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PREVENTION & REHABILITATION: EDITORIAL

The middle crossed syndrome — New insights into core function

In the Rehabilitation and Prevention section of this edition, two papers have been selected which have investigated core function looking at two different aspects, evaluating two different trains of thought. The first of these papers, by Pardehshenas et al. *Lumbopelvic muscle activation patterns in three stances under graded loading conditions: Proposing a tensegrity model for load transfer through the sacroiliac joints*. This is a review of the current proposed mechanisms for sacro-iliac joint stability and proposes evidence for an alternative — or additional — tensegrity-based mechanism.

The second relevant paper, *Immediate improvements in activation amplitude levels of the deep abdominal muscle following a sacroiliac joint manipulation during rapid upper limb movement* by Barbosa et al. (2014), also evaluates the sacro-iliac joint, but assesses the effect of local muscle EMG following sacro-iliac joint manipulation (Grade V/cavitation).

This second study suggests that manipulative intervention alters local muscle recruitment and may aid understanding of one mechanism for how HVLA, a long-established and evidence-based form of treatment for low back pain patients, may interact with the recently emergent field of motor control in low back pain groups.

It is with these two new pieces of research in mind, that the focus of this editorial is on a clinical observation that this author has made, which may offer similar insights into the growing understanding of the function of the core musculature.

A remarkable insight

In 1979, perhaps one of the most useful clinical insights in 20th Century manual medicine was published. The world of bodywork and movement therapies would never be the same again as the influence of the muscular system on the joints was described by Vladimir Janda in his lower-crossed, upper-crossed and stratification (or "layered") syndromes (Janda, 1979).

Muscle imbalance

Muscle imbalance physiology has been a very useful tool to help to better understand the joint-oriented focus of manual therapies, such as osteopathic and chiropractic; how a joint becomes "tight", for example, and how disruption to a joint's optimal instantaneous axis of rotation may occur as a result of such imbalance; and the potential ramifications of this across time.

Janda explained that, in his observation, certain muscle groups that had a greater tonic activation during infant development, such as the flexors and adductors of the hip, or the shoulder protractors, are more prone to shortening and facilitation. As such, Janda commented that the lower crossed syndrome was the "mother" syndrome and that the upper crossed syndrome would be born as the result of the lower crossed occurring (see Fig. 1).

However, in the clinical experience of the author, working primarily in the United Kingdom, it would seem that from a prevalence point of view, the layered or stratification pattern is by far the most common muscle imbalance sequence to be observed in the clinical population. Why this is, is difficult to say for sure. Speculatively, Janda was working primarily with hospitalized patients in the Czech Republic, so this may have skewed his observations in one direction. By the same token, working in the Western 21st Century environment, it is rare to find a patient whose abdominal wall muscles function as they should (and probably once did as a child), and rare to work with a patient who sits for any less than 10 h of their day. It is possible that the deep longitudinal system, as described by Vleeming (1997) may correspond with Janda's observations of the layered syndrome; where instability or pain in the sacroiliac joint as studied by Hungerford et al. (2003) may increase activation of the biceps femoris, presumably in an attempt to increase lumbo-pelvic stability? However, it may be that with increasing levels of obesity and deconditioning that the requirement for compensatory strategies to help stabilize the pelvis have increased since Janda's original observations?

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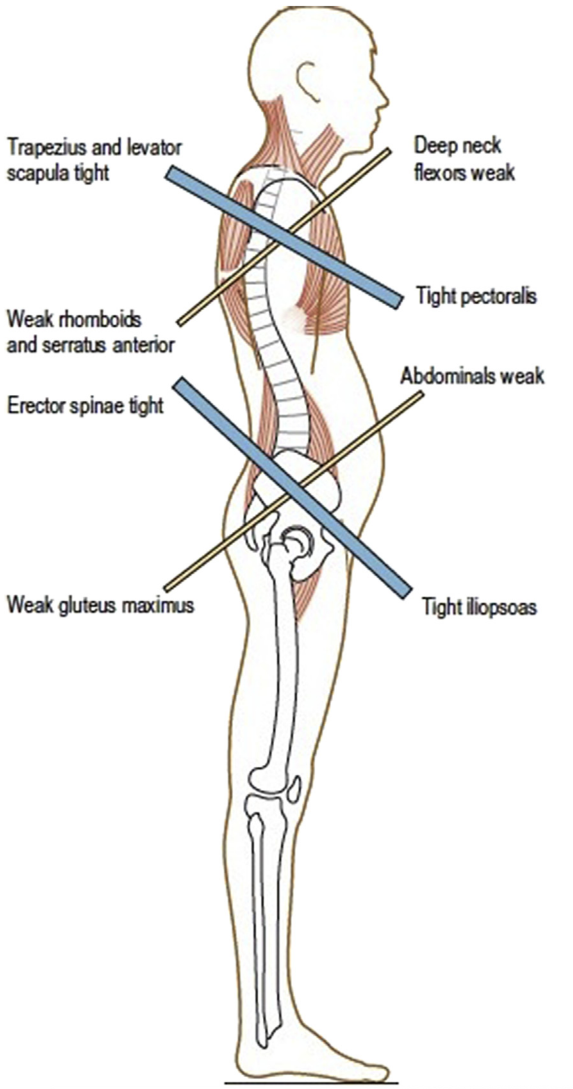

Figure 1 Janda's upper and lower crossed syndrome patterns.

