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The musculoskeletal contribution to the evolution of chronic lumbopelvic pain: 1. The lumbar spine and pelvis

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Abstract
Where there is no proven infection or obvious local pathology, the occurrence of chronic pelvic pain syndrome (CPPS) may involve contributions from the musculoskeletal, neurological, urological, gynaecological and immune systems. In the first part of this article, the potential musculoskeletal contributions of the lumbar spine and pelvis to CPPS are described. This provides the practitioner with a systematic assessment to identify the postural alignment strategies, habitual movement patterns and interactions of the lumbopelvic cylinder that may be contributing to an individual's presenting condition. However, persistent pain is also associated with changes in the central nervous and immune systems, and therefore, we need to be reminded that the purely structural-pathology-based model for explaining CPPS is outdated. Furthermore, since CPPS is often associated with negative cognitive, sexual and emotional consequences, these may also need to be addressed in order to provide optimum care for the patient.

Keywords: chronic pelvic pain syndrome, movement, musculoskeletal pain.

Introduction

Although it is generally accepted that movement changes with pain, there is little agreement regarding the processes that underlie alterations to movement and the relevance of these to rehabilitation of musculoskeletal pain (Hodges & Moseley 2003, Tsao *et al*. 2010). Additionally, one of the main difficulties in the diagnosis of pain in the pelvis is the overlap of signs and symptoms in various conditions, including medical conditions not directly related to musculoskeletal injuries (Nam & Brody 2008). These can include urinary tract infection, prostatitis, and other urinary, bowel and sexual dysfunctions. The urological, neurological, muscular, skeletal and fascial systems may all have roles to play to varying degrees, and consideration of each is necessary to provide a more accurate diagnosis and a more valid paradigm on which to base treatment. Furthermore, pain perceived to be within the pelvis can be referred from the thoracolumbar spine, sacroiliac joint and hip (Lee 2004), and since the body operates as a system, each component of the system of movement is capable of influencing the distal and proximal regions.

In this article, the present authors consider the concept of movement as a physiological system, and describe a method of assessment based on analysis of a patient's movement (dys-)function, combined with an assessment of his or her injury history and pain presentation (Sahrmann 2002). Rehabilitation is then focused upon restoring efficient movement patterns and

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improving function, and less on treating the pain *per se*. Manual therapists have traditionally used the client's pain pattern and physical findings, such as pain provocation tests, to identify structures contributing to mechanical pain. However, in the presence of central sensitization and neurogenic pain mechanisms, the reliability of such a patho-anatomical assessment to identify the sources of pain can be limited, particularly as the relationship between pain and the state of the tissues becomes weaker as pain persists (Moseley 2007). Classification of movement patterns, which are used to identify the mechanical causes of pain, may be similarly limited in the presence of central sensitization, where any mechanical stimulus may be sufficient to generate a painful response. At all times, then, current pain physiology, and other contributing factors to chronic pelvic pain (CPP), need to be considered when assessing the movement system.

Assessment of the movement system

The movement system is modulated by many factors from across the somatic, psychological and social domains (Moseley 2007). It is recognized that the nervous system is likely to coordinate muscle activity to meet the demands for stable movement, so it will not only be affected by the task, posture or movement direction, but potentially, the real or perceived risk of injury (Hodges & Cholewicki 2007). Motor changes have been documented to occur throughout the movement system, from the motor neuron level and coordination of muscle behaviour to changes in the organization of the motor cortex (for a review, see Tsao *et al.* 2010). Strategies adopted during pain and injury can increase protection of injured or painful parts, but may also have mechanical consequences that can prolong pain states or result in a higher incidence of recurrence (Hodges & Moseley 2003; van Dieën *et al.* 2003). In controlled clinical trials, rehabilitation of these motor changes has been linked to clinical recovery, resulting in improvements in pain and dysfunction (Cowan *et al.* 2003; Ferreira *et al.* 2006). More recently, such improvements have also been shown to be associated with recovery of plastic changes in the motor cortex (Tsao *et al.* 2010).

Various classifications for the analysis of movement and the subclassification of movement dysfunction have been proposed (McGill 2002; Sahrmann 2002; McKenzie & May 2003; O'Sullivan 2005), and in some instances, good evidence of the validity and reliability of these has been published (Van Dillen *et al.* 1998, 2003; Dankaerts *et al.* 2006; Harris-Hayes & Van Dillen 2009; Harris-Hayes *et al.* 2010). It is beyond the scope of this paper to describe the benefits and limitations of each classification system; however, it is reasonable to suggest that the multidimensional problem of chronic low back and pelvic pain should also encompass biopsychosocial principles (Linton 2000; Waddell 2004; Woby *et al.* 2004, 2007). Based upon the work of Sahrmann (2002), the following section describes the evaluation, classification and subsequent rehabilitation of lumbopelvic movement disorders.

Lumbopelvic movement disorders

Sahrmann (2002) suggested a classification system for the analysis of lumbopelvic movement and the subsequent prescription of treatment based on clinically assessed movement system dysfunction. A central tenet of this system is that faulty movement can induce pathology, not just be a result of it, and musculoskeletal pain syndromes are seldom caused by isolated events but are the consequence of habitual imbalances in the movement system (Sahrmann 1993). Therefore, specific postures and movements that produce pain need to be identified and corrected since misalignment and aberrant movement patterns might result in further pain and future recurrences (Van Dillen *et al.* 2003).

The objective examination has two major components:

(1) The patient reports the response of symptoms to the movement pattern tested, i.e. whether there is an increase or decrease in symptoms.
(2) The bony and/or joint alignment is assessed in various positions, as outlined in Table 1, taken from Van Dillen *et al.* (2003).

There are several unique components of this examination system:

(1) the effect of active limb movements on spinal movements and symptoms;
(2) the relative timing of movements of the spine and proximal joints during limb and trunk movements; and
(3) the effect on symptoms of modifying lumbar alignment or movement during repetition of a previously symptomatic test (Van Dillen *et al.* 2003).

Table 1. Items derived from an original examination (Van Dillen *et al.* 1998) that are proposed to be important for the classification of mechanical low back pain, organized by test position, symptom behaviour with variations of the test position or movements within the test position, and clinical judgements of the quality of alignment or movement.

Test position	Symptom behaviour with variations	Quality of the alignment or movement
Standing	Standing Posterior pelvic tilt against a wall Forward bending Corrected* forward bending Return from forward bending Corrected return from forward bending Side-bending	Shape of the lumbar curve (with and without a flexible ruler) Asymmetry of the lumbar curve Regularity of the lumbar curve (with and without a flexible ruler) Swayback posture Lumbar flexion Lumbar extension Relative flexibility† Hip extension Lumbar extension Pelvic and shoulder sway Asymmetrical lumbar region movement
Sitting	Sitting with the lumbar region flat Sitting with the lumbar region flexed Sitting with the lumbar region extended Knee extension Corrected knee extension	Lumbar region rotation or pelvic rotation‡
Supine	Hips and knees flexed Hips and knees extended	–
Hook- (crook-) lying	Hip abduction with lateral rotation Corrected hip abduction with lateral rotation	Relative flexibility
Prone	Prone Corrected prone Knee flexion Hip rotation Hip extension	Relative flexibility Asymmetrical pelvic rotation Relative flexibility Asymmetrical pelvic rotation
Quadruped	Natural alignment Corrected alignment Arm lifting Rocking backward Corrected rocking backward Rocking forward	Lumbar region alignment Asymmetry of the lumbar region Alignment of the hip joint Asymmetrical lumbar region rotation Relative flexibility Pelvic rotation or tilt

*Corrected test items are follow-up items in which the lumbar region is repositioned to achieve a neutral alignment, or movement of the lumbar region is restricted relative to what was observed with the previous symptomatic test item. The effect of the changes in alignment and movement on symptoms is assessed.

†A judgement of relative flexibility refers to a judgement made by the examiner about the relative timing of the movement of the lumbar region and the proximal joints when the patient performs a trunk or limb movement. In general, a patient exhibits a relative flexibility impairment if the lumbar region moves in the first 50% of the range of the overall movement or excessively during the overall movement.

