Masterclass

Rehabilitation of pelvic floor muscles utilizing trunk stabilization

Ruth Sapsford[a,b,]*

[a] *Mater Misericordiae Hospital, South Brisbane 4101, Qld., Australia*
[b] *School of Health and Rehabilitation Sciences, The University of Queensland, Brisbane 4072, Qld., Australia*

Abstract

The pelvic floor muscles (PFM) are part of the trunk stability mechanism. Their function is interdependent with other muscles of this system. They also contribute to continence, elimination, sexual arousal and intra-abdominal pressure. This paper outlines some aspects of function and dysfunction of the PFM complex and describes the contribution of other trunk muscles to these processes. Muscle pathophysiology of stress urinary incontinence (SUI) is described in detail. The innovative rehabilitation programme for SUI presented here utilizes abdominal muscle action to initiate tonic PFM activity. Abdominal muscle activity is then used in PFM strengthening, motor relearning for functional expiratory actions and finally impact training.
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1. Introduction

Ten years ago musculoskeletal physiotherapists would not have considered the pelvic floor muscle (PFM) complex when treating patients with low back pain or sacroiliac joint (SIJ) dysfunction and physiotherapists teaching PFM exercises for the treatment of stress urinary incontinence (SUI) discouraged the use of the abdominal muscles. These beliefs are now changing.

Research has led to an increased understanding of the synergy between the abdominal and PFM and in fact all the muscle groups surrounding the abdominal capsule. The PFM are now considered to have the dual function of providing trunk stability (Richardson et al., 1999) and contributing to continence and elimination of both bladder and bowel.

The synergy of the abdominal and PFM presents the opportunity for a different approach to the rehabilitation of pelvic floor (PF) dysfunction, which may improve clinical outcomes. Five to seven year follow up of women with urinary incontinence after vaginal delivery indicates that the benefit of initial conservative intervention, such as a PFM strengthening programme, is not maintained (Wilson et al., 2002). Clinicians dealing with PF function believe that cognitive PFM

exercise should be performed pre-, peri- and post-partum and for the rest of life (Chiarelli et al., 2003). Those who have had to exercise therapeutically for any condition will attest to the tedious nature of an ongoing programme. Pain and limited movement are great motivators, but most people anticipate that general activity will then maintain function. In many women who have had vaginal deliveries general activity does maintain PFM function without any specific PFM exercises (Gordon and Logue, 1984). Why does this not happen in all women?

This paper aims to outline the synergies between the PFM and the abdominal muscles during function and dysfunction and suggest an approach to rehabilitation for the most common problems.

2. The pelvic floor as a musculoskeletal unit

The PF is a musculoskeletal unit and like similar units has passive, neural and active subsystems of control (Panjabi, 1992). The fascias of the passive subsystem are thickened into ligaments, but they do not resemble strong articular ligaments. The degree of movement of these fascial layers is variable and depends on the extent of stretch associated with vaginal deliveries. This stretch caused by parturition can be compounded by regular straining at stool (Spence-Jones et al., 1994). Genetic variation in the composition of connective tissue can

*Address for correspondence. 44 Glen Road, Toowong 4066, Qld., Australia. Tel./fax: +61-7-3870-7596.

E-mail address: rsapsford@ozemail.com.au (R. Sapsford).

also contribute to increased extensibility (Vierhout and Terlouw, 2001).

The neural subsystems of control rely on differing sensory feedback from the abundant muscle spindles within the antigravity PFM. Slow or rapid stretch of the spindles will generate, via gamma efferent motor nerves, a slow sustained or a dynamic brief muscle activation. These neural responses can be disturbed in women who have had vaginal deliveries. Eighty per cent of women undergoing their first vaginal delivery have evidence of denervation and reinnervation of pubococcygeus (PC), the main PFM (Allen et al., 1990). Neurological damage has also been shown in the external anal sphincter (EAS) following vaginal delivery (Snooks et al., 1984; Sultan et al., 1994). Some women experience loss of awareness of bladder fullness, and can lose a large volume of urine without warning in the first couple of days after delivery. This neurological deficit usually resolves within the first week. However reflex inhibition from local trauma can cause ongoing deficits in muscle recruitment even when the pain has subsided. A similar scenario may occur in men who have had prostatectomies.

The role of the active subsystem is to maintain continence and provide organ support against gravity at rest and with slow, rapid and unpredictable loading. These functions require the ability to act prior to increases in intra-abdominal pressure (IAP) (Constantinou and Govan, 1982). The PFM also contribute to elimination, sexual response, IAP and lumbo-pelvic stability. Local pain may cause inhibition of local muscles, but may also delay the timing of contraction. This can lead to loss of bladder control.

