There is not yet strong evidence that exercise regimens other than pelvic floor muscle training can reduce stress urinary incontinence in women: a systematic review

Kari Bø[1] and Robert D Herbert[2]

[1]Norwegian School of Sport Sciences, Department of Sports Medicine, Oslo, Norway, [2]Neuroscience Research Australia, Sydney, Australia

Question: What evidence is there for alternative exercises to specific pelvic floor muscle training for treatment of stress urinary incontinence in women? **Design**: A systematic review was conducted with searches of PubMed and PEDro to January 2013. The quality of randomised trials was evaluated using the PEDro scale. Each type of exercise was classified as being in a Development Phase, Testing Phase, or Refinement and Dissemination Phase. **Participants**: Women with stress or mixed urinary incontinence with predominantly stress urinary incontinence. **Intervention**: Exercise regimens other than pelvic floor muscle training. **Outcome measures**: The primary outcome was urinary leakage. **Results**: Seven randomised controlled trials were found: three on abdominal training, two on the Paula method, and two on Pilates exercise. The methodological quality score ranged between 4 and 8 with a mean of 5.7. There was no convincing evidence for the effect of these exercise regimens so they remain in the Testing Phase. Because no randomised trials were found for posture correction, breathing exercise, yoga, Tai Chi, and general fitness training, these were classified as being in the Development Phase. **Conclusion**: There is not yet strong evidence that alternative exercise regimens can reduce urinary leakage in women with stress urinary incontinence. Alternative exercise regimens should not yet be recommended for use in clinical practice for women with stress urinary incontinence. **Bø K, Herbert RD (2013) There is not yet strong evidence that exercise regimens other than pelvic floor muscle training can reduce stress urinary incontinence in women: a systematic review. *Journal of Physiotherapy* 59: 159–168]**

Key words: Alternative, Exercise, Fitness, Pelvic floor, Stress urinary incontinence

Introduction

Urinary incontinence is a common complaint in women. Reported prevalence rates vary between 32% and 64% (Milsom et al 2009). The most common types of female urinary incontinence are *stress urinary incontinence*, defined as complaint of involuntary loss of urine on effort or physical exertion (eg, sporting activities), sneezing or coughing, and *urgency urinary incontinence*, defined as complaint of involuntary loss of urine associated with urgency (Haylen et al 2010). Many women also present with mixed urinary incontinence, which is a combination of the two. Urinary incontinence affects quality of life and participation in social activities, especially physical activity and exercise (Milsom et al 2009).

Kegel was the first to report the effect of regular, specific strength training of the pelvic floor muscles on female urinary incontinence and pelvic organ prolapse (Kegel 1948). He claimed that 84% of a series of gynaecological patients were cured of urinary incontinence after pelvic floor muscle training. Now many randomised controlled trials have evaluated the effects of pelvic floor muscle training for female urinary incontinence. These trials have compared the effect of pelvic floor muscle training to no treatment or to training regimens with and without biofeedback, electrical stimulation, or vaginal weighted cones (Dumoulin and Hay-Smith 2010, Herderschee et al 2011, Hay-Smith et al 2011). The broad findings of these trials are clear: supervised intensive pelvic floor muscle training reduces the risk of remaining incontinent. The absolute reduction in incidence proportion of women with incontinence reported in randomised trials comparing effects of pelvic floor muscle training and regular care varies greatly between studies (ARR 5–85%, NNT 1 to 20), but most studies report clinically important reductions in risk (Shamliyan et al 2008). Training may be conducted in a variety of ways (for example, it may be supervised or unsupervised, with or without vaginal cones, biofeedback, or electrical stimulation). The best results are obtained with supervised individual training and close follow-up (Hay-Smith et al 2011). Systematic reviews of randomised controlled trials in the general female population conclude

What is already known on this topic: Urinary incontinence is common in women, affecting quality of life and participation in social activities. Extensive high-quality evidence confirms that specific pelvic floor muscle training reduces stress urinary incontinence and mixed urinary incontinence.

What this study adds: Abdominal training, the Paula method, and Pilates have each been examined as adjuncts or alternatives to pelvic floor muscle training in several randomised trials, but the data do not support their effectiveness. The efficacy of yoga, Tai Chi, breathing exercises, postural training and general fitness training in treating stress urinary incontinence has not been examined in any randomised trials.

that there is Level 1, Grade A evidence of the effectiveness of pelvic floor muscle training, and there is consensus that pelvic floor muscle training should be first-line treatment for stress urinary incontinence and mixed urinary incontinence (Dumoulin and Hay-Smith 2010).

In spite of the strong evidence of the effectiveness of pelvic floor muscle training for treatment of stress urinary incontinence and mixed urinary incontinence there seems to be increasing interest in using other exercise regimens to treat stress urinary incontinence (Sapsford 2004, Hay-Smith et al 2011). We will refer to these as 'alternative exercises'. Alternative exercises include training of the deep abdominal muscles, contraction of the ring muscles of the mouth and eyes (the Paula method), Pilates exercise, yoga, Tai Chi, breathing exercises, posture correction, and general fitness training. The effectiveness of some alternative exercise regimens was also explored by Hay-Smith et al (2011), but these exercises were not the focus of that Cochrane review. A framework for this review is provided by our paper on how new therapies become incorporated into clinical practice (Bø and Herbert 2009). In that paper we presented a three-phase protocol for the introduction of new therapies into clinical practice (Box 1). The central idea is that the *development* phase for new therapies involves clinical observation, laboratory studies, clinical exploration, and pilot clinical trials. Once there are sufficient data from such studies to believe that the therapy could be effective, its effectiveness is tested with a randomised controlled trial. We argued, as have many before us (eg, Chalmers 1977), that new therapies should not be considered to have been shown to be effective, or be introduced into routine clinical practice, until they have been shown to have clinically important effects in properly conducted randomised controlled trials. Thus the *testing* phase involves the conduct of randomised trials. Lastly, once an intervention has been shown to be effective, usually with more than one randomised trial (Ferreira et al 2012), further trials may be conducted to examine how best to administer the therapy and to whom the therapy is best administered. This is the *refinement and dissemination* phase. It is only at this last phase that clinicians should be actively encouraged to adopt the new therapy. However, not all therapies thought to be effective in the first phase will be shown to be effective in clinical trials. We will classify alternative interventions for treatment of stress urinary incontinence or mixed urinary incontinence according to whether they are currently in the Development Phase, the Testing Phase, or the Refinement and Dissemination Phase.

