The muscle designation debate: the experts respond

Joanne Bullock-Saxton, Donald Murphy, Chris Norris, Carolyn Richardson, Pamela Tunnell

Introduction

Leon Chaitow

A number of the *Journal of Bodywork and Movement Therapies* readers have communicated their confusion over the apparent contradictions in the way different researchers and clinicians refer to muscle characterizations. When words such as 'postural/phasic' or 'stabilizer/mobilizer' are applied to particular muscles, practical as well as linguistic difficulties become apparent.

It was decided that an exercise in clarification should be initiated, and in order to achieve this leading physiotherapists, manual medicine and chiropractic researchers and clinicians, were invited to express their understanding of the issues. The objective is quite simply an attempt to remove confusion.

Questions were posed by the editor, in consultation with associate editor Craig Liebenson, to which brief, succinct, responses were requested.

It was stressed that, wherever possible, research validation should be quoted with the answers, however personal opinions based on clinical experience would also be welcome. As well as answering the questions, each respondent was offered the opportunity to make a 'position statement'.

It is hoped that out of this exercise a clearer picture will emerge of current thinking on this topic, and that commissioned papers will take the process further.

The editor wishes to thank all those who participated in this endeavour, in which the only winners will be currently confused practitioners and therapists, and ultimately their patients.

The questions posed were as follows:

1. It has been suggested that 'postural' muscles tend towards overuse and eventual shortening, whereas phasic muscles tend towards disuse and weakness.

  - Jull G, Janda V 1987 Muscles and motor control in low back pain: Assessment management. In: Twomey L (ed) Physical Therapy of the Low Back. Churchill Livingstone, New York
  - Bullock-Saxton J, Janda V, Bullock M 1993 Reflex activation of gluteal muscles in walking. Spine 18: 704

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Expand on why you consider this suggested model valid, and if not why not?

2. It has been suggested that dynamic phasic muscles which tend to weakness contain a predominance of slow twitch Type 11 fibres and that postural muscles which tend to shortening contain a predominance of Type 1 fibres.

- Hu J 1992 Stimulation of craniofacial muscle afferents inducing prolonged facilitatory effects in trigeminal nociception brainstem neurons. Pain 48: 53
- Liebenson C 1996 Rehabilitation of the spine. Williams & Wilkins

Please comment.

3. The designation of muscles as stabilizers (deep, slow twitch) with a propensity to weaken and lengthen; and mobilizers (superficial, with propensity to shorten and tighten) is a more recent characterization. Further categorizations occur within this model including 'primary' stabilizers (unable to provide significant joint movement) and 'secondary' stabilizers (able to stabilize and move joints) and 'tertiary' stabilizers (which can at times provide defensive rigidity).

- Richardson C, Jull G, Toppenberg R, Comeford M 1992 Techniques for active lumbar stabilisation for spinal protection. Australian Journal of Physiotherapy 38: 105–112
- Norris C 1999 Functional Load Abdominal Training Journal of Bodywork and Movement Therapies 3: 150–158

Expand on why you consider this suggested model valid, and if not why not?

4. For the most part stabilizer muscles appear to be similar to

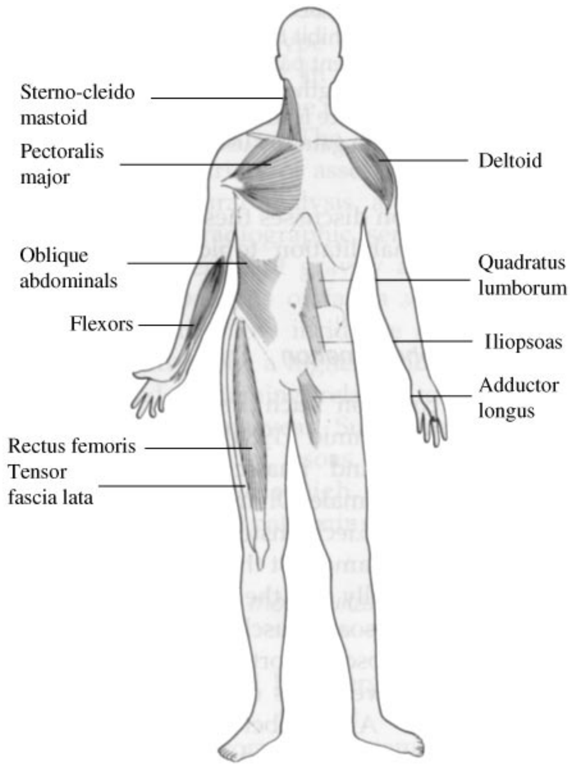

Fig. 1 The major postural muscles of the anterior aspect of the body.

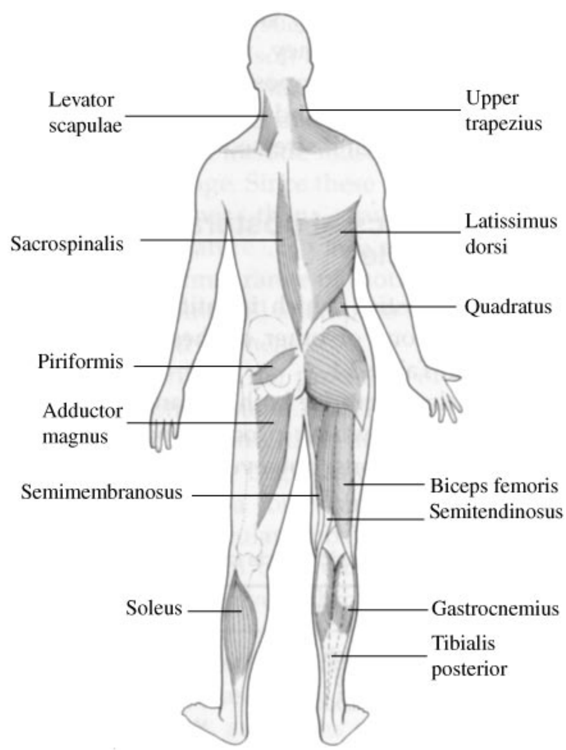

Fig. 2 The major postural muscles of the posterior aspect of the body.