The contribution of the PFM to IAP and trunk stability can be explained by its feedforward activation in response to trunk perturbation, resulting from rapid arm movement (Hodges et al., 2002). The PFM respond in a similar manner to the other components of the local muscle system including the transversus abdominis (Hodges and Richardson, 1996), the diaphragm (Hodges et al., 1997) and the deep fibres of lumbar multifidus (Moseley et al., 2002).

3. Co-activation of the abdominal and pelvic floor muscles

Recent research has monitored electromyographic (EMG) activity in the PFM and abdominal muscles during voluntary activity (Sapsford et al., 2001; Neumann and Gill, 2002). With a maximal voluntary contraction of the PFM, monitored by digital vaginal palpation of PC, all the abdominal muscles, transversus abdominis (TrA) obliquus internus (OI), obliquus externus (OE), and rectus abdominis (RA) were activated. The response in RA was minimal. Changes in passively maintained positions of the lumbar spine varied the proportion of EMG in the abdominal muscles, particularly the obliques. In lumbar flexion the OE showed the greatest activity, whereas in lumbar extension TrA produced the dominant response (Sapsford et al., 2001). When only a gentle PFM contraction was performed TrA produced the dominant response irrespective of lumbar spine position. Conversely when various abdominal isometric manoeuvres were performed, increasing abdominal muscle EMG activity resulted in increasing EMG activity in PC and EAS (Sapsford and Hodges, 2001).

Co-activation of the PFM and the deep fibres of lumbar multifidus has been observed clinically (Richardson et al., 1999), but no studies confirming this co-activation have been found.

4. Pelvic floor muscles

The PFM are divided into three layers.

Superficial—bulbospongiosus, ischiocavernosus and superficial transverse perinei muscles and the external anal sphincter.

Intermediate—intrinsic urethral sphincter, deep transverse perinei, and in females, compressor urethrae and the urethrovaginal sphincter (DeLancey, 1990).

Deep—levator ani comprising puborectalis (PR), pubococcygeus (PC) and iliococcygeus, and ischiococcygeus, also known as coccygeus. Fibres between PC and the vagina have also been described (DeLancey, 1990).

The PFM are the only transverse load bearing muscle group in the body. Biopsy samples taken from PC in asymptomatic females showed between 67% and 76% slow twitch fibres (Gilpin et al., 1989). Continuous tonic PFM activity has been demonstrated at rest in lying, sitting and standing (Vereeken et al., 1975; Deindl et al., 1993). This continuous tonic activity makes these muscles ideally suited to antigravity support. The external anal sphincter also exhibits tonic activity, which is responsible for approximately 15% of anal resting pressure. While PFM activity has been assessed during cognitive and functional activation using a range of modalities it has been shown that automatic functional responses do not necessarily mirror voluntary activation (Deindl et al., 1994; Wijma et al., 1991).

Functional tasks such as lifting, nose blowing, laughing, coughing, sneezing, and valsalva (a forced expiratory effort against a closed glottis) recruit the PFM with the abdominal muscles to increase IAP, generate an expiratory force and maintain continence. In all of these tasks the PFM complex must ensure urethral and anal closure before the increase in IAP if continence is to be maintained. Nose blowing, coughing, sneezing and laughing recruit the same PFM, diaphragmatic and abdominal muscle patterns, but with variations in strength and power. See Figs. 1–4 for diagrammatic
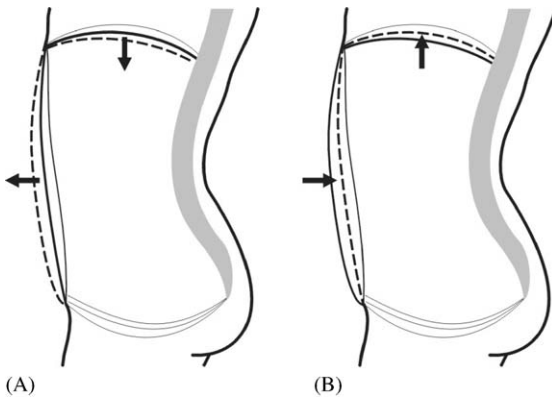
Fig. 1. Breathing at rest. (A) In quiet inspiration, the diaphragm descends and the abdominal wall moves anteriorly. (B) In quiet expiration, the diaphragm ascends and the abdominal wall moves posteriorly. Reproduced with permission of C P Sapsford.
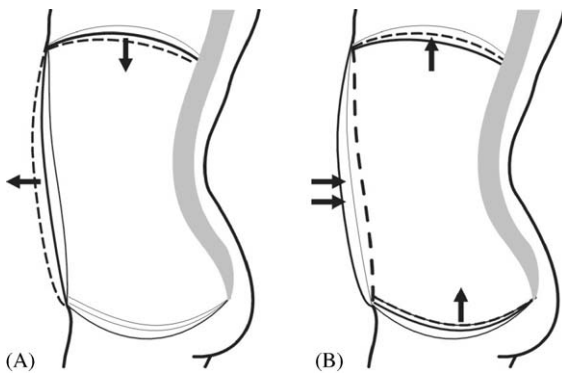