Box 1. A six-stage protocol for the introduction of new therapies into clinical practice.

Stage 1: Clinical observation or laboratory studies	Development Phase
Stage 2: Clinical exploration	
Stage 3: Pilot studies	
Stage 4: Randomised clinical trials	Testing Phase
Stage 5: Refinement	Refinement and Dissemination Phase
Stage 6: Active dissemination	

We conducted a systematic review to examine evidence of the effectiveness of these alternative exercise regimens. The aim was to critically appraise the current evidence of the effectiveness of alternatives to pelvic floor muscle training for treatment of stress urinary incontinence or mixed urinary incontinence to answer the following question:

> What evidence is there for alternative exercises to specific pelvic floor muscle training for treatment of female stress urinary incontinence?

Method

Identification and selection of studies

We searched specifically for trials investigating one of eight alternative exercise regimens (training of the deep abdominal muscles, the Paula method, Pilates exercise, yoga, Tai Chi, breathing exercises, posture correction, or general fitness training for other parts of the body not including specific pelvic floor muscle contractions) for women with stress urinary incontinence or mixed urinary incontinence with predominantly stress urinary incontinence. A computerised search was conducted of the PubMed database using the search terms: ((urinary AND incontinen*) OR pelvic floor) AND (Yoga OR Tai Chi OR Pilates OR breathing OR posture OR transversus abdominis OR fitness). The advanced search on PEDro used the terms 'incontinence' and 'clinical trial'. In PubMed the search was limited to randomised controlled trials reported in the English, Scandinavian, or German languages. The final searches were conducted on 4 January 2013.

Studies were included in the review if they were randomised controlled trials investigating the effectiveness of exercise regimens other than specific pelvic floor muscle training. Pelvic floor muscle training could be carried out with or without biofeedback, electrical stimulation, vaginal cones, and resistance devices (Dumoulin and Hay-Smith 2010, Hay-Smith et al 2011, Herderschee et al 2011, Parsons et al 2012). The inclusion criteria for the review are presented in more detail in Box 2. Exclusion criteria were: studies on women with other forms of urinary incontinence or lower urinary tract symptoms, studies on women with neurological diseases, and studies on bladder training.

Assessment of characteristics of studies

The included trials were classified according to preset criteria: type of alternative exercise regimens, comparison intervention, participants and diagnoses, interventions, primary outcome measures, and results. We considered methodological limitations of each of the trials. The PEDro scale for rating quality of randomised controlled trials was used to score methodological quality (Maher et al 2003). Two researchers classified and scored each trial independently. Disagreements were resolved by discussion.

The results are presented in the following way. Each alternative exercise regimen is considered in turn. First we provide a brief description of the theoretical justification for the therapy. Then the evidence supporting the intervention is presented, beginning with the evidence from laboratory studies and observational (epidemiological) studies and

Box 2. Inclusion criteria.

Design
- Randomised trial

Participants
- Females
- Stress urinary incontinence

Intervention
- Abdominal muscle training
- Paula method
- Pilates exercise
- Yoga
- Tai Chi
- Breathing exercises
- Posture correction
- General fitness training
- Any other exercise regimen that is a possible alternative to specific pelvic floor muscle training[a]

Outcome measures
- Presence or absence of urinary leakage
- Urinary leakage reported as a continuous variable (eg, pad test)
- Urinary incontinence included in questionnaires on pelvic floor dysfunction

Comparisons
- Intervention versus control
- Intervention versus specific pelvic floor muscle training[a]
- Intervention plus specific pelvic floor muscle training[a] versus specific pelvic floor muscle training alone

[a]Specific pelvic floor muscle training can be performed with or without biofeedback, electrical stimulation, vaginal cones, or resistance devices.

concluding with randomised trials. We did not attempt to systematically search for laboratory or epidemiological studies as this would have been very difficult and the focus was on randomised trials. We finish the presentation of each therapy with a statement about where, in the process of development and testing, the therapy can be considered to be (Bø and Herbert 2009).

Results

Flow of studies through the review

Electronic searching identified 447 studies, among which seven eligible trials were found. The flow of studies through the review and the reasons for exclusion of studies are presented in Figure 1.

Description of studies. Among the seven randomised controlled trials that were included, three assessed abdominal training, two assessed the Paula method, and two assessed Pilates exercise. A summary of each study is presented in Table 1.

Quality. The methodological quality score of the included trials ranged between 4 and 8 with a mean of 5.8. The criteria met by each of the included trials are presented in Table 2.

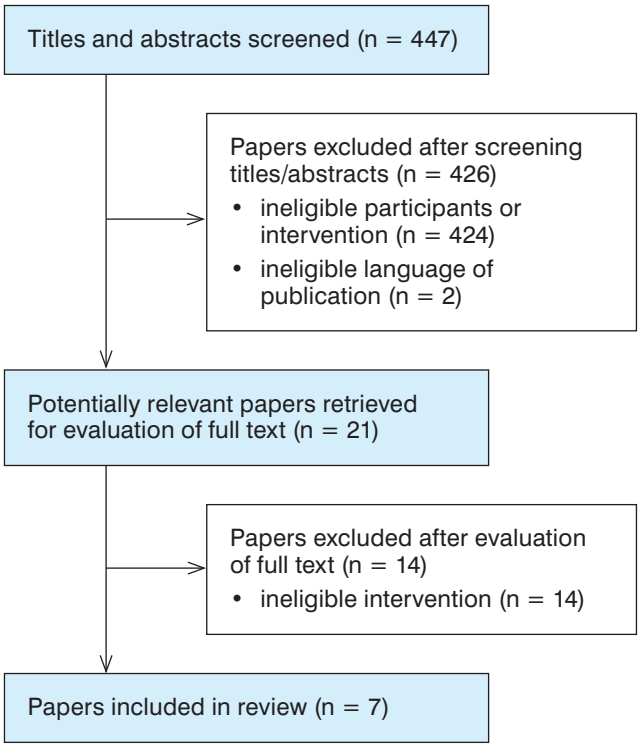

Figure 1. Identification and selection of studies.

Abdominal muscle training

Sapsford has claimed that 'Abdominal muscle training to rehabilitate the pelvic floor muscles may be useful in treating urinary and fecal incontinence' and that 'exercise of the abdominal muscles may be beneficial in maintaining pelvic floor muscle co-ordination, support, endurance and strength' (Sapsford and Hodges 2001).