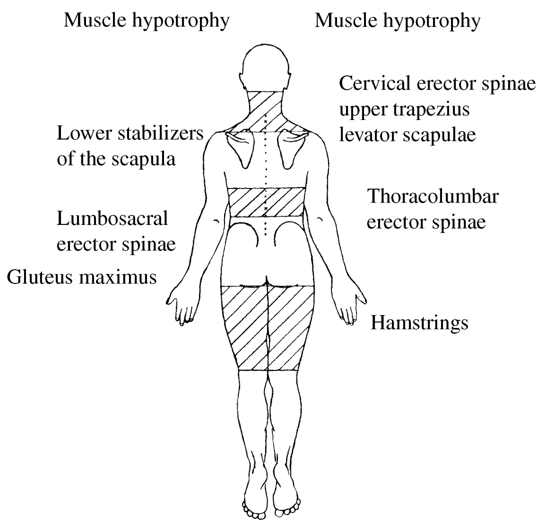

Fig. 3 The layer syndrome. (reproduced for Jull and Janda 1987).

phasic muscles, while mobilizer muscles are similar to postural muscles. However, the quadratus lumborum muscle appears to be the source of confusion. How do you classfy this?

Similarly, can you comment on how you classify the

- multifidus,
- transverse abdominus,
- rectus abdominus muscles.

5. Comment on where (if at all) you see fibre type of muscles as being a feature of your thinking regarding their characterization as phasic, postural, stabilizer, mobilizer, etc?
6. Do you have a different way of designating or characterizing muscles that is of practical clinical value to you?

Note: The responses to these questions are listed in alphabetical order. Most of the responding researchers and clinicians have followed the question sequence in providing their insights, however Dr Bullock-Saxton chose instead to provide a position statement which took a global view of the issues raised.

Response from Joanne Bullock-Saxton

Position statement — a global view

Thank you for the opportunity to respond to the questions that you pose for comment among clinicians and researchers world wide. Confusion does arise with the use of differing nomenclature that is in this case, predominantly describing differences in activation pattern of various muscles. All of the questions have a common theme, and for this reason I have tried to give a response to the questions from a global perspective rather than each question separately.

The nomenclature devised to describe muscle functions over the last decades have attempted to classify general movement patterns, as well as responses observed to occur associated with injury/disease. Most observation until recently has been limited in this regard to inferences about deep muscles through observation of biomechanics and assessment with EMG. More recently studies using fine wire EMG, MRI and Diagnostic Ultrasound have provided some detail about the function of more deep muscles. However, the reader of the research literature must keep in mind that all of these methods of measurement of muscle function have limitations.

A reminder of some of the common denominators related to our function seems essential at the outset of consideration of the questions raised in this debate. All human bodies have similar muscle alignment about joints of relatively similar structure and range of motion. Most human bodies will be involved in activities of lying, sitting, standing and walking. These activities are all performed against the constant force of gravity. It is known that the force of gravity combined with movements of daily living stimulates peripheral receptors, that send neural messages to the spinal cord and then to subcortical and cortical nuclei. The motor response to the sensory

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stimulus is regulated according to the needs of the movement pattern, on the whole the majority of signals are inhibited.

This is of course an extremely simplistic illustration of motor control, but the overview does serve the purpose of illustrating that we are designed to move in an environment that imposes upon us a force. Naturally there will be some muscles, through their attachment to our skeletal system and due to the characteristics of our articular system that will work more often against this force of gravity. This situation will influence the quantity of sensory information from the muscles and the periarticular tissues, and thus the information that passes through the spinal cord to the CNS for interpretation and action. As an example, our upper limb is arranged biomechanically to enable us to eat, groom and dress ourselves, our scapular elevators and protractors, shoulder flexors and internal rotators, elbow flexors and wrist flexors are all more readily activated and also, all work against gravity. These muscles are also predominantly activated in pain withdrawal responses. In the lower limb, muscles that work against the force or gravity also correspond with those that are activated in a pain withdrawal response and include pelvic elevators (pelvic hitchers, such as QL), hip adductors, hip flexors, knee flexors and ankle plantar flexors. Essentially however, I would hesitate to call these muscles any name, although they are what Janda would have termed 'postural' muscles. The terminology obviously influenced by the nature of our anatomy and our movement within our environment.

Of relevance to this particular debate is the genesis and subsequent research development of clinical observations first made by Janda in the 1960's. Janda (1964, 1977, 1978) described an observation of dysfunction in muscles in chronic pain patients that was similar to patterns of 'over' and 'under' activity seen in subjects with cerebral palsy (CP). Those with CP demonstrating patterns of muscle activity reflecting a loss of central inhibition to the constant peripheral afferent information of the force of gravity generated by patterns of daily living. Janda (1978, 1984) has proposed that these patterned responses can occur not only in the case of cerebral accidents/dysfunction but also in the case where there is an altered degree of activity from peripheral sensory receptors or an alteration in the stimulation threshold of spinal cord cells. Peripheral injury, inflammation, altered joint biomechanics are a few examples where peripheral afferent information may alter. Recent literature studying the effect of peripheral pain stimuli (Coderre & Melzack 1987; Cook et al. 1987; Grubb et al. 1993; Schaible & Grubb 1993; Woolf 1983) has supported these claims. These researchers describe how pain stimuli are capable of altering the sensitivity to central perception of pain and other afferent stimuli as well as altering the efferent response not only at one segmental level, but to many levels both ipsilateral and contralateral to the source of the stimuli.

What Janda has really reminded the clinician is that an understanding of the deficit in the neural system is essential for treatment. Treatment of the muscle pattern response without this perspective can be misdirected and futile. Effectively the muscles are the reflection of either some peripheral neural change or some central neural change. Treatment will only be effective if directed at the correct neural disruption. Again recent research is tending to confirm these initial statements. Panjabi (1992) has emphasized the importance of the triad of the three musculoskeletal systems of (a) control subsystem (peripheral and central neural control), (b) active subsystem (muscles) and (c) passive subsystem (articulating surfaces and periarticular soft tissues), functioning well to provide adequate spinal stability. Richardson and colleagues also strongly emphasise the need to address neural control issues related to motor control and muscle coordination when rehabilitating patients with chronic low back pain (Richardson et al. 1998). Thus the emphasis is on the neural dysfunction that is reflected in a muscle, rather than in the muscle itself.