‡Because rotation and side-bending are coupled motions in the lumbar region, items that refer to judgements of alignment and movement of lumbar region rotation or pelvic rotation include side-bending alignment or movement.

The information obtained from this assessment allows the patient to be assigned to one of five different categories, which are named after the type of mechanical factors that are hypothesized to contribute to mechanical LBP (Van Dillen *et al.* 2003):

(1) lumbar flexion;
(2) lumbar extension;
(3) lumbar rotation;
(4) lumbar rotation with extension; and
(5) lumbar rotation with flexion.

Although the classifications are described as lumbar movement impairments, the analysis is technically of the lumbopelvic region. Additionally, not only do proximal regions of dysfunction affect distal segments of the movement system, the lumbar spine refers pain to the pelvis and hip, and CPP definitions involve the pelvis, anterior abdominal wall, lower back and/or buttocks (ACOG 2004; Fall *et al.* 2010).

The musculoskeletal factors that need to be considered include the passive and active stiffness of the lumbopelvic spine and hips, which will be influenced by the muscular and fascial systems, all under neuronal control. Therefore, assessment of the neural system is also critical because irritability of the nerve trunk and its ability to glide along its neural canal will affect the perceived length of the muscle (Hall *et al.* 1998; Walsh & Hall 2009a, b). Structural differences, such as bony variation of the pelvis and femur, and imbalances of the strength, length, timing and magnitude of recruitment of the trunk and hip muscles, also need to be assessed during test movements as well as specific functional activities.

Lumbar flexion syndrome. The primary dysfunction in this syndrome is that the lumbar spine range of motion (ROM) into flexion is more flexible than the hip ROM into flexion. The habitual movement of the individual is towards flexion with spinal movements and movements of the extremities. The spinal alignment tends to be relatively flexed in different postures (Fig. 1), and symptoms are elicited and/or aggravated when the patient moves towards the flexed position. When movement into flexion is restricted, the symptoms are abolished or diminished. The syndrome is more common in individuals between the ages of 18 and 45 years, and it is also more common in males. Habitually flexed work postures or repeated forward bending are often reported, and there is increased relative stiffness in the hip extensors (particularly the hamstrings) relative to the erector spinae (Sahrmann 2002).

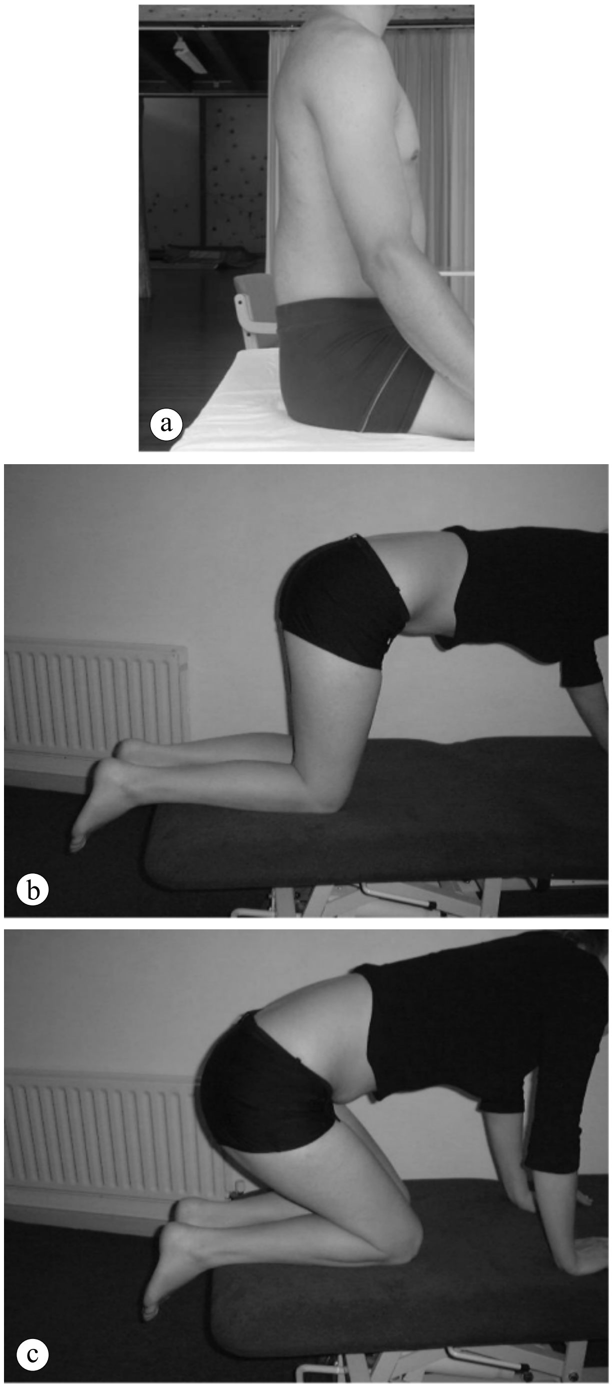

Figure 1. (a) Sitting, (b) quadruped and (c) backward rocking in relative lumbar spine flexion.

Lumbar extension syndrome. The primary dysfunction in this syndrome is that the lumbar spine ROM into extension is more flexible than the hip ROM into extension. Functionally, this means that the lumbar spine can extend more readily than the hip extensors can extend the hip (Sahrmann 2002). Therefore, the hip flexor muscles exert an anterior shear force on the lumbar spine