Theory: Deep abdominal muscle contraction will make the pelvic floor muscles co-contract and co-ordination of pelvic floor muscle contraction with deep abdominal muscle contraction is more effective than specific strength training of the pelvic floor muscles to enhance continence (Sapsford 2001, Sapsford 2004).

Non-randomised studies: Five laboratory studies, using surface, wire, and concentric needle electromyography (EMG), have shown co-contraction of the pelvic floor muscles during abdominal contraction (Bø and Stien 1994, Sapsford et al 2001, Sapsford et al 1998, Sapsford and Hodges 2001, Neumann and Gill 2002). These studies were conducted in continent women, in whom co-contraction is expected (Jones et al 2006, Peng et al 2007); it is possible that different responses might be observed in incontinent women. Two newer laboratory studies, also conducted on continent women, used suprapubic and perineal ultrasound to show that in some women contraction of the transversis abdominus muscle presses the pelvic floor downwards (Bø et al 2003) or opens up the levator hiatus instead of lifting and constricting the pelvic openings (Bø et al 2009).

Jones et al (2006) found that both continent women and women with stress urinary incontinence demonstrated co-contraction of the pelvic floor muscles during deep abdominal contractions, but in another study they found that

Table 1. Summary of included studies (n = 7).

Study	Participants	Intervention	Primary outcome	Results
Dumoulin (2004)[a]	Women with SUI at least 3 months post-partum Exp = 23 Con = 20 (1 dropout)	8 weeks intervention, 1 day/wk with PT, 5 days/wk at home Exp = PFMT, electrical stimulation and TrA muscle training Con = PFMT, electrical stimulation	Modified 20-min pad test with standardised bladder volume, with cure defined as < 2 g	Absolute reduction in risk of not being cured = 4% (95% CI −22% to 30%) in favour of Exp
Hung (2010)	Women with SUI or MUI Exp = 31 (4 dropouts) Con = 33 (2 dropouts)	4 months intervention following vaginal palpation Exp = 8 visits with PT, including diaphragmatic breathing, tonic activation of TrA and PFM, strengthening of TrA/PFM/IO, functional expiratory exercises (eg, cough), impact activities (eg, jump) Con = Oral instruction and usual information on UI, PFMT, and bladder hygiene	Self-reported improvement	Absolute reduction in risk of remaining the same or getting worse = 30% (95% CI 11% to 47%) in favour of Exp
Sriboonreung (2011)[a]	Women with SUI Exp = 21 (2 dropouts) Con = 19 (3 dropouts)	12 weeks intervention, 3 days/wk Exp = PFMT and abdominal training Con = PFMT	1-hr pad test after drinking 500 ml of water	Mean difference = 1 g (95% CI 0 to 2) in favour of Exp
Liebergal-Wischnitzer (2005)	Women with SUI or MUI Exp = 30 (2 dropouts) Con = 31 (2 dropouts)	Exp = Paula method: individual therapy 45 min/wk including PFMT and daily 15–45 min at home for 12 wks Con = Group PFMT 30 min/wk for 4 wks and daily 15 min at home and phoned by PT every second wk	1-hr pad test after drinking 500 ml of water	Mean difference = 4 g (95% CI −3 to 11) in favour of Con
Liebergal-Wischnitzer (2009)	Women with SUI Exp = 117 (25 dropouts) Con = 123 (39 dropouts)	Exp = Paula method: individual therapy 45 min/wk including PFMT and daily 15–45 min at home for 12 wks Con = Group PFMT 30 min/wk for 4 wks and daily 15 min at home and phoned by PT every second wk	1-hr pad test after drinking 500 ml of water	Mean difference = 1 g (95% CI 1 to 2) in favour of Con
Savage (2005)	Women with SUI and an Oxford grading of ≥ 2 Exp = 6 Con = 5 (1 dropout)	12 weeks intervention, 6 individual PT sessions of 30–45 min Exp = Pilates, with co-contraction of PFM and abdominals, breathing and contraction during limb lifting and 10–15 min home exercise every second day Con = PFMT individualised and 'knack', no holding time	Kings Health Symptom severity score questionnaire	Insufficient data supplied
Culligan (2010)	Women with or without SUI Exp = 28 (2 dropouts) Con = 24 (8 dropouts)	12 weeks intervention, 6 individual PT sessions of 30–45 min Exp = Pilates including PFM contractions Con = PFMT 'with biofeedback, vaginal manipulation, massage, neuromuscular re-education, manual therapy focussing strictly on the pelvic floor'	PFM strength. Secondary: PFDI-20, PFQ-7	PFDI-20 improvement: Exp: 48%, Con: 53% PFQ-7 improvement: Exp: 44%, Con: 55%

[a]This trial had an additional randomised group that is not described here as the data were not relevant to this review. Con = control = pelvic floor muscle training, Exp = experimental = alternative exercise for pelvic floor muscle, IO = internal oblique, MUI = mixed urinary incontinence, PFDI-20 = pelvic floor stress inventory short form, PFIQ-7 = pelvic floor impact questionnaire, PFM = pelvic floor muscles, PFMT = pelvic floor muscle training, PT = physiotherapist, SUI = stress urinary incontinence, TrA = transversus abdominis

Table 2. PEDro Scale criteria and ratings for the included studies (n = 7).

Study	Treatment	Random allocation	Concealed allocation	Groups similar at baseline	Participant blinding	Therapist blinding	Assessor blinding	Follow-up > 85%	Intention-to-treat analysis	Between-group difference reported	Point estimate and variability reported
Dumoulin (2004)	Abdominal training	Y	Y	Y	N	N	Y	Y	Y	Y	Y
Hung (2010)	Abdominal training	Y	Y	N	N	N	Y	Y	Y	Y	Y
Sriboonreung (2011)	Abdominal training	Y	Y	Y	N	N	N	Y	Y	Y	Y
Liebergall-Wischnitzer (2005)	Paula method	Y	Y	N	N	N	N	Y	N	N	Y
Liebergall-Wischnitzer (2009)	Paula method	Y	Y	Y	N	N	Y	N	N	Y	N
Savage (2005)	Pilates exercise	Y	Y	N	N	N	Y	N	N	N	Y
Culligan (2010)	Pilates exercise	Y	Y	Y	N	N	N	N	N	Y	Y

Y = yes, N = no.

the response of the pelvic floor muscles was more delayed during cough in women with stress urinary incontinence compared to women who were continent (Peng et al 2007). Arab and Chehrehrazi (2011) did not find any difference in co-contraction of abdominal muscles during pelvic floor muscle contraction between women with stress urinary incontinence and continent women.

