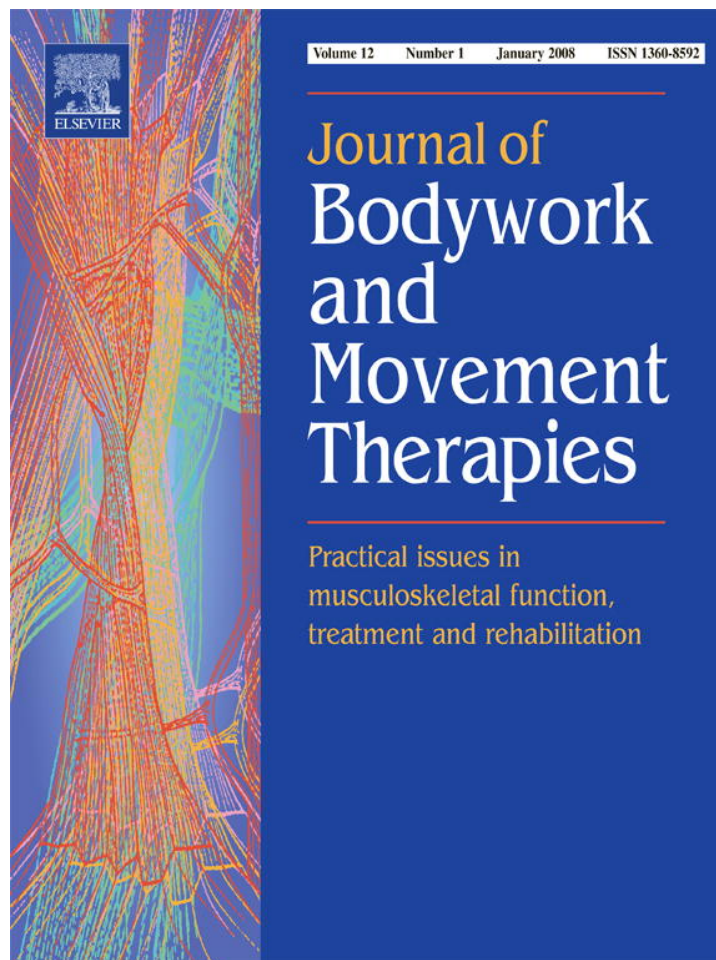


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CLINICAL PHYSIOLOGY

A model of movement dysfunction provides a classification system guiding diagnosis and therapeutic care in spinal pain and related musculoskeletal syndromes: A paradigm shift—Part 1

Josephine Key, Dip. Phys, PGD. Manip. Ther.* , Andrea Clift, B. App. Sc. (Phys), Fiona Condie, Dip. Phys; Masters (Manip), Caroline Harley, MSc, MACP, SRP

Edgecliff Physiotherapy Sports and Spinal Centre, Suite 505 Eastpoint Tower, 180 Ocean Street, Edgecliff, N.S.W. 2027, Australia

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Summary An integrative functional model largely based upon clinical observation and analysis of the more common features of neuromusculoskeletal-dysfunction encountered in clinical practice is presented as a working hypothesis in Part 1. This endeavours to incorporate contemporary knowledge and practice.

The enlightened work of Professor Vladimir Janda has undoubtedly been seminal in the development of this model; however a further evolution of his work is elaborated on in this paper. Thinkers from the human potential movement as well as the scientific community have provided further valuable insights to assist our understanding of function.

A related simple classification system of two main clinical subgroups with back pain and related disorders is offered in Part 2. These are based upon the most usual dysfunctional postural and movement strategies. Further distillation provides a number of dysfunction syndromes which will have predictable consequences.

This is not a mathematical, computer generated or theoretical biomechanical model. This model describes 'what it is' that we see in our patients, and endeavours to be an overview of the movement related causes of back pain. It provides a clinically useful and practical framework to assist the practitioner in diagnosis and to

*Corresponding author. Tel.: +61 02 93261168; fax: +61 02 93281695.

E-mail address: edgecliffphysio@iprimus.com.au (J. Key).

URL: <http://www.edgecliffphysio.com.au> (J. Key).

better understand the development and perpetuation of most spinal pain and related disorders. In so doing, more rational, functional and effective manual and exercise therapy interventions can ensue.

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A model of neuromusculoskeletal dysfunction principally of the torso

Achieving consistently successful therapeutic outcomes in the treatment of spinal pain and related disorders can remain an elusive problem in the clinical setting.

Perhaps the focus has been too specific to the lumbar spine, without understanding its functional relationship to the rest of the axial skeleton, including the occiput and proximal limb girdles—all of which function as an interrelated system.

Highly complex neuromuscular function is required if we are to effectively exist and move in a gravity based environment. Movement control is learned and becomes automatic with the option for some voluntary control. A normally functioning postural reflex mechanism underpins and provides this complex normal neuromuscular function.

