New strategies in the treatment and rehabilitation of the lumbar spine

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**Abstract**  New theoretical concepts in the treatment and rehabilitation of the lumbar spine are proposed. Sequentially applied and practical care approaches based on the functional restoration philosophy proposed by Liebenson are suggested. (A practitioner’s Manual, 2nd edn. Lippincott Williams and Wilkins, Baltimore). This paper concentrates on general care programs involving spinal manipulative therapy, body work and exercise therapy as a continuum of care. The reflex nature of spinal manipulative therapy (SMT) using a high-velocity thrust (HVT) is explored as a possible functional evolutionary lineage of the proposed neuromuscular response. This re-enforces the concept that SMT should not be applied as a stand alone therapy, but should be viewed as a tool providing a ‘window of opportunity’ into which integrate other modalities in a progressive fashion in order to address any presenting motor control disorders.

Low back pain (LBP) is a widespread problem that is generally, poorly understood. Many spinal care professionals appear to lack the ability to consistently and accurately diagnose structural lesions implicated in the generation of LBP. The most sensitive finding we can scientifically come to is either non-specific LBP, or LBP with radicular signs. There is very poor inter-practitioner reliability in the diagnosis of this collection of disorders. Up to 85% of LBP has no definite etiology and is classified as such (Snook et al. 1998).

Practitioners often rely heavily on modern scanning techniques, but these too lack specific reliability. Whilst scanning procedures provide very detailed and sensitive appraisal of the lumbar spine, a closer examination of their diagnostic value is questioned (Karppinen et al. 2001). A recent study of MRI scans indicates that approximately 52% of pain-free subjects have disc bulges and approximately 24% have a disc prolapse (Weishaupt 1998).

As a virtual epidemic LBP appears even more frustrating. It is one of the most frequent and disabling health problems with many studies indicating 80% of the population will suffer LBP in their lifetime. In the United States, LBP costs about 24 billion dollars a year,
and 5.6% of the population suffer this crippling illness every year (Loney & Stratford 1999).

**Prescription strategy**

Present therapies have varying degrees of success in the treatment of LBP. There are a multitude of approaches presently available for the treatment of LBP. Some of these are definitely contra indicated for most LBP complaints, i.e. bed rest (Slipman et al. 2000). Still other modalities fail to show any real impact on improved outcomes for most musculo-skeletal injuries — i.e. heat packs and ultrasound (Pinnington 2001). Ultrasound treatment in most studies appears to have been shown to be as effective turned off as turned on (Pinnington 2001, Vander Windt et al. 2001).

The jury is still out on the effective use of some aspects of body work and exercise therapy. The specific application of these therapies is still in its infancy. Most studies on body work or exercise therapy fail to utilize a 'prescription' strategy when applying care. A prescription strategy is the sequential application of various modalities aimed at the restoration of normal neurologic, energetic, biomechanical and cognitive subsystems (NEBCS) interactive function. Most research into physical therapy modalities have focused on a single care 'stand alone' approach, i.e. comparing a control group to spinal manipulative therapy or a control group to exercise therapy. Viewed in isolation, the true benefits of physical therapy may not be accurately evaluated.

The author believes that spinal manipulative therapy (SMT), body work and exercise therapy need to be applied and studied as a continuum of care providing a sequential and overlapping application of therapeutic modalities. This task-driven approach to care aims to build upon the multi-layered improvements derived from treatment. The goal of functional restoration is to secure an individual the ability to speedily return to activities of daily living. This sequential application of care best describes the prescription strategy.

**Spinal manipulative therapy**

SMT provided by qualified and skilled practitioners forms part of a care practice offering rapid and effective relief of subacute LBP. The positive effects of SMT may include improved biomechanical function (Lehman & McGill 2001, Keller & Colloca 2000), enhanced soft tissue repair (Gibbons & Tehan 2001) and neuro-muscular reflexive changes (Budgell 2000, Bolton 2000, Dishman & Bulbulian 2000, Haldeman 2000).

Recent use of infra-red scanning techniques to monitor the wavelet activity during diastolic and systolic blood flow in fine digital capillaries before and after SMT may provide further insight into its reflexive nature (Haynes 2002c).