Randomised trials: No trials compared abdominal muscle training with no treatment. Three trials incorporated abdominal muscle training in one of the interventions, as presented in Table 1. Dumoulin et al (2004) reported that adding transversus abdominis training to pelvic floor muscle training did not have a statistically significant effect on risk of remaining incontinent after 8 weeks of training (absolute risk reduction 4%). However the confidence interval for the effect was very wide (95% CI –22 to 30) so these data do not clearly rule out clinically important effects. Hung et al (2010) compared the effect of supervised abdominal muscle training and pelvic floor muscle training with unsupervised pelvic floor training alone and found that abdominal muscle training was associated with a large absolute reduction in risk of self-reported lack of improvement of 30% (95% CI 11 to 47). However this study has several serious limitations including that, while participants in the control group were instructed in pelvic floor muscle training on one occasion, it appears that they did not receive ongoing supervision or feedback so the control intervention was not best practice. In addition, more than half the participants had no leakage on a pad test at baseline. Sriboonreung et al (2011) did not find any additional effect of adding abdominal training to pelvic floor muscle training on incontinence, and the confidence interval for this effect (mean difference in pad test result of –1 g, 95% CI –2 to 0) was sufficiently narrow to rule out the possibility that abdominal training conferred clinically significant benefits. In our opinion the evidence from randomised trials is currently ambivalent and does not provide strong support for the effectiveness of abdominal muscle training.

Phase: Testing phase.

Paula method

Theory: All sphincters in the body work simultaneously, so exercising the ring muscles of the mouth, eyes, or nose will result in co-contraction and strengthening of the pelvic floor muscles (Liebergall-Wischnitzer et al 2005).

Non-randomised studies: Two research groups assessed whether contraction of the muscles around the mouth and eyes results in co-contraction of the pelvic floor muscles (Bø et al 2011, Resende et al 2011). Bø et al (2011) used perineal ultrasound to measure constriction of the levator hiatus and Resende et al (2011) used surface EMG to measure activation of the pelvic floor muscles during the Paula method. Neither research group found any co-contraction of the pelvic floor muscles during contraction of the mouth or eyes.

Randomised trials: No trials compared the Paula method with no treatment. Two trials, one a pilot study of 59 women and the other a large trial of 245 women, have been conducted by one group of researchers (Liebergall-Wischnitzer et al 2005, Liebergall-Wischnitzer et al 2009). In both trials, participants randomised to the group receiving Paula therapy attended up to 9 hours of individualised instruction and practised the Paula method including additional pelvic

floor muscle contractions for up to 63 hours at home. Control group participants attended up to 3 hours of group classes and practised pelvic floor muscle exercise for up to 21 hours at home. The outcomes slightly favoured pelvic floor muscle training in both trials. Mean difference in change in leakage with a one-hour pad test was 4.1 g (95% CI 2.6 to 10.8) in the 2005 trial and 1.0 g (95% CI 0.5 to 1.5) in the 2009 trial. Interpretation of these trials is complicated by the fact that the pelvic floor muscle training was far from optimal. In addition, there was a very high loss to follow-up (28%) in the 2009 trial. These randomised trials provide no evidence of a clinically worthwhile effect of the Paula method and suggest the intervention is not effective.

Phase: Testing phase.

Pilates exercise

Modern Pilates exercise programs incorporate exercises that involve breathing and contraction of pelvic floor muscles. The pelvic floor muscles are not specifically trained, but pelvic floor muscles are trained incidentally during exercise and movement.

Theory: The co-contraction of pelvic floor muscles that occurs incidentally during Pilates exercises will counteract increases in intra-abdominal pressure that occur during exercise, preventing leakage and strengthening pelvic floor muscles (Lately 2002).

Non-randomised studies: One ultrasound study by Baessler and Junginger (2010) found that both yoga and Pilates exercise without pre-contraction of the pelvic floor muscles descended the bladder neck by 0 to 17 mm. In five of the 10 subjects there was no lift when precontraction was added to the exercises.

Randomised trials: No trials compared Pilates with no treatment. Two trials have compared the effects of Pilates exercise to other interventions, as presented in Table 1. One was a pilot study of 10 participants (Savage 2005). Insufficient data were provided to permit between-group statistical comparisons. A second study (Culligan et al 2010) compared changes in pelvic floor muscle strength and pelvic floor symptoms in 62 women assigned either to Pilates exercise or pelvic floor muscle training. The mean strength gains experienced by the two groups were similar, with a mean difference 0.4 cmH_2O favouring pelvic floor muscle training (95% CI –3.7 to 4.6). These women had 'no or little pelvic floor dysfunction', and it is not reported how many of them had pelvic floor dysfunction. Consequently this study does not provide information about the effectiveness of Pilates training for treating urinary incontinence.

Phase: Testing phase.

Yoga

Theory: Yoga emerged from ancient Indian spiritual beliefs, but in western countries has evolved into various programs for stretching, breathing, balance, and strengthening exercise, sometimes associated with meditation. Some yoga programs involve contraction of the anal sphincter and the pelvic floor muscles (Teasdill 2000, Kaminoff 2007).

Non-randomised studies: No studies were found.

Randomised trials: No randomised trials of yoga for treatment of urinary incontinence were found.

Phase: Development phase.

Tai Chi

Theory: Tai Chi is an ancient exercise regimen originating from China and has widespread use as exercise for general health in China. Chang (1986) describes an exercise called 'the dear' involving contraction of the anal sphincter. The exercise is recommended for both men and women for conditions related to the pelvic area.

Non-randomised studies: No studies were found.

Randomised trials: No randomised trials on the effect of Tai Chi on female stress urinary incontinence were found.

Phase: Development phase.

Breathing exercises

Theory: The pelvic floor works in co-ordination with breathing. Holding the breath may increase intra-abdominal pressure and thus cause descent, stretching, and weakness of the pelvic floor muscles. Lee et al (2008) suggested that 'non-optimal strategies for posture, movement and/or breathing create failed load transfer which can lead to pain, incontinence and/or breathing disorders'. Caufriez (1997) has developed a technique called the abdominal hypopressive technique, which combines a special respiration technique with abdominal indrawing. He hypothesizes that it 'relaxes the diaphragm, decreases intra-abdominal pressure and may activate the abdominal and pelvic floor muscles simultaneously'.