Neuromuscular dysfunction is the result of a changed adaptive response to our environment—gravity, stress and the postural and movement demands of our work, sport, recreational and leisure pursuits—the way in which we live and manage our lives coping with the physical, mental and emotional challenges which occur.

In patients with spinal pain and related disorders, this neuromuscular dysfunction appears to fall into certain predictable, common patterns of response. While each person with back pain presents individually, we can clinically observe the tendency for some common features, which can be collated into a general paradigm of dysfunction—a framework from which to analyse and understand the presenting patient.

The recognition of underlying motor control impairments and the need for a related classification system of clinical subgroups with back pain has been advocated by Sahrman (2001, 2002), O'Sullivan (2005, 2006) and Dankaerts et al. (2006a).

This model offers a simple classification of clinical subgroups with back pain based on the altered strategies they adopt for postural and movement control. These underlying changed patterns of response appear to be an inherent tendency which we variably yet consistently observe in the young and old, from the elite sportsman, yoga practitioner to the office worker and the couch potato. Appreciating the features of the

model as outlined, guides the assessment process and provides predictive and preventative insights—the presenting symptom picture usually being an acute or subacute episode on a variable picture of underlying neuromusculoskeletal dysfunction at various stages of disorder.

The postural reflex mechanism

Good movement control requires good postural control which is dependent upon normal functioning of this system. This is not present at birth but the motor development of the infant will become highly complex and varied. This includes the development of the righting, equilibrium and other adaptive and protective reactions, which allow the development of motor skill in a gravity-based environment (Bobath, 1966, p. 1).

The actions mediated by the normal postural reflex mechanism essentially involve small shifts and adaptive movements of the axial skeleton and proximal limb girdles. They become learned automatic responses in the process of our sensorimotor development. They are a necessary prerequisite and form the background of control upon which all economical skilled actions of the torso and limbs can occur. The system is dependent upon gravity, suitable demand and adequate proprioceptive and other afferent information for its well-being.

The quality of mature motor behaviour is variable. In some, full integration and transformation of the primitive reflexes and early responses fails to occur, despite normal development in other areas, resulting in less effective proprioceptive and motor integration. Janda (1978) has written eloquently about the subtle sensorimotor dysfunctions seen in patients with entrenched spinal pain and related disorders.

Ideally, we demonstrate a “central intelligence” in the torso—balancing upright control, movement and breathing in an energy efficient manner.

Classification of muscles

Structural and functional classifications of muscles have been attempted by many.

Janda (1980) considered that impaired central motor regulation results in defective or uneconomical movement patterns because of imbalanced action between two structurally and functionally different muscle groups—The Postural Muscles—prone to overactivity and tightness which tends to create relative underactivity, inhibition and/or weakness in the antagonistic Phasic Muscles (1987a). His nomenclature is confusing for our purpose as you will see. However, conceptually and functionally his approach is very helpful.

Bergmark (1989) examining stability in the lumbar spine, presented a concept of functional muscle classification into local and global muscles as they acted to control local stability in the lumbar spine including transfer of load between the thorax and pelvis. This paper has been very influential and often quoted. This is interesting, as his is a study in mechanical engineering looking at forces and load transfer rather than functional control of movement. Of concern is that he admits that how the CNS controls loads is not sufficiently understood to allow detailed modelling (p. 12); does not include iliopsoas in the local system or accord it any role in lumbar control (p. 20); and considers the thoracic cage as a rigid body (p. 31. p. 48), While his muscle classification principle is useful, it needs to be applied to more than the lumbar spine and we need to appreciate that control of the lumbar spine will be dependent upon control through the entire axial skeleton.

We propose a model that encompasses a similar polarity of spatially defined muscle function but applied to the body as a whole. Systemic local function balanced by systemic global activity. In health, the whole functions dynamically to permit grace, economy of effort in fruitful and refined action.

This classification is functionally related and conceptual as no muscle or system works in isolation but as part of a coordinated synergy between the systems related to need.

The systemic local muscle system (SLMS)

We propose that the role of the SLMS is more closely linked to the underlying functions of the normal postural reflex mechanism: providing antigravity support and the more 'intrinsic' movements—spinal segmental control, small postural shifts and adjustments, discrete movements and also respiration. The muscles work synergistically in patterns as a coordinated system response.

The muscles in this system are deep, providing *inner support and control of the axial skeleton and around the body's centre of gravity*. They may be uni or poly segmental.

Their early activation prior to a movement occurring (Hodges, 1999; Hodges et al., 1999; Mosely et al., 2000) renders the torso as an adjustable, yet stable base of support to allow for more effective and even forceful actions of the large more superficial global muscles as required. Their early action is also necessary to create appropriate axial 'postural sets' for effective control of head and limb movements.

The muscles in this system are more akin to Janda's Phasic Muscles—they appear to have an inherent tendency to hypotonia, atrophy and inhibition and to be less readily activated in movement patterns particularly under conditions of pain, injury, fatigue and stress (Janda, 1968, 1987a; Janda, 1984, 1985, 1989, 1995).