The information from the light electronic photography (LEP) monitoring the activity of the fingerfold capillaries is assembled and formatted in a computer, that in turn creates a highly sensitive systolic and diastolic blood flow graph resulting from the digital capillary bed (Grace 1997).

Much fluctuation in the normal diastolic and systolic flow is noted, referred to as wavelet activity (Pellar et al. 1985, Shore et al. 1995). The wavelets are illustrative of the specific activity at the particular assessment site, at that instant. It is believed the device records the general ‘tone’ of the autonomic nervous system (Grace 1997).

A single case study conducted by the author using such methods provided the following data.

1. Pre-adjustment reading (see Graph 1) provided normal

**Graph 1** Pre-adjustment reading.
The practitioner then applied specific SMT high-velocity thrust (HVT) to correct previously sites of apparent dysfunction (identified using static and motion palpation). These sites were: right posterior ilium, fixated fourth and fifth thoracic spinal articulations, and right posterior transverse process of C2.

1. Post-adjustment (see Graph 2), a dramatic settling of wavelet activity noted 10 min after SMT.
2. Post-adjustment reading 2 and 3 (see Graphs 3 and 4) taken approximately 1 h and then 2 h after SMT. During this time there appears an extremely hyper-facilitated wavelet response.
3. Post-adjustment reading 5 days later reading returns to normal (see Graph 5).

If this technology is as accurate as indicated by the manufacturer (Grace 1997), then the micro-hemodynamic response documented, may provide further evidence of a reflex motor-sensory modulation effect provided by SMT (see Box 1, Fig. 1). It may also prove to be a valuable clinical tool if there is future research indicating its validity in measuring post-SMT reflexive responses.

**SMT and chronicity**

However, effective SMT is in the treatment of sub-acute LBP, evidence suggests it poorly addresses the prevention of re-occurrence and patterns of chronicity. The author believes SMT provides a window of opportunity to integrate complementary therapies aimed at dysfunctions involving *neurological, energetic, cognitive and biomechanic sub-systems* (NECBS) (Fig. 2).

The neurologic element involves the neural pathways and synapses that connect with, and form the central nervous system. The energetic element is the muscular...
system and the synergy of muscles active in movement formations. The cognitive element is the higher perceptual function that provides for abstract elements in our relationship with ourselves and the external environment. Finally, the biomechanic sub-system represents the bony and articular units that provide muscle attachments and osseous levers (see Fig. 3).

To achieve improved outcomes, new techniques as well as properly applied standard practices need to be implemented to complement any gains from SMT. A practitioner is required to recognize the need to quickly progress a client from a therapist-dependent passive care paradigm through to progressive active care solutions, whilst incorporating education and self-help tools to empower the LBP sufferer (Liebenson et al. 1996).

Functional care encompasses such an approach. These programs involve the assessment of skills an individual requires for efficient locomotion. Impediments to normal locomotion involving NECBS can be multi-factoral (see Figs 3 and 4). If these impediments are linked to pain generation, then a sequential, multi-skilled program is presented to treat and rehabilitate movement dysfunctions.

The functional care system is a progressive care approach utilizing a ‘prescription strategy’ involving SMT, body work and exercise therapy as a continuum of care (Liebenson et al. 1996); as opposed to single care, ‘one size fits all’ practitioner-dependent approach to neuro-musculo-skeletal disorders.

The multi-factoral inputs in LBP generation have been well established by many studies over the last decade. The importance of integrated interdependent function of NECBS in efficient movement outcomes and the resultant loss of efficient movement outcomes because of NECBS dysfunction is constantly linked to pain generation (Hodges & Richardson 1997, 2003).
Box 1 Theory of reflex sensory motor modulation

It is proposed that SMT may provide a circuit breaker within sub-conscious sensory-motor control mechanisms to allow time to reassess engram programming that may have provided faulty and inefficient homeostatic reactions (see Graph 2).

It may be a mechanism that the self-programming nervous system utilizes as a type of 'virus scan' program initiator for faulty or inefficient engram settings. Soon after an adjustment a hyperfacilitated wavelet response may represent a period of trial and error of sensory-motor settings as the system searches for the most suitable homeostatic response (see Graphs 3 and 4) (Haynes 2002c).