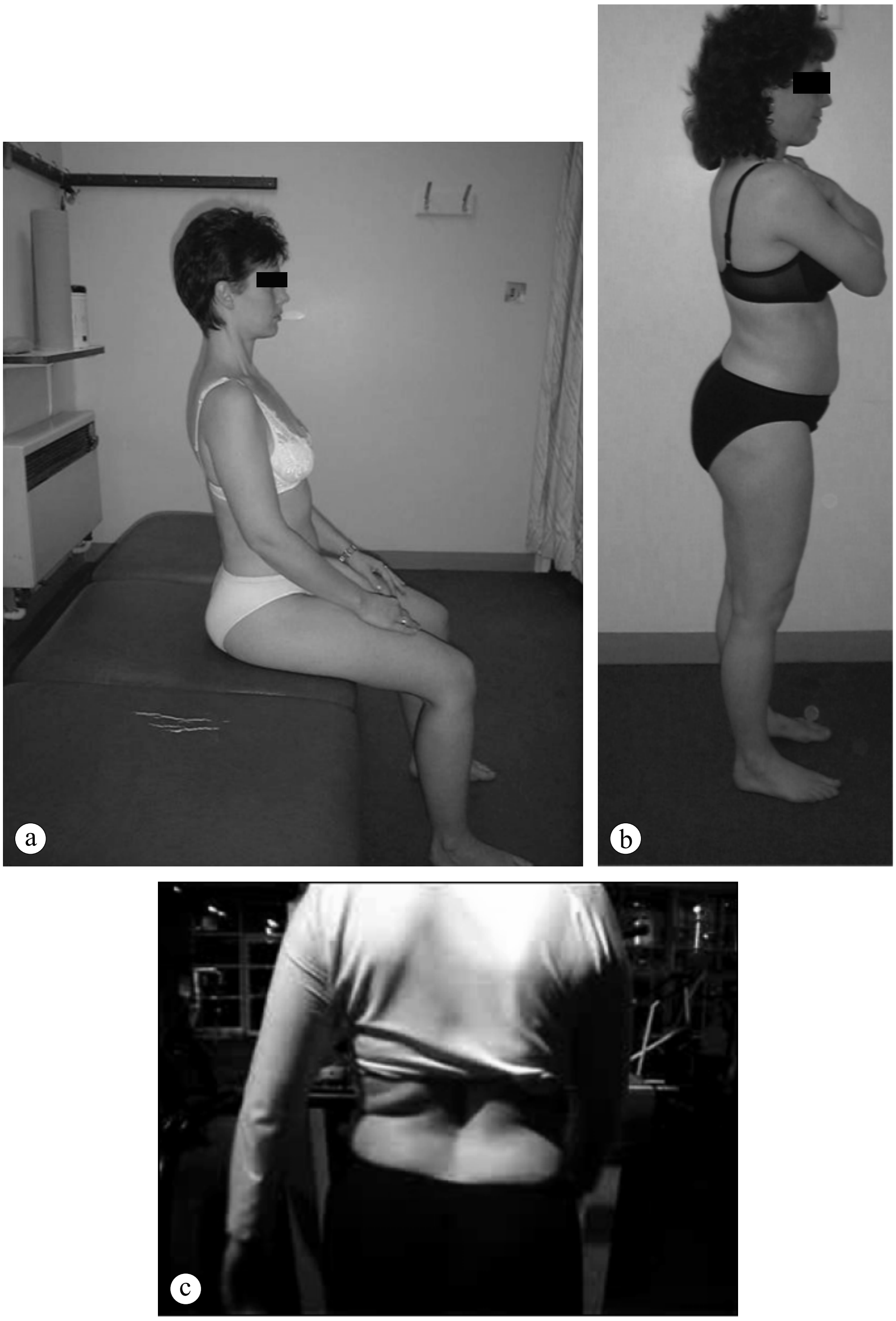

Figure 2. (a) Sitting, (b) standing and (c) walking in relative lumbar spine extension.

as well as a forward rotation moment on the innominates bilaterally. The patient's habitual movement is towards extension with spinal movements and movements of the extremities (Fig. 2). When movement into extension is restricted, the symptoms are abolished or diminished (Sahrmann 2002). The patients are usually over 55 years of age and there is no reported gender bias. This pattern is often found in patients with acute recurrent low back pain (LBP) or chronic ongoing LBP (Sahrmann 2002).

Lumbar rotation syndrome. This syndrome describes a three-dimensional dysfunction of a spinal segment. The primary dysfunction is increased lumbar segmental rotation, side-flexion and translation, relative to other spinal segments (Sahrmann 2002) (Fig. 3). These three motions occur together because of the complex interaction of the shape of the zygapophysial joint articular surface, the control of the ligamentous restraint systems, and the flexibility of segmental and global muscle system (White & Panjabi 1990). Clinical spinal instabilities usually involve increased arthrokinematic glides and fit into this group. The rotational stress on the lumbar spine can be produced directly via lumbar spinal rotation/side-flexion/translation, or

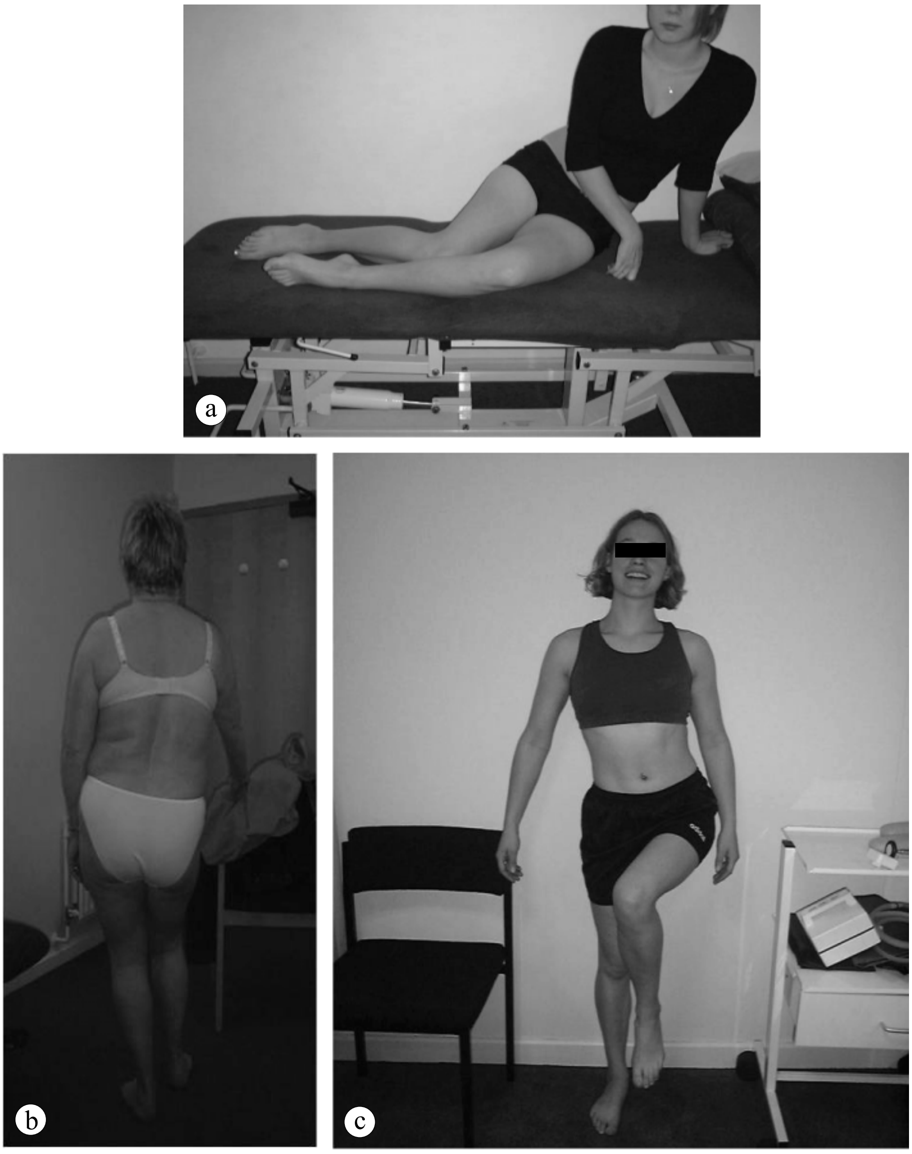

Figure 3. (a) Sitting, (b) standing and (c) walking in relative lumbar spine rotation.

indirectly, rotation of the pelvis can produce a relative rotation of the lumbar spine segments (White & Panjabi 1990). In certain patients, there is an observable rotation of the lumbar spine, while in others, there is no obvious dysfunction (Sahrmann 2002). The signs and symptoms are similar to those described for lumbar flexion syndrome; however, these are elicited with spinal rotation and diminished when lumbar rotation is restricted (Van Dillen *et al.* 2003).

Lumbar rotation with flexion. In response to spinal or extremity movement, the patient moves the lumbar spine in the direction of rotation and flexion. The lumbar spine tends to assume a flexed and rotated position in habitual postures. Symptoms are often unilateral, are aggravated by postures involving flexion and rotation, and are eased by limitation of flexion and rotation. Symptoms are often aggravated when moving from sitting to standing or performing functional movements that involve more than one plane (Sahrmann 2002).

Lumbar rotation with extension. In response to spinal or extremity movement, the patient moves the spine in the direction of rotation with extension. The lumbar spine tends to assume an extended and rotated position with habitual postures. Symptoms are often unilateral and elicited by extension rotation movements of the lumbar spine (Sahrmann 2002). This syndrome is more common in patients over the age of 55 years who have a history of chronic LBP and pelvic pain. It is also more common in those individuals who participate in sports that involve significant amounts of torsion in the lumbar spine, such as

Box 1. Common postural types (Sahrmann 2002; Kendall *et al.* 2005): (ASIS) anterior superior iliac spine; and (PSIS) posterior superior iliac spine

Ideal standing posture (Fig. 4) can be described as a position:

- in which markers on the lateral tip of the acromion, the midpoint of the greater trochanter and the tip of the lateral malleolus all line up to form an angle of approximately 180°;
- in which the lumbar lordosis, thoracic kyphosis and pelvic tilt are all in neutral;
- that is lumbar neutral – the spinal curve should be 20–30°, there should be less than 1.5 cm difference in prominence of the left and right region 5 cm lateral from the spinous process;
- that is pelvis neutral – the line between the ASIS and PSIS is within 15° of the horizontal line (this may vary in women), and there is no lateral tilt or rotation;
- that is hip neutral – no angle between the peak of the iliac crest and the greater trochanter to the line along the thigh; and
- that is knee neutral.