However, there are some important differences:

- We feel it is this system that has a greater role in basic postural control. Janda (1963) saw his Postural Muscle group as more important in postural control.
- Janda was more concerned about the effects of the postural muscles and clearer about classifying them. Those classified as phasic were less numerous (Janda, 1987a). He stated that those muscles he had not classified "can be described as neutral or not yet determined" (Janda, 1980) or "doubtful" (Janda, 1986). We have included more muscles in this system than Janda did.
- He did not necessarily see the Phasic Muscle activity as a deep or systemic response.
- We feel iliacus and psoas are important inclusions in this deep system. Janda classified them in his postural group.

Optimal movement function depends on adequate sensory input into and from this system (Kuno, 1984). Normal studies involving reduced mechanical loading or microgravity and related reduced proprioceptive input have demonstrated atrophy and conversion of these deep muscles from slow tonic firing to more phasic function (Richardson, 2001, 2005).

Their efficient action promotes a supple upright-ness—'buoyancy', elongation, opening, and flexibility of the torso. When the system is working well, the person has equipoise, grace and lightness in movement.

Suggested classification of muscles belonging to the SLMS (influenced by Janda, 1987a)

1. L/S 'cylinder' as known: Transversus abdominus; Lumbar multifidus; Pelvic floor; Diaphragm
 2. Rotatores interspinales intertransversarii entire axial spine—proprioceptive role+
 3. Multifidus of axial spine—1° deep
 4. Intercostals
 5. Iliacus; Psoas
 6. Deep neck flexor group
 7. Deep abdominal group; 1° lower Tr.A; IO
 8. Quad. lumborum—1° medial
 9. Glutei— × 3
 10. Lower scap. stabilisers /adjacent deep intersegmental muscles
 11. Deep rotators hip and shoulder
 12. Intrinsic foot muscles
 13. Jaw, masticatory, speech mms
-

Classification of Global system muscles related to torso function [after Janda—the Postural Muscles] (Janda, 1987a)

1. Some erector spinae 1° T/L; C/T
 2. Superficial abdominals
 3. Quad. lumborum—lateral
 4. Lat. Dorsi—especially lateral
 5. Pectorals—major; minor
 6. Serrati—ant; post—sup & inf.
 7. Sternocleidomastoid
 8. Scalenes
 9. Upper trap; levator scapulae
 10. Hamstrings
 11. Piriformis
 12. Hip flexors—RF. TFL.? Psoas
 13. Short hip Adductors
 14. Flexors of the upper limb
 15. Extensors of the lower limb
-

The systemic global muscle system (SGMS)

This system equates to Janda's Postural Muscle group (Janda, 1980, 1987a); and Bergmark's (1989) Global muscles, with subsequent adoption by Richardson et al. (1999, 2000), O'Sullivan (2000, 2004) and Comerford and Mottram (2001).

These more superficial muscles provide for the more 'extrinsic' movements and are activated in situations of larger perturbations of the torso and situations requiring large movements, 'actions' and effort. They require a stable and adaptable base of support provided by good preceding systemic local muscle activation.

They have an inherent tendency to be easily activated (O'Sullivan et al., 2006), strengthened and dominate in posture and movement patterns in low and high load situations and are prone to tightness (Janda, 1987a). *Their action is increased in states of pain, fatigue, stress and effort or when working out new or complex movement patterns (Janda, 1980).*

A generally overactive global system will manifest in the person moving in a loping, heavy and somewhat grounded and awkward manner. This system is dominant in states of action, stress, tension and effort—the 'flight and fight' response with related sympathetic dominance.

Of note

Depending on the neuromuscular strategies a person adopts, muscles belonging in one functional system may begin to act as the other, e.g. superficial abdominals may become weak/under active; psoas may become overactive and tight and act as a global muscle.

Clinically, Kendall et al. (1993, p. 152) observed differences in the length and activation between the upper and lower abdominal group as a whole—upper strong, lower weak were most common, followed by both upper and lower weak.

Urquhart (2004) presented a study showing regional variation in the structure and recruitment of transversus abdominis in a normal population.

Control of movement

The control of movement is a very complex subject. In the ideal normal state, we see neural organisation which allows appropriate timing and coordinated activation between the two muscle systems, in the execution of an infinite variety of patterns of adaptable postural adjustment and related movement synergies according to need. All movement stems from a starting point or posture. The dynamic

'postural set' largely provided by early and adequate activity of the SLMS will determine the quality and pattern of the ensuing movements. Sophisticated movement is reliant upon well-developed axial control. This will of course include spinal stability and spatial antigravity control.

There is a tendency to think of upright posture as a static representation, but functionally 'there is always a movement' (Wildman, 2003) or adjustment, albeit slight, in order to maintain antigravity equilibrium.