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Response from Donald R. Murphy

Position statement

It is important to be as accurate as possible when describing the function and dysfunction of muscles. This importance is for two primary reasons. First, interpractitioner and interdisciplinary communication is enhanced when all concerned can have a common language in which they are communicating, even if there is not always (goodness knows!) complete aggreement regarding the specifics of the topic discussed. Second, and more importantly, it is our conceptual understanding of function and dysfunction that drives the clinical decisions that we make in practice. Thus, the accuracy or inaccuracy of our concepts will determine the success or failure of our management approach. So I see this exercise not merely as one of semantics, but rather an important look at some of the essential concepts under which we work in treating patients with neuromusculoskeletal pain syndromes.

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1. It has been suggested that postural muscles tend towards overuse and eventual shortening, whereas phasic muscles tend towards disuse and weakness. Expand on why you consider this suggested model valid, and if not why not?

When Janda first suggested the designation of muscles into categories of 'postural' (tonic) and 'phasic' classifications, it served as a useful way of conceptualizing several of his clinical theories. The most important of these theories was based on his clinical observation, and laboratory measurement (Janda 1978) of relative tightness and inhibition (this is the word that I prefer rather than weakness — more on this later) of certain muscles. It seemed that there were certain muscles that tended to easily become tight and hyperactive, and certain muscles that tended to become inhibited and underactive. In looking further at these muscles, it appeared that those that tended toward tightness had certain common characteristics and those that tended toward inhibition had certain common characteristics.

I do not know that there is a precise distinction between 'tonic' and 'phasic' muscles, and whether a certain category of muscles tend toward overuse, while others tend toward underuse. To my knowledge, there is no data on over- or underuse of certain muscles. It seems to me that the imbalance of activity in muscles relates more to the nervous system's selective activation (or lack thereof) of certain muscles, than properties of the muscles themselves. In other words, if a muscle becomes hypertonic (increased muscle tone) or hypotonic (decreased muscle tone), this occurs as a result of certain neurological events that occur, not because the muscle is 'tonic' or 'phasic' (Johansson & Sojka 1990, Stokes & Young 1989).

2. It has been suggested that dynamic phasic muscles which tend to weakness contain a predominence of slow twitch Type 11 fibres and that postural muscles which tend to shortening contain a predominence of Type 1 fibres

The subject of fibre type in various muscles is a difficult one, as there is a great deal of individual variation, with widely disparate percentages of 'slow twitch' and 'fast twitch' fibres in different people (Weber et al. 1993). Probably the most thorough review of this topic has been that of Ng et al. (1998), who found that there is a general trend toward more slow twitch fibres in back muscles

(53–73%) but that there is not a great preponderance of this type of fibre compared to type II.

Perhaps more important than clarifying the difference between tonic and phasic muscles and fibre types is clarifying the difference between ‘inhibited’ and ‘weak’. A great deal of confusion exists here and proper understanding of these concepts is critical in order for correct treatment decisions to be made. The term ‘weak’ refers to the ability of a certain muscle to generate torque production. The quality being addressed with this word is ‘strength’. But, in my experience, lack of proper strength is not commonly an important issue in the clinical syndromes with which patients consult every day. This observation is supported by several studies that have shown that strength is not a prominent factor in initial onset of low back pain, or in risk for chronicity (Hunter et al. 1998; Hildebrandt et al. 1997; Leamon 1994; Frymoyer 1992; Adams et al. 1987). However, it is common to find that inhibition of certain muscles, especially muscles that have an important stabilization role, in patients with spinal complaints (Aleksiev et al. 1996; Hodes & Richardson 1996; Radebold et al. 2000; Solomonow et al. 1999). ‘Inhibition’ refers to the ability of a muscle to react to stimuli. These stimuli may be external, in the form of a perturbation that has the potential to cause injury, and to which the muscle must respond with protective muscle activity, or internal, in the form of a centrally ordered movement pattern (Murphy 2000a). So it is important to realize that, while most muscles in patients with spinal complaints will have sufficient strength to perform their role in movement and stability, if the central nervous system is not properly activating them at the right moment, to the correct magnitude and in harmony with the other muscles involved in the activity, dysfunction and microtrauma may result. From a clinical standpoint, this is far more important than ‘weakness’.

3. The designation of muscles as stabilizers (deep, slow twitch) with a propensity to weaken and lengthen; and mobilizers (superficial, with propensity to shorten and tighten) is a more recent characterization. Further categorizations occur within this model including ‘primary’ stabilizers (unable to provide significant joint movement) and ‘secondary’ stabilizers (able to stabilize and move joints) and ‘tertiary’ stabilizers (which can at times provide defensive rigidity). Expand on why you consider this suggested model valid, and if not why not?

I think that the classification scheme of stabilizers/mobilizers is good, as it brings us somewhat closer to the real clinical and functional properties of each muscle. However, the classification scheme of primary/secondary/tertiary stabilizers is much better, as it recognizes that virtually all muscles are capable of providing a stabilizing function, although some are better equipped than others. For example, the lumbar erector spinae muscles are considered relatively poor stabilizers of the spine (Richardson & Jull 1995), but are capable, at times, of co-contracting with other muscles in enhancing, if not solely providing, stability (Cholewicki et al. 1995). On the other hand, the multifidis muscles, while being excellent stabilizers (Wilke et al. 1995), produce little or no joint movement.

4. For the most part stabilizer muscles are similar to phasic while mobilizer muscles are similar to postural. However, the quadratus lumborum muscle appears to be the source of confusion. How do you classify this muscle? Similarly, can you comment on how you classify the

- **multifidus,**
- **transverse abdominus,**
- **rectus abdominus muscles.**

Little is known about the quadratus lumborum (QL). McGill et al. (1996) recently demonstrated the stability function of the QL, when they measured the EMG activity in this muscles while progressively heavier weights were handled by normal subjects. They found that the activity in the QL steadily increased as more weight was handled. Importantly, no lateral bending of the trunk took place, so the activity seen was purely for the purpose of maintaining stability of the lumbar spine. The activity development in the QL was greater than that in the rectus abdominis, internal oblique, external oblique and erector spinae. They did not measure the transverse abdominis or multifidis. Certainly from an anatomical standpoint, the QL appears to be an efficient stabilizer, as its attachments are fairly close to the center of rotation of the spine.

The question remains, to what extent is the QL active in mobilizing the lumbar spine or pelvis, i.e. what is its capacity as a ‘mobilizer’? Classically, the QL is thought to contribute to lateral flexion of the lumbar spine, hip hiking, unilateral stance and hip abduction (Lehmkuhl et al. 1983). To my knowledge, little work has been done to accurately determine the extent to which it contributes to these movements. I would classify it as secondary stabilizer.