Limitations of the muscle imbalance syndromes are mainly in their interpretation. Like many other clinical entities, it is tempting to rule them in or rule them out, based on absolutes rather than the shades of gray usually observed in clinic. The textbook case is the exception, not the rule.

It is possible to see, for example, most of the features of a lower crossed syndrome on one side of the body, with a layered syndrome on the opposite side, which may result in the classic pelvic torsion often treated by manual therapists.

In addition, Janda's muscle imbalance syndromes are dealing primarily with sagittal plane mechanics. Other's, such as Portafield and DeRosa (1998), have discussed frontal plane mechanics, including the lateral system, which incorporates the hip adductors and abductors on one side, and the quadratus lumborum on the opposite side (and, due to motion coupling, must include influences in the transverse plane). However, there has been little focus on transverse plane mechanics; yet it is locomotion in the transverse plane that human beings uniquely master across the first 5—7 years of life (Haywood and Getchell, 2005), to move with maximum efficiency through the gravitational field.

The transverse plane

Motion in the transverse plane is complex as it requires bilateral engagement of the hemispheres, but in an asymmetrical firing pattern. There are many descriptions of transverse plane or spiralic muscle chains around the trunk (Beach, 2010), from as far back as Da Vinci, yet the two that have received most clinical attention are the anterior and posterior oblique slings. These two slings are engaged in any speed of human gait above 0.75 m/s (in other words, any speed beyond "ambling") and serve as systems of reciprocal contraction and elastic recoil, creating a very efficient way to store energy and to move forwards.

Anterior oblique sling

The anterior oblique sling is described variably (Chek, 1998; Lee, 1998), as including the adductors of the hip, the internal oblique of the same side, the external oblique of the opposite side, the external intercostals and the pectoral group of the opposite side. When one leg is behind in gait, the opposite arm is behind, creating a stretch through that sling, a stimulation of the spindle cells, and a recoil which drives them through as opposing limbs reciprocate in gait's next step.

Posterior oblique sling

The posterior oblique sling is described (Chek, 1998; Lee 1998; Vleeming, 1997) as including the gluteus maximus of one side and the latissimus dorsi of the other side joining together over the midline via the superior lamina of the posterior layer of the thoracolumbar fascia. When one leg is ahead in gait, the opposite arm is also ahead, creating a stretch through that posterior oblique sling, a stimulation of the spindle cells, and a recoil which activates them to engage and drive the body forward (while at the same time their opposing limbs reciprocate during the gait cycle's next step) (see Fig. 2).

The premise of Janda's muscle imbalance syndromes is that as certain muscle groups differentiate into tonic dominance or phasic dominance they develop the tendency to either shorten or tighten (tonic dominance) or to lengthen or weaken (phasic dominance). This differentiation is believed to occur primarily during infant development, but will also continue into adult life based on which groups are over-utilized or under-utilized; and in what length tension relationship this occurs. For example, someone who sits slumped at their desk for many years will develop lengthening of their thoracic erector group and shorting of their upper rectus abdominis.

As far as this understanding is accurate, would it not also be reasonable to suggest that handedness or laterality patterns (discussed in Wallden, 2011) will also influence muscle usage, recruitment, length-tension relationship and differentiation of function?

