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# THORACIC RING CONTROL: A MISSING LINK?

**Internationally recognised researcher and clinician LINDA-JOY LEE, APAM, outlines the significance of a dysfunctional thorax in relation to healthy, whole-body function.**

The thorax has long been characterised as an inherently stiff and stable structure due to the ribcage (Geelhoed et al 2006, McConnell 2005, Takeuchi et al 1999). However, minimal data support this belief. While the ribcage does increase the stiffness of the thoracic spine, as well as the critical buckling load sustainable by the osseoligamentous thoracolumbar spine by a factor of three or four, these loads are still well below those that the spine is exposed to in normal function (Andriacchi et al 1974). Support from neuromuscular forces is essential. Biomechanical data show that the intact thorax is mobile in all planes (Lovett 1905, Gregersen & Lucas 1967, Watkins et al 2005). In contrast to the limited rotation of lumbar spine segments, the primary movement of the thorax is rotation (transverse plane motion), followed by lateral bending (coronal plane motion), with significantly less flexion and extension range of motion (Lovett 1905, Gregersen & Lucas 1967, Watkins et al 2005, Willems et al 1996). Thus, the evidence supports that the thorax is inherently flexible in nature.

In both research and clinical realms, the thoracic spine is commonly considered in isolation from the ribs and ribcage, with separate assessment and treatment techniques for each (Giles & Singer 2000, Lee DG 1994, Maitland 1964, Mitchell & Mitchell 2002). However, multiple articulations and strong ligaments connect the ribs to their related thoracic spinal segment, and it is proposed that where there are anterior attachments, the true functional spinal unit of the thorax is a 'ring' (Lee LJ 2003a, 2005, 2013, Lee LJ et al 2010, Molnar et al 2006). For example, the fifth thoracic ring is comprised of the right and left fifth ribs and their anterior attachments to the sternum, the T4–5 thoracic vertebrae and the T4–5 intervertebral disc (Lee DG 1994, Lee LJ 2003a, 2005). Measurement of the integrated thoracic ring is challenging, but recent data support that, during functional movements, the thoracic spine and ribs move as an integrated three-dimensional complex. Small changes in thoracic spine alignment in the sagittal plane (flexio/extension) create three-dimensional changes in the shape of the ribcage at multiple levels (Lee LJ et al 2010). Novel clinical techniques use manual palpation at the lateral aspect of the ribs to assess and treat the three-dimensional thoracic ring (Lee LJ 2003a, 2003b, 2005, 2007, Lee & Lee 2008). Given the strong attachments of the ribs and related vertebrae, and the distance from the axis of motion, movement of the ribs is used to determine vertebral mobility and assess the movement of the entire ring (Lee LJ 2003a). These techniques are consistent with the findings of Keene (1906).

Each typical thoracic ring has 13 articulations (Standring 2008), and in total the 136 joints of the thorax provide significant mobility. The capacity for movement within and between the segments of the thorax, along with the requirements for control of upright posture and respiration, requires complex coordination of muscle activity by the central nervous system (CNS) to meet the demands of stability and movement. For example, during tasks that create perturbations to the thorax in the sagittal plane (flexion/extension), the deep multifidus and superficial longissimus are similarly recruited to control challenges to stability. In contrast, when challenges to stability occur in the transverse plane, the CNS controls the deep multifidus and superficial longissimus differentially. Differential control of these two layers of thoracic paraspinal muscles is only apparent in the plane where the thorax has the greatest movement, in the transverse plane, for control of opposite rotational perturbations (Lee LJ et al 2005, Lee LJ et al 2009, Lee LJ et al 2011).

These data are consistent with clinical proposals that the most common direction for poor control in the thorax is related to control of rotational forces (Lee LJ 2003a, 2008). Due to the coupling of lateral translation with rotation (Gregersen & Lucas 1967, Lovett 1905), functionally a loss of rotational control can also manifest as poor control of lateral

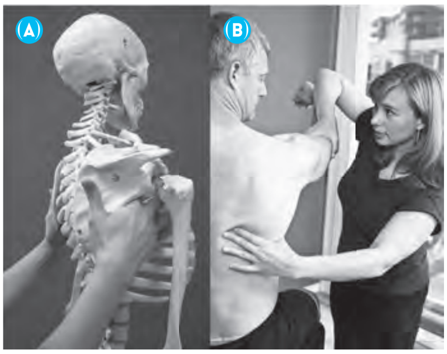



**FIGURE 1.** Thoracic ring assessment and correction (from The Thoracic Ring Approach): (**A**) illustrates palpation technique for upper thoracic rings used in both assessment and treatment; (**B**) shows correction of a lower thoracic ring during resisted arm flexion to determine if restoring optimal biomechanics and neuromuscular control to the thoracic ring will result in positive change for the meaningful task and if the thoracic ring is the driver for the patient's shoulder problem. (Reproduced with permission from Linda-Joy Lee Physiotherapist Corp.)