I think it is pretty clear that both the multifidis and the transverse abdominis should be considered primary stabilizers. That is, they provide excellent stability, but do not, in and of themselves, produce joint movement (Hodges 1999). The rectus abdominis should be considered a tertiary stabilizer. It is not an effective primary or secondary stabilizer, as it is placed too far from the center of rotation of the spine. However it, like the erector spinae, is capable of generating tension sufficient to assist in stabilization when it co-contracts with the primary and secondary stabilizers. One must be careful, however, when training a patient for stability, to avoid excessive activation of the rectus abdominis, as this can cause inhibition of the transverse abdominis (O'Sullivan et al. 1998).

5. Please comment on where (if at all) you see fibre type as being a feature of your thinking regarding such characterizations?

As I suggested before, I do not feel that fibre type is essential in the designation of a muscle as primary, secondary or tertiary stabilizer. The primary reason for this is that a stabilizer muscle functions to both provide ongoing stability on a continuous basis over a period of time and to respond to perturbations that have the potential to cause injury. Continuous activity is provided by the slow twitch fibres in the muscle and response to perturbation is provided by the fast twitch fibres. So, a balance of both types of fibres is necessary for proper stability. Much more important is the muscle's anatomical location, particularly the proximity of the belly of the muscle to the center of rotation of the joint(s) its job it is to protect. Those muscles that maintain a position relatively close to the center of rotation, such as the transverse abdominis, multifidis and deep cervical flexors play a more prominent role in stability. Those whose lever arm is farther from the center of rotation, such as the rectus abdominis or sternocleidomastoid, play a lesser role. Also, the shorter muscles, such as the suboccipitals, tend to better stabilizers than longer muscles, such as the erector spinae.

6. Do you have a different way of designating or characterizing muscles that is of practical clinical value to you?

I think that the primary, secondary and tertiary stabilizer designation is a good one for clinically classifying muscles with regard to stabilization. I use a variation of the original Janda designations with regard to muscle that tend to become inhibited, hypertonic and tight (Murphy 2000a). First, as I stated before, I think it is essential that we make a clear distinction between 'weak' and 'inhibited'. Also, I think it is important to make the distinction between 'tight' and 'hypertonic'. The reason for this is that each muscle condition requires a different treatment approach. Hypertonicity is defined as, literally, too much muscle tone. Muscle tone involves two characteristics of a muscle: (1) the degree of resistance to stretch and (2) the readiness with which the nervous system activates the muscle in response to stimuli (Davidoff 1993, Basmajian & DeLuca 1985). Therefore, by definition, hypertonicity is an abnormal increase in the resistance to stretch of a muscle and an abnormal increase in the readiness with which the nervous system activates the muscle in response to stimuli. As was discussed previously with regard to inhibition, these stimuli can be peripheral, as in an external perturbation, or internal, as in a centrally ordered movement pattern. Notice that in this definition, there is nothing regarding resting length of the muscle. This is because resting length has nothing to do with muscle tone. However, when muscle tightness exists, there is both an increase in muscle tone and a decrease in the resting length of the muscle, presumably as a result of shortening of the connective tissue elements of the muscle (Janda 1994). In my clinical experience, when true muscle tightness is present, a different type of treatment (i.e., postfacilitation or Active Release [Leahy & Schneider 2000]) is required, as compared to hypertonicity, in which case postisometric relaxation is best.

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Response from Chris Norris

Position statement

Categorization of muscle is useful as a clinical guide, but is not an exact science. By categorizing muscles into stabilizor and mobilizor groups the clinician can focus attention on the type of management likely to be required. Stabilizor muscles are likely to be poorly recruited, lax in appearance, show an inability to perform inner range contractions over time, and as a result alter body alignment by failing to provide a stable base for other muscles to work from. Mobilizor muscles on the other hand are likely to the tight, and show preferential recruitment in synergistic activities. These muscles will tend to dominate movements and may alter posture by restricting movement and preventing optimal segmental alignment. The combination of muscle laxity and poor holding ability on the one hand with muscle tightness and dominance on the other hand within an antagonistic muscle pairing will alter the equilibrium point of the joint, tending to pull the joint towards the tight muscle. An inability to move actively through full range due to a combination of tightness with poor inner range control will change the nature of a movement entirely. Although these changes may be subtle, over time stress accumulation may give chronic pathologic changes within soft tissue and possible degenerative changes within bone.

Any relatively simplistic categorization of muscle is fraught with problems. The danger with muscle imbalance categorization is that practitioners will expect set changes to occur and fail to adequately assess a patient. When this occurs, important deviations from the imbalanced norm can be missed and treatment outcomes will be impaired. Although muscle imbalance categorization can usefully assist the astute practitioner, they are not cast in stone. Assessment will still be

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required but can be refined to reveal the subtleties of muscle reaction to altered use and pathology. If a muscle has poor inner range holding, this must be enhanced, and a variety of protocols exist to do this. If a muscle is tight, a number of procedures are available to lengthen it. Once muscle balance has been restored, habitual changes in posture (local and general, static and dynamic) must be addressed. Only then can we truly say that the patient has moved closer to optimal alignment and reduced an important risk factor for musculoskeletal pain.

1. It has been suggested that postural muscles, when stressed through overuse tend to shorten, whereas phasic muscles tend towards disuse and weakness. Expand on why you consider this suggested model valid, and if not why not?

The terms postural and phasic used by Jull and Janda (1987) can be misleading. In their categorization, the hamstring muscles are placed in the postural grouping while the gluteals are placed in the phasic grouping. The reaction described for these muscles is that the postural group (represented by the hamstrings in this case) tend to tighten, are biarticular, have a lower irritability threshold and a tendency to develop trigger points. This type of action would suggest a phasic (as opposed to tonic) response, and is typical of a muscle used to develop power and speed in sport for example, a task carried out by the hamstrings. The so called 'phasic group' is said to lengthen, weaken and be uniarticular, a description perhaps better suited to the characteristics of a muscle used for postural holding. The description of the muscle responses described by Jull and Janda (1987) is accurate, but the terms postural and phasic do not seem to adequately describe the groupings.