Fig. 2. Nose blowing. (A) With inspiration for nose blow, diaphragmatic descent and abdominal wall movement are similar to that in quiet breathing. (B) With blowing, the abdominal wall pulls in and the PFM are contracted. Increased force in blowing requires stronger muscular effort. Reproduced with permission of C P Sapsford.
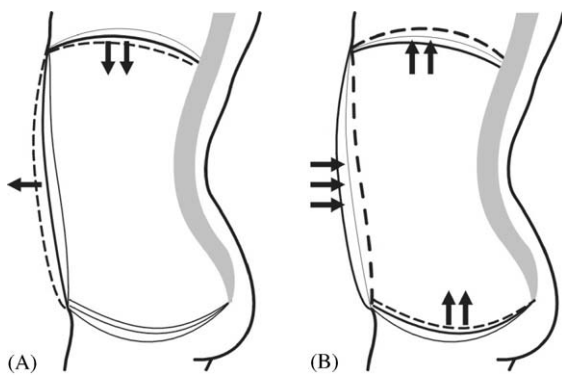

Fig. 3. Coughing. (A) Inspiratory effort before a cough requires rapid diaphragmatic descent, and the abdomen often moves further forward. (B) With coughing, the abdomen pulls in hard, PFM are contracted strongly and the diaphragm is forced higher. Reproduced with permission of C P Sapsford.

representation of these muscles during inspiratory and expiratory actions.

Studies of PFM function have generally been undertaken in females, as PF dysfunction is predominantly a
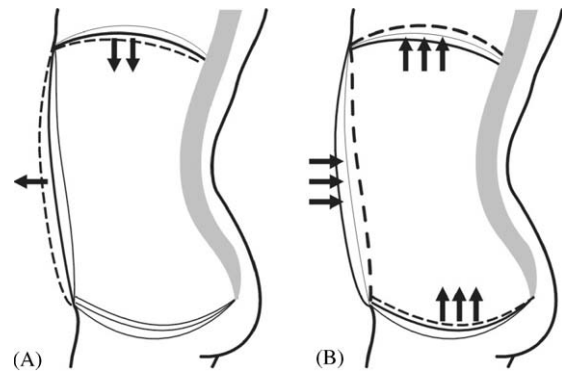

Fig. 4. Sneezing. (A) Inspiratory effort in sneezing is probably similar to that in coughing. (B) Sneezing requires a faster and stronger recruitment of abdominal and PFM muscles than coughing. Reproduced with permission of C P Sapsford.

female problem, with vaginal delivery considered the catalyst in most cases (Viktrup, 2002). Women who have had elective caesarean sections are at less risk of dysfunction in the short term (Snooks et al., 1984; Viktrup, 2002), but in the longer term are still vulnerable (MacLennan et al., 2000). However (SUI) does occur in nulliparous women during high impact activities and with sneezing and coughing, though with a much lower prevalence than in parous women (Bo et al., 1994; Nygaard et al., 1994). It is after radical prostatectomy for cancer of the prostate that men may experience ongoing SUI. Changes in abdominal muscle activity have not been investigated in those with PFM dysfunction.

5. Pelvic organ control

Urinary continence depends on both tonic and phasic PFM activity. These contribute to

- a stable bladder during filling and coughing (Mahony et al., 1977);
- a urethral closing pressure at rest > bladder pressure;
- an increase in urethral closing pressure that precedes and is greater than the rise in IAP with effort and impact activities.

Support of the uterus, cervix and vagina is provided by both fascia and muscle. The upper vagina rests above the rectum and both are positioned over the levator plate with the cervix close to the coccyx. Increases in IAP press the pelvic organs against the supporting muscle (Berglas and Rubin, 1953). Both tonic and phasic PFM activity contribute to this support.