The author proposes that the evidence suggests a long-acting reflex sensory-motor modulation of tissue structures distant from the adjustment site occurring in some individuals, in certain circumstances. The author has used the device on six clients and the long-term wavelet response in two individuals was absent. Interestingly, those without the long-term wavelet response also presented with chronic health problems. It is possible that the lack of long-term wavelet response in two subjects may also imply a lack of specificity in the practitioners diagnostic and/or therapeutic skills.

The author also believes the sequence of events occurring after SMT and recorded on the LEP may be explained in the following terms:

Specific SMT may provide a reflex settling or modulation of homeostatic subconscious motor responses. This activity, lasting for approximately 20 min, may provide a short period of sensory-motor re-assessment of functional homeostatic engram settings. It is proposed that there is very little involvement of supra spinal structures in this sensory-motor modulation (Haynes 2002c).

The author further suggests such sensory-motor reflex modulation may be part of a primitive response mechanism developed during pre-chordate evolution (Haynes 2002c). It is pertinent that neural maturation, its hierarchical behavior and its morphologic evolution, together with ontogenic learning, are part of a layered process of development. The earliest system becomes part of the sub-system of the next evolutionary solution. It is salient that functional morphology of most human traits can be dissected from specific evolutionary pathways and many of these provide the basis for skillful human environmental interaction (Kardong 2002, Kent 1992).

An understanding of pre-vertebrate evolution, for example, the acorn worm with its neural tube, segmental body structure, nerve ring and rudimentary cephalic structures, may throw some light on the reflex nature of SMT. It is interesting to note the origins of vertebral metamerism may have evolutionary roots in pre-vertebrate segmentalism (Ruppert & Barnes 1994).

Note: there is no evidence, at this time, to support the proposition regarding pre-vertebrate origins of the reflex nature of SMT. The idea appears to sit more snugly within the realms of science fiction. However, the model proposed is an example of looking beyond the ‘water-wheel’ philosophy of mechanistic function and searching the complex pathways and patterns of ‘dynamical systems’ which will be briefly explored later in this article.


Alterations to NECBS may lead to inefficient static and active postures. Adaptive plastic changes then occur through the muscular system and are normally divided into two groups, either prone to tightness or weakness (Janda 2000) (see Table 1). Many resultant dysfunction’s may then arise. The alterations to NECBS with its associated effect on motor control strategies lead to changes in the function of articular motion segments.

Functional characteristics of motion segments

A motion segment or segments can have four functional alterations (Commerford & Mottram 2001a, b):

1. Segmental instability. Low and slow stabilizer muscular recruitment strategy involving one vertebral motion segment. Leinonen et al. (2001), for example, have shown that individuals that suffer LBP have a weak and slow activation of the dorsal stabilizer muscles (Multifidus) in the lumbar spine. Treatment for segmental instability may involve exercises to restore normal reflexive segmental muscular stiffness. The most widely validated segmental spinal stabilizing exercises are those prescribed in the text ‘Therapeutic Exercise for Spinal Segmental Stabilisation in Low Back Pain’ by Richardson et al. (1999) (see part ‘a’ in Box 2).

2. Segmental restrictions. When single vertebral motion segments meet a pathologic barrier leading to a loss of normal articular motion in one or more movement planes. Possible causes of segmental restrictions include excessive joint loading or reflex segmental muscular spasm. Often the areas of segmental restrictions are distant from the site of pain and are key links in providing a ‘window of opportunity’ to integrate other complementary care programs. Treatment may involve SMT or muscle energy techniques on the fixated motion segments.

3. Multi-segmental restrictions. Multiple consecutive motion segments can exhibit reduced mobility associated with a loss of myofascial extensibility. Over activity of segmentally related muscles known as the ‘mobilizers’ (see Table 1) in either active or resting postural tasks, primarily contribute to this presentation. For example, manual therapists have often found the ilio-psoas to be over active in LBP complaints (Janda 2000). When the ilio-psoas is over active, it may lead to an altered posture (lower crossed syndrome).
resulting in numerous biomechanical functional changes (Janda 2000). Techniques aimed at restoring muscular extensibility include bodywork, specific stretching and articular mobilizing techniques (see parts ‘b’ and ‘c’ in Box 2).

Multisegmental restrictions may result from central mechanisms attempting to limit the degrees of freedom available to consecutive motion segments during a movement pattern.