2. It has been suggested that dynamic phasic muscles which tend to weakness contain a predominence of slow twitch Type 11 fibres and that postural muscles which tend to shortening contain a predominence of Type 1 fibres

In addition to basic type I (slow twitch/slow oxidative/SO) and type II (fast twitch/fast glycolytic/FG) muscle fibres, histochemical staining (myosin ATPase) reveals several further fibre subtypes, including type IIA (fast-oxydative-glycolytic or FOG) (Staron et al. 1983). Adaptation of muscle due to decreased usage has mostly been studied by limb immobilization experiments, usually using rat hindlimb muscle. The predominant decline appears to be in the type I (SO) fibres with a corresponding increase in the proportion of IIA (FOG) fibres (Oishi et al. 1992). One explanation for this change is that the type I fibres are most affected by immobilization because it is these fibres whose activity is reduced the most. Type I fibres are normally active at low tension levels roughly 20–30% maximum voluntary contraction (MVC) (Sale 1992) the type of activity used in daily living. Larger diameter fibres (IIA and IIB) are recruited at much higher levels (up to 90% MVC) during strength training activities, and these activities are obviously not used as frequently. Greater reduction in size and loss of number is seen in type I fibres showing selective atrophy. The uniarticular muscles showing an 'antigravity' function with a predominance of type I fibres such as the soleus and vastus medialis have both been shown to waste more during immobilization. Next in order of atrophy are the slow antigravity muscles, which cover multiple joints such as the erector spinae. The muscles with a predominance of type II fibres show the least wastage in fibres (Appell 1990; Lieber 1992).

3. The designation of muscles as stabilizers (deep, slow twitch) with a propensity to weaken and lengthen; and mobilizers (superficial, with propensity to shorten and tighten) is a more recent characterization. Further catagorizations occur within this model including 'primary' stabilizers (unable to provide significant joint movement) and 'secondary' stabilizers (able to stabilize and move joints) and 'tertiary' stabilizers (which can at times provide defensive rigidity). Expand on why you consider this suggested model valid, and if not why not?

The designation of muscles into stabilizors and mobilizors would seem to more accurately describe both the function of the muscles and the muscle reaction seen clinically. Further division into primary and secondary stabilizors usefully differentiates between those muscles which can or cannot contribute significantly to joint movement. Certain muscles, for example the Multifidus (Hides et al. 1994) and Vastus medialis (Stokes and Young 1984) have been shown to respond by inhibition (rather than disuse atrophy) to swelling and pain. These muscles produce little torque but are affected by subtle changes in joint alignment.

4. For the most part stabilizer muscles are similar to phasic while mobilizer muscles are similar to postural. However, the quadratus lumborum muscle appears to be the source of

confusion. How do you classify this muscle? Similarly, can you comment on how you classify the

- **multifidus,**
- **transverse abdominus,**
- **rectus abdominus muscles.**

The quadratus lumborum has been shown to be significant as a stabilizor in lumbar spine movements (McGill 1996) while tightening has also been described (Janda 1983). It seems likely that the muscle may act functionally in medial and lateral portions with the medial portion being more active as a stabilizor of the lumbar spine and the lateral more active as a mobilizor. Such sub-division is seen in a number of other muscles for example the gluteus medius where the posterior fibres are more posturally involved (Jull 1994) the internal oblique where the posterior fibres attaching to the lateral raphe are considered stabilisors (Bergmark 1989) the external oblique where the lateral fibres work during flexion in parallel with the rectus abdominis (Kendal et al. 1993). The multifidus may be classified as a stabilizor together with the transversus abdominis as both lie close(r) to the axis of rotation of the spine than do other muscles in the spinal or abdominal groups respectively. The rectus abdominis may be classified as a mobilizor as it is more superficial (and therefore further from the axis of rotation). In addition, the rectus shows preferential recruitment, tending to dominate abdominal muscle actions. Clinically when this happens, patients find recruiting the transversus abdominis more difficult.

5. Please comment on where (if at all) you see fibre type as being a feature of your thinking regarding such characterizations?

Although fibre type has been used as one factor to categorize muscles, its use clinically is limited as an invasive technique is required. It is therefore the functional characteristics of the muscle that is of more use to the clinician. Stabilizing muscles show a tendency to laxity and an inability to maintain a contraction (endurance) at full inner range. Mobilizing muscles show a tendency to tightness through increased resting tone. The increased resting tone of the muscle leads to or co-exists with an inclination for preferential recruitment where the tight muscle tends to dominate a movement. The stabilizing muscle in parallel shows a tendency to reduced recruitment or inhibition as a result of pain or joint distension.

6. Do you have a different way of designating or characterizing muscles that is of practical clinical value to you?

A further categorization of muscles has been used by Bergmark (1989) and expanded by Richardson et al. (1999). They have used the nomenclature of local (central) and global (guy rope) muscles the later being compared to the ropes holding the mast of a ship. The central muscles are those which are deep, or have deep portions attaching to the lumbar spine. These muscles are seen as capable of controlling the stiffness (resistance to bending) of the spine and of influencing intervertebral alignment. The global category includes larger more superficial muscles. Global muscles include the anterior portion of the internal oblique, the external oblique, the rectus abdominis, the lateral fibres of the quadratus lumborum and the more lateral portions of the erector spine (Bogduk 1991). The local categorization includes the multifidus, intertrasversarii, interspinales, transversus abdominis, the posterior portion of the internal oblique, the medial fibres of quadratus lumborum and the more central portion of the erector spinae. The global system moves the lumbar spine, but also balances/accommodates the forces imposed by an object acting on the spine.

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Response from Carolyn Richardson

Position statement

For many years traditional exercise therapy was mainly focussed on building strength or endurance of whole muscle groups, e.g. rotators of the trunk, extensors of the knee, internal rotators of the shoulder. Those involved in rehabilitative exercise gradually realized that people with injury not only needed general strength and endurance of whole muscle groups to perform an activity, e.g. lifting a load, but also needed more specifically directed exercise.

More specifically exercise regimes were necessary to take into account that some individual muscles of a synergistic group:

1. have distinct and different individual functions,
2. react in different ways to injury of the associated joint (reflex inhibition and excitation),
3. react in different ways to lack of use or lack of gravitational load,
4. react in different ways to specific patterns of use (e.g. ballistic, repetitive activity).

In each of the above it can be easily predicted that individual muscles would fall consistently into basically two groups.

