferred motor control strategy.
The weight shift and body orientation control strategy on the DuraBoard is thought to activate whole body reflexes and reactions as well as involving cognitively guided movement intentions. This complex communication across the midline allows integration of whole body movement patterns to be coordinated and controlled. Balancing in a horizontal orientation provides a unique stimulus to the brain involving the bilateral nature of the left and right sides of the body. The control of the body’s orientation through this complex interaction most probably involves complex neural communications across the midline. With full body contact in prone or supine the body has no fixed reference for balance and the brain has to balance the needs of every segment and left and right body position for correct orientation. This occurs as a result of communication across the midline of the brain forcing the left to intermesh with the right. The full body instability mechanism trains this cortical and sub cortical process.

In addition, the exercise apparatus with its large platform does not allow a fixed and stable environment reference point from which movements can be calculated. When movements are performed the body uses the most stable body segment to aid in preparing a muscular response. With balance boards of smaller dimensions or Swiss balls, full body exercises can only be performed by adults with some form of contact with a fixed surface, such as the floor, which provides a stable reference point. The DuraBoard provides an environment where no segment has a stable reference point (Figs. 1, 4 and 5).

Indeed, full body exercises, such as push ups, are not intended to be performed on the balance boards of smaller dimensions, which have been developed principally for balancing exercises.

The author believes that a large surface unstable platform carrying all the body’s points of support leads to advantageous exercise outcomes that are not possible using devices that hold only partial body support.
Core stability and the unstable platform device

1. Unstable platform device and infant motor development

Observing core stabilizing programs such as the quadruped cross crawl, dead bug, pelvic tilts, supine bridge, are all activities rehearsed in infant motor development. It seems that in many ways core stability programs involve re-inventing the 'stability' wheel originating from infant motor development.

That is, evolution over millions of years has dictated that the complex skill of bipedal locomotion and environmental manipulation can only develop through a sequential motor progression and repetitive training routine. Through time and training eventually new, more complex motor programs are developed. Through this process the infant has "invented the wheel" of core stability.

Therefore it seems to this author, when conducting core stability exercises, we are re-inventing the wheel, except for one major difference. In an adult, we incorporate all previous sensory experiences to provide influences on our motor responses.

So in fact when performing any motor activity it is difficult to escape from long rehearsed, possibly faulty, learned responses, sometimes termed faulty engrams. These possibly faulty learned responses are bound to be challenged when confronted with having to perform the same tasks on a large dimension labile surface, with the potential for learning better responses.

The training on the board creates an environment that in many ways mimics the one the infant would experience when first starting to crawl or walk. When an exerciser is conducting movement patterns on the labile surface board they should be coached by a skilled practitioner to perform the movement patterns correctly, replacing the intuitively guided, trial and error learning process of the infant.

2. DuraBoard and quadruped exercises

This paper has thus far:

- Detailed the strategy of multi-segmental stability and methods designed to restore preferred patterns of muscular control (using labile surfaces).
- Compared the path in the acquisition of sophisticated motor control in the infant and the programs designed to train multi-segmental stability in the adult.
- Discussed the potential of a new labile large surface training device.

An attempt will now be made to bond these concepts together by applying an example involving the practical intent and function of this large dimension, labile board.

The quadruped cross crawl exercise is a fitting example (Fig. 9). It features in both infant motor development and adult movement training and rehabilitation. It has been suggested in Box 3 that both motor training programs' share many characteristics. In addition the posture demanded by the board provides a unique orientation strategy to train body support zones (described in the section on support zones).

Studies have confirmed that quadruped posture promotes an increased activation of multifidus and improves kinesthetic awareness of transversus abdominis.

During the activation sequence of the exercise muscular slings act to stabilize and orient the body. This activation involves muscles located on both dorsal and ventral body surfaces and acts across the body's midline.

In Box 2 a number of muscular recruitment strategies are proposed to be activated and trained during infant crawling. The author suggests the same muscular recruitment patterns are initiated and reinforced during adult quadruped exercise training.

It is further anticipated that the quadruped movement pattern may also provide force transmissions involving the ipsilateral gluteus maximus and the contralateral latissimus dorsi to increase "force closure" of the ipsilateral sacro-iliac joint. Force closure is believed to be an essential element of lumbo-pelvic stability.

Libenson points out that that all functional exercises involve the whole body. He also implies that force transmissions in functional tasks pass from the lower limb to upper limb via various diagonal loops and slings. The posterior sling involves the gluteus maximus and latisimus dorsi and the anterior sling entails the oblique abdominals and the pectorals. Similarly, the quadruped exercise also involves the whole body and the author believes it prepares these muscular synergies for upright functional tasks.