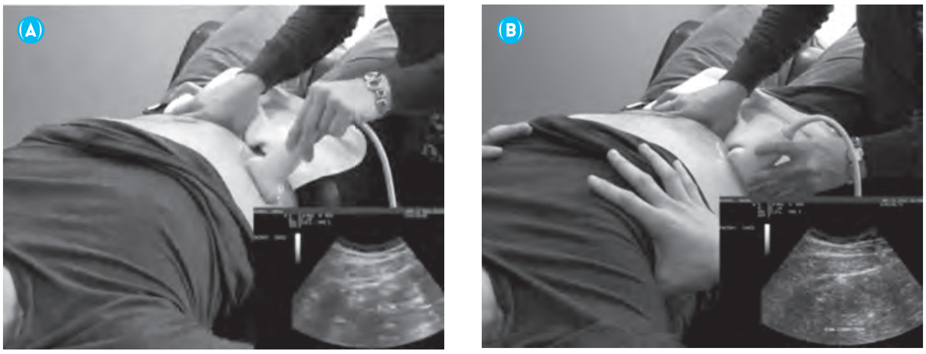



**FIGURE 2.** The thoracic rings are a common underlying cause for dys-synergies of the abdominal wall, inability to recruit transversus abdominins and/or pelvic floor, asymmetry of transverus abdominis and pelvic floor contraction, and/or hypertonicity and asymmetry of the superficial and deep layers of the abdominal wall and/or the pelvic floor (Lee LJ 2004, Lee LJ 2007). (**A**) With verbal cues designed to elicit a bilateral symmetrical contraction of transversus abdominis, there is a response from the left transversus abdominis but no response on the right. Changing cues, effort, and paying more attention to the right side do not change the ability to recruit the right transversus abdominis.
(**B**) When the driving thoracic rings are corrected (3rd and 4th), the same cues result in immediate recruitment of the right transversus abdominis in a symmetrical manner with the left transversus abdominis—symmetry of recruitment is restored. In thoracic-driven abdominal wall dysfunction, transversus abdominis contraction occurs in response to a cue directed to control of the thoracic rings, not in response to abdominal wall cues. (Reproduced with permission from Linda-Joy Lee Physiotherapist Corp.)

translation forces (Lee LJ 2003a). Similarly, loss of rotational control can be coupled with loss of lateral bending control.

Shifting from the paradigm that the thorax is stiff and requiring mobilisation to one where the thorax is flexible and requiring optimal neuromuscular control provides greater insight into why the thorax can drive distal problems. This is because it moves away from conceptualising the thorax as a static, stiff box to being a dynamic stack of ten rings, much like a 'slinky' or a shock-absorbing spring. When there is loss of optimal sequencing, force modulation, and synergy between the muscles around the thoracic ring, between the ten thoracic rings, and between the rings and other regions of the body, there are many possible consequences throughout the whole body. These consequences can result in non-optimal loading of multiple different structures and regions of the body that can drive conditions as diverse as hip osteoarthritis, impingement and groin pain, pelvic girdle and low back pain, incontinence and prolapse, Achilles tendinopathy, patellofemoral pain, shoulder impingement, lack of 'core stability', and headaches. Furthermore, due to the anatomical relationships to the sympathetic chain and innervation of the viscera, the thorax can drive other non-optimal experiences such as sensitisation of the sympathetic nervous system and gastrointestinal symptoms.