The dysfunctional state

Our clinical observation supported in part by frank and extrapolative research findings shows that patients with spinal pain syndromes consistently show imbalance in the activity and timing between the two systems and in the strategies they adopt to organise body alignment, postural control and movement.

The observed tendency is that systemic local muscle system activity is:

- *Delayed* (Hodges and Richardson, 1996, 1998; Hungerford et al., 2003).
- *Inadequate with relative underactivity, inhibition, weakness* (Hides et al., 1996, 2000)—"the shy muscles".
- *Poorly sustained* low grade tonic activity—they develop a higher ratio of fast to slow twitch fibres and become more phasic (Mannion et al., 1997)—"shy muscles".
- Show more *stereotypical and inappropriate patterns of axial postural presetting and control*.

This will affect the functions ascribed to the normal postural reflex mechanism and result in variable dysfunctional control of posture to support movement.

In conjunction, the observed tendency of systemic global muscle system activity is that it is:

- *Early*—preceding SLMS activity (Hungerford et al., 2003).
- *Over active and dominant* in patterns of abnormal activation for antigravity control and movement (Dankaerts et al., 2006c).
- These muscles are *easily strengthened, hypertrophy and become tight and short* (Janda, 1987a) "the bullies"—they are generally the ones that everyone is obsessively stretching!!
- *More tonically active* rather than phasic as the

system becomes co-opted into a more postural role (Gleeson, 2001). The patient 'holds himself up' against gravity and then often cannot voluntarily let them go—particularly around the body's centre of gravity.

- Normal studies have indicated that these muscles become more active in situations involving reduced gravitational loading and related decreased sensory input (Belavy et al., 2005).

When overactive, the global muscles of the trunk can act to shorten, compress and constrict parts of the torso—acting rather like very tight outer clothing, while the behaviour of the SLM's resembles loose old underwear instead of firm elastic yet flexible supporters!

In the dysfunctional state, a reciprocal relationship evolves whereby reduced deep system activity necessitates the adoption of more superficial system strategies, which in turn inhibits or disallows effective deep system activation. The dysfunction becomes reinforced, perpetuated and entrenched.

As posture and movement control is largely an automatic function, this repeated adoption of the abnormal strategies means they become *habitual, learned* and begin to *feel normal*—"Habituation is the simplest form of learning—a slow, relentless adaptive act, which ingrains itself into the functional patterns of the central nervous system" (Hanna, 1988, p. 53).

We have noticed in our spinal pain population, a tendency for two main forms of basic muscle tonus—those who have 'lower tone' and are 'looser' with more of a tendency to antigravity collapse, and those whose tone is more hyperactive with general tightness, tension and stiffness. This could be an expression of subtle primary CNS dysfunction (see Janda, 1978, 1987a)—the clumsy kid. Janda (1977, 1987b) has also drawn attention to the similar patterns of excess 'postural muscle' activity seen in postural problems and those with spastic syndromes.

Also, we agree with Janda (1968, 1987a) that secondary subtle CNS dysfunction results from altered demand and inadequate sensory input and proprioceptive control related to modern living. Imbalanced action between the SLMS and the SGMS, as well as within each system will be the result. Adequate activation is more difficult in those with a tendency to low tone, while inhibition is more difficult in the overactive group. All will have difficulty with activation of the deep system and inhibition of the superficial system albeit to varying degrees.

Clinically observed functional sequelae of muscle system dysfunction

The patient, over time, begins to deal with gravity and movement in a more primitive, coarse manner. We have discerned 12 significant and interrelated features as an expression of this imbalanced activity. Of necessity they are presented in summary:

1. *Difficulty resolving being 'up' and moving against gravity*—the deep system is somewhat

'switched off' and so when upright he will tend to hang/sag/collapse relying on passive ligamentous support and /or seek external passive support. He finds it difficult to modulate flexor/extensor activity to correctly align his spine so that the occiput is balanced over the sacrum. Control of the body's centre of gravity is affected. He will display general or regional lack of extension control and rely on abnormal SGMS activity e.g. thoraco-lumbar erector spinae (Dankaerts et al., 2006b). This quickly