Kyphotic–lordotic standing posture (Fig. 2b) can be described as a position:

- in which markers on the lateral tip of the acromion, the midpoint of the greater trochanter and the tip of the lateral malleolus all line up to form an angle greater than 195°, and the back is swayed towards the rear and the hips forward;
- that involves lumbar lordosis – the inward curve is increased in depth (greater than 30°);
- that involves thoracic kyphosis – often increased in depth;
- that involves anterior pelvic tilt – ASIS is 20° lower than PSIS; and
- in which the hips are flexed – the hip angle of flexion between the peak of the iliac crest and the greater trochanter to the line along the thigh is more than 10°.

Sway standing posture (Fig. 5) can be described as a position:

- in which markers on the lateral tip of the acromion, the midpoint of the greater trochanter and the tip of the lateral malleolus all line up to form an angle of less than 165°, and the back is swayed towards the rear and the hips forward;
- that involves lumbar lordosis – often decreased in length;
- that involves thoracic kyphosis – often increased in length, shoulders more than 5 cm posterior to the greater trochanter;
- that involves neutral to posterior pelvic tilt – for posterior pelvic tilt, ASIS is 20° higher than PSIS;
- in which the hips are extended – the hip angle of extension between the peak of the iliac crest and the greater trochanter to the line along the thigh is more than 10°; and
- in which the knees are hyper-extended – backward bowing of the knee joint and the tibia may be posterior to the femur.

Flat back standing posture (Fig. 6) can be described as a position:

- in which markers on the lateral tip of the acromion, the midpoint of the greater trochanter and the tip of the lateral malleolus all line up to form an angle of approximately 180°;
- that involves lumbar lordosis – flat, inward curve absent (this may be normal in men);
- that involves thoracic kyphosis – flat, outward curve absent;
- that involves neutral to posterior pelvic tilt: for posterior pelvic tilt, ASIS is 20° higher than PSIS;
- in which the hips are neutral to extended – the hip angle of extension between the peak of the iliac crest and the greater trochanter to the line along the thigh is more than 10°; and
- in which the knees are neutral to hyper-extended – backward bowing of the knee joint and the tibia may be posterior to the femur.

Asymmetry can be described as any of the postural shapes mentioned above combined with:

- paraspinal asymmetry – the left and right paraspinal regions from the lumbar spinous processes to 5 cm lateral to this have a difference in prominence of greater than 1.5 cm;
- scoliosis/rib hump – the ribs are more prominent on one side;
- lateral tilt – one iliac crest is more than 1.5 cm higher than other (Fig. 7a, b);
- rotation – ASIS on one side is anterior to ASIS on the other; and
- lateral shift – the pelvis is shifted away from the midline (Fig. 7c).

golf, squash, tennis and racquetball (Harris-Hayes & Van Dillen 2009).

Common postural types (Sahrmann 2002; Kendall *et al.* 2005) are described in Box 1.

Table 2, taken from Van Dillen *et al.* (2003), shows the proposed mechanical LBP categories, along with the associated signs, symptoms and general treatment guidelines. Although it should be stressed that this movement assessment system has not yet been fully validated, the construct validity of the movement-impairment-based classification system provided support for three out of the five categories (Van Dillen *et al.* 2003), and the inter-tester reliability based on this classification system has been shown to be substantial (Harris-Hayes & Van Dillen 2009).

Table 2. Proposed mechanical low back pain categories with associated signs and symptoms, and general treatment guidelines (taken from Van Dillen *et al.* 2003)

Category	Associated signs and symptoms	General treatment guidelines
Flexion	Tendency for the patient to move the lumbar spine in the direction of flexion with movements of the spine or extremities. Lumbar spine alignment tends to be flexed relative to neutral with the assumption of postures. Symptoms occur or increase with positions and movements associated with flexion of the lumbar spine. Symptoms are decreased with restriction of lumbar flexion	Functional instruction: (1) Bed positioning/mobility: don't curl your spine as you sit up in bed; roll to your side and push yourself up with your arms to come to sitting (2) Sitting: sit with your back supported, your shoulders over your hips, your hips and knees level, or your knees positioned lower than your hips; you may need a small towel roll in your lower back region for support; don't sit slumped (3) Sit to stand: scoot yourself to the edge of the chair, keeping your back upright; get up against the edge of the chair before sitting down; don't bend your back getting up and down; bend the hips and knees (4) Standing: don't stand with your pelvis swayed forward Exercise: (1) Train trunk muscles (paraspinals and abdominals) to work isometrically with performance of limb movements (e.g. standing against a wall, flex shoulders while keeping the lumbar region neutral) (2) Training to isolate hip flexion without lumbar spine flexion (e.g. rock backwards in quadruped, keeping the lumbar region neutral) (3) Exercise to increase flexibility of any muscles contributing to lumbar flexion (e.g. stretch the gluteus maximus while supine, keeping lumbar region supported in neutral) (4) Exercise to shorten muscles that may assist in reducing lumbar spine flexion alignment (e.g. iliopsoas strengthening in sitting while keeping the lumbar region neutral) Support: (1) Taping of the lumbar region to discourage lumbar flexion (2) Use of abdominal support, particularly during activities that encourage lumbar flexion
Extension	Signs and symptoms are similar to those described for flexion except that these are associated with extension of the lumbar spine. Symptoms are decreased with restriction of lumbar extension	Functional instruction: (1) Bed positioning/mobility: position a pillow(s) under your knees when back-lying or under your abdomen when face-lying; slide your legs up so that your hips and knees are bent; avoid allowing your back to arch when you move your legs; roll to your side, moving your trunk and legs together; drop your legs over the side of the bed as you push yourself up to sitting or lower yourself to side-lying (2) Sitting: sit with your back and feet supported, and your hips and knees level; relax your back against the chair; don't sit on the edge of the chair (3) Sit to stand: come forward in the chair by pushing with your hands while keeping your back slightly rounded; lean forward; push with your legs; as you straighten up, don't arch your back – pull in your abdominals; lean forward when you lower yourself into the chair to sit (4) Standing: occasionally lean up against a wall with your knees and hips bent slightly; pull in your abdominals and relax your back against the wall Exercise: (1) Training of the trunk muscles to work isometrically with performance of limb movements (particularly the abdominal muscles) (2) Training to perform hip extension without increased lumbar region extension (e.g. perform return-from-forward bending emphasizing hip extension over lumbar extension) (3) Exercise to increase the flexibility of any muscles contributing to lumbar region extension (e.g. bend your knee in prone while keeping the lumbar region stationary to stretch the hip flexors) (4) Exercise to shorten muscles that may assist in reducing lumbar spine extension alignment (e.g. pull in your lower abdominals while standing with your back against a wall with knees and hips flexed slightly)

Continues

Table 2. (*Continued*)