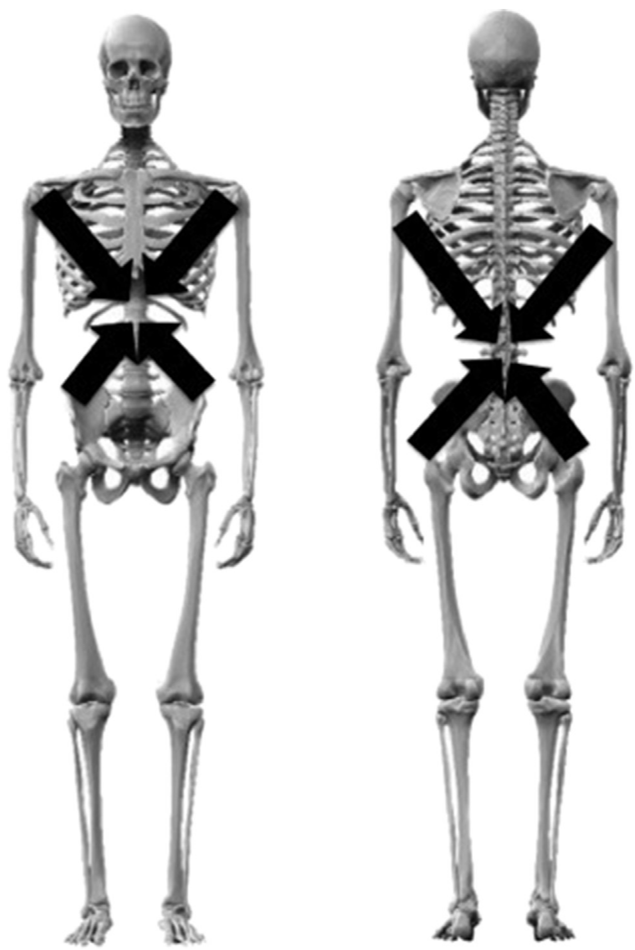

Figure 2 The anterior and posterior oblique sling mechanisms. These myofascial slings serve to effectively generate power, and to store and recoil elastic energy in steady state gait.

The middle-crossed syndrome

A clinical observation which appears to reflect these laterality patterns is that it is more common to find that a right footed person is more stable standing on, or jumping off, their *left* leg; but better at throwing, pushing or pulling with their *right* arm. This suggests, from a load transfer perspective, that the left leg (which is bearing the weight of the body) and the right arm (which is expressing that load), are most likely to be utilized by that individual. Repeatedly taking such loading through these limbs will be likely, due to the SAID Principle (specific adaptation to imposed demands (Baechle and Earle, 2000)), to result in the interconnecting sling becoming stronger and neurally facilitated. This may also therefore present clinically as the muscle appearing or measuring as being "tighter". The stronger a muscle is, the larger (and more numerous) its muscle fibers and associated series and parallel elastic components; essentially making them a stiffer, more resistant spring (Sahrmann, 2002). This situation may be observed clinically in the pattern illustrated below (see Table 1).

Common clinical findings

Common clinical findings in the middle-crossed syndrome in a right handed, right footed individual are:

1) in gait, the umbilicus deviates leftward on right foot ground contact, but stays central on left ground contact.
2) in active straight leg raise (ASLR) testing, the umbilicus deviates rightward on right leg lift, but stays central on left leg lift (see practical section for "cheat mechanisms")
3) in supine lateral ball roll (SLBR), the umbilicus deviates leftward (and/or the right hip drops), when moving across the ball to the left, but stays central when moving to right.

These findings are typically reversed for a left dominant individual.

It is acknowledged that a percentage of people are *ambidextrous* or *contradextrous* (left handed & right footed, for example), but no clear clinical pattern has yet been identified for these groups. In the former case, even ambidextrous individuals tend to have a favored hand or foot; so they will tend to follow the patterns described above.

Ramifications

What are the ramifications of such an imbalance? In the short term, the ramifications of this kind of imbalance are likely negligible. The body is well designed to tolerate

Table 1 Sling systems and typical patterns of dominance, based on laterality patterns.

Sling system	Right dominance	Left dominance
Stronger, facilitated, shorter, stiffer		
Posterior oblique sling	Right shoulder — left hip	Left shoulder — right hip
Anterior oblique sling	Right shoulder — left hip	Left shoulder — right hip
Deep longitudinal system	Left hamstrings — right LES	Right hamstrings — left LES
Lateral system	Left glute med — right QL	Right glute med — left QL
Weaker, inhibited, longer, less stiff		
Posterior oblique sling	Left shoulder — right hip	Right shoulder — left hip
Anterior oblique sling	Left shoulder — right hip	Right shoulder — left hip
Deep longitudinal system	Right hamstrings — left LES	Left hamstrings — right LES
Lateral system	Right glute med — left QL	Left glute med — right QL

asymmetrical loads. However, across time, asymmetry will always take its toll on any structure. In this instance, certain structures will become more stressed due to lack of stability/ability to resist gravitational or other extrinsic loads (see Fig. 3).

One such example might be that it is common to find someone who is right-footed to exhibit medial rotational instability at the right hip, resulting in relative adduction of the knee and pronation of the foot on that right side when under load. This individual may be more prone to meniscal wear and tear, or medial collateral strain to their right knee as a result.

Ramifications of these patterns are that clinicians may be able to identify causative pathways, and patients may therefore benefit both proactively and reactively to minimize stress on that tissue; as part of a prevention/conditioning program, or as part of a rehabilitation program.