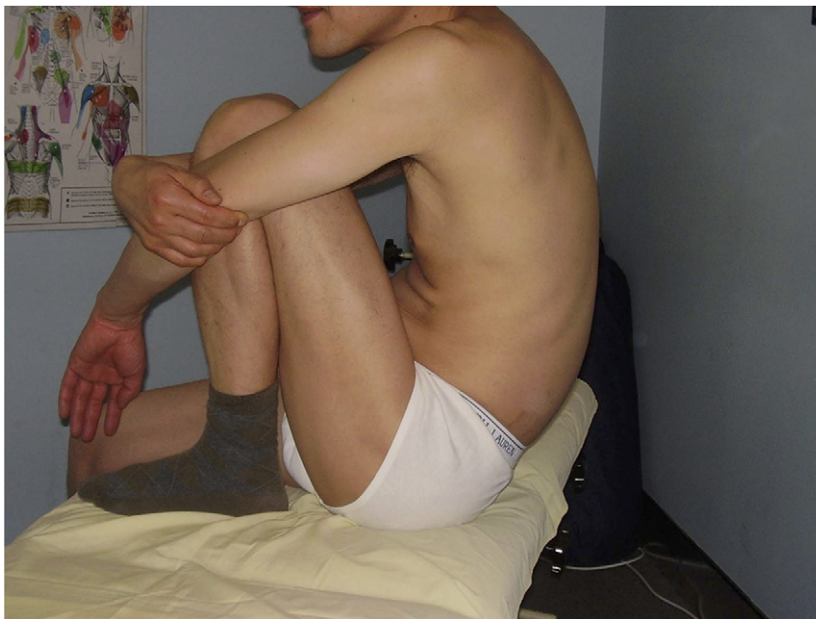


Figure 1 *Passive collapse*: note how he also hangs off his arms!—The deep system is off!



Figure 2 *Over activation of the superficial system*: note the use of a more primitive gross extension pattern.

becomes tiring and so he collapses again. He adopts either of two extremes—passive collapse or over activating various global muscles. Thus he cannot achieve a non-effortful 'up' via his deep system (Figs. 1 and 2).

2. *Defective pelvic control* is universal and considerable. This feature alone deserves its own paper. However, for now, the dysfunction is apparent in the following ways:

- Difficulty achieving activation of the SLMS for *intra pelvic control* and related.
- *Difficulty controlling the position of the pelvis in space, and movements of the pelvis on the legs and the lumbar spine.* The patient attempts to control the pelvis by abnormal SGMS activity around the centre of gravity of the body, which then becomes over stabilised while lumbar control and spatial pelvic positioning and control is diminished.
- *Deranged spatial pelvic control* manifests as:
 - an increased anterior or posterior shift from the neutral position and related diminished rotation in two planes (Fig. 3):
 - In the sagittal plane: the pelvis tends to be postured and moved from either excess posterior or anterior rotation—with diminished counter rotation.

- In the horizontal plane: diminished control of ipsilateral backward and/or forward pelvic rotation will affect adaptive postural pre-positioning of the pelvis to support lower limb movements.

Gracovetsky (1997, p. 244) proposes that this rotation of the pelvis in the horizontal and sagittal plane is important in driving the transmission of movement up through the spine in walking.

- *The position of the pelvis (sacrum) in space will affect the alignment and control of the rest of the axial skeleton.* When the pelvis is posteriorly rotated as is common, the neutral lumbar lordosis is lost. This will affect and jeopardise segmental control, transmission of the movement wave and control up the spine including rotation amongst other things.

3. The patient has *reduced selective initiation of small subtle movements from within the spine and proximal limb girdles.* The under-active deep system makes it *difficult to get intersegmental movement in the stiff regions* while at the same time he finds it *hard to control movement in the relatively mobile regions*, e.g. lumbar and cervical spines. These small movements and adjustments are critical

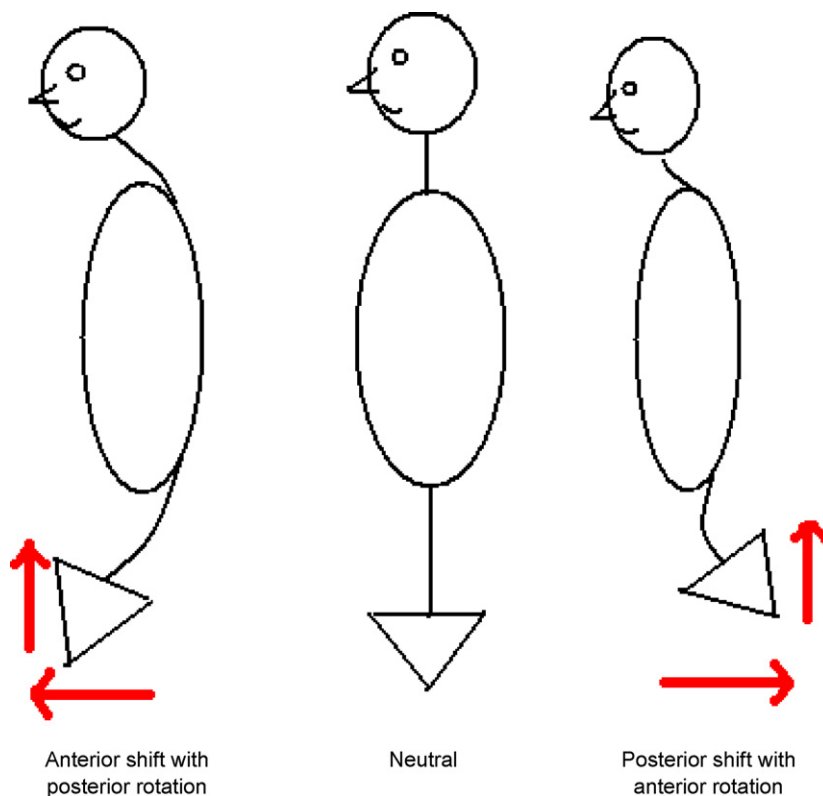


Figure 3 Schematic lateral view showing pelvic shifts with associated sagittal rotation.