Anal continence depends on both tonic and phasic PFM activity to achieve

- a sensory awareness of rectal filling that triggers increasing EAS activation.

- anal closing pressure that is greater than rectal pressure when rectal contents are present.

PF dysfunction can occur in either the urethrovesical, uterovaginal or anorectal systems and frequently in more than one at the same time (Maglinte et al., 1999). Disturbances and deficiencies in PFM activity can be associated with the conditions listed below, though it is important to be aware that other factors, such as fascial laxity and smooth muscle dysfunction, are also involved. Varying degrees of anterior vaginal wall laxity occur after vaginal delivery. Greater fascial stretching occurs with a more prolonged second stage of labour, or frequent straining to evacuate. However only a small proportion of cases of vaginal laxity develop into symptomatic vaginal prolapses (Samuelsson et al., 1999).

6. Disturbances in pelvic organ function

Poor tonic support is likely to be a factor in the following conditions:

- Urinary frequency—increased daytime voiding.
- Urinary urgency—a sudden compelling desire to void, with inability to defer.
- Urinary seepage—can be an insensitive loss—leading to dampness during upright activities.
- Vaginal prolapse—a suprapubic or vaginal heaviness/dragging, with or without a palpable vaginal 'lump'.

Inadequate tonic support and strength contributes to the following:

- Stress urinary incontinence—involuntary leakage of urine with effort, exertion or impact.
- Urge urinary incontinence—involuntary leakage associated with urgency.
- Obstructed defaecation (type B)—the inability to empty the rectum even with straining, due to lack of rectal support.

Overactive PFM and non-release of PFM have been implicated in the following conditions:

- Voiding dysfunction—hesitancy in commencing flow, slow or interrupted stream, incomplete emptying.
- Dyspareunia and vaginismus—painful penetration during coitus.
- Obstructed defaecation (type A)—sometimes referred to as anismus—inability to release the anus to evacuate rectal contents.
- Perineal and perianal pain—muscle pain that tends to be worse in sitting, or in actively sustained lumbar flexion postures.

Considering that the PFM is part of the local muscle system of trunk stability, deficits in other local muscles may affect PFM tonic activity and the timing of its phasic recruitment during functional activities. Acute low back pain (LBP) has been found to alter the motor control of the lumbar multifidus and TrA (Hides et al., 1994; Hodges and Richardson, 1996). LBP may be the trigger which reduces tonic PFM support in a number of conditions such as prolapse, urinary frequency, SUI, urgency, urge incontinence (Eisenstein et al., 1994). SIJ dysfunction also interferes with the stability system of the trunk. Urinary urge incontinence has been reported in this condition, and resolved when the SIJ pain was relieved (Dangaria, 1998; O'Sullivan et al., 2001).

7. Stress urinary incontinence

SUI is the most common type of urinary dysfunction in younger women. Vaginal delivery is recognized as the predominant cause (Viktrup, 2002), but not all sufferers develop this condition immediately postpartum. Some women develop it many years after childbearing has been completed. Others experience SUI prior to pregnancy, and its occurrence during pregnancy can be partially attributed to the hormones relaxin and progesterone.

Conservative management of SUI by rehabilitation of the PFM is advocated as a primary intervention. This approach has no adverse effects and has been shown to be effective in mild-to-moderate cases of urine loss (Bo et al., 1999). Treatments have generally focussed on increasing PFM strength. However, there are a number of fascial and muscle deficiencies that contribute to SUI. Understanding this pathophysiology may also assist in determining the optimum conservative rehabilitation strategies and the likely outcome from muscle rehabilitation.

- *Low urethral closing pressure at rest* - < 20 cm H_2O— can be due to changes in tissue quality with age, lack of oestrogen, neuropathy and scar tissue. This is termed intrinsic sphincter deficiency, and may be manifested in seepage incontinence when upright as well as loss with effort. Resting urethral pressure has not been improved by PFM strengthening programmes (Bo et al., 1999).
- *Deficient urethral and bladder neck support*: The urethra is supported by the anterior vaginal wall which has fascial attachments to PC. Fascial stretch allows excessive vaginal movement in a dorsal and caudal direction during increases in IAP. The urethrovesical angle widens and the bladder neck descends and opens allowing ingress of urine (Schaer et al., 1995). In some women urethral closure with coughing is maintained but urine loss with impact activities such as running or repeated jumping occurs. Paravaginal fascial tears can also result in lack of

vaginal support. These can only be remedied by surgery (Maher, 2003).