Non-randomised studies: In a laboratory study of six healthy continent women, Hodges et al (2007) assessed the responses of pelvic floor muscles during arm movements and different respiratory tasks using anal and vaginal surface EMG. They found that all but one woman had greater vaginal EMG activity during expiration than in inspiration. During breathing with increased dead space for 90 sec, pelvic floor muscle EMG increased during both respiratory phases compared to quiet breathing, but was greater during expiration. Intra-abdominal pressure increased during inspiration, and during hypercapnea intra-abdominal pressure increased more during inspiration. However, vaginal EMG was greater during expiration, which the authors attributed to a response of the pelvic floor muscles to contraction of the abdominal muscles. Lee et al (2008) used these data to suggest that 'development of pelvic floor dysfunction is also related to other disorders such as low back pain and breathing disorders'.

Stüpp et al (2011) found that the abdominal hypopressive technique was significantly less effective than voluntary pelvic floor muscle contraction alone in activating the pelvic floor muscles measured with vaginal surface EMG and there was no additional effect of adding the hypopressive technique to the pelvic floor muscle contraction.

A laboratory study of 12 healthy women with mean age 31 (range 20 to 51) measured vaginal pressure in the posterior fornix during cough and different exercises with and without conscious breathing (O'Dell et al 2007). In contrast to the previous findings, these authors did not find any difference in intra-abdominal pressure with breath-holding or expiration.

Randomised trials: No randomised trials have compared incontinence outcomes in women allocated to receive breathing exercise with pelvic floor muscle training or allocated to pelvic floor muscle training with and without breathing exercises during pelvic floor muscle contraction.

Phase: Development phase.

Posture correction

Theory: Carriere (2006) has claimed that 'poor posture' can lead to pain and dysfunction in the pelvic floor. Lee et al (2008, p 333) stated that 'optimal strategies for transferring loads will balance control of movement while maintaining optimal joint axes, maintain sufficient intra-abdominal pressure without compromising the organs (preserve continence, prevent prolapse or herniation) and support respiration. Non-optimal strategies for posture, movement and/or breathing create failed load transfer which can lead to pain, incontinence and breathing disorders'.

Non-randomised studies: Carriere (2006) and Lee et al (2008) support their claims by citing a cross-sectional study by Smith et al (2006). However the study by Smith and colleagues did not incorporate any data on posture. Pool-Goudzwaard et al (2004) use data from an in vitro cadaver study to suggest that the pelvic floor muscles stabilise the pelvic girdle. Contradictory results have been found by others (Fitzgerald and Mallinson 2012, Stuge et al 2006).

A non-randomised controlled trial of 52 women with stress urinary incontinence found that 'global postural re-education' was more effective than pelvic floor muscle training, with an absolute difference in cure rate of 16% (Fozzatti et al 2010).

Randomised trials: There have been no randomised trials of the effects of postural correction on urinary incontinence.

Phase: Development phase.

General fitness training

Theory: It has been suggested that the co-contraction of the pelvic floor muscles and increase in intra-abdominal pressure expected to occur during general movements will act as a training stimulus and that those who are physically active therefore have less stress incontinence (Bø 2004, Kikuchi et al 2007).

Non-randomised studies: No interventional studies were found. Several prevalence studies show high prevalences of stress urinary incontinence among elite athletes and sports participants (Bø 2004). Other cross-sectional studies found that physically active women have less urinary incontinence (Hannestad et al 2003, Kikuchi et al 2007).

Randomised trials: No trials were found comparing general fitness training or exercise programs without pelvic floor muscle training to pelvic floor muscle training alone, other methods or no treatment of stress urinary incontinence.

Phase: Development phase.

Discussion

Seven randomised trials were found investigating the effects of alternative methods for treatment of stress urinary incontinence. None of them compared the effect of the alternative exercise regimens with no treatment. The methodological quality of these trials varied between 4 and 8 on the PEDro scale. Given that it is not possible to blind the participants or the trainers in complex interventions, 8 would be the highest possible score in these trials. To date there is no evidence from high quality randomised controlled trials to support use of alternative exercise regimens to reduce stress urinary incontinence symptoms.

A limitation of the current review is that, while we systematically reviewed randomised controlled trials of the effects of the various interventions, no attempt was made to systematically review the non-randomised and pre-clinical (laboratory studies). It would be difficult or impossible to conduct a comprehensive search of this literature, or to systematically evaluate the quality of the laboratory studies. However the primary conclusions of the review are necessarily based on the findings of randomised trials, so the failure to conduct a systematic review of non-randomised and pre-clinical studies should not have biased the conclusions of the review.

A systematic review of trials investigating the effects of deep abdominal training on urinary incontinence concluded that there was no evidence this intervention is more effective than pelvic floor muscle training (Bø et al 2009). However a new randomised controlled trial (Hung et al 2010), conducted by the researchers who first advocated deep abdominal training for treatment of urinary incontinence, has been published since the former review. In that trial the focus was on respiration in co-ordination with transversus abdominis and pelvic floor muscle training (Hung et al 2010). However, the trial has several important limitations: most importantly there was no actual leakage (medians of 0 leakage volume and 0 episodes of leakage) in most subjects in either group at baseline, and the control group did not receive a structured pelvic floor muscle training program. In addition, there was a large baseline imbalance in the type of incontinence with significantly (27%) more participants in the alternative group reporting urgency. Another randomised trial (Sriboonreung et al 2011) confirmed that there was no additional effect of adding abdominal training to pelvic floor muscle training. There is, therefore, still no robust evidence to support the practice of adding deep abdominal training to pelvic floor muscle training for stress urinary incontinence or mixed urinary incontinence.

The Paula method is derived from a similar theoretical framework to abdominal training because it is based on the idea that a co-contraction of other muscles (in this case contraction of ring muscles of the mouth and eyes) can train the pelvic floor muscles (Liebergall-Wischnitzer et al 2005). However, two independent research groups did not find any co-contraction of the pelvic floor muscles during contraction of ring muscles of the mouth and eyes, so it would appear unlikely on the basis of these laboratory studies that there would be any effect of a training regimen applying the Paula method (Bø et al 2011, Resende et al 2011). The two randomised trials suggest that the Paula method has similar effects to, or is slightly less effective than, a very poorly implemented program of pelvic floor muscle training.