The various loops and slings of muscular synergies active in the quadruped exercise are linked to the thoraco-lumbar fascia. This muscular element allows the core to be functionally tied to the upper and lower limb and the cervical spine. It is also theorized that this multi-segmental fascial and muscular envelope provides a purposeful proprioceptive function. The author believes the quadruped exercise strongly activates the thoraco-
lumbar fascia and the multi-segmental proprioceptive receptors. The quadruped posture also provides a relatively low load to be supported by the spine whilst exercises are being performed. Additionally, when conducting an exercise routine in the quadruped posture, as an infant or an adult, the body is allowed to experience single leg support. Practicing this skill promotes the awareness of the pelvis being held and correctly oriented in space. Pelvic orientation during the single support phase of locomotion provides the egocentric reference for an ongoing movement task. For both infants and adults the quadruped exercise posture provides many dynamic inputs to effect improvements in motor control efficiency. The focus when applying such an exercise should be based more on altered motor control abilities than on any painful presenting symptoms. When quadruped exercise is applied on the DuraBoard it is the author’s experience that the speed and intensity of muscular sling responses is improved (involving restoration of body weight shift awareness) and preferred motor control patterns are re-enforced involving task specific balance activities (Fig. 9). Using alternate exercise options also allows training diversity of movement tasks during a motor control rehabilitation program (see Figs. 4, 6 and 8). The client can also be progressed to more loaded exercise options on the board (spine extensions Fig. 7) and onto functionally relevant tasks (lunges Fig. 10) (Figs. 6–10).

**How to apply the exercise on the unstable platform**

The client is first trained in the correct execution of the quadruped exercise on the floor. The practitioner attends to specific body positioning and key movement activities such as:

![Figure 6](image1.png) **Figure 6** Supine bridge using swiss ball locked to board as a point of body contact.

![Figure 7](image2.png) **Figure 7** Spine extension over swiss ball locked to unstable platform.
The start position

- Hands are positioned under shoulders and knees are located under hips.
- Head is positioned in a neutral position whilst holding a gentle chin tuck.
- Shoulders gently push away from hands to fix the scapula to the thorax.
- A gentle lumbar lordosis is held and the abdomen is drawn in to activate the transversus abdominis.

Exercise execution

- Client is instructed to slowly extend either arm holding thumb pointing to the ceiling to increase activity of the lower trapezius. The practitioner at all times observes and instructs on holding good form.
- Next, the client is instructed to slowly push the opposite heel towards the back wall. It is important that the movement occurs from the hip. Incorrect strategies include lumbar spine extension and hip hiking.
- Client is instructed to hold the hip and shoulder extended posture for three to five seconds and then return slowly to the start position. The slow return is an important aspect of the exercise and is performed with grace and poise.
- Repetitions of up to ten either side as well as the other prescribed exercises are conducted daily.

After about a week the client is progressed to the DuraBoard. The client is instructed on the intent of

Figure 8 Unstable platform is used as the support surface for other exercise training tools.

Figure 10 Lunges on the unstable platform.

Figure 9 Quadruped cross crawl exercise on the unstable platform.
the program and reasons for training on an unstable platform.

The Board is set at low intensity challenge and the client is asked to crawl onto the platform. The client will instantly feel the roll of the board. After a short time they will center themselves and get a feel for the orientation task.

When the board is held steady the client is instructed to lift gently either hand. The client is instructed to prevent the board tilting whilst performing the movement. An automatic weight shift occurs and an instant multi-segmentally related muscular strategy is enacted to resist the reactive destabilizing forces working through the body. The client is asked to feel the forces acting between the points of body contact, with the practitioner actively touching the contracting muscular slings to reinforce body awareness.

The other hand can be tested, then either knee. After an awareness of weight shift is experienced, then the client is asked to reproduce the quadruped exercise previously described.

**Conclusion**

A multitude of beneficial effects can arise from a carefully designed exercise program. The many benefits can include improvements in biomechanical function as well as enhanced social, psychological and metabolic performance. Exercise training can have an influence at many levels of human performance.

An increasingly popular form of exercise for fitness training and rehabilitation is the use of labile surfaces to alter the environment in which exercises are performed. Evidence exists suggesting this form of exercise increases the speed and intensity of muscular sling responses involved in multi-segmental stability. Further, labile surface training intends to initiate, educate and enhance the preferred motor control strategies implicated in multi-segmental stability. The author proposes this process occurs through the activation of a motor learning program reliant on mechanistic sensory feedback to develop a sophisticated repertoire of motor control based on the so called perceptual "motor schema".

To fashion a sophisticated adult motor control strategy, the infant must first pass through an intuitively guided exercise program. This program shares many characteristics with adult multi-segmental training programs performed on labile surfaces.

However there are a number of important differences that are not addressed by the present labile surface tools. In response to these concerns the author has developed an innovative labile surface exercise tool that mimics many of the environmental challenges faced by the infant. In this way the author proposes that a unique motor learning experience is created.

The numerous novel features of this device may provide a skillful practitioner with powerful tools to provide enhanced rehabilitation and exercise training programs and may lead to improved outcomes and a speeding up of functional restoration.

**References**