Category	Associated signs and symptoms	General treatment guidelines
Rotation	Signs and symptoms are similar to those described for flexion except that these are associated with rotation of the lumbar spine. Symptoms are decreased with restriction of lumbar rotation	Functional instruction: (1) Bed positioning/mobility: when side-lying, place a pillow(s) between your knees, and a towel roll in the area between your ribs and pelvis on the side that you are sleeping; slide your legs up so that your hips and knees are bent; roll to your side, moving your trunk and legs together; drop your legs over the side of the bed as you push yourself up to a sitting position or lower yourself to side-lying; don't side-bend or rotate your trunk as you get up or down from bed (2) Sitting: sit with your back supported; don't rotate or bend your trunk to one side; don't lean on an elbow for support; don't cross your legs or sit on one leg; don't shift from side to side as you sit for prolonged periods (3) Sit to stand: don't move forward by rotating one hip forward at a time (4) Standing: don't stand on one leg; stand with your weight evenly distributed over both legs Exercise: (1) Training of trunk muscles (particularly the lateral abdominals) to work isometrically with performance of limb movements (e.g. lift one arm in quadruped while holding your trunk stationary) (2) Training to isolate hip rotation, abduction and adduction without lumbar region rotation or side-bending (e.g. laterally rotate and abduct your hip in side-lying while holding your trunk stationary) (3) Exercise to increase the flexibility of any muscles contributing to lumbar region rotation or side-bending (e.g. laterally rotate one hip in prone while holding your pelvis stationary) (4) Exercise to shorten muscles contributing to lumbar region rotation or sidebending on one side (e.g. laterally rotate and abduct one hip in side-lying with pillows between your knees while holding your pelvis stationary) Support: (1) Taping of the lumbar spine region to discourage lumbar region rotation (2) Use of abdominal support, particularly during activities that encourage lumbar region rotation
Rotation with flexion	Tendency for the patient to move the lumbar spine in the direction of rotation and flexion with movements of the spine or extremities. Lumbar spine alignment tends to be flexed and rotated relative to neutral with the assumption of postures. Symptoms (often unilateral) occur or increase with positions and movements associated with rotation and flexion of the lumbar spine. Symptoms are decreased with restriction of lumbar rotation and flexion	The same as for the rotation and flexion categories with an emphasis on (1) symmetry of performance of functional activities, (2) attaining symmetry of muscle activity, and (3) support to discourage flexion and asymmetry of alignment and movement of the lumbar region
Rotation with extension	Signs and symptoms are similar to those described for rotation with flexion except that these are associated with rotation and extension of the lumbar spine. Symptoms (often unilateral) are decreased with restriction of lumbar rotation and extension	The same as for the extension and the rotation categories with an emphasis on (1) symmetry of performance of functional activities, (2) attaining symmetry of muscle activity and flexibility with exercises, and (3) support to discourage extension and asymmetry of alignment and movement of the lumbar region

Box 2. Voluntary activation of the transversus abdominis (TVA) independently of the other trunk muscles (Richardson *et al.* 1999)

Activation of the TVA:

- Palpate approximately two finger's breadth down from the anterior superior iliac spine along the inguinal ligament and one finger's breadth medially.
- Ask the patient to breathe in, and then, on the out-breath, to relax and let go of the stomach. Ask the patient to then draw in the low lateral abdominal wall (below the umbilicus) as if to pull the stomach away from the waistband and breathe normally (Fig. 8)
- Palpate for symmetrical tensioning, without excessive bulging, underneath the palpating fingertips, or verify with real-time ultrasound imaging to observe the thickening and shortening of the abdominal muscle (Hodges *et al.* 2003)
- Once the patient can activate the TVA with minimal activity of the abdominal muscles, he or she should hold the contraction, while breathing normally, for up to 10 s
- Three sets of 10 repetitions, twice a day, has been shown to be effective (Tsao & Hodges 2008)

Common substitution patterns or faults:

- movement of the trunk or pelvis out of a neutral position;
- asymmetry;
- breath-holding, apical breathing;
- drawing in of the upper abdominal wall;
- rib cage depression with a decrease of the infrasternal angle;
- lateral flaring or bulging of the waist;
- excessive superior, inferior or lateral movement of the umbilicus; and
- bearing down of the pelvic floor (the Valsalva manoeuvre).

Facilitation techniques for the TVA:

- Alternative starting positions, such as crook-lying, four-point kneeling, side-lying, standing, sitting forward lean or prone.
- Visualize the lower abdomen as an old-fashioned corset, and as the stays are drawn in, the waist narrows and flattens into an hourglass shape.
- Ensure that the abdomen is relaxed to start with, which is often easier in sitting or standing forward lean, four-point kneeling, or prone.
- Tactile feedback:
  - Ask the patient to put one hand above the umbilicus and the other below. As soon as movement is felt above the umbilicus, drawing in should cease.
  - Ask the patient to palpate you, noting the difference between bulging and tensioning, and then ask him or her to self-palpate.
- Facilitation using the pelvic floor muscles can be particularly useful for asymmetry of contraction as can psoas muscle activation (described below in Box 5).

The aim of the assessment is to identify the postural alignment strategies and the habitual movement patterns that may contribute to an individual's presenting condition. Each syndrome has specific key tests, which help to identify the alignment strategies assumed by the individual and confirm the direction of the movement patterns. The patient is then observed while performing symptom-provoking functional activities to determine if the same strategies are repeated. Functional instruction is then directed toward modifying the individual's preferred strategies. Exercise prescription is directed toward correcting the patient-preferred movement and alignment strategies identified by the examination. The emphasis is on modifying the strategies that (1) are symptom-provoking and (2) can be modified to decrease the patient's symptoms during the examination (Van Dillen *et al.* 2003). This systematic approach is repeated in order to classify movement-impairment syndromes of the hip and is described by Chaitow & Lovegrove Jones (2012). It should also be emphasized that, in the present authors' opinion, should patients hold negative beliefs about and attitudes to pain, and exhibit fear-avoidance behaviours without understanding current pain biology, the way in which these corrective exercises are explained could contribute to their fear of movement and potentially make their pain problem worse. In such instances, addressing a patient's attitudes, beliefs and understanding needs to be the therapist's main priority (O'Sullivan 2005).

The lumbopelvic cylinder and chronic pelvic pain

The muscles of the lumbopelvic cylinder (LPC) are altered in the presence of postural changes, respiratory demands, lumbopelvic pain (LPP) and stress incontinence (Hemborg *et al.* 1985;

Box 3. Voluntary activation of the pelvic floor muscles (PFMs) (Laycock & Jerwood 2001; Messelink *et al.* 2005): (TVA) transversus abdominis

Activation and facilitation of the PFMs:

- In a supine, crook-lying position, with a pillow under the head and legs supported, the International Continence Society (ICS) guidelines to facilitate a PFM contraction are to squeeze the muscles of the pelvic floor as if attempting to stop the flow of urine, or prevent wind or flatus escaping (Messelink *et al.* 2005).
- Recent research and clinical experience suggest that the following are useful additional instructions: "Squeeze around the back passage, as if you were trying to prevent breaking wind (flatus), bring that feeling forward towards the urethra/pubic bone and then lift, as if you were elevating the PFMs, while breathing normally." This elicits a consistent PFM contraction, resulting in a cranioventral lift of these muscles and the pelvic organs (Lovegrove Jones 2010).
- With consent, confirm the ability of the volunteer to perform an elevating, sustained PFM contraction by vaginal or rectal palpation, real-time perineal (Fig. 9) or transabdominal ultrasound. The patient should have a sensation of a "lifting" rather than "bearing down" contraction, which can also be verified by observation of the perineum "lifting". If verification is not possible in any of the ways outlined here, then palpating abdominally, approximately two finger's breadth down from the anterior superior iliac spine along the inguinal ligament and one finger's breadth medially, as in the evaluation of a TVA contraction described above, will give an indication of whether co-activation of the TVA and the PFMs has occurred. Recent evidence has indicated the presence of co-activation in healthy continent and incontinent women (Sapsford *et al.* 2001; Urquhart *et al.* 2005; Jones *et al.* 2006).
- Once the patient can activate the PFMs, he or she should hold the contraction while breathing normally for up to 10 s. The coordination of a pelvic floor contraction and normal relaxed breathing seems to be very difficult for some subjects. If this is the case, then repeated, low-effort practice is advised. The ability to voluntarily relax the PFMs after contraction (Messelink *et al.* 2005), particularly with PFM overactivity, is essential, and the presence of pain on voluntary contraction should be noted (Whelan 2012).

Box 4. Voluntary activation of the deep segmental fibres of the lumbar multifidus muscle (Richardson *et al.* 1999)

Activation of the multifidus:

- In prone-lying (often over a pillow, which is helpful), palpate the medial paraspinal muscles at each segmental level in turn, just to the side of the lumbar vertebrae, and let the fingertips sink firmly into the muscle.
- Instruct the patient to breathe in, and then, on the out-breath, to relax and let go of the stomach. Slowly and gently hollow and pull up the lower stomach towards the spine, and gently swell the muscles into the palpating fingertips.
- Palpate for a symmetrical tensioning, underneath the palpating fingertips, or verify with real-time ultrasound imaging to observe thickening of the muscle (Hides *et al.* 1992).
- Once the patient can activate multifidus, he or she should hold the contraction while breathing normally for up to 10 s.