Theoretically non-specific exercises could strengthen pelvic floor muscles. It has been claimed that Pilates exercises and yoga include contractions of the pelvic floor muscles that

could strengthen them and treat stress urinary incontinence/mixed urinary incontinence. The challenge is that several studies have shown more than 30% of women with pelvic floor dysfunction are not able to contract the pelvic floor muscles correctly even after thorough individual teaching and feedback (Benvenuti et al 1987, Bump et al 1991, Bø et al 1988). The most common errors are to bear down or to use hip adductor, gluteal, or abdominal muscles instead of the pelvic floor muscles (Bump et al 1991, Bø et al 1988). Group training of pelvic floor muscles has been shown in several randomised controlled trials to be effective, but these programs included individual instruction and feedback of the contraction (Bø et al 1990, Bø et al 1999, Mørkved and Bø 1997, Mørkved et al 2003). It is not yet known whether it is possible to teach women participating in a general group-based exercise class to contract the pelvic floor muscles. Culligan et al (2010) concluded, on the basis of their finding that Pilates training produced similar strength gains to pelvic floor muscle training, that their results may 'lead to widespread use of Pilates-based exercise programs to treat and prevent pelvic floor dysfunction'. In our opinion that conclusion is premature because no randomised trials have demonstrated benefical effects of Pilates exercise on clinically important outcomes (continence) in a sample of incontinent women. Indeed, observational data suggest that this is not the case: a study on group fitness instructors showed that the prevalence of incontinence was the same amongst female yoga and Pilates instructors as in the general population, suggesting that the exercises did not provide a beneficial effect (Bø et al 2011).

The suggestion of an association or causal link between breathing, posture, and pelvic floor muscle dysfunction should be tested in case-control or cohort studies with blinded assessors. A large cross-sectional study found associations between incontinence, low back pain, and respiratory disease (Smith et al 2006), but it is quite possible the associations were confounded, so that while participants had multiple complaints at the same time the conditions were not causally related. Cross-sectional studies usually provide weak evidence of causality.

There are two contradictory hypotheses on the effect of general exercise on the pelvic floor, previously described by Bø (2004). One hypothesis holds that general exercise makes pelvic floor muscles co-contract, and thus strengthens pelvic floor muscles and prevents stress urinary incontinence. The other hypothesis is that repetitive or heavy impact on the pelvic floor, such as is caused by heavy lifting or marathon running, may fatigue, stretch, and weaken the muscles. There is some evidence that bouts of strenuous exercise may weaken the pelvic floor muscles immediately after the intervention (Ree et al 2007), and new symptoms of pelvic floor dysfunction have been seen to emerge after 6 weeks of strenuous exercise (Larsen and Yavorek 2007). It is difficult to establish whether habitual physical activity increases or decreases the risk of incontinence using observational studies because women with stress urinary incontinence often discontinue physical activity. The issue can only be properly resolved with randomised controlled trials.

Systematic reviews on the effect of pelvic floor muscle training on stress urinary incontinence/mixed urinary incontinence have concluded that intensive supervised training can produce clinically important effects (Dumoulin and Hay-Smith 2010, Hay-Smith et al 2011, Herderschee et al 2011, Parsons et al 2012). This systematic review has demonstrated that the alternative methods of exercising pelvic floor muscles have not been convincingly shown to be effective with high quality randomised controlled trials. Thus these interventions should be considered to be in a Development or Testing phase. Accordingly, these alternative methods should not yet be used routinely, or recommended for routine use, in clinical practice (Bø and Herbert 2009).

Several alternative interventions are still in the development phase (yoga, Tai Chi, breathing exercises, posture correction, and fitness training). It will be necessary to conduct further laboratory studies investigating potential mechanisms of these interventions. Promising laboratory studies might justify further uncontrolled clinical exploration and pilot randomised studies. The patients in these studies should be fully informed of the exploratory and experimental nature of the treatment.

When laboratory studies and uncontrolled clinical observations or pilot studies suggest a clinically important effect of the new alternative method, it might be appropriate to commence the Testing phase and conduct high quality randomised controlled trials. Three of the alternative interventions (abdominal muscle training, the Paula method, and Pilates exercise) have been subjected to randomised controlled trials and are therefore currently in the Testing phase. Arguably, however, the Development phase for these interventions has been insufficiently rigorous. There is not yet convincing evidence from high quality randomised trials of a clinically important effect of these interventions, so they should not yet be used routinely, or recommended for routine use, in clinical practice.

As we have acknowledged before (Bø and Herbert 2009), many clinicians will feel that strict adherence to a model in which new interventions are not routinely practised until they have been demonstrated to have clinically important effects in randomised controlled trials will stifle innovation, ideas, and further development (Crosbie 2013). We argue that patients have a right to expect they will be treated with interventions that have been shown to be effective. In general, patients do not want to waste time and money on ineffective treatments, and patients generally trust that the interventions they are offered are effective.

In summary, no trials were found comparing alternative exercises to no treatment. It has not yet been conclusively demonstrated that abdominal training, the Paula method, Pilates, yoga, Tai Chi, breathing exercises, postural training, or general fitness training is effective for the prevention or treatment of stress urinary incontinence either as an alternative or an adjunct to pelvic floor muscle training. Further development and testing, ultimately with randomised controlled trials, is needed before these alternative interventions become routine clinical practice. ■

Correspondence: Professor Kari Bø, PhD, Norwegian School of Sport Sciences, Dept of Sports Medicine, PO Box 4014, Ullevål Stadion, 0806 Oslo, Norway. Email: kari.bo@nih.no

References

Arab AM, Chehrehrazi M (2011) The response of the abdominal muscles to pelvic floor muscle contraction in women with

and without stress urinary incontinence using ultrasound imaging. *Neurourology and Urodynamics* 30: 117–120.

Baessler K, Junginger B (2010) Gymnastics for urinary incontinence – destroying the myth. *Neurourology and Urodynamics* 29: 1052–1053.

Benvenuti F, Caputo GM, Bandinelli S, Mayer F, Biagini C, Sommavilla A (1987) Reeducative treatment of female genuine stress incontinence. *American Journal of Physical Medicine* 66: 155–168.

Bump R, Hurt WG, Fantl JA, Wyman JF (1991) Assessment of Kegel exercise performance after brief verbal instruction. *American Journal of Obstetrics and Gynecology* 165: 322–329.

Bø K (2004) Urinary incontinence, pelvic floor dysfunction, exercise and sport. *Sports Medicine* 34: 451–464.

Bø K, Bratland-Sanda S, Sundgot-Borgen J (2011) Urinary incontinence among fitness instructors including yoga and Pilates instructors. *Neurourology and Urodynamics* 30: 370–373.