for: segmental control; movement transmission along the spine; positioning and controlling his proximal limb girdles; and the myriad small shifts and postural settings used for 'stability' via the righting, equilibrium and other adaptive reactions. Similarly, there is likely to be an evident reduced ability to disassociate movements between hips pelvis and lumbar spine

4. The patient has *poor kinaesthetic, proprioceptive and spatial awareness*. This limits effective motor planning and control. He has difficulty appreciating and finding a neutral alignment of his spine (O'Sullivan et al., 2003) and various spatial relationships of his limbs to his torso e.g. if a sloucher and attempting to "sit up" he may feel as though he is doing a back bend, and he will generally over compensate with a more total gross extensor pattern of muscle activity, e.g. 'military posture'.
5. Instead of an infinite variety of adaptable postural sets, adjustments and movements, the patient has a *reduced repertoire*, tending to adopt more *primitive and stereotypical* movement strategies. These consist of *more gross flexor and extensor patterns* with poor proximal control e.g. hip flexion is associated with excess lumbar flexion with loss of control of the neutral lordosis; when on all fours, a tendency to more total flexion patterns—either tonus shift or overt movement. He becomes what we have termed a "primary A-P mover" - a flexer/extender. He finds it *difficult to modulate coactivation of the deep flexors and extensors* to achieve balanced alignment and control of his torso (Figs. 4 and 5). Incidentally, Janda (1978) noted that in dysfunction, movements of the upper limb tend to favour over activation of the flexors, and those of the lower limb the extensors—rather similar to the patterns seen in an upper motor neuron lesion.
6. The muscle system imbalance and preponderance of activity in the more primitive coarse extensor and flexor synergies, *hampers the initiation and control of rotation throughout the spine, and between the spine and proximal limb girdles*. Understanding and appreciating the importance of rotary control in optimal torso function is very often overlooked in most therapeutic approaches (Figs. 6 and 7). Normal movement patterns always contain an element of rotation and weight shift, even if slight. Equilibrium and balance reactions depend on small rotary movements and postural shifts.

The approaches of Bobath and Bobath (1964) and Proprioceptive Neuromuscular Facilitation (Knott and Voss, 1968) use rotation to help inhibit and break up primitive mass movement responses and to facilitate more desirable movement patterns.

The Feldenkrais method (1972) explores non-habitual three-dimensional movement learning via gentle antigravity movements which utilise a lot of rotation.

McGill (2004, p. 113) notes the important role of arm swing in walking to assist rotation between the proximal girdles in decreasing the loading stress on the spine by up to 10%.

7. The muscle system imbalance will *limit effective weight shifts* over the person's base of support and through his spine. He frequently seeks a wide base of support and so limits the challenge of perturbations to his system. When these do occur, rather than resolving the challenge through deep system control, he tends to react by adopting gripping, splinting strategies using various global muscles acting around and lowering the centre of gravity of the body. In addition he may over employ grabbing/fixing strategies of the upper limb in predominant gross flexor synergies in an attempt to stabilise himself.
8. The patient tends to move from and in SGMS predominant "*patterns of excess tension or stress*" in a more gross explosive way, using *too much unnecessary effort* and breath holding. He wants to move quickly as he finds sustained low load activity of the systemic deep muscles difficult to achieve. This is probably in part due to reduced afferent input (Comerford and Mottram, 2001).
9. *Dysfunctional breathing patterns* (DBP) are adopted. Features of this are:
 - Inadequate SLMS control of the 'internal cylinder' means a poor 'spatial ring' for effective function of the diaphragm. In addition, collapse of the thorax towards the pelvis and stiffness within it further hampers diaphragm activity with related reduced intercostal action. The patient adopts an abnormal SGMS strategy of *habitual upper chest breathing* using the accessory muscles of respiration in low demand situations—scaleni, sternocleidomastoid, pectorals, serratus anterior, upper trapezius (Kendall et al., 1993, p. 329).
 - The habitual upper chest-breathing pattern is generally associated with Hyperventilation Syndrome, which will have significant effects on motor control and hyper arousal.



Figures 4 and 5 Dominance of gross flexor synergies when on all fours—both subjects had been asked to get onto their hands and knees and chose this initial strategy.