- *Deficient PFM tonic activity*: The ability to sustain a prolonged PFM hold is reduced in women with SUI in comparison with nulliparous women, and resting tonic activity can be absent (Deindl et al., 1994). Prolonged moderate exercise almost exclusively relies on slow twitch fibres. Tonic muscle activity may be a precursor to effective phasic recruitment during effort activities such as lifting and running.
- *Delay in PFM recruitment*: PFM activity during increases in IAP may not be generated at the right time. In an EMG study of nulliparous women with SUI on physical exertion and coughing, it has been noted that the urethral pressure drops to zero at the instant of the cough yet the urethral sphincter and PC muscles were recruited with coughing. This finding of zero urethral pressure may indicate either a delay in muscle recruitment or muscle strength that is inadequate to hold against the IAP (Bo et al., 1994).
- *Asymmetrical PFM contraction*: Unilateral recruitment of the PFM may occur with voluntary effort, or only when coughing (Deindl et al., 1994). Partial peripheral neuropathy can occur with vaginal delivery, but unilateral recruitment with coughing indicates a neural deficit. Voluntary PFM activity is controlled by the motor cortex (Blok et al., 1997a). However it is the pons, without any connection to the motor cortex, which controls the automatic aspects of micturition (Blok et al., 1997b).
- *PFM weakness*: Muscle strength is generally weaker in women presenting with SUI than in asymptomatic subjects (Gunnarsson and Mattiasson, 1999). However greater PFM strength does not necessarily result in continence (Hextal et al., 1999).
- *Diaphragmatic breathing* increases abdominal antero-posterior diameter with inspiration and the resultant stretch on the abdominal muscles may enhance their contraction force during a cough (Van Lunteren et al., 1989). A strong isometric abdominal contraction develops a strong PFM contraction (Sapsford and Hodges, 2001). Global abdominal muscle holding that may occur with LBP (Richardson et al., 1999) restricts the precontractile abdominal stretch that generally occurs during the inspiratory effort of a cough. A similar effect occurs if the abdominal wall is very lax and the diaphragm is low at rest. In these patients even quiet inspiratory effort requires upper rib cage elevation. This may affect the recruitment of the abdominal muscles and consequently the PFM during a cough. Compression of the upper rib cage and lateral widening of the lower rib cage occur in coughing. In tetraplegics upper rib cage compression is effected by the clavicular portion of pectoralis major, but lower lateral rib cage widening is deficient (Estenne and DeTroyer, 1990).

- *Weak abdominal muscles*: The effectiveness of coughing relies on the generation of adequate intrathoracic pressure to expel the irritant as the glottis open. Intrathoracic pressure is usually generated by rib cage compression and the increase in IAP by contraction of TrA and the OE muscles. However in tetraplegics, who have no abdominal muscle innervation, the abdominal wall bulges out as they cough (Estenne and DeTroyer, 1990). This bulge is due to transmitted pleural pressure, as the diaphragmatic EMG activity does not differ from that in healthy subjects during coughing (Estenne and Gorini, 1992). A similar bulging of the abdominal wall is noted in many women with SUI as they cough. It can occur even during nose blowing, especially in a slumped supported position when there is no pretensioning of the abdominal muscles. Weak abdominal muscles can allow this to happen, but the mechanism of upper rib cage elevation for inspiratory effort may also be a factor. When the abdominal wall is bulged in this manner there is decreased activity in the PFM (Sapsford and Hodges, 2001). Figs. 5 and 6 show changes in muscle recruitment in patients with SUI.

8. Assessment of pelvic floor muscle dysfunction

The following clinical and subjective tests may help to determine the mechanism causing SUI.

- Firm hand contact over the vagina and perineum can detect vaginal bulging and perineal descent during coughing. This can be detected in standing. The presence of a vaginal prolapse at the introitus may interfere with this. If running and jumping usually result in urinary incontinence, using hand pressure to restrict vaginal descent during a test of repeated
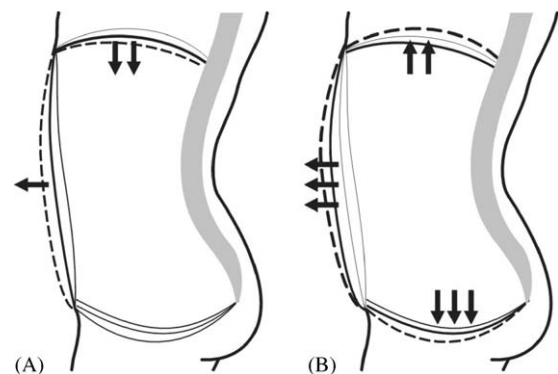