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Group A

1. more linked with joint stabilization,
2. more likely to undergo reflex inhibition with injury to associated joint,
3. more likely to atrophy quickly due to lack of use or lack of gravitational load,
4. more likely to decrease activity and change their function when exposed to ballistic repetitive exercise.

Group B

1. more linked with efficient movement of joints,
2. more likely to undergo reflex excitation with injury to associated joint,
3. not prone to atrophy quickly due to lack of use or lack of gravitational load,
4. more likely to become more active (and tighten) when exposed to ballistic repetitive exercise.

In consultation over the years with members of basic scientific disciplines, e.g. anatomy and biomechanics, I have summarized my latest thoughts in the book *Therapeutic Exercise for Spinal Segmental Stabilisation in Low Back Pain* (Richardson et al. 1999).

Group A are 'monoarticular' muscles or muscles capable of controlling one joint or one area of the spine. These could also be referred to as 'local' muscles. Group B are the 'multijoint' muscles that are capable of moving several joints at the same time. These muscles are also phyogenetically the oldest. They could be referred to as 'global' muscles. This nomenclature allows clinical disciplines to communicate with other basic science disciplines to facilitate research and learning.

1. It has been suggested that postural muscles, when stressed through overuse tend to shorten, whereas phasic muscles tend towards disuse and weakness. Expand on why you consider this suggested model valid, and if not why not?

I think these are confusing terms. Group B (multi-joint) are the postural muscles. 'Postural' does describe one of the functions of this group as they are the muscles often used to efficiently control the upright posture, e.g. hamstrings rather than gluteals in standing posture. The 'phasic' term for group A is a little more difficult to explain. In studying lack of use in animal models these muscles, motor units and muscle fibres have a tendency to change from tonic to phasic with disuse and perhaps with joint injury (Appell 1990).

2. It has been suggested that dynamic phasic muscles which tend to weakness contain a predominence of slow twitch Type 11 fibres and that postural

muscles which tend to shortening contain a predominence of Type 1 fibres

Not correct. Muscle fibre types in humans are different to animal and bird models. Mostly a genetically determined percentage in each muscle. There are some exceptions such as soleus. It is likely the control, rather than muscle fibres, which is important (Edstrom 1970, Kuno 1984).

3. The designation of muscles as stabilizers (deep, slow twitch) with a propensity to weaken and lengthen; and mobilizers (superficial, with propensity to shorten and tighten) is a more recent characterization. Further catagorizations occur within this model including 'primary' stabilizers (unable to provide significant joint movement) and 'secondary' stabilizers (able to stabilize and move joints) and 'tertiary' stabilizers (which can at times provide defensive rigidity). Expand on why you consider this suggesed model valid, and if not why not?

When teaching joint stabilization exercises specifically, I had taken the clinical nomenclature of Margaret Rood of stabilizers and mobilizers as it was in line with my thoughts on muscles designed for a stability role (Richardson & Bullock 1986). These terms are good for teaching physiotherapists but I found that they did not allow communication with other disciplines so important for research and furthering knowledge. In our recent text other terms are used.

4. For the most part stabilizer muscles are similar to phasic muscles, while mobilizer muscles are similar to postural muscles. However, the quadratus lumborum muscle appears to be the source of confusion. How do you classify this muscle? Similarly, can you comment on how you classify the

- **multifidus,**
- **transverse abdominus,**
- **rectus abdominus muscles.**

Quadratus lumborum consists of two functionally different parts (Bergmark 1989). (Medial fibre are local spinal segmental stabilizers, and the lateral fibres global, acting to assist lateral bending). 'The medial portion of the quadratus lumborum may in the future be shown to be functionally separate to the lateral part of the muscle and contribute directly to the segmental support of the spine.' (Richardson et al. 1999).

5. Please comment on where (if at all) you see fibre type as being a feature of your thinking regarding such characterizations?

I do not think the percentage of fibre type determines categorizations. They will determine how well a person can optimally perform, i.e. endurance athletes have high slow twitch percentage but this percentage is usually high in all their skeletal musculature.

6. Do you have a different way of designating or characterizing muscles that is of practical clinical value to you?

For practical clinical value I think monoarticular and multijoint are valuable terms for the muscles controlling the perpheral joints. The spine is more complicated. For the muscles controlling the spine and pelvis, I recommend Bergmark's categorization into local and global muscles based on how well they stabilise the joints or transfer external load. Local and global can be used for the peripheral joints as well.

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Response from Pamela W. Tunnell

Position Statement

The questions addressed in this discussion are complex, especially those of the correspondence between muscle fibre type and whole muscle designations. A good deal of confusion arises from the imprecise use of terms such 'tight', 'weak', 'inhibited', 'overactive', 'overuse' and 'underuse' and this can perhaps most easily be cleared up. Human muscles are built to provide us with considerable versatility and for adaptability and thus they are to some extent structurally variable and individualized. When we do categorize them into two groups for ease of discussion and understanding of their common features, we create generalizations that are useful but do not adequately explain every muscle. It is essential to bear in mind that balanced and appropriate co-activation of both muscle groups is required for normal posture and movement, however we choose to categorize them. Each system of muscle classification discussed below highlights a highly clinically relevant aspect of the muscular system which is important to the management of our patients.

1. It has been suggested that postural muscles tend towards overuse and eventual shortening, whereas phasic muscles tend towards disuse and weakness. Expand on why you consider this suggested model valid, and if not why not?

This model describes the condition of muscle imbalance that often develops within the skeletal musculature in which one group of muscles tends to become overactivated and tight while the other tends to become inhibited and weak (Janda 1978; Jull & Janda 1987). These classifications arose from Janda's clinical observation and research (Janda 1978) and are not readily explainable by the anatomical, histological, biochemical and physiological attributes of the muscles (Janda 1984). While this condition of muscle imbalance may be precipitated by injury and pain, it need not be. Aspects of individual lifestyle such as stress, fatigue, emotional state, and inadequate propriosensory input due to lack of variety of movements and sedentary lifestyle are common causes of muscle imbalance (Jull & Janda 1987). In light of this discussion, it is interesting to note that in many publications describing this situation, Janda refrains from using the terms 'postural muscles' and 'phasic muscles' to describe these muscle characteristics and instead uses the terms 'tightness prone' and 'inhibition prone' muscles. In this model, the 'postural' muscles are those used to maintain the most typical functional posture of humans, single leg stance. This is considered to be the case because gait is the most typical function of man and at least 85% of the gait cycle is spent in single leg stance (Janda 1963).