- See Bradley (1998), Chaitow et al. (2002) and Chaitow (2004).
- In movement, an altered breathing rate is frequently adopted at different times:
 - The patient may initiate a movement with a *diaphragm “cinch”/breath hold* and related central fixing by the global muscles at the body’s centre of gravity in association with unnecessary effort which further favours mid-upper torso global activation.
 - Variable increase in breathing rate and volume inappropriate to the level of activity.
 - The abdominals are accessory muscles of expiration in high demand situations and are often over employed in low demand situations. We have noted that attempts to control the pelvis are frequently attempted by abnormal global system activity around the body’s centre of gravity, including the upper abdominal group. The current misunderstanding of some research findings (Hodges and Richardson, 1996, 1998) and the misleading therapeutic directive “to pull your tummy in”, as well as the recent “core stability” and Pilates craze, is causing



Figures 6 and 7 Lack of active control of rotation leads to myo-articular rotary restriction. Both subjects were placed in prone recovery position with contralateral forward shoulder and pelvic rotation. Predictably, both subjects presented with sciatica; subject above could not tolerate the position, is post surgery and not surprisingly, is still experiencing pain.

a lot of people to develop DBP. Not to mention neck tension and the compounding of neuromuscular dysfunction patterns in the torso and most likely their back pain!

Thompson et al. (2004) noted the negative effects of global abdominal bracing combined with an increase in chest wall activity and breath holding, on effective pelvic floor function.

If you don't breathe well, you can't move well. If you don't move well, you can't

breathe well. "Breathing is the link between motion and emotion" (Wildman, 2003). Emotional stress and anxiety are a potent cause of altered breathing and related specific postural and movement responses, which favour activation of the global system of the upper torso.

The patient thus finds it difficult to organise the dual roles of breathing and movement in a harmonious way. What we have termed "central intelligence" and control is

more often than not, fundamentally disturbed.

10. *Thoracic dysfunction*—this deserves its own paper, however, the main features are:

The thorax has a big respiratory role, a big postural adaptive role and provides attachments for many of the large global muscles of the torso.

Antigravity collapse, an under active deep system and imbalanced overactivity of the large global muscles attaching to the thorax, serve to functionally convert this to a 'semi-rigid barrel'. This means that postural shifts, selective movement and segmental control *within the thorax* are reduced.

The thorax is generally functionally stiff and in time, becomes structurally stiff.

Overactivity of the anterior chest muscles (pectorals; lateral latissimus dorsi; serratus anterior), and related myofascial tightness hampers thoracic and shoulder girdle 'opening' and movement options.

To compensate for the lack of movement within the thorax, the patient will generally employ variable increased global muscle activity over the thoracolumbar junction (anteriorly, laterally, posteriorly or all), as he attempts to control movements of the upper torso and limb girdle; the 'thoracic barrel' on the lumbar spine; while at the same time trying to control the pelvis in space.

This reduced postural adaptive and movement control within the thorax will have predictable consequences over time

- Mid/low thoracic dysfunction provides poor adaptive support for control of the lumbopelvic complex and movements of the lower limb. Lumbar, hip and lower limb pain syndromes are a predictable consequence.
- Upper thoracic dysfunction jeopardises orienting the head in space and control of the head on the neck. Cervical pain syndromes are a predictable consequence.
- Mid/upper thoracic dysfunction impinges on activities of the upper limb—predictably shoulder and upper limb pain syndromes ensue.

Most patients demonstrate a variable increase in the thoracic kyphosis. A few present with a flat straight spine which when analysed, still displays the same general thoracic dysfunctions to some extent.

The patient usually demonstrates a "dome". This describes an increased stiff local kyphosis with reactive segments over the apex,



Figure 8 Thoracic kyphosis with evident 'dome' when viewed from above.



Figure 9 Thoracic kyphosis with evident 'dome'.



Figure 10 Thoracic kyphosis with evident 'dome'.

generally around T5/6/7/8, with related poor adjacent deep intersegmental and medial scapular muscle activity (Figs. 8–10). In the normal state, energy efficient walking requires a derotation between the pelvis and shoulder girdle. Gracovetsky (1997) and Kapandji (1974) cite a normal study performed by Gregerson and Lucas in 1967 which impressively shows that this derotation occurs maximally at T7. The presence of a “dome” limits this movement occurring, which must then be compensated for somewhere else—usually the lumbar or cervical spine. Functionally, this is then required to become the site of relative flexibility (Sahrmann, 2002).

Farfan (1973) postulated that excess flexion rotation stress in the lumbar spine is a cause of lumbar disc problems. If the lumbar lordosis is not controlled and movement transmission, particularly rotation, is blocked through the thorax and the junctional regions, the patient has to abnormally compensate with abnormal movement in the lumbar and likewise the cervical spines. Disc and related problems are then, predictably a matter of time.

11. The neuromuscular strategies adopted by the patient will create *predictable biomechanical and articular changes* in time:

- *Change in the normal spinal curves*—altered pelvic position; reduced lordosis; increased kyphosis—depending upon the stage of disorder, functional problems become struc-

tural and begin to mutually reinforce one another. This results in altered loading stress on the joints and soft tissues and altered line of pull of muscles.