4. Multi-segmental instability. This involves a loss of co-ordinated balanced interplay between muscle groups required to achieve an efficient movement outcome whilst holding multiple motion segments stable within the field of gravity. When putting all the above-mentioned dysfunctional patterns together, a picture of a loss of preferred motor control strategy replaced by an alternate one is seen, and is exemplified by

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**Fig. 1** Proposed model for reflex sensory-motor modulation.
a pattern known as multi-segmental instability. This is illustrated by poor global movement patterns, particularly in walking and stand to sit activities seen in LBP patients (Selles et al. 2001). Treatment may involve core stabilizing exercises and may incorporate unstable surface devices (see part ‘d’ Box 2).

Muscular and neurologic plasticity

When there is a change in demands placed upon a muscle or groups of functionally related muscles adaptations and alterations to muscle patterns may take place. If a permanent muscular function adaptation develops, the process is known as ‘muscular plasticity’ (Herzong et al. 1999).

The ability of the CNS to alter the pattern of movements under its control, influenced by a multitude of events, can lead to permanent adaptations mediated through CNS control (Herzong et al. 1999). This is termed ‘neurologic plasticity’.

The changes seen in motor control patterns involving muscular and articular functions are established in the repertoire human movement by alterations in synaptic functions mediated by neurotrophins and other proteins (Herzong et al. 2000, Schindler & Poo 2000).

Neurotrophin and synaptic plasticity

Muscular function alterations (muscular plasticity) involve genetic encryption’s facilitated by neurotrophin effecting the function of neural pathways (neural plasticity) and facilitated by an individuals environment, task, skill and practice over time (Bittner &
During development, sets of genes can be expressed at particular times with pre-specified roles that provide functions – expressed as proteins. These proteins are reliant on the environment in which they are expressed (Schinder & Poo 2000). Such a protein group is known as the ‘neurotrophins’ (NT). NT is a nerve growth factor (NGF).

The infant nervous system is most susceptible to the influences of NGFs, but evidence also indicates
The adult nervous system can also be affected by similar changes (Snider 1994). The adult human brain also has the ability to adapt and alter neuro-functional expressions in response to experiential and environmental factors.

NGF’s including NT influence the development and establishment of pathways involving sensory input, central processing and motor effector nerves during a life span (see Fig. 4).

Repetitive neuronal activity increases the likelihood of the expression, secretion and activity of NT at a synaptic level (Snider 1994). The level of secretion of these molecules can increase or decrease synaptic transmission and alter the relationship of these synapses to other synapses.

NT effects can be (Schindler & Poo 2000):

(i) To change pre-synaptic transmission release and effect post-synaptic sensitivity.
(ii) To provide ongoing maintenance of neuronal circuitry in response to centrally mediated demands.

**But how does dysfunction develop**

It is proposed that the progressive development of more sophisticated motor strategies during the advancement from early, intermediate and finally mature motor responses – from infant to adult, can provide the necessary basis for systematic dysfunctional
changes to evolve in the adult. This may be due to the actions of the many complex influences, both predictable and unpredictable that effect motor development and motor performance (see Box 3).

**En Bloc**


The lumbar spinal articulations are effectively ‘locked-down’ to the pelvis providing the unskilled neural control mechanism with ‘training wheels’ that should lead to the development of more skillful movement patterns in time, with practice. The *en-bloc* skill produces a reduction in the degrees of freedom available to consecutive spinal articulations to enable the safe practice of upright locomotion and allow pursuit of alternative movement tasks (Whiting 1984, Assaiante & Amblard 1995). This skill allows a conservatism of neurologic focus for upright standing and locomotion whilst a stable environment for the practice of associated multiple motor tasks take place (see Box 4).