It is important to understand that the terms 'overactive' and 'inhibited' refer to altered neurological states of a muscle. In an 'overactive' muscle, the threshold of activation is lowered; and the muscle may be activated earlier and more often than normal and may be included in movements or functions in which it would normally be silent. An inhibited muscle exhibits an elevated threshold of activation and is left out of movements where it would normally be included (Janda 1980). The terms 'weak' and 'tight', on the other hand, refer to biomechanical properties of muscle. Weakness denotes a loss of muscle strength and tightness denotes shortening or loss of muscle extensibility due to structural changes such as fibrosis or proliferation of the non-contractile (connective tissue) elements of the muscle.

Detailed clinical observation of patients including routine assessment of muscle extensibility, coordination, movement patterns and strength, as well as close observation of individuals in routine situations in daily life have shown that the patterns of muscle imbalance described by Janda are very frequently found. The degree of tightness or weakness varies from individual to individual, but the pattern of tightness and weakness rarely does. In my clinical experience, exceptions to this pattern are infrequent enough that this finding is a significant one in and of itself and serves as a reminder that an especially thorough assessment is in order to shed light on the factors at work in the individual's motor system. I find this model itself to be highly clinically valuable both in assessing the underlying imbalance which may set the stage for an acute or chronic pain episode and for anticipating the type of imbalance which may develop after a trauma and being able to take steps to normalize it early on.

2. It has been suggested that dynamic phasic muscles which tend to weakness contain a predominence of slow twitch Type II fibres and that postural muscles which tend to

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shortening contain a predominence of Type I fibres: Please comment

Here I find it useful to distinguish between classification systems used for muscle fibers and those used for designating whole muscles. Although as many as eight different muscle fibre types have been identified (Romanul 1964), discussions of muscle fibre type often focus on two main types called Type I and Type II fibres. A third, intermediate type is also often discussed in which the Type II fibres are subdivided into Type IIA and IIB. Type I (tonic/postural) muscle fibres correspond to red muscle. Their metabolic energy is derived from the oxidative metabolism of glucose, therefore they contain high levels of myoglobin which binds oxygen in muscle and low amounts of enzymes used in anaerobic metabolism. They have a slow twitch time (100 ms) and are slow fatiguing. These properties make them capable of prolonged, low-intensity work and they are therefore considered to be well suited for endurance and stabilization. Type I fibres comprise about 40% of most human muscles (Garoutte 1996).

Type II (phasic) muscle fibres correspond to white muscle and derive their metabolic energy from the anaerobic metabolism of glycogen. They contain low levels of myoglobin and high levels of ATPase and myophosphorylase, the enzymes used in this anaerobic process. They have a fast twitch time (30 ms), are rapidly acting and incapable of continuous activity. Type IIB fibres are fast-fatiguing and Type IIA fibres, an intermediate type, are more fatigue resistant. Type II fibres make up about 60% of most human muscles and are described as being rapidly acting fight-or-flight muscles (Garoutte 1996). In humans, no skeletal muscle consists solely of slow or fast twitch fibres and there are numerous intermediate forms. Each muscle contains variable numbers of slow and fast fibres depending on the specific functions of the muscle (Ng et al. 1998; Garoutte 1996). This creates considerable versatility and adaptability in functional potential; therefore, in my opinion, attempts to classify muscles into just two subgroups may be oversimplified and potentially misleading. Proportions of fibre types within a muscle are believed to be largely genetically determined but have been shown to be readily altered by training, immobilization and pain (Jull and Richardson 1994; Garoutte 1996; Hides 1994; O'Sullivan 1997). Each motor unit within a muscle contains fibres of only one type, that is, each motor neuron activates fibres of only one type and the type of fibres in a motor unit has been shown to change in response to altering the innervation to the muscle. Evidently it is the frequency of incoming action potentials that determines the biochemical makeup of the fibres, as a slow twitch muscle stimulated rapidly converts to fast twitch (Buller 1960). Smaller motor units, usually made up of Type I fibers, have a lower threshold of activation and are therefore recruited first in a muscle contraction.

The designation of whole muscles as postural or phasic is not clear cut when considering the relative percentage of Type I and Type II fibres alone. Additional aspects of muscle architecture are considered to be important determinants of these designations but detailed discussion is beyond the scope of this paper. Among these are the shape and arrangement of fibres (fusiform vs penniform), the number of joints crossed by the muscle, the muscle's function, the depth of the muscle and the location and angle of its attachments relative to the joint (Hamill 1995, Norkin 1992).

In summary, many factors enter into the designation of a muscle as postural or phasic. Chief among these seem to be the neural input to the muscle and how the muscle is used in the body (Buller 1960), which varies from person to person based on individual motor patterns and habitual activities, among other things. In the most clear-cut and simplified situation, we might like to find that postural muscles contain a higher percentage of slow-twitch, Type I fibres and that phasic muscles contain a majority of fast-twitch, Type II fibres. However, fibre type does not seem to to be the only nor perhaps the most important factor involved. In general, as it is a complex subject, I think we have yet to fully appreciate the significance of individual motor variations, which amount to differences in neural regulation and may have an important influence in determining muscle structure.

3. The designation of muscles as stabilizers (deep, slow twitch) with a propensity to weaken and lengthen; and mobilizers (superficial, with propensity to shorten and tighten) is a more recent characterization. Further categorizations occur within this model including 'primary' stabilizers (unable to provide significant joint movement) and 'secondary' stabilizers (able to stabilize and move joints) and 'tertiary' stabilizers (which can at times provide defensive rigidity). Expand on why you consider this suggested model valid, and if not why not?

This model seeks to describe the functions served by various skeletal muscles and to categorize them according to the predominant roles they play in the motor system. Because stability and mobility are key functions of muscle, because muscles can and do adapt their function to the demands placed upon them, and because stability requirements are not the same for all joints, I find that functional classification of muscles is clearest and most meaningful when the joint and function in question are clearly specified. Any muscle of the body is capable of providing stability during some function (Jull and Richardson 1994; Richardson et al. 1999) and in my mind it would be an oversimplification, no matter how attractive, to imply that any muscle has only one function.