Common substitution patterns or faults:

- asymmetry of contraction;
- breath-holding; and
- bracing and increasing intra-abdominal pressure with overactivation of the abdominal muscles, which results in movement of the trunk or pelvis out of a neutral position, and into spinal flexion or posterior tilt.

Facilitation techniques for the multifidus:

- Encourage visualization of the muscle tissues as deep triangles that extend down and out from each of the spinous processes.
- The patient should be instructed to feel the contraction on the therapist first, so as to understand the concept of an isometric swelling contraction.
- Use other starting positions, such as side-lying, standing or sitting.
- In standing, move from a position of upright standing to swaying, palpating the differences in tension of the medial paraspinals.
- In standing, palpate the dysfunctional multifidus with one hand, and lift the opposite arm forward and away from the body from 0° to 90°, palpating the superficial fibres to highlight changes in tension. Sustain the contraction when multifidus activity decreases. Maintain active muscle tension during slow, repetitive arm flexion. Maintain this multifidus contraction and keep tension in the muscle during slow arm movements with relaxed breathing (Fig. 10).
- In walk stance, with full weight on the rear foot, palpate the tension in the dysfunctional multifidus on the rear foot side, and move the body weight forward onto the front foot. The multifidus should activate just after the heel lift. Try to sustain the contraction during a slow weight transfer with relaxed breathing.

Box 5. Voluntary activation of the posterior fascicles of the psoas muscle (Gibbons *et al.* 2002): (ASIS) anterior superior iliac spine

Activation and facilitation of the posterior fascicles of the psoas:

- With both the lumbar spine and hip in neutral, gently distract the femur in supine or side-lying (Fig. 11). Maintain the distraction and instruct the patient to take a breath in, and then, on the out-breath, to relax and let go of the stomach, while slowly and gently drawing in or shortening the hip into the acetabulum without moving the pelvis or lumbar spine. It may be helpful to push the femur into the acetabulum several times in order to give the sensation of the action required.
- Then palpate both the ASIS and the soft tissue below in the anterolateral groin (5 cm below the ASIS). The upper finger assesses for control of movement of the pelvis and maintenance of the lumbopelvic neutral position, while the lower finger checks for excessive activity in the rectus femoris and sartorius muscles.
- Once the therapist is confident that the patient is able to activate the muscle, the patient lies in prone on the plinth, with one leg firmly extended to help maintain balance and the other hanging freely over the edge with the foot on the floor. The side with the leg hanging freely is the side to be assessed. In pelvic and lumbar neutral, and with the trunk muscles relaxed, each lumbar vertebral level is manually palpated to assess the relaxed joint play displacement in the transverse and anterior directions. When the patient then facilitates the psoas contraction, each vertebral level is palpated again in order to assess the contracted joint play in the transverse and anterior directions. Ideally, there should be a significant palpable increase in resistance to manual displacement (stiffness) at each level.

Common substitution patterns or faults:

- movement of the trunk or pelvis out of a neutral position;
- pushing down with the contralateral leg to provide stability for the trunk; and
- dominant or excessive activation of the rectus femoris, tensor fasciae latae or trunk muscles, which is indicated by a resistance to passive rotation by the hip or pelvis (suggest that the patient uses less effort).

Hides *et al.* 1996; Hodges & Richardson 1996, 1998; Moseley *et al.* 2002; Hodges & Gandevia 2000; O'Sullivan *et al.* 2002; Jones *et al.* 2006; Hodges *et al.* 2007; Dickx *et al.* 2008). However, it appears that skilled voluntary activation of muscles with altered motor recruitment can reduce pain, disability and the recurrence rate of musculoskeletal conditions (Hides *et al.* 2001; Cowan *et al.* 2003; Ferreira *et al.* 2006), as well as restore motor coordination, including automatic postural adjustments (Cowan *et al.* 2003; Tsao & Hodges 2007, 2008), reversing cortical reorganization in people with recurrent pain (Tsao *et al.* 2010). Therefore, these findings suggest that, in addition to the five categories of movement dysfunction described above, the muscles of the LPC should also, when appropriate, be evaluated and rehabilitated in patients with CPP, although no scientific trial to date has evaluated such a clinical approach in this subgroup of patients with chronic pain.

The pelvic floor muscles (PFMs) form the bottom of the LPC, with the respiratory diaphragm serving as its top and the transversus abdominis (TVA), the sides. The spinal column is part of this cylinder and runs through the middle, supported posteriorly by segmental attachments of the lumbar multifidus and anteriorly by segmental attachments of the psoas (the posterior fascicles) to the abdominal muscles (Jones 2001). Intra-abdominal pressure (IAP) is generated by co-activation of the PFM, the diaphragm and the abdominal muscles (Hemborg *et al.* 1985; Hodges & Gandevia 2000), implying that coordinated co-activation of the muscles of the LPC is necessary in order to balance the functional demands of continence, respiration and lumbopelvic stability (Hemborg *et al.* 1985; Hodges & Gandevia, 2000; Pool-Goudzwaard *et al.* 2004; Hodges *et al.* 2007). The muscles of the LPC work at low levels at all times and increase their activity when the central nervous system can predict timing of increased load, such as occurs in coughing, lifting or limb movements (Constantinou & Govan 1982; Moseley *et al.* 2002; Barbiv̌ *et al.* 2003). Further details regarding the diaphragm and the PFMs can be found in Chaitow *et al.* (2012) and Whelan (2012), respectively, while Boxes 2–5 describe the assessment and rehabilitation of the muscles of the LPC.

Integration of voluntary activation of the lumbopelvic cylinder into function

When the muscles of the LPC are working efficiently, both voluntary and involuntary activation of any one muscle should elicit a co-contraction with the others. Although this has been shown with the TVA, the multifidus and the PFMs (Sapsford *et al.* 2001; Richardson *et al.* 2002; Urquhart *et al.* 2005; Jones *et al.* 2006), to date this has not been scientifically verified with the posterior fascicles of the psoas

Figure 4. Ideal standing posture.

muscle. However, in the present authors' clinical opinion, the methods of eliciting a psoas contraction described in Box 5 are effective in facilitating the activation of the TVA or PFMs on the deficient side, particularly when asymmetry of contraction is observed in these muscles. Once the patient is able to elicit a satisfactory co-contraction of the LPC, the activation of these muscles should be incorporated into previously aggravating static postures and functional tasks (O'Sullivan *et al.* 1997). The ability to immediately perform a task without pain with the addition of a voluntary activation of any of the muscles of the LPC can be a powerful rehabilitation tool, significantly reduce fear of movement, and change attitudes and beliefs about what the pain means to a patient. However, skilled training of sustained voluntary activation of the TVA in supine, without integrating this with function, was sufficient to reduce pain and disability, and create reorganization of the motor cortex in individuals with recurrent LBP (Tsao & Hodges 2008; Tsao *et al.* 2010).

The neural system and chronic pelvic pain

As discussed above, the nervous system probably coordinates muscle activity to meet the demands for stable movement, so it will not only be affected by the task, posture and movement direction, but potentially by high real – or perceived – risk of injury (Hodges & Cholewicki 2007). Therefore, assessment of the relative stiffness of the global pelvic and hip musculature,

Figure 5. Sway standing posture.

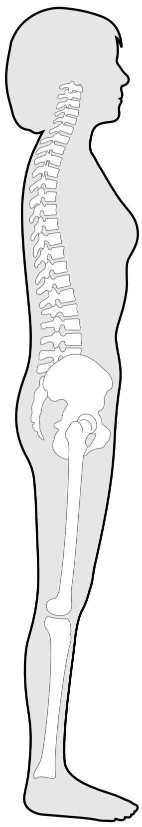

Figure 6. Flat back standing posture.