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**Table 1** Comparing the function of muscles prone to tightness and those prone to weakness

<table>
<thead>
<tr>
<th>Local muscle system</th>
<th>Global muscle system</th>
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<tbody>
<tr>
<td>Stabilizer</td>
<td>Mobilizer</td>
</tr>
<tr>
<td>Phasic muscles</td>
<td>Tonic muscles</td>
</tr>
<tr>
<td>Often supplied by large alpha a1 motor neurones</td>
<td>Often supplied by small alpha a2 motor neurones</td>
</tr>
<tr>
<td>High in white muscle fibers</td>
<td>High in myoglobin–red muscle fibers</td>
</tr>
<tr>
<td>Commonly under subconscious control</td>
<td>Are under conscious control</td>
</tr>
<tr>
<td>Mostly segmentally attached</td>
<td>Mostly large multi-segmental muscles</td>
</tr>
<tr>
<td>First to fire to create ‘muscular stiffness’</td>
<td>High in stamina to accomplish full range of movement strategies</td>
</tr>
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</table>

**Features in dysfunction**

<table>
<thead>
<tr>
<th>Prone to weakness</th>
<th>Features in dysfunction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lose their normal speed and strength of reaction in dysfunction</td>
<td>Prone to tightness</td>
</tr>
<tr>
<td>Increased resting length</td>
<td>Often become over-active in dysfunction</td>
</tr>
<tr>
<td>Often have infiltration of fatty tissue into muscle matrix</td>
<td>Decreased resting length</td>
</tr>
<tr>
<td>Often atrophy</td>
<td>Often develop trigger points</td>
</tr>
<tr>
<td></td>
<td>Often hypertrophic</td>
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**Box 2** New techniques to treat and rehabilitate the lumbar spine

A brief summary is provided of techniques that the author has devised in response to the alternative motor control patterns that will be explained in future articles in JBMT:

(a) **Side posture multifidus reactivation technique.** The author proposes a new skill that may reactivate the multifidus contraction strategy (it remains scientifically untested). This activity may be lacking in some individuals suffering low back pain (Hides et al. 1994, Leinonen et al. 2001). The program provides for a simple pass/fail test to assess the health of the multifidus firing pattern. The technique then aims to cognitively restore reflex activity of the multifidus muscle using a biofeedback skill to restore awareness and perception of the desired contraction strategy. A progressive program of contraction restoration can be provided that allows quantification of skill and provides documentation of skill acquisition.

(b) **Motor synergy co-release technique.** An active release technique to simultaneously release the overactivity in quadratus lumborum and ilio-psoas.

(c) **Motor synergy co-release stretch.** A self-help tool to simultaneously elongate the ilio-psoas and quadratus-lumborum.

(d) **Unstable platform device.** The author has designed and has a patent pending on a dynamic, progressive and quantifiable rehabilitation and exercise device to promote multi-segmental stability and orientation.

The board provides a functionally relevant, versatile surface to perform core stabilizing movement activities. The device converts a flat earth exercise into a functionally challenging client specific labile environment (Haynes 2002a, b). The device also provides a progressive quantifiable program allowing for documentation of start up skill and skill acquisition (Haynes 2002a, b).

Incorporated in its design is the concept of multi-segmental stability training as an act that ‘re-invents the wheel’. In effect it provides an environment that mimics that which is first encountered by an infant when learning a new movement skill. (Core stability training only imitates the evolutionary mastered exercise program innately provided to the developing infant.)
Based on the specifics of the task at hand, the dynamical systems theory describes the workings of any complex system. For example, the weather can be analyzed in similar terms. The multiple factors that provide for weather patterns lead to a threshold of activity that triggers an event. Even with such complex and seemingly unpredictable events, patterns emerge (seasons) and such features can be used to help predict probabilities of future events (El Nino).

The dynamical systems theory is useful for presentation and avoids the complex jargon of this area (Mitra et al. 1998). However, if we discover the intent and avoid the complex jargon of this theory, it may provide a useful package to better understand the individual with their individual presentations. Ideally, we should work towards discovering the simple patterns that develop from the complex human–environment–task model.

Incorporated in its design is the concept of multi-segmental stability training as an act that ‘re-invents the wheel’. In effect it provides an environment that mimics that which is first encountered by an infant when learning a new movement.
At around 7 years of age, the en bloc is normally replaced by the previously shelved ‘articulated’ strategy and coincides with reintegration of vestibular and somato-sensory mechanisms with the previously dominant visual skill (Assaiante 1998).

The en bloc may persist into adulthood (Assaiante and Amblard 1995). The author also believes that en bloc may also replace the articulated strategy in the adult due to injury, lack of use, habitual postures, etc.

The adult en bloc utilizes the alternative training skill that requires excessive antagonist/agonist co-contracture of axial muscles leading to greater metabolic demand and higher joint loading characteristics (Milner 2002).