The problem of spinal stabilization is unique. The term 'axial organ' has been coined to refer to the spine and highlights the fact that the spine, while composed of many segments, has a unique function as a distinct and unified organ within the motor system. It functions as the structural axis or core of the motor system around which the peripheral trunk and extremities are organized (Richardson et al. 1999). However, the spine can only function effectively in this capacity with adequate neuromuscular activity and coordination (Gardner-Morse et al. 1995). This requires perception/proprioception, planning, timing, coordination, speed, endurance and strength. Thus, anticipatory organization of the axial organ is requisite to posturing or movement of the acral/peripheral elements of the body. Research has demonstrated the feed-forward spinal stabilization response that occurs before intentional movement begins (Cresswell 1994). The CNS must choose a postural set for each activity, whether static or dynamic. Thus, effective stabilization of the spine consists firstly of stabilization of the individual spinal segments into a spinal posture which is both safe for the spine and biomechanically consistent with the task at hand, and secondly of activity of the more peripheral trunk muscles which transfer loads from the trunk to the pelvis and minimizes the loads experienced by the spinal segments (Bergmark 1989).

Stabilization of peripheral joints, while as important, does not involve this same problem. I find this functional model of classification valid and useful but I am inclined to use somewhat different terminology, especially when discussing spinal stability (see Question 6).

4. For the most part stabilizer muscles are similar to phasic while mobilizer muscles are similar to postural. However, the quadratus lumborum muscle appears to be the source of confusion. How do you classify this muscle? Similarly, can you comment on how you classify the

- **multifidus,**
- **transverse abdominus,**
- **rectus abdominus muscles.**

Based on the factors discussed in Question 2, I disagree that stabilizers are mostly similar to phasic muscles and mobilizers to postural. As defined by Norris, stabilizers are similar to postural in some important features, including their slow-twitch nature and being well suited for endurance activities (Norris 1999). Based upon clinical experience and current research (McGill 1996), I consider the quadratus lumborum (QL) to exhibit characteristics of both categories and to possibly have functionally distinct parts within the muscle. I view it as both a peripheral spinal stabilizer which tends to overactivity and tightness and, in its medial fibres, a segmental stabilizer of the spine. The QL can react variously, for example, in cases of coronal plane dysfunction or asymmetry such as scoliosis, pelvic obliquity or poor lateral stabilization of the pelvis during gait. In these situations the QL may become overactive and tight on one side and inhibited and weak on the other. This example accents the reality that in the end a muscle's function depends on the forces it is responding to and the task it is trying to accomplish for the body. While there are many principles of function that help us clinically, our goal should be to assess and understand each patient as they are rather than making them fit into the categories we have previously described.

I consider the multifidus and transverse abdominis to be intrinsic spinal stabilizers, both of which tend towards inhibition and weakness in dysfunction (Cresswell 1993; Richardson et al. 1999; Hodges 1999; Cholewicki et al. 1997). Finally, I view the rectus abdominis to be a secondary spinal stabilizer (contributing to sagittal plane stabilization of the spine as when pushed unexpectedly from behind) which also tends toward inhibition and weakness. Research has shown that the rectus abdominis is often overactivated in an uncoordinated fashion when the deeper abdominal muscles do not function well, that its function is not properly dissociated from that of the deeper abdominals (Richardson et al. 1999) and my clinical experience bears this out. At the same time I find that the rectus abdominis itself is often poorly toned, elongated and weak or inhibited and I do not find contradiction in these descriptions. The rectus abdominis is, in my view, simply the muscle within the overall poorly functioning abdominal wall which activates in attempting to substitute for the poorly functioning deeper muscles.

5. Please comment on where (if at all) you see fibre type as being a feature of your thinking regarding such characterizations?

The characterizations made above are based primarily on a combination of clinical experience and understanding of motor system function with a secondary contribution from available research on muscle fibre types. Although clearly the distribution of fibre types must be consistent with the functions of the various muscles, neither our understanding of the complexities of motor function nor the research on fibre types is sufficient enough to allow us to clearly explain the relationships at present. Since many intermediate forms of fibre types have been identified, it makes sense that classification of muscles into two groupings, while helpful in their simplicity, are bound not to be able to accurately describe all situations.

It may be that one conclusion to be drawn is that of human adaptability and versatility. Many muscles play a role both in movement and in stabilization; they possess the fibre distributions and neural capability to activate either function as needed. Patterns of motor activity are highly individualized. For example, gait is one of the most basic human movements and yet it is so individualized that we are often able to recognize an individual at a distance by the distinctive features of their carriage and movement long before we can visually discern their features. If muscle fibre type is determined in part by how we activate our muscles this would help to explain the wide variations in fibre types and the lack of clear preponderance of one fibre type over another in many muscles. Factors of individual variability in motor regulation are rarely taken into account in research trials and indeed would be very difficult to take into account in study design. Additionally, when considering how the muscles respond in pain and dysfunction, I believe there are reactions which occur fairly universally (Richardson et al, 1999) as well as those which are individualized. This would contribute another source of variation in attempting to correlate muscle fibre types with muscle function.

6. Do you have a different way of designating, characterizing, muscles which is of practical clinical value to you?

When assessing overall muscle imbalance I use Janda's designations of muscles prone to overactivity/tightness and those prone to inhibition/weakness, bearing in mind the factors of individual variability discussed previously as well as the fact that some of the designations are unclear or unknown at present. I find these terms somewhat lengthy and it is understandable that they become shortened into more convenient ones. At the same time, the present confusion demonstrates to me that it is worth using a few extra, more explicit words for the sake of clarity in communication since it is unlikely that in any audience all listeners/readers will have enough familiarity with the complexities of the subject to not become confused by the more abbreviated terms.

When discussing spinal stabilization, I prefer to use the term 'intrinsic spinal stabilizers' to refer to the short, intrinsic muscle of the spine proper and to muscles with segmental spinal attachments which are well positioned for segmental spinal control. This includes the intertransversarii, interspinales and rotatores, which may function chiefly in the proprioceptive aspect of segmental stabilization (Bogduk 1991), the multifidus and transverse abdominis (Hodges 1999). I use the term 'secondary spinal stabilizer' to refer to the more peripheral trunk muscles like the erector spinae, rectus abdominis, external oblique and quadratus lumborum which play a crucial role in spinal stabilization not at the segmental level but rather by controlling and transferring loads from the trunk to the pelvis; these muscles are also capable of producing movement and torque.

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