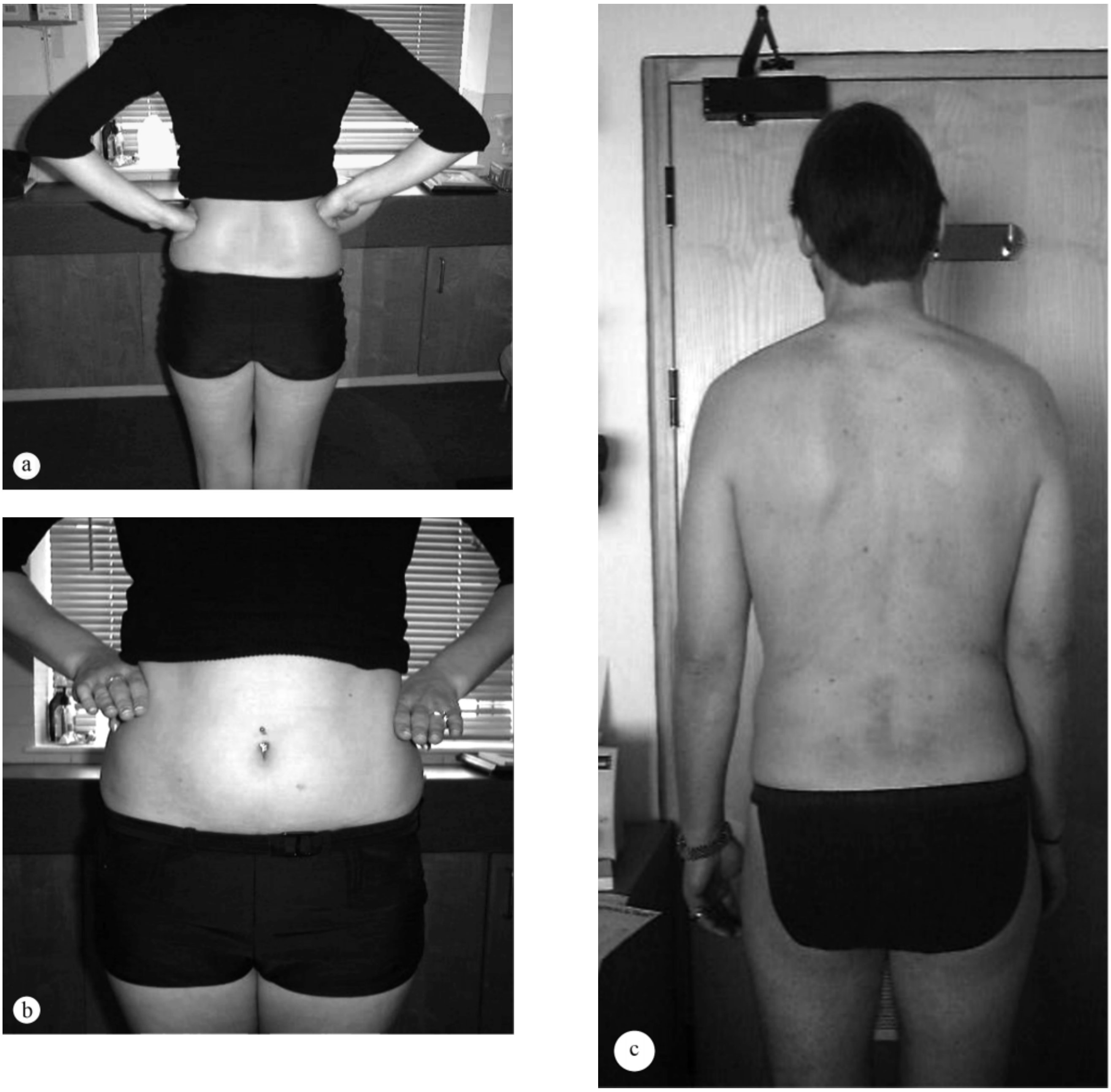

Figure 7. (a) Lateral tilt from behind, (b) lateral tilt from front and (c) lateral shift from behind.

and the muscles of the LPC, allows the relative stiffness between the proximal and distal movement systems to be evaluated so that treatment can then be targeted at the specific dysfunction. Another potential confounding variable in the assessment of muscle length and relative stiffness is the ROM of joints associated with the muscle (Kendall *et al.* 2005). Hence in order to accurately assess the length of a muscle, knowledge of the underlying joint ROM is essential. Muscle tissue consists of both contractile and non-contractile components, and a shortened muscle may be caused by decreased length in the non-contractile component, increased tone in the contractile component, or neurogenic/neuropathic components. As mentioned earlier, assessment of the neural system is crucial to the full understanding of pelvic dysfunction since the ability of the nerve trunk to glide along its neural canal will influence the perceived length of the muscle (Hall *et al.* 1998; Walsh & Hall 2009a, b). As described by Lovegrove Jones (2012), a number of significant nerves around the pelvis are associated with CPP, and some of these are amenable to direct assessment, such as the sciatic, femoral and pudendal nerves. For example, in lumbopelvic flexion dysfunction, the hips will be relatively stiff in flexion compared to the lumbopelvic spine. The examiner will need to assess whether this is a result of, for example,

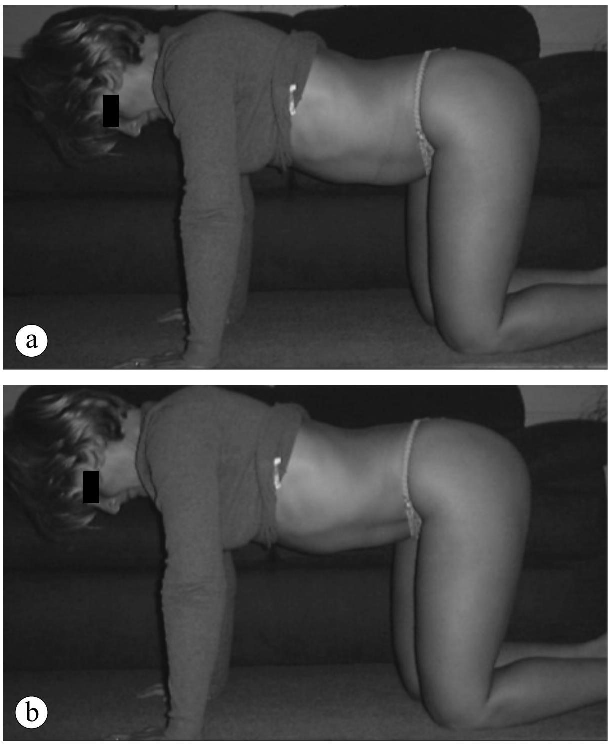

Figure 8. (a) Relaxed abdomen in four-point kneeling and (b) activation of the transversus abdominis muscle.

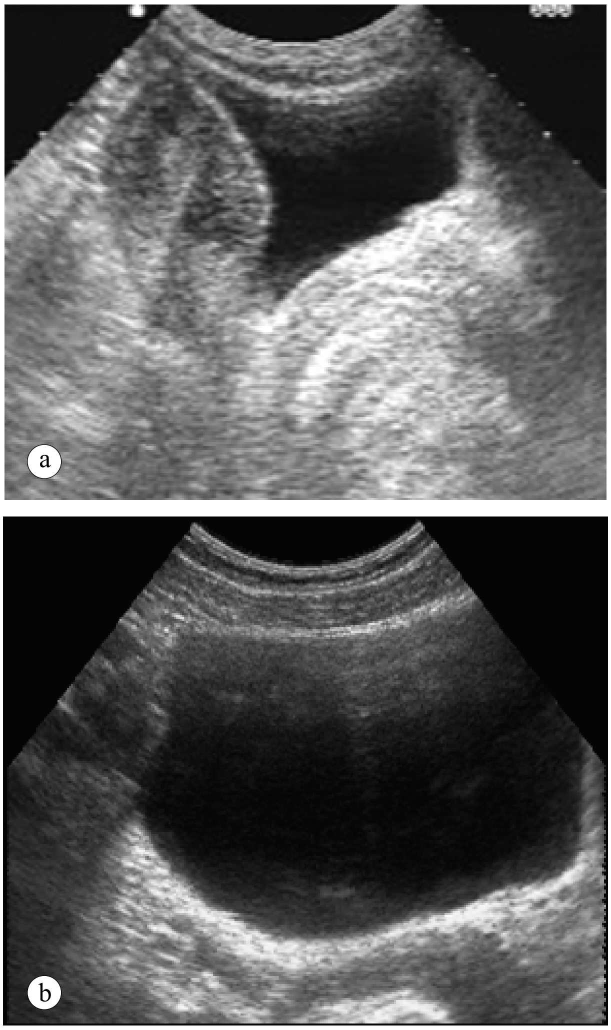

Figure 9. Transabdominal ultrasound transducer placement for (a) sagittal and (b) transverse ultrasound imaging of the bladder. Reproduced with permission from Whittaker (2007).