- *General/regional loss of extension through spine*—particularly within the thoracic spine. Protocols advocated by McKenzie (1989, 1998) partly address this aspect.
- The regions of segmental stiffness can act like ‘blocks’, while the abnormally, relatively flexible/hyper mobile segment(s) act like ‘hinges’. They feed off one another—the patient cannot get movement into the stiff regions and can’t adequately control the relatively mobile segments or regions. This creates further compensations up and down the spine. Clinically, symptomatic joints occur in both the stiff regions and the relatively over mobile regions (Fig. 11).

12. *Clinically observed and found regions of stiffness*

- The thoracic spine and rib cage.* Variable segmental and rib loss of extension, rotation and side bending. Presence of a ‘dome’ and related myofascial tightness.
- The junctional regions*—transitional zones where the function of the spinal column changes. “These ‘key regions’ are usually the place where the spinal column suffers first. Disturbance of function here jeopardises the functioning of the spinal column as a whole causing secondary lesions”



Figure 11 Evident 'Hinge' around L3/4, and 'Block' from thoraco lumbar area into thoracic spine and 'dome,' when prone on elbows.

(Lewit, 1985, p. 24). Loss of mobility in these regions requires compensated movements in adjacent functional regions e.g. cervical and lumbar spines, shoulders, etc. Sahrman (1996, 2001, 2002) reminds us to consider 'what are the sources, and what are the causes of the pain'—the 'criminals' and the 'victims'.

- *Craniocervical Junction—C0/1/2/3*—has a complex biomechanical function and an important functional role in mediating postural tone throughout the body via proprioception from the deep neck muscles and the vestibular system. Common articular restrictions are reduced flexion (0/1); rotation (1/2); side bending (2/3).
- *Cervicothoracic Junction—C7/T1/2 and ribs 1 and 2*—commonly lose extension (widow's hump); rotation and side bending.
- *The Dome—T5/6/7/8*—clinically find loss of extension, rotation and side bending.
- *Thoraco lumbar Junction—T10/11/12/ L1/2*—usually hyper stabilised; variable loss of extension, rotation, lateral shift/ side bending. T12 is a segment of frequent dysfunction (Greenman, 1996, p. 206).
- *Lumbosacral junction—L5 and sacrum; closely linked to sacroiliac function* Clinically almost universal finding is loss

of extension L5/sacral nutation and reduced swivel between the two.

Note three of the five junctional regions relate to the thorax.

A cervical or lumbar problem will usually show local and regional neuromuscular dysfunction with attendant symptomatic joint restrictions at the superior and inferior junction, although usually one will be dominant.

- (iii) *Intrapelvic joints—principally Sacroiliac joint*. Important for load transfer between the legs and upper body (see Vleeming et al., 1997; Lee, 1989; Lee and Vleeming, 2000). Commonly sacral counter nutation, torsions and changed iliac rotation on the sacrum.
- (iv) *Hip joints*. Always show variable patterns of restriction of flexion, extension and rotation in one or both directions. This has a potent effect on control of the pelvis on the legs, in space and on lumbo-pelvic control.

Conclusion

A local pain symptom is usually an expression of a local, regional and general dysfunction of the neuromusculoskeletal system.

Appreciating the more common features of neuromusculoskeletal dysfunction in spinal and

related pain syndromes outlined in this model helps guide assessment, functional diagnosis and intervention.

In beginning to provide a more comprehensive map of the nature of the common movement dysfunctions seen in back pain patients, this model poses many questions about certain current therapeutic approaches.

While Panjabi's (1992) stability model is undoubtedly valuable, to see most people with low back pain as only having an 'instability problem' is misguided. McGill (2002, p. 137) says "stability is a popular term when discussing the low back but it may be widely misunderstood and inappropriately used" (also see McGill, 2004).

In addition, much current stability training seems to be concerned with 'not letting the spine move,' and risks further imprinting neuromuscular fixing strategies around the central body.

'Stability', from a functional perspective, is *postural and movement control* of the whole spine and its related girdles—being able to appropriately adjust and move in *all* regions of the spine, to and from numerous positions as required. The torso needs to function as an appropriately stable, yet malleable base for all head, limb and body movement control.

It is important to appreciate the therapeutic need to get functionally appropriate, selective movement and control into the thorax, and proximal limb girdles and their large ball and socket joints, while at the same time improving control in the cervical and lumbar spine and pelvis in space.

The desired patterns of movement control need to address the functional needs of the patient and encourage activation of the deep system and deactivation or inhibition of the overactive superficial system.

The old paradigm of a specific exercise for a specific muscle needs re-examining. McGill (2004, p. 167) also suggests "those who are focusing on just transversus (or any other single muscle) are creating dysfunctional spines". "It is the total pattern of all muscles that determines spine stability". We agree.

This empirical model invites future primary research in order to formally test and validate its observations. In the meantime, it is offered in order to assist the practitioner in the clinic now.

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