Fig. 5. Stress urinary incontinence—nose blow, cough and sneeze. (A) In patients with SUI who have weak abdominal muscles, the nose blow, cough and sneeze inspiratory effort may be similar to that in healthy subjects. There is often less abdominal wall excursion and more rib cage movement. (B) During the expiratory phase, the abdominal wall bulges forward and the PFM are forced down. Reproduced with permission of C P Sapsford.
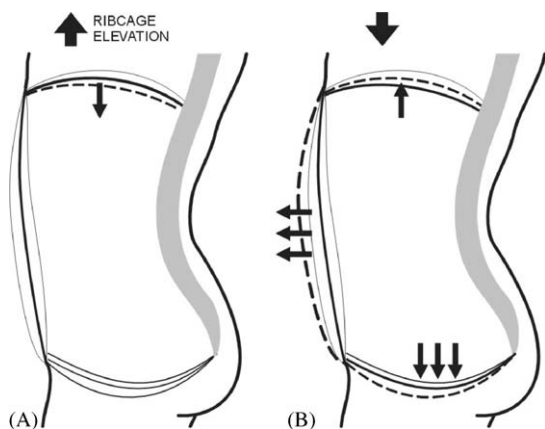
Fig. 6. Inspiratory rib cage elevation in stress urinary incontinence—nose blow, cough and sneeze. (A) When rib cage elevation is used for inspiratory effort before a nose blow, cough and sneeze, the abdominal wall tends to be stretched and drawn in a little, even though the diaphragm descends. (B) With the expiratory effort, the rib cage drops down and the abdominal wall is forced out and the PFM are forced down. Reproduced with permission of C P Sapsford.

jumping can result in little or no loss. This confirms that vaginal laxity is a factor in incontinence for that patient. However incontinence associated with a weak urethral sphincter mechanism will not change.

- Poor tonic PFM activity is likely if the tonic hold in TrA is deficient. A sense of vaginal heaviness and urinary urgency may accompany the incontinence. Many of these women note that the abdomen sags when they lean forward in standing, and this may represent lack of an automatic postural hold in TrA.
- PFM activation and strength are frequently assessed by digital vaginal palpation by experienced PF physiotherapists. An alternative clinical test to confirm the correct activation can be achieved by external hand contact over the vaginal entrance. The patient is asked to contract the PFM by drawing the urethra and vagina closed and towards the head. There should be a drawing in and upward movement of the vaginal entrance and perineum. The patient can also detect this with her hand. A perceived bulging indicates that increased IAP is forcing the pelvic organs and vagina down. This can be due to diaphragmatic descent and breath holding with or without a firm abdominal wall.
- A subjective awareness of contraction of abdominal muscle and vaginal tension status (PFM activity) during sitting at rest and with functional tasks can indicate correct or incorrect PFM and abdominal muscle recruitment. Changes in status in both muscle groups, as the patient moves from one sitting position to the next and performs the set tasks, are frequently detected. A hand on the lower abdomen is needed to feel the direction of abdominal wall movement during coughing. Subjective abdominal and vaginal awareness in slumped supported sitting, upright unsup-

ported sitting, and with resisted lifting and coughing in the upright posture can be recorded in the following manner. Tests can be conducted in other positions.

Slump/sit		Upright/sit		Resisted lift		Coughing	
PF	Abd	PF	Abd	PF	Abd	PF	Abd
?	↓	↑	↑	↑	↑	↓	↓

Muscle looseness at rest, or a decrease in activity, is indicated by a downward arrow. An increase in activity is indicated by an upward arrow. When the subject is unable to detect the muscle condition an interrogation mark is used. Retesting as treatment progresses will detect subjective changes as muscle function improves.

- A diaphragmatic breathing pattern at rest should be confirmed in both lying and sitting.
- Co-activation of PF and abdominal muscles can be detected by palpating TrA medial to the anterior superior iliac spines (ASIS) during a gentle sustained periurethral hold. It is possible to detect asymmetry in TrA during the periurethral hold. This test should be conducted in lying initially, as the global abdominal muscles can be relaxed thus making TrA changes easier to detect.

9. Treatment of pelvic floor muscle dysfunction

It is important to realise that muscle rehabilitation is not the only strategy used when treating patients with various types of pelvic floor dysfunction. However it is the aspect covered by this paper. A continence physiotherapist has a full understanding of other interventions that can be used.