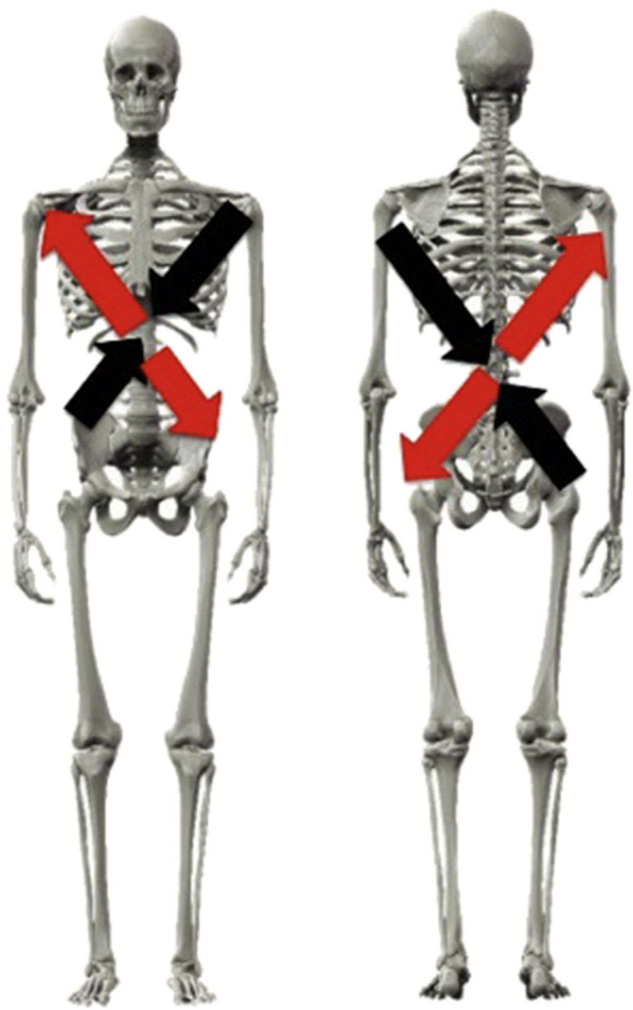

Figure 3 The middle crossed syndrome. Clinically it is often observed that the weaker slings are those going from the dominant leg to the non-dominant arm. In this instance, the pattern observed would most commonly be seen in a left handed/left footed individual — the weaker of the slings traversing from the left hip to the right shoulder.

Assessment and correction

Assessment of the middle crossed syndrome is described in more detail in the accompanying practical paper, alongside suggestions for possible corrective interventions.

Other insights into functional stability of the core

Returning to the other papers featured in this section, the Pardehshenas et al. paper gives an indication that the previously described mechanisms of force and form closure may be incomplete. Although there is no discussion of bracing versus hollowing in their discussion, which may be a different way to interpret their EMG findings, it is likely that the proposed tensegrity mechanism for stability has much merit. In conjunction with the established mechanisms — including an understanding of the hollowing-to-bracing continuum — this fresh perspective contributes to our understanding of how the body stabilizes itself in normal activities, including single leg stance and load-carrying. In short, there appears to be "more to it" than the mechanisms used to explain sacro-iliac joint stability well documented in the existing literature, though this does not necessarily question their usefulness; just their completeness.

With regard to the Barbosa et al. paper, the key finding is that EMG signal, recorded over the lower (transverse fibers of) internal oblique and transversus abdominis during random upper limb movement, increased following manipulation of the sacro-iliac joint. Such high-velocity low-amplitude thrusts or Grade V mobilizations, which cavitate the joint, have been shown in previous studies to reduce the motor evoked potential at the cortical level, and increase the silent period at the subcortical level, as well as to decrease excitability at the spinal cord identified via assessment of the Hoffman-reflex. What this means in practical terms appears to be that there is decreased efferent neural drive to segmentally associated musculature following manipulation; though the picture may be more complex (Fryer and Pearce, 2013).

One challenge in research assessing motor evoked potentials is that they are measured via transcranial magnetic stimulation to evoke an electrical reading, measured by EMG, at the target muscle. Since EMG is open to many different measurement artefacts, and is easiest to assess in superficial musculature, there are naturally some limitations to assessing the effect of motor evoked potential to the deeper or "inner unit" muscles. Hence, most research has been conducted on superficial, outer-unit musculature.

One possible interpretation of the data therefore is that part of HVLA's efficacy in helping low back pain patients may be through decreasing motor drive to outer unit musculature (essentially inhibiting the previously facilitated), thereby both reducing compressive loading, and that this may offer a window of opportunity for deeper intrinsic musculature, normally inhibited in pain conditions, to re-engage. Indeed, spinal HVLA techniques have been observed to enhance proprioceptive tasks and overall motor recruitment; which may indicate a role in "neurological re-setting" (Fryer and Pearce, 2013) consistent with the description above.

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Matt Wallden, DO
E-mail address: matt@primallifestyle.com

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