Consider the possible impact when there is non-optimal neuromuscular control of the fourth thoracic ring during a squat, resulting in left translation and right rotation of the fourth ring (upper thorax) upon initiation of the squat motion. This movement of the fourth thoracic ring creates both a lateral and rotational perturbation to the trunk. To counter this perturbation, activity in the right external oblique and left internal oblique may increase, resulting in asymmetrical abdominal wall activation and potentially an opposite rotation in the lower thorax. Commonly, the pelvis and hips counter-rotate in order to compensate for the rotation of the upper thorax, so that the pelvis rotates to the left and the right hip moves forward. The twist in the thorax alters all muscle relationships around the thorax, affecting scapular, neck and head neuromuscular control and position. Because all abdominal muscles are innervated from the lower thorax (T7–L1/2), the thorax twist may further contribute to abdominal wall dys-synergies via neural mechanisms. Excessive and asymmetrical contraction of the superficial muscles such as the external obliques (EO), changes in diaphragm activity (attaches to the lower six thoracic rings) and depression of the scapulae restrict mobility and compress the thorax, affect the balance between intra-thoracic and intra-abdominal pressure, and create increased pressure in the lower abdomen (a 'pressure belly'). In response to the increase in intra-abdominal pressure, the pelvic floor muscles can become hypertonic, contributing to pain syndromes and/or stress urinary incontinence (SUI). Interestingly, the EO attaches as high as the fifth thoracic ring, and increased activity of the EO and pelvic floor occurs in some women with SUI (Smith et al 2007).

Left lateral translation of the fourth thoracic ring also affects the position of the centre of mass over the feet, which affects control of postural equilibrium and alters medial–lateral forces all the way down the kinetic chain to the feet, altering muscle activation and loading patterns. For example, left translation of the trunk often correlates with decreased right gluteus medius and maximus activity due to decreased weight-bearing on the right leg. Combined with compensatory pelvis rotation, this creates an altered axis of movement and control of the right hip, providing a biologically plausible mechanism to explain thoracic-driven hip impingement and groin pain. In these subgroups, the hip symptoms do not resolve without treatment to change neuromuscular control of the driving thoracic rings. Figures 1–5 show clinical examples of thorax-driven shoulder pain, abdominal wall dysfunction, low back pain, and foot pain.

These examples illustrate that a patient with non-optimal strategies for control in the thorax can present with a wide variety of symptoms and functional problems. So how does the

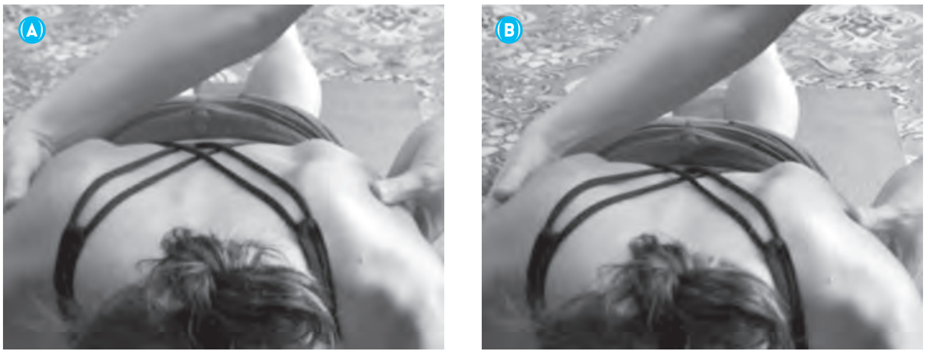
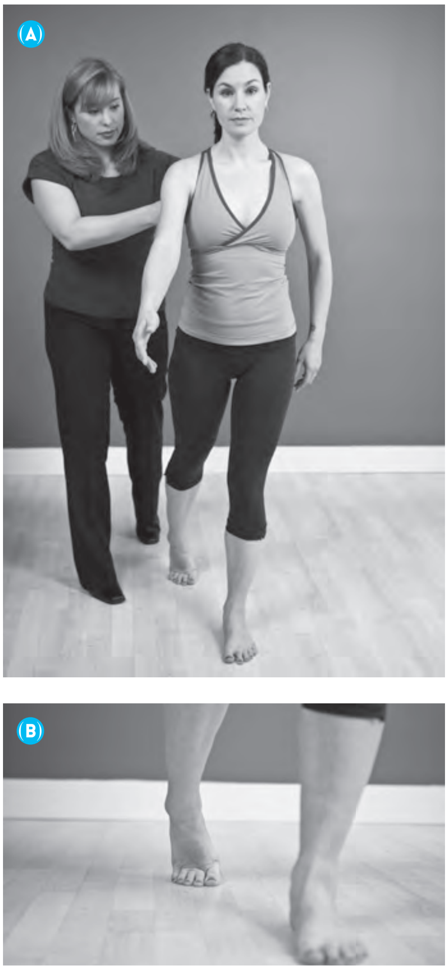