Bø K, Brækken IH, Majida M, Engh ME (2009) Constriction of the levator hiatus during instruction of pelvic floor or transversus abdominis contraction: a 4D ultrasound study. *International Urogynecology Journal and Pelvic Floor Dysfunction* 20: 27–32.

Bø K, Hagen RH, Kvarstein B, Jørgensen J, Larsen S (1990) Pelvic floor muscle exercise for the treatment of female stress urinary incontinence: III. Effects of two different degrees of pelvic floor muscle exercise. *Neurourology and Urodynamics* 9: 489–502.

Bø K, Herbert RD (2009) When and how should new therapies become routine clinical practice? *Physiotherapy* 95: 51–57.

Bø K, Hilde G, Stær-Jensen J, Brækken IH (2011) Can the Paula method facilitate co-contraction of the pelvic floor muscles? A 4D ultrasound study. *International Urogynecology and Pelvic Floor Dysfunction* 22: 671–676.

Bø K, Larsen S, Oseid S, Kvarstein B, Hagen R, Jørgensen J (1988) Knowledge about and ability to correct pelvic floor muscle exercises in women with urinary stress incontinence. *Neurourology and Urodynamics* 7: 261–262.

Bø K, Mørkved S, Frawley H, Sherburn M (2009) Evidence for benefit of transversus abdominis training alone or in combination with pelvic floor muscle training to treat female urinary incontinence: a systematic review. *Neurourology and Urodynamics* 28: 368–373.

Bø K, Sherburn M, Allen T (2003) Transabdominal measurement of pelvic floor muscle activity when activated directly or via a transversus abdominis muscle contraction. *Neurourology and Urodynamics* 22: 582–588.

Bø K, Stien R (1994) Needle EMG registration of striated urethral wall and pelvic floor muscle activity patterns during cough, valsalva, abdominal, hip adductor, and gluteal muscles contractions in nulliparous healthy females. *Neurourology and Urodynamics* 13: 35–41.

Bø K, Talseth T, Holme I (1999) Single blind, randomised controlled trial of pelvic floor exercises, electrical stimulation, vaginal cones, and no treatment in management of genuine stress incontinence in women. *BMJ* 318: 487–493.

Carriere B (2006) Interdependence of posture and the pelvic floor. In Carriere B, Feldt CM (Eds) The pelvic floor. New York: Georg Thieme Verlag, pp. 68–81.

Caufriez M (1997) Gymnastique abdominale hypopressive. Bruxelles: Caufriez, pp. 8–10.

Chalmers TC (1977) Randomize the first patient. *The New England Journal of Medicine* 296: 107.

Chang ST (1986) The complete system of self-healing: internal exercises. California: Tao Publishing, pp. 38–52.

Crosbie J (2013) Does a stubborn commitment to 'evidence' stifle innovative thinking? *Journal of Physiotherapy* 59: 69–71.

Culligan PJ, Scherer J, Dyer K, Priestley JL, Guingon-White G, Delvecchio D, et al (2010) A randomized controlled trial comparing pelvic floor muscle training to a Pilates exercise program for improving pelvic muscle strength. *International Urogynecology Journal* 21: 401–408.

Dumoulin C, Hay-Smith J (2010) Pelvic floor muscle training versus no treatment, or inactive control treatments, for urinary incontinence in women. *Cochrane Database of Systematic Reviews*: CD005654.

Dumoulin C, Lemieux MC, Bourbonnais D, Gravel D, Bravo G, Morin M (2004) Physiotherapy for persistent postnatal stress urinary incontinence: a randomized controlled trial. *Obstetrics and Gynecology* 104: 504–510.

Ferreira ML, Herbert RD, Crowther MJ, Verhagen A, Sutton AJ (2012) When is a further clinical trial justified? *BMJ* 345: e5913. doi:10.1136/bmj.e5913.

Fitzgerald CM, Mallinson T (2012) The association between pelvic girdle pain and pelvic floor muscle function in pregnancy. *International Urogyencology Journal* 23: 893–898.

Fozzatti C, Herrmann V, Palma T, Riccetto CL, Palma PC (2010) Global postural re-education: an alternative approach for stress urinary incontinence? *European Journal of Obstetrics, Gynecology, and Reproductive Biology* 152: 218–224.

Hannestad YS, Rortveit G, Daltveit AK, Hunskaar S (2003) Are smoking and other lifestyle factors associated with female urinary incontinence? The Norwegian EPINCONT study. *British Journal of Obstetrics and Gynaecology* 110: 247–254.

Haylen BT, de Ridder D, Freeman RM, Swift SE, Berghmans B, Lee J, et al (2010) An International Urogynecological Association (IUGA)/ International Continence Society (ICS) joint report on the terminology for female pelvic floor dysfunction. *Neurourology and Urodynamics* 29: 4–20.

Hay-Smith EJC, Herderschee R, Dumoulin C, Herbison PG (2011) Comparisons of approaches to pelvic floor muscle training for urinary incontinence in women. *Cochrane Database of Systematic Reviews*: CD009508.

Herderschee R, Hay-Smith EJC, Herbison GP, Roovers JP, Heineman MJ (2011) Feedback or biofeedback to augment pelvic floor muscle training for urinary incontinence in women. *Cochrane Database of Systematic reviews*: CD009252.

Hodges PW, Sapsford R, Pengel LHM (2007) Postural and respiratory functions of the pelvic floor muscles. *Neurourology and Urodynamics* 26: 362–371.

Hung H-C, Hsiao S-M, Chih S-Y, Lin H-H, Tsauo J-Y (2010) An alternative intervention for urinary incontinence: Retraining diaphragmatic, deep abdominal and pelvic floor muscle function coordinated function. *Manual Therapy* 15: 273–279.

Jones RC, Peng Q, Shishido K, Perkash I, Constantinou CE (2006) 2D ultrasound imaging and motion tracking of pelvic floor muscle (pelvic floor muscles) activity during abdominal manoeuvres in stress urinary (SUI) women. *Neurourology and Urodynamics* 25: 596-597.

Kaminoff L (2007) Yoga anatomy. Champaign IL USA: Human Kinetics pp: 2–77. Kegel AH (1948) The nonsurgical treatment of genital relaxation; use of the perineometer as an aid restoring anatomic and functional structure. *Annals of Western Medicine and Surgery* 2: 213–216.

Kikuchi A, Niu K, Ikeda Y, Hozawa A, Nakagawa H, Guo H, et al (2007) Association between physical activity and urinary incontinence in a community-based elderly population aged 70 years and over. *European Urology* 52: 868–875.

Larsen WI, Yavorek T (2007) Pelvic prolapse and urinary incontinence in nulliparous college women in relation to paratrooper training. *International Urogynecology Journal*

and Pelvic Floor Dysfunction 18: 769–771.

Lately P (2002) Updating the principles of the Pilates method – Part 2. *Journal of Bodywork and Movement Therapies* 2: 94–101.

Lee DG, Lee LJ, McLaughlin L (2008) Stability, continence and breathing: the role of fascia following pregnancy and delivery. *Journal of Bodywork and Movement Therapies* 12: 333–348.

Liebergall-Wischnitzer M, Hochner-Celnikier D, Lavy Y, Manor O, Arbel R, Paltiel O (2005) Paula method of circular muscle exercises for urinary stress incontinence – a clinical trial. *International Urogynecology Journal and Pelvic Floor Dysfunction* 16: 345–351.

Liebergall-Wischnitzer M, Hochner-Celnikier D, Lavy Y, Manor O, Shveiky D, Paltiel O (2009) Randomized trial of circular muscle versus pelvic floor training for stress urinary incontinence in women. *Journal of Women's Health* 18: 377–385.

Maher CG, Sherrington C, Herbert RD, Moseley AM, Elkins M (2003) Reliability of the PEDro scale for rating quality of randomized controlled trials. *Physical Therapy* 8: 713–721.

Milsom I, Altman D, Lapitan MC, Nelson R, Sillen U, Thom D (2009) Epidemiology of urinary (UI) and faecal (FI) incontinence and pelvic organ prolapse (POP). In Abrams P, Cardozo L, Khoury S, Wein A (Eds) Incontinence. 4th International Consultation on Incontinence. Committee 1. France: Health Publication Ltd, pp. 35–111.

Mørkved S, Bø K (1997) The effect of postpartum pelvic floor muscle exercise in the prevention and treatment of urinary incontinence. *International Urogynecology Journal and Pelvic Floor Dysfunction* 8: 217–222.

Mørkved S, Bø K, Schei B, Salvesen KA (2003) Pelvic floor muscle training during pregnancy to prevent urinary incontinence: a single-blind randomized controlled trial. *Obstetrics and Gynecology* 101: 313–319.

Neumann P, Gill V (2002) Pelvic floor and abdominal muscle interaction: EMG activity and intra-abdominal pressure. *International Urogynecology Journal and Pelvic Floor Dysfunction* 13: 125–132.

O'Dell KK, Morse AN, Crawford SL, Howard A (2007) Vaginal pressure during lifting, floor exercises, jogging, and use of hydraulic exercise machines. *International Urogynecology Journal and Pelvic Floor Dysfunction* 18: 1481–1489.

Parsons K, Irani J, Fall M, Hanus T, Llorente C, Loch T, et al (2012) European Association of Urology 2012 Guidelines. European Association of Urology: Arnhem.

Peng Q, Jones R, Shishido K, Constantinou C (2007) Ultrasound evaluation of dynamic responses of female pelvic floor muscles. *Ultrasound in Medicine & Biology* 33: 342–352.

Pool-Goudzwaard A, van Dijke GH, van Gurp M, Mulder P, Snijders C, Stoeckart R (2004) Contribution of pelvic floor muscles to stiffness of the pelvic ring. *Clinical Biomechanics* 19: 564–571.

Ree M, Nygaard I, Bø K (2007) Muscular fatigue in the pelvic floor muscles after strenuous physical activity. *Acta Obstetricia et Gynecologica Scandinavica* 86: 870–876.

Resende APM, Zanetti MRD, Petricelli CD, Castro RA, Alexandre SM, Nakamura MU (2011) Effect of the Paula method in electromygraphic activation of the pelvic floor: a comparative study. *International Urogynecology Journal* 22: 677–680.

Sapsford R (2001) The pelvic floor. A clinical model for function and rehabilitation. *Physiotherapy* 87: 620–630.

Sapsford R (2004) Rehabilitation of pelvic floor muscles utilizing trunk stabilization. *Manual Therapy* 9: 3–12.

Sapsford R, Hodges P (2001) Contraction of the pelvic floor muscles during abdominal maneuvers. *Archives of Physical Medicine and Rehabilitation* 82: 1081–1088.

Sapsford R, Hodges P, Richardson C, Cooper D, Markwell S, Jull G (2001) Co-activation of the abdominal and pelvic floor muscles during voluntary exercises. *Neurourology and Urodynamics* 20: 31–42.

Sapsford R, Markwell S, Clarke B (1998) The relationship between urethral pressure and abdominal muscle activity. Abstract. 7th National Continence Foundation of Australia Conference on Incontinence, Australia.

Savage AM (2005) Is lumbopelvic stability training (using Pilates model) an effective treatment strategy for women with stress urinary incontinence? A review of the literature and report of a pilot study. *Journal of the Association of Chartered Physiotherapists in Women's Health* 97: 33–48.

Shamliyan TA, Kane RL, Wyman J, Wilt TJ (2008) Systematic review: randomized controlled trials of nonsurgical treatments for urinary incontinence in women. *Annals of Internal Medicine* 148: 459–473.

Smith MD, Russell A, Hodges PW (2006) Disorders of breathing and continence have a stronger association with back pain than obesity and physical activity. *Australian Journal of Physiotherapy* 52: 11–16.

Sriboonreung T, Wongtra-ngan S, Eungpinichpong W, Laopaiboon M (2011) Effectiveness of pelvic floor muscle training in incontinent women at Maharaj Nakorn Chiang Mai Hospital: a randomized controlled trial. *Journal of the Medical Association of Thailand* 94: 1–7.

Stuge B, Mørkved S, Dahl HH, Vøllestad N (2006) Abdominal and pelvic floor muscle function in women with and without long lasting pelvic girdle pain. *Manual Therapy* 11: 287–296.

Stüpp L, Resende AP, Petricelli CD, Nakamura MU, Alexandre SM, Zanetti MR (2011) Pelvic floor muscle and transversus abdominis activation in abdominal hypopressive technique through surface electromyography. *Neurourology and Urodynamics* 30: 1523–1526.

Teasdill W (2000) Yoga for pregnancy. Chicago: Contemporary Books, pp 46–47.