short, stiff hamstrings; a long erector spinae; or an irritable sciatic nerve. Similarly, in lumbopelvic extension dysfunction, one or more of the hip flexors could be stiff relative to the abdominal muscles, the patient may have restricted hip motion because of joint degeneration, or the femoral nerve may also restrict hip extension; all these factors need to be evaluated. To differentiate muscle stiffness from increased neural mechanosensitivity limiting the apparent length of a muscle, the use of differentiation via slump testing, cervical spine movement or ankle dorsiflexion is essential (Hall *et al.* 1998; Walsh & Hall 2009a, b).

Additionally, patients with CPP experience changes in the fascial system that may result in restrictions to neural or soft-tissue movement. Any assessment of this system relies on skilled observation of the tissues in the areas surrounding the pelvic region, especially the anterior thigh, the inguinal triangle, the anterior abdominal and trunk region, the posterior trunk region, the perineum, and the transperineal areas.

As discussed above, the musculoskeletal causes of CPP are many and varied, but sport and leisure activities can result in an increased risk of sustaining an injury, particularly when the activities in question are excessively pursued early in life (Antolak *et al.* 2002). Failure to recognize and diagnose musculoskeletal injuries in difficult-to-access regions of the pelvis and pelvic floor myofascial system have the potential to result in an acute impairment becoming a chronic disability. People with LPP who regularly participate in sports that require repeated rotation of the trunk and hips have less overall passive hip rotation motion and more asymmetry of rotation between sides than people without LPP (Van Dillen *et al.* 2008). These findings suggest that the specific directional demands imposed on the hip and trunk during regularly performed activities may be an important consideration in the prevention of and intervention in sporting injuries involving the lumbopelvic area.

In general though, studies have suggested that aerobic exercise has a therapeutic effect on CPP (Giubilei *et al.* 2007), and inactivity is associated with negative long-term effects (Orsini *et al.*

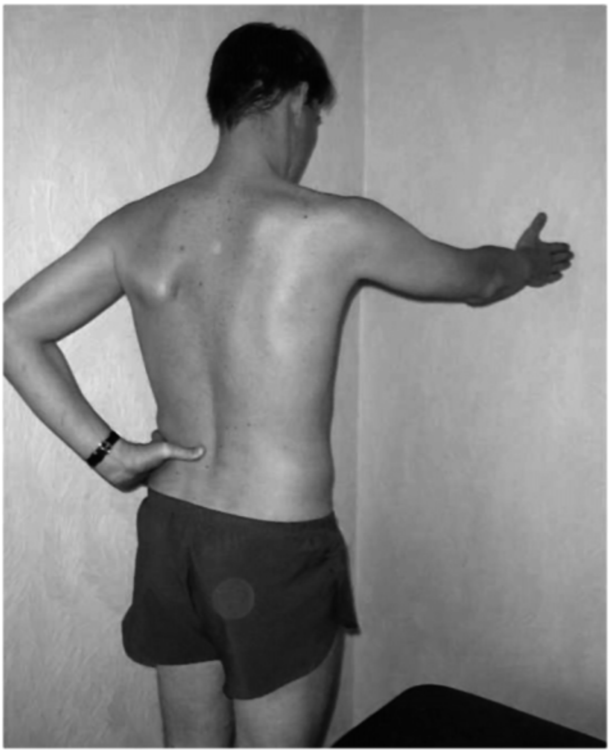

Figure 10. Contralateral arm lift.

2006). However, there remains some controversy regarding the role of cycling and urogenic disorders (Taylor *et al.* 2004; Sommer *et al.* 2010). Some researchers have suggested that there is a significant relationship between cycling-induced perineal compression leading to vascular, endothelial and neurogenic dysfunction, and the development of erectile dysfunction (Sommer *et al.* 2010), while others have implied that the overall prevalence of erectile dysfunction in the cycling community does not appear to be greater than that of historical controls (Taylor *et al.* 2004). It should be emphasized that exercise in general and non-impact aerobic/cardiovascular exercise in particular have received extensive support in the medical literature over a period of more than half a century (Brock 2005), and should be encouraged.

The next article in this two-part series will appear in the Autumn 2013 edition of *JACPWH* (No. 113). This will discuss the general effect of aerobic activity on CPP and then specific groin injuries, and will include a classification of movement-impairment syndromes of the hip to aid assessment and rehabilitation. This will be followed by a discussion of cycling and other sporting activities associated with CPP.

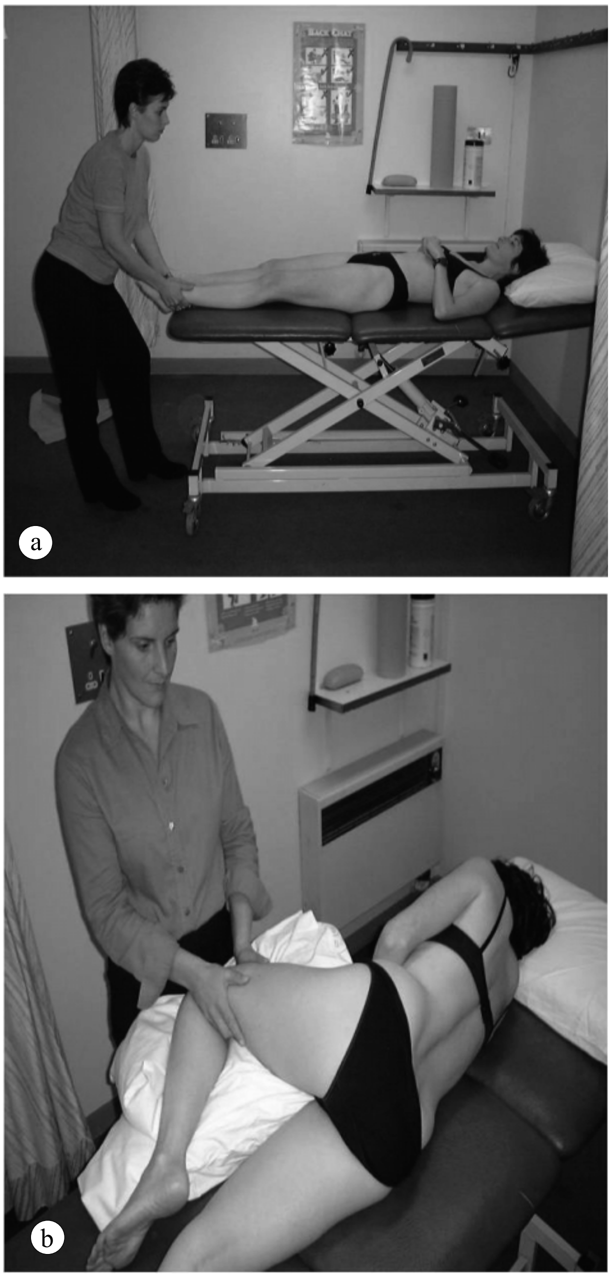

Figure 11. Facilitation of the longitudinal action of the posterior fascicles of the psoas muscle in (a) supine and (b) side-lying.

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