**FIGURE 3.** Assessment of thoracic ring control during plank task. Patient reported inability to do plank exercises due to difficulty breathing and low back pain during this task. **(A)** With correction of upper thoracic rings (3 and 4), there was no low back pain and the patient was able to breathe and feel her abdominals and pelvic floor contract; **(B)** shows the change in thoracic and lumbar spine position once the correction to the upper thoracic rings is released. Note the rotation and extension load that is imparted from the upper thorax to the lumbar spine. This patient also reported an inability to feel a pelvic floor contraction without thoracic ring correction that was restored with thoracic ring correction. (Reproduced with permission from Linda-Joy Lee Physiotherapist Corp.)



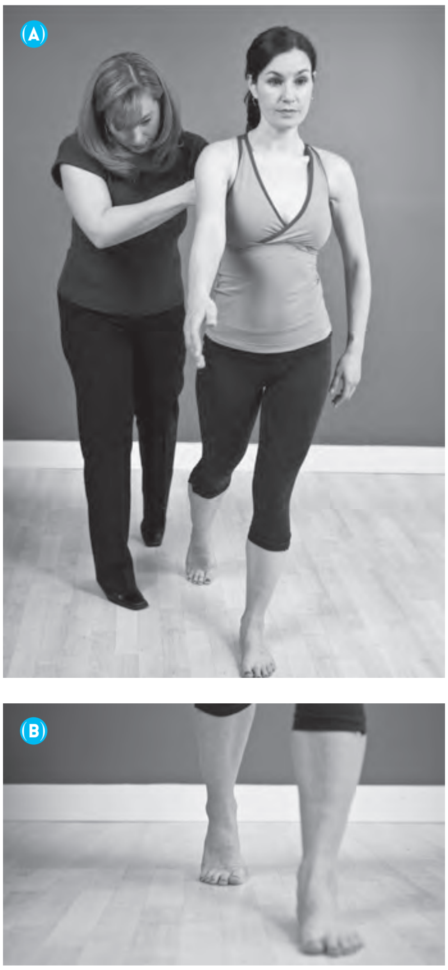




**FIGURE 4.** (**FAR LEFT**) **(A)** Example of a patient with right plantar foot pain during running. During left step forward, the right foot demonstrates lateral weight bearing on push-off, with valgus forces at the ankle. At initiation of the step forward, the fourth thoracic ring is felt to translate left, creating a segmental right rotation. Optimally the upper thorax should rotate left, and therefore the movement of the fourth thoracic ring is non-optimal. The resultant left shift of the thorax over the base of support requires the compensatory valgus at the ankle to neutralise the center of mass over the base of support. **(B)** Close-up of the impact on the right foot of the early left translation of the 4th thoracic ring. (Reproduced with permission from Linda-Joy Lee Physiotherapist Corp.)

**FIGURE 5.** (**NEAR LEFT**) **(A)** Correction of the fourth thoracic ring during the left step forward task results in optimal weight bearing through the right ankle and foot during push-off, and reduction of the patient's symptoms. The thorax can drive distal problems in the hip, knee, ankle and foot due because of rotational mechanisms and the effect that lateral translation of the thorax has on the centre of mass relative to the base of support. **(B)** Close-up of the right foot in push off in response to the fourth thoracic ring correction. Note the significantly improved position. (Reproduced with permission from Linda-Joy Lee Physiotherapist Corp.)

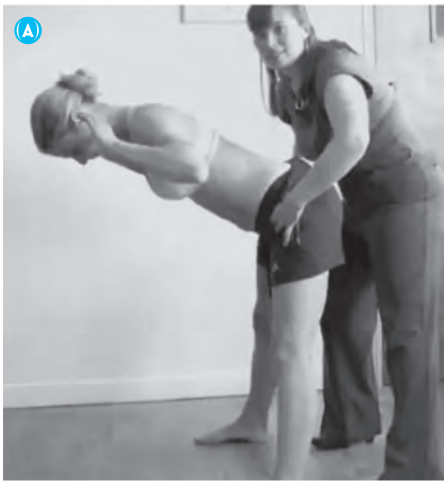




**FIGURE 6.** Meaningful task analysis—deadlift simulation. This patient complained of right hamstring pain/tension that limited her range of motion and ability to perform deadlifts. Both the pelvis and the fourth thoracic ring showed loss of optimal control during the movement. Comparison of a pelvis correction (**A**) to a fourth thoracic ring correction (**B**) during meaningful task analysis enables determination of the primary driver for the task. The fourth thoracic ring correction allowed much greater range of motion without hamstring symptoms, supporting the hypothesis that the primary driver is the fourth thoracic ring. Further tests are needed to determine the underlying impairment for the fourth thoracic ring to choose appropriate treatment techniques. Retraining optimal strategies for control of the fourth thoracic ring during deadlift-related movement and loads will be a key part of the treatment program.

clinician decide whether or not to treat the thorax? It is clear that location of pain or tissue changes do not always direct us to the primary underlying driver. Rather, a whole-body assessment paradigm is needed to determine how thorax dysfunction relates to the presenting problem. Meaningful Task Analysis was initially proposed as an assessment framework to determine whether or not dysfunction in the thorax was the underlying cause, or driver, of the patient's problem (Lee LJ 2008). Assessment of thoracic ring biomechanics and control is performed during tasks that are meaningful to the patient—tasks where symptoms or other non-optimal features, such as decreased power, are experienced. If non-optimal alignment, biomechanics or control of the thoracic rings occurs during the task, a thoracic ring 'correction' is performed, whereby optimal thoracic ring movement and control is provided through gentle but specific manual facilitation at the specific ring level (Lee LJ 2003a, 2005, 2007). If this 'thoracic ring correction' changes the ease of task performance, meaningful complaint/symptom, and optimises transfer of loads through other areas of the body, then there is support that dysfunction of the thorax is driving the problem. Manual corrections during task performance are also provided to other areas of the body (Figure 6) to compare the impact of changing alignment, biomechanics, and control at other areas to the thoracic ring correction. In cases where the thoracic ring is the primary driver, corrections to other areas either have a negative effect or not as positive an effect as the thoracic ring correction (Lee LJ 2003a, 2005, 2008). This clinical reasoning framework is a key feature of the Thoracic Ring Approach (Lee LJ 2011, 2012) and the Integrated Systems Model (Lee & Lee 2011).

Treatment for a thoracic ring driver is multimodal, and often requires release and down-training of hypertonic muscles related to the driving thoracic ring. An essential component is neuromuscular retraining and building muscular capacity (strength, endurance) for more optimal control of the thorax. This includes specific thoracic ring taping and progressive exercises targeted to restore both segmental ring control and interregional control during functional loading related to the patient's meaningful task (Lee LJ 2003a, 2005, 2008, Lee & Lee 2008).

The thorax forms the largest region of the spine and trunk and is essential for respiration while ensuring effective transfer of loads for optimal whole-body function and performance. The Thoracic Ring Approach (Lee LJ 2011, 2012) incorporates current research on the thorax and provides innovative clinical assessment and treatment skills for the thorax as a three-dimensional series of 'thoracic rings'. The approach also considers the multiple links between the thorax and all other regions of the body and proposes multiple mechanisms by which the thorax can drive pain or problems elsewhere in the body, some of which have been discussed here. In the context of whole-body function, a dysfunctional thorax, whether painful or pain-free, can be 'the primary driver' for pain and problems anywhere from your head to your toes. Having trouble training or restoring symmetrical abdominal wall function? Persistent groin pain despite surgery and local exercises? Recurrent neck pain, low back pain or pelvic girdle pain? Perhaps the thorax is the missing link.

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**Dr Linda-Joy Lee is a clinician, educator and researcher known for her skills in movement and performance analysis to restore total body function. She is an associate member of the Centre for Hip Health and Mobility (Vancouver) and an honorary senior fellow at the University of Melbourne. Her interest in trunk stability, motor control of the thorax, and the relationship of the thorax to lumbopelvic problems led to a PhD. Linda-Joy practices at Synergy Physiotherapy (North Vancouver), is an associate editor for the *British Journal of Sports Medicine*, and a specialised consultant for Rowing Australia.**