The author believes that the en bloc may involve the synergistic dysfunctional overactivity of ilio-psoas and quadratus lumborum because both muscles:

1. are located close to the individual vertebral axis of rotation (Bogduk 1997),
2. have lumbar spinal segmental attachment (Bogduk 1997),
3. have caudal direction of pull (Bogduk 1997),
4. have attachments to the pelvis and thorax (Bogduk 1997),
5. are morphologically hypaxial spine or hip flexors in most mammals (Kent 1992). It is not till human evolution that specialized structural mechanisms for bipedal verticalism led to the repositioning of the previously hypaxial quadratus lumborum into a position as a weak spine extensor (Kardong 2002, Kent 1992).

Therefore, structurally, morphologically, biomechanically, neurologically and functionally both quadratus lumborum and ilio-psoas are linked.

The author proposes that in adult dysfunction these muscles may act as en bloc synergists perhaps activating old mammalian neurologic mechanisms.

The en bloc strategy is effective as a training program in the infant but if it presents in the adult, as theoretically proposed, can be dangerous and ineffective because of:

1. extra size, weight and distance between articulating segments,
2. requirements to perform complex and physically demanding activities,
3. the ability to generate much greater torque,
4. the distance from base of support to centre of mass is much greater.

The theoretical en bloc in adults can lead to loss of myo-fascial extensibility by limiting the degrees of freedom available to articulations during movement tasks, compensatory movement dysfunctions, altered postures, visco-elastic fatigue, overload and eventual tissue failure.

It is implied that en bloc in the adult coincides with a loss of segmental stiffness associated with an overall change in motor control patterns. Associated with the adult en bloc are other systematic motor control strategy alterations that are originally part of the transitional motor control skills exhibited in the infant from early unassisted standing lasting to the age of about 4–6 years (Woolacott & Assainte 2002). Interestingly, the en bloc in the infant and the dysfunctional motor control in the adult with LBP show similar motor control characteristics to that of the elderly. These similarities are listed in Table 2.

The adult en-bloc strategy is complicated by the secondary adaptations that develop due to the multitude of complex predictable and unpredictable events influencing the ever evolving neuro-musculoskeletal system producing an individual specific functional unit. (The en-bloc strategy may be covered in greater length in a future article.)

### Table 2

**Comparison in gait characteristics between the infant to six years, after six, the healthy adult, the adult with LBP and the elderly**

<table>
<thead>
<tr>
<th>Infant 4–6-year old ‘en bloc’</th>
<th>Adult and post 7 year old motor control</th>
<th>LBP motor control</th>
<th>Elderly motor control</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Step frequency is lower</td>
<td>Normal step frequency</td>
<td>As with infant</td>
<td>As with infant</td>
</tr>
<tr>
<td>(b) Double support duration longer</td>
<td>Shorter double support phase</td>
<td>As with infant</td>
<td>As with infant</td>
</tr>
<tr>
<td>(c) Head and trunk stiffness is higher (en bloc strategy)</td>
<td>Present with the mature ‘articulated’ strategy</td>
<td>As with infant</td>
<td>As with infant</td>
</tr>
<tr>
<td>(d) Co-ordination of lower limb movements lower</td>
<td>Skillful co-ordination of limb movements</td>
<td>As with infant</td>
<td>As with infant</td>
</tr>
<tr>
<td>(e) Wide base of support</td>
<td>Base of support within normal limits</td>
<td>As with infant</td>
<td>As with infant</td>
</tr>
<tr>
<td>(f) There is an in phase co-ordination of thorax and pelvis during walking</td>
<td>Out of phase pelvis-thorax co-ordination at preset walk speed</td>
<td>As with infant</td>
<td>As with infant</td>
</tr>
<tr>
<td>(g) Absence of mature postural responses characterised by APA’s</td>
<td>APAs are present</td>
<td>As with infant</td>
<td>As with infant</td>
</tr>
<tr>
<td>(h) Greater postural sway in early walkers compared to more mature infants</td>
<td>Less postural sway than in infants or elderly</td>
<td>As with infant</td>
<td>As with infant</td>
</tr>
</tbody>
</table>

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skill. (Core stability training only imitates the evolutionary mastered exercise program innately provided to the developing infant.)

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