State of the art pelvic floor muscle assessment – which tool should we use?

EC31, 30 August 2011 09:00 - 12:00

Start	End	Topic	Speakers
09:00	09:05	Introduction	• Fetske Hogen Esch
09:05	10:00	Dynamic Palpation	• Maeve Whelan
10:00	10:30	Manometry, electromyography and dynamometry	• Melanie Morin
10:30	11:00	Break	None
11:00	11:30	Ultrasound	• Judith Thompson
11:30	12:00	Case Study/ Discussion	All

Aims of course/workshop

Aim:

To highlight the various tools which can be used in the assessment of the pelvic floor –

a) Dynamic Palpation

1. To know where to internally palpate the pelvic floor to identify areas of hypertoncity and hypotoncity
2. Visualize the change in a pelvic floor contracting correctly as shown with "before and after" MRI scans

b) Manometry, electromyography and dynamometry

1. Present a critical review on the use of manometry, electromyography and dynamometry.
2. Enable the selection of the appropriate tool and analyze the pelvic floor dysfunctions

c) Ultrasound

1. Present an evidence-based approach to these tools
2. Present their validity and reliability
3. Present the relationships between findings, signs, symptoms and diagnosis

Educational Objectives

This workshop is required to promote and maintain the educational value of teaching effective, evidence-based clinical skills of pelvic floor muscle (PFM) assessment to clinicians and researchers. Directed and effective assessment informs appropriate application of treatment, hence this topic is critical to all clinicians who base their interventions on the assessment of the pelvic floor musculature. The topics covered will explore the scientific and clinical rationale of the methods of PFM assessment presently used by clinicians. All selected tools have been refined in recent years. It is important that clinicians can selectively choose the most appropriate assessment tool for their patient population and practice. The speakers possess a depth and breadth of clinical expertise and research in PFM assessment and evaluation for conditions affecting both men and women, (eg. pelvic pain, incontinence) and have extensive experience at the level of international presentations, successfully engaging participants.

Dynamic Palpation

With the ongoing research in Ultrasound imaging and MRI scanning, the physiotherapist's skills in palpating tears and fascial defects in the pelvic floor have much improved.

The nature of trauma in whatever form to the pelvic floor is that it will load and inhibit the damaged soft tissue and surrounding intact muscles. Where US and MRI are useful to see defects and patterns of activation they do not tell where the loaded areas in the pelvic floor are. This can be done by palpation only.

Dynamic palpation is the use of palpation not just to measure the pelvic floor muscles, fascia and organ position at rest and contracting but rather to compare the resting position and contracting values once the effect of the negative forces have been off loaded. To proceed without addressing this is to continue to train the muscles in the negative pattern that the patient has presented with in the first place.

Objectives:

- To know where to internally palpate in the male and female pelvic floor in order to identify negative load
- To be able to visualize the change in an off loaded pelvic floor as shown with a series of "before and after" MRI scans

Published Papers

Whelan M (2011) Chapter 15, Practical anatomy, examination, palpation and manual therapy release techniques for the pelvic floor In: Practical Physical Medicine Approaches to Chronic Pelvic Pain & Dysfunction, Eds. Chaitow L, Lovegrove R., In press, Elsevier

Whelan M (2010) Exploring Pelvic Pain in Men, Irish Medical Times, June 24th 2010

Whelan M (2010) Calm your overactive pelvic floor, Charter Continence Care, Issue 22, Summer, p 5-7

Whelan M (2008) Ch 7, Patient Assessment, Vaginal Palpation In: Therapeutic management of incontinence and pelvic pain. Eds. Laycock J. Haslam J. p60-61

Whelan M (2008) Ch 11b Advanced Manual Therapy for the Pelvic Floor In: Therapeutic management of incontinence and pelvic pain. Eds. Laycock J. Haslam J. p95-98

Whelan M (2006) Changing the Pelvic Floor, Journal of the Association of Chartered Physiotherapists in Women's Health Spring, 98, 20-27

Dynamic Palpation

ICS Education Course
August 30th 2011
Maeve Whelan SMISCP

Advantages & Disadvantages

- Provides immediate feedback to patients
- Easy to learn
- Quick
- Not expensive
- Physiotherapists, doctors and nurses can relate
- Not just strength and endurance measured but muscle defects, tone and pain