There are several stages to be undertaken in PFM rehabilitation. Progression from one stage to the next depends on the ability to perform the first step before embarking on the next. The status of the abdominal muscles on initial assessment may determine the order of treatment. In patients with strong global abdominal muscle holding, the retraining of a diaphragmatic breathing pattern needs to be the first treatment step.

1. *Diaphragmatic breathing*: The correct breathing pattern should be checked in lying and sitting, both unsupported and supported. Visual feedback using a mirror can be very helpful when sitting. Practice should aim to minimize upper rib cage elevation, though limitations imposed by certain respiratory conditions have to be taken into account.
2. *Tonic activation*: PFM rehabilitation should begin with tonic activity, as this is often deficient (Deindl et al., 1994). This differs from many other programmes for SUI which focus on strong PFM holds sustained for up to 10 s. As with rehabilitation

of TrA in patients with LBP (Richardson et al., 1999), retraining of a tonic PFM action involves very gentle and prolonged muscle holds. Some patients need to learn to relax global abdominal muscle activity prior to commencing this approach. Using an independent TrA contraction to gain a PFM co-contraction helps to ensure the very low-level PFM activation required. Use of tactile input medial to ASIS, by both patient and therapist, teaches and confirms the correct abdominal activation.

In patients without back pain this reeducation can be commenced in standing. An advantage of this upright position is that the lumbar curve is maintained and the dependent abdominal contents create some tension in the abdominal wall. This tension of the abdominal wall makes it easier to detect the gentle muscle activation required. Patients must be able to report their subjective awareness of the periurethral and/or perivaginal and perianal tensioning response during the independent TrA activation, and/or the release as the abdominal wall is released. This is critical to the success of this approach. If this perineal response is not detected, it may indicate that the PFM are not being recruited and consequent increases in IAP can aggravate many PF conditions. When a patient holds a gentle TrA contraction in standing the patient should also be aware of a suprapubic firmness radiating from the midline to both sides above the inguinal ligaments. As with muscle activation for lumbar stabilization, TrA must be recruited without respiratory effort or spinal movement (Richardson et al., 1999).

Five repetitions up to five times a day holding for as long as possible can be used as a starting programme. Each abdominal hold should gradually be increased to up to 30 or 40 s and more. At this stage the focus of muscle holding remains abdominal. The action should be progressed from tactile abdominal awareness to 'thinking just above the pubic bone' and learning to develop a gentle abdominal firmness in this region. Use of this gentle action before and during lifting improves the sense of PFM support during the lift. Awareness of perineal tensioning and release with the abdominal activation and relaxation should be checked a few times a day.

An alternative method to achieve tonic PFM activity is to use a minimal periurethral PF hold in unsupported upright sitting with a neutral lumbar curve. The desired action is to imagine holding the flow of urine. Hand contact over the lower abdomen can detect an isometric abdominal response. This is a preferable method for those with chronic back problems who tend to recruit global abdominal muscles. However many women have been encouraged to perform strong PFM contractions and must realise the difference with this approach. In patients with current LBP it is advisable to address the back pain before treating the PF problem.

While many patients initially over activate the TrA/PFM co activation, a small degree of OI activity may not be detrimental to PF dysfunction sufferers if there is no back pain. This exercise is then gradually incorporated into daily activities in standing and walking.

3. *Muscle strengthening*: Once a TrA/PFM co-contraction can be maintained easily with walking for more than 15 s, strength training is added to the tonic work. The TrA ability to hold is tested functionally by palpating the activation and asking the patient to walk. It is important to assess the ease with which the patient walks and to feel the abdominal wall release as they relax. During strength training the patient should palpate TrA and OE muscles. This will help to develop an awareness of abdominal activation. It can be difficult to be aware of an abdominal contraction without this palpation. A gentle lower abdominal action as used for TrA is commenced first, then the patient is requested to keep pulling the lower abdomen in towards the spine. The patient should hold hard and then pull up the periurethral PF as far as possible. This can be done in reverse order. The patient should hold this for 3–5 seconds, breathing as the hold is maintained. This action uses TrA and the obliques, but avoids spinal movement thus minimizing RA activity. The principles of strength training should be used to determine the number of repetitions per day, but the therapist should be cognisant of motivational and compliance factors.

The amount of internal vaginal movement detected by the patient with the added periurethral lift will vary with the degree of fascial laxity and the strength of the abdominal muscles. Once the abdominal muscles have been strengthened, further elevation with the added PFM activation is often negligible. It is difficult to state how strong the PFM needs to be. This depends on the demands put upon the muscle, and the extent of the fascial laxity. Some women want to be able to run, others wish only to walk. The fascial laxity is very variable but greater laxity requires greater strength to stabilise the musculofascial unit.

4. *Functional expiratory patterns*: 'To improve a specific performance by strengthened musculature, the muscles must be trained with movements as close as possible to the desired movement or actual skill' (McArdle et al., 1991, p. 465). Thus nose blowing, coughing, sneezing and laughing all need retraining in a similar manner, using a motor relearning approach of deliberate and repeated practice of the necessary sequence of breathing and muscle activation. Nose blowing should be

commenced first as this is a slower pattern and thus easier to master. The patient should be sitting upright, unsupported, in front of a mirror. A diaphragmatic breath increases the antero-posterior diameter of the abdomen. The nose blow is commenced from this full inspiration and incorporates a strong cognitive abdominal pulling in contraction as the nose blowing takes place. The use of a sustained blow gives time to concentrate on the correct pattern of abdominal activation. Once the patient can perform the expiratory pattern, she should be asked to comment on her perceived vaginal response. This nose blow pattern needs to be practised five or six times repeatedly once or twice a day. It should be performed effectively and consistently before progressing to coughing retraining. As with all expiratory patterns practice is eventually progressed to lying and all sitting and standing postures. The recruitment of the correct pattern is hardest in positions of abdominal laxity e.g. lying, slumped supported sitting and forward lean standing.

Coughing requires stronger and faster abdominal muscle activation. In sitting there is some vaginal support from the chair and this gives the patient improved awareness and more confidence that she will not leak urine as she practises. The retraining commences in upright unsupported sitting using the same pattern as for nose blowing. This pattern becomes more effective as the abdominal muscles gain strength. In laughing the abdomino/PFM pattern must be able to be repeated and sustained.

Sneezing requires the greatest muscle power and correct timing. Placing the hands around the lower ribs with fingers palpating over the external oblique muscles can aid in detecting the correct lower rib expansion and muscle action. This lateral widening of the lower rib cage with abdominal muscle concentric contraction should occur in all forceful expiratory patterns. The inspiratory phase requires rapid diaphragmatic descent as with coughing. The second phase of the sneeze, the compressive phase, needs to be practised many times with increasing rapidity in front of a mirror. As this is performed, the abdominal wall is seen to pull in and up and the lower rib cage is felt to widen laterally. Further abdominal pulling in occurs in the third or expulsive phase. In all of these expiratory patterns an awareness of vaginal tightening must be reported.

5. *Impact activities*: After this retraining programme many women will be able to cough and sneeze without loss, but they may not be able to run or do repeated jumping activities such as impact aerobics. In a number of those women excessive bladder neck mobility will require surgery. However for some women this abdominal and PFM tonic and strength retraining programme does enable them to be continent while they are running. These women begin their impact retraining using tonic TrA holds as they run, initially on soft grass surfaces and if possible, running uphill. Uphill running minimizes the impact force and puts more demands on trunk stability mechanisms with resultant increasing PFM activity. Women gradually extend the distance and the force that they generate. Unpredictable demands on the PF with uneven surface running should be added. They will comment that the TrA hold seems to become automatic as they run. Patients have used this approach for retraining for tennis, netball, and playing soccer with the children. While regular straining at defaecation has not been implicated in isolated SUI, it is a factor in utero-vaginal prolapse and this may have accompanying SUI (Spence-Jones et al., 1994). Thus attention to defaecation dynamics should be included for all patients (Markwell and Sapsford, 1995).

10. Conclusion

This paper has attempted to review the impact of different aspects of thoraco/abdomino/pelvic muscle functioning on urinary continence and incontinence. Whilst surgery is likely to remain the only successful option for women with extensive PF fascial laxity, implementation of the regimen outlined in this paper provides a different approach to amelioration of mild-to-moderate SUI. That one programme of exercise can rehabilitate abdominal and PF muscles, contribute to the prevention of LBP and aesthetically enhance abdominal contours must appeal to many women. There are very few women who do not bemoan their lax abdominal muscles following child bearing and as they get older. That this abdominal laxity has a bearing on PFM function will be new information for many.

Motivation and compliance are important considerations in prescribing an exercise programme. If the isometric abdominal work and the retrained functional tasks are incorporated into daily living activities the benefits gained from the initial intervention are more likely to be maintained. Long-term outcomes of treatment of SUI may then improve. This paper has presented new concepts into dysfunction and conservative management of SUI. Rigorous research is needed to prove these concepts before such programmes will be universally accepted.

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