- Subjective bias
- Lack of inter-tester reliability
- Lack of sensitivity
- Correlation only on narrow measuring scale
- Only one value to measure lift and squeeze
- Dependant on experience of tester

Advantages & Disadvantages

- Suitable for both sexes
- Can differentiate between left and right
- Can detect a reflex contraction with cough
- Can detect ability to hold with cough
- Can be used in sitting and in standing

Qualitative PFC – Kegel (1948)

- A correct contraction is a squeeze around the urethral, vaginal and anal openings and an inward lift observed at the perineum
- Vaginal palpation – a method to evaluate the ability to perform a correct contraction
- The perineometer – manometer to measure PFM strength through vaginal squeeze pressure

Qualitative PFC

- Correct
- Uncertain / straining
- Contract only with help from other muscles
- No contraction
- Confirmed by observation of drawing in (Bo & Finckenhagen 2001, Frawley 2006,)

Digital palpation methods

- 40 methods of palpation described in literature (Van Kampen 1996)
- Worth
- Brink
- Laycock
- Devreese
- ICS
- Slieker-ten Hove
- Lovegrove Jones

- Reliability
- Correlation with other measures of PFM assessment
- Clinical importance

What are the problems ?

- **Worth et al 1986**
- Description
  - Single digit palpation, no specific location

	Pressure	Duration	Ribbing	Position
1	No pressure	0-1 sec	Soft & flabby	Finger easily slips out
2	Mod pressure	2-3 sec	Different but not ribbed	Finger somewhat gripped
3	Firm pressure	>4 sec	Ribbed	Finger forcibly gripped

- Significant correlation between self reported orgasm and the CVM Rating Scale
- No correlation between age, race , parity, episiotomy or self reported Kegel exercises

- **Brink et al.** 1989,1994
- Description
  - Examiner's index and middle fingers orientated vertically inserted along post vagina to level of examiner's PIP
  - Version 2 (1994) 2 digits supine to assess lateral contraction inserted 6-8 cms and vertical to assess AP

Squeeze pressure	Muscle contraction duration	Vertical displacement
1= none	1=none	1=none
2= weak squeeze	2=<1 sec	2=finger base moves anteriorly
3=mod squeeze	3=>1sec	3= whole length of finger(s) moves anteriorly
4=strong squeeze	4=>3secs	4=whole finger(s) move anteriorly, are gripped and pulled in

Brink et al. 1989,1994

- Negative correlation between muscle strength and urine loss and age (Brink et al. 1989)
- Highest inter-rater reliability, 94% agreement, on pressure (Brink et al. 1994)
- No significant relationship between digital test and history of being able to stop urine stream or other leakage measures (Brink 1994)

Brink scale

- **Good correlation** between max perineometer pressure and total Brink score, n=100 (Hundley et al. 2005)
- PF strength in women with incontinence as assessed with Brink scale **was not** related to pad test measures of incontinence severity scale, n=643
  (Fitzgerald MP et al. , 2007)
- **Poor correlation** with POP stage, Brink scores overlapped across POP stages n=317 (Weber 2007)

Oxford grading

(Laycock & Jerwood 2001)

- Description
  Index finger 4-6cm inside vagina at 4 o'clock and 8 o'clock with moderate pressure

•Power
•Endurance
•Repetitions
•Fast
•Every
•Contraction
•Timed

Grade	Muscle contraction strength (denoted by P for power in acronym	
0	nil	nil
1	flicker	flicker
2	Increase in tension, no discernible lift	weak
3	Lift of muscle belly and elevation of post vaginal wall / in drawing of perineum	good
4	Good contraction / elevation of posterior vaginal wall against resistance	mod
5	Strong resistance to elevation of post vaginal wall / finger drawn into vagina	strong

Oxford grading

- 46.7% exact, strong reliability between assessors - 15 point scale (Laycock & Jerwood 2001)
- 53% agreement on 15 point scale, 79% agreement between therapists on 6 point scale (Frawley 2006)
- Highest reliability was in sitting, then standing, then crook lying (Frawley 2006)
- Intertester reliability needs to be established where 2 or more physicians are involved in pre and post-treatment assessment (Jeyaseelan et al. 2001)

Oxford grading

- High inter-tester reliabaility and compares favourably with perineometry (Isherwood & Rane 2000)
- Highly significant correlation between digital measurment and perineometry (Laycock & Jerwood 2001)
- Correlation between digital assessment and dynamometric measurement can be defined as moderate to good (Morin et al. 2004)
- PFM strength using Oxford scale improved in POP intervention group (Hagen 2009)

Oxford grading

- No significant correlation between vaginal palpation using Oxford grading and vaginal squeeze pressure using vaginal balloon to fibreoptic microtip pressure transducer (Bo & Finckenhagen 2001)
- Teaching "the Knack" for timing during cough, women can significantly reduce urine leakage during a cough using the knack. Reduction in urine loss **was not** significantly correlated with digital measure of PFM strength (Miller et al 1998)

ICS (Messelink et al. 2005)

- Recommended ICS scale (Pelvic Floor Clinical Assessment Group)

Grade	Description
Absent	No contraction palpated or present
Weak	Weak contraction palpated
Normal	Normal contraction palpated
Strong	Strong contraction palpated

- Not validated till 2009 by Slieker-ten Hove et al.
- Recommendations to include
  - Voluntary relaxation after pelvic floor muscle contraction
  - Contraction/relaxation of PF during increases in intra-abdominal pressure (IAP) recorded as present or absent
  - Pain
  - Asymmetry

ICS Validation (Slieker-ten Hove et al. 2009)

- Correlation of voluntary PFM contraction poorer than Oxford scale reliability studies

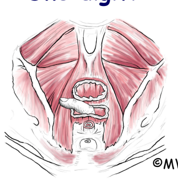
Grade	Description
Absent	No contraction palpated or present
Weak	Weak contraction palpated
Normal	Normal contraction palpated
Strong	Strong contraction palpated

- Moderate to substantial intra-tester reliability for ICS recommendations – suitable for clinical practice
- Disappointing inter-tester reliability – questionable for research
- Poor inter-tester reliability for palpation and movement of perineum during cough
- Good inter-tester reliability for pain during palpation
- Mod inter and intra-tester for fast contractions and closing of hiatus
- Poor inter and intra-tester for symmetry of contraction

Problems

- Sensitivity of digital assessment to change is questionable, subjective appreciation of force level by digital evaluation is possible only when large differences of force exist (Morin 2004)
- Location of position of palpating finger for repeated measurement
- How many fingers
- Length of examiner's finger
- Variability in size of hiatus
- Variability in resting position of pelvic floor
- Variability in pressure exerted by palpating finger

- **One digit?**



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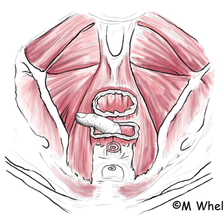
- **Two digits?**

O'Rahilly 2009

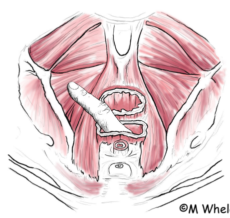
- Two fingers places the vaginal tissue under tension and distorts the anatomical relationship (Kegel 1952)
- Stretching the tissue may produce an enhanced response (Chiarelli 1989)
- The initial phase of passive muscle stretching is associated with a reflex rise in tone (Jahnke et al 1989)
- Unknown whether wide diameter device or 2 finger palpation stretches PF either inhibiting or facilitating (Bo and Sherburn 2005)
- One digit if lumen contact is circumferential or two if contact is not complete (Bo & Finckenhagen 2001, Frawley 2006)

Palpation - where?

- PFM located in the distal third of the vagina, index finger inserted up to proximal interphalyngeal joint (Kegel 1948, 1952)
- One finger, location not specified, CVM (Worth et al. 1986)
- Two digits, 4-6 cms into the vagina with palm facing down (Brink et al. 1989)
- Index and middle 6-8cms vertical (Brink et al. 1994)
- Index finger 4-6cms inside vagina positioned at 4 o'clock and 8 o,clock (Laycock & Jerwood 2001)
- Two distal phalynges of index and middle fingers inserted and positioned laterally in order to evaluate both sides (with an out-breath) (Morin et al. 2004)
- 2 ½ distal phaylanges of the index finger with palmar side towards caudal part of the vagina (Devreese et al. 2004)



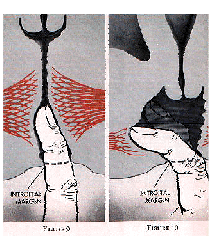
2½ distal phaylanges or
4-6 cms or
proximal interphalyngeal joint
*Central
*Antero-lateral



4-8 cms
*Central
*Posterolateral

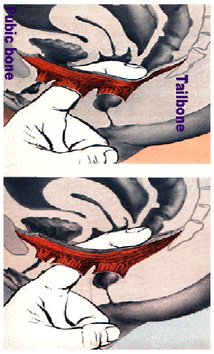
Kegel 1952

Palpation of the pubococcygeus for tone and function



- "The index finger introduced to about the second joint and moved about normally meets resistance in all directions.
- When the pubococcygeus is atrophic, the middle third of the vagina is roomy; the walls are thin and feel as though detached from the surrounding structures, particularly anteriorly and laterally.

- Normal patients can voluntarily contract the pubococcygeus firmly about the palpating finger.
- When atrophy has occurred, no such contractions can be elicited."



www.incontinet.com

- "Firm pressure on the posterior segment of the puboccygeus (or the levator ani plate) may produce an antagonistic contraction.
- When repeated several times, the patient will become aware of the function of this muscle."

- **Devreese et al. 2004**
- Description
  - 2 ½ distal phalynges of the index finger with palmar side towards caudal part of the vagina

Sup PF contracts at same time or before deep PF
0 – not coordinated
1 – co-ordinated

Inward PF movement of 1 cm and contraction of deep abdominals – coordinated
Downward PF movement and/or outward mvt. of abd wall – not co-ordinated

Tone: Sup & Deep	Superficial	Deep
Hypo	0 no noticeable contraction	0 no noticeable contraction
Normo	1 flicker	1 flicker
	2 inward displacement and squeeze around proximal finger	2 inward displacement of distal finger without extension
	3 inward displacement and strong squeeze around proximal finger	3 inward dispalcement of distal finger with total extension
		4 as above plus can be resisted by patient but no contact with cranial vagina
		5 above but PF tightens around finger

Abdominal muscles

- SUI can be attributed to an imbalance between pelvic floor and lower abdominal muscle function, correct contraction pattern is at least as important as muscle strength (Devreese et al. 2004)
- Coordination can probably compensate for weak muscle tone (Miller 2002, Thompson & O'Sullivan 2003, Devreese et al. 2004,,)
- Co-contraction of abdominals and PF is important (Sapsford et al. 2001, Hodges et al. 2007, Juninger et al. 2010)

Digital palpation & real-time ultrasound

- Strong correlation with digital palpation strength and palpation during voluntary PFMC using TransPer US. **Displacement of bladder neck** has best agreement (Dietz et al. 2002)
- Compared TransAb US with TransPer US and palpation. Modest correlation **bladder base motion** with PFM strength (Oxford scale) on TransAb US (Thompson et al. 2005)
- No association bet **post bladder wall** motion in transverse or sagittal plane and digital palpation strength (Sherburn et al 2005)

Digital palpation & real-time ultrasound

- TrAbd US looking at **bladder base movement** when simultaneously tested with digital palpation and TrAbd US and digital palpation score tested separately; significant correlation between US and palpation in both cases, better correlation in simultaneous testing (Arab 2010)

- Transvaginal US - Shortened **saggital hiatal diameter** i.e. distance from pubic symphysis to anorectal junction correlated best with PFMC strength by Oxford grading (Yang 2009)

- **Lovegrove Jones 2010**

- Description:
  - Functional scale of PFM contraction
  - One finger initially inserted palmar side to the caudal part of the vagina and then rotated 180°. The pad of the index finger is extended cranially to locate the urethro-vesical junction

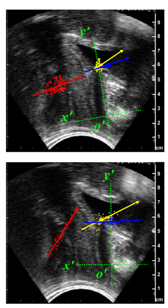
Grade	Muscle contraction
0	Absent: not present
1	Poor: present to a minor degree, able to feel sensation on two aspects of palpating finger
2	Fair: able to feel sensation on two aspects of palpating finger
3	Good: obvious sensation of displacement on all aspects of palpating finger
4	Functional: able to maintain displacement on cough

Lovegrove Jones 2010

- Correlation in both continent and incontinent groups between digital measurements and transperineal US
- Greater displacement was not reflective of greater PFM strength
- Displacement of **anorectal angle** correlates highly with **displacement of urethra** in continent but moderately in women with SUI
- Ventral displacement correlates better to digital strength than cranial lift
- Functional scale is a valid digital measurement of PFM displacement which has good correlation with transperineal ultrasound (Lovegrove Jones, PhD 2010)

Direction of Displacement

- Direction of PFM contraction is not always in a ventral-cranial direction, nor does it always directly support the urethra
- PFM contraction can result in posterior bladder wall displacement when the bladder is prolapsed low into the pelvic cavity Miller 2002



(Peng et al. 2006)

Consider resting position -

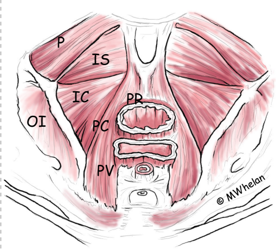
- A stretched/weak PF may be positioned lower within the pelvis compared to a well trained or non-injured PF
- Time for injured muscle to reach optimal contraction may be too slow to prevent leakage / stop organ descent
- Lift with greater range may equally be due to a fascial disruption allowing greater ROM and not related to strength (Bo & Sherburn 2005)
- Lift from standing position PF has to come from greater distance so lift measured may be greater just because it is coming from a lower resting position and not because it is stronger (Lovegrove Jones 2010)

Consider resting position -

- Low maximal strength at shorter lengths may make it difficult to demonstrate a difference in muscle strength before and after a PFM rehabilitation program or between continent and incontinent women (Dumoulin 2004)

So – what influences:

1. Resting position
2. Resting tone
3. Superficial versus deep
4. Direction of displacement ??????????



Lev ani Lev plate ATFP TALA
Ant wall Post wall Organ position

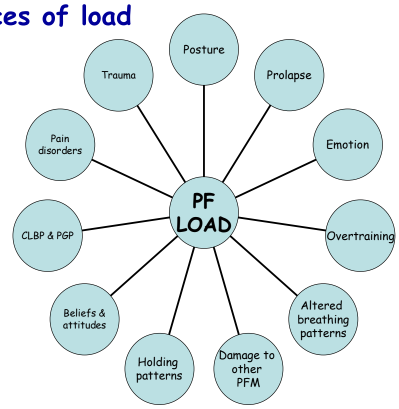
The levator plate

- The levator plate is the midline raphe of the iliococcygeus muscle (Law & Fielding 2008)
- When the body is in the standing position the levator plate has been described as being horizontal (Herschorn 2004)
- The upper axis of the vagina is horizontal and lies parallel to the levator plate (Singh 2001)
- The levator plate becomes more horizontal/rises with muscle contraction to support the pelvic contents when intra-abdominal pressure is increased (Zacharin 1980)
- The role of the iliococcygeus is that of creating posterolateral shelf support for the pelvic floor (Strohbehn 1996)

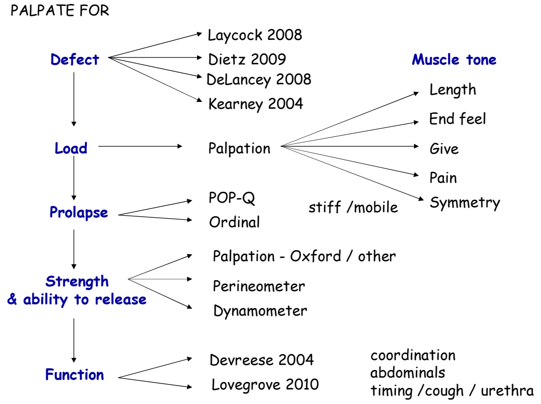
Pelvic floor load

- Damage to pubovisceral muscle may result in increased load on iliococcygeal muscle causing downward displacement (Hsu et al 2006)
- Overload of suspensor structures can be caused by levator plate sagging (Beco 2008)
- Unilateral avulsion seems to have an impact on the adjacent or contralateral intact puborectalis muscle, with it becoming spastic and more tender (Dietz 2009)
- When a muscle has taut band or trigger points the surrounding muscles become overloaded (Travel & Simons 1999)
- MRI of proplase with and without ring pessary; muscle load changes within 24 hours of ring pessary removal (Hoyte 2001 ICS)

Sources of load



PALPATE FOR



OFF LOAD

Muscle tone
- Length
- End feel
- Give
- Pain
- Symmetry

Load → Palpation → Length / End feel / Give / Pain / Symmetry

stiff /mobile

Prolapse → POP-Q / Ordinal

Strength & ability to release → Palpation - Oxford / other; Perineometer; Dynamometer

Function → Devreese 2004; Lovegrove 2010

coordination
abdominals
timing /cough / urethra

Muscle tone

Length
- long / gaps / loss of attachment
- normal resting tone 1/3rd length
- short / high

End feel
- soft, flaccid
- spongy
- hard, fibrous, taut

Give
- releases easily
- normal / gives
- doesn't move / springy / resistant

Pain

Symmetry

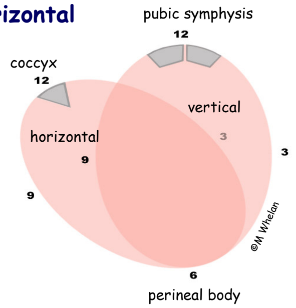
Dietz 2009

- Palpating finger parallel to the urethra with tip of finger at bladder neck and palmer surface pressed against posterior surface of symphysis pubis
- If finger can be moved over the inferior pubic ramus without encountering any contractile tissue for another 2-3 cms, this implies avulsion injury on that side

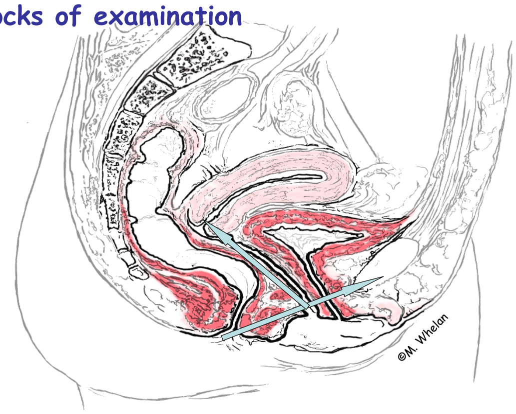
To assess morphological integrity

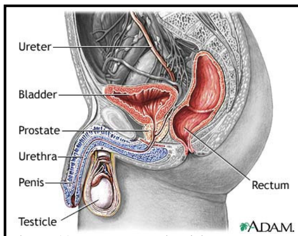
Grade	Levator resting tone
0	Muscle not palpable
1	Muscle palpable but very flaccid, wide hiatus, minimal resistance to distension
2	Hiatus wide but some resistance to distension
3	Hiatus fairly narrow, fair resistance to palpation but easily distended
4	Hiatus narrow, muscle can be distended but high resistance to distension, or pain
5	Hiatus very narrow, no distension possible, woody feel, possibly with pain: "vaginismus"

Clocks of examination: Superficial - vertical Deep - horizontal



Clocks of examination





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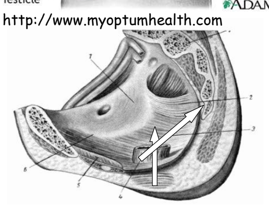


http://www.proctological-clinic.com Sobotta'a Atlas

Vertical

Sphincter – cutaneous
- superficial
- deep

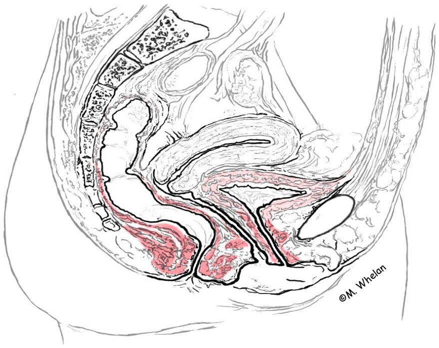
Anterior wall – prostate
- fascial tension
- attachment lev ani

Horizontal

Lateral attachments lev ani

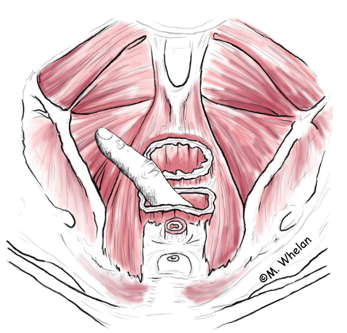
Posterior wall – puborectalis
- pubococcygeus
- iliococcygeus
- coccyx

Pelvic floor at rest



Pelvic floor contracting

Pelvic floor physiotherapy



Assess
- Negative load & muscle inhibition
- Taut bands & trigger points

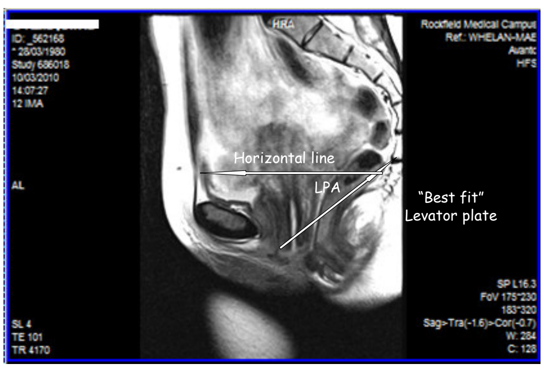
Treat
- Stretch
- Ischaemic compression
- PNF

Facilitate
- Recruit new fibres
- Improve contraction
- Improve excursion
- Be direction specific
- Improve release

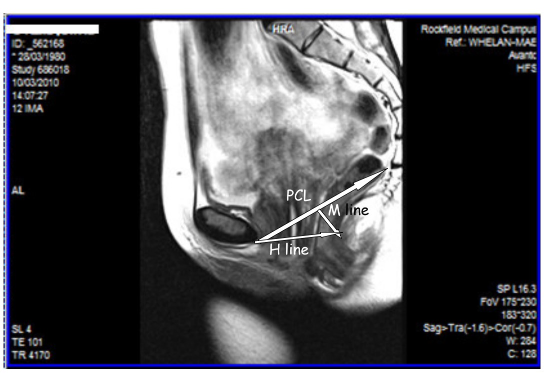
Strengthen

Levator plate

- Prolapse patients will have increased levator plate angles (Singh et al.2001, Hsu et al. 2006, Song et al. 2009)
- Stress incontinent women have PF laxity, lower PFM volume and bladder neck descent in comparison with asymptomatic indicating the role of PFM in organ support and therefore continence (Hoyte 2001)



Levator plate angle (LPA) – a "best fit" line through the levator plate and the angle formed with horizontal line through the pelvis



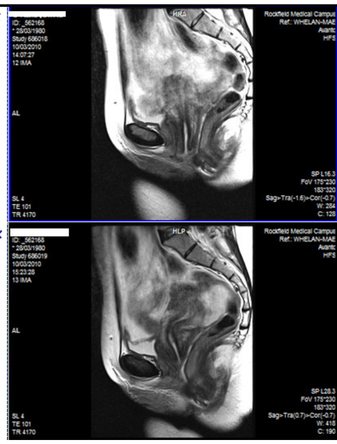
PCL – inf pub sym to last joint of coccyx (Comiter et al. 1999)

H line – distance from inf pub sym to posterior ARJ

M line – perpendicular from PCL to distal H line

At rest pre tx
14.07 p.m.

At rest post tx
15.23p.m.



Changes of:

LPA
9 degree

M line 5.3mm

H line 3.9mm

Conclusions & Questions arising

- Advantages and disadvantages to digital palpation
- No gold standard & no single method
- Lack of consistency in research

- Does concept of load play a part?
- Clinical implications?
- Research implications?

"The fate of the injured person depends to a large extent on the initial care that her injuries receive. Skilled competent care may salvage function in seemingly hopeless situations; inept care for even a trivial injury may end in disaster"

Committee on Trauma, American College of Surgeons 1961, quoted by DeLancey JOL & Ashton-Miller (2008)

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Manometry, Electromyography and Dynamometry to assess the Pelvic Floor Muscles: How can we use them?

Manometry, electromyography and dynamometry are three tools currently used in clinical and research settings to assess the pelvic floor muscles (PFM). In this presentation, we will describe the constituents and the methodology associated with these tools. Available research evidence about the psychometric properties of these instruments will also be reviewed. Their respective advantages and limitations will be discussed in order to enable clinicians and researchers to better select the appropriate tool and analyze the pelvic floor dysfunctions evaluated.

Perineometry

In 1948, Dr. Kegel (1948) developed an intravaginal device, the perineometer, to assess the PFM strength. The vaginal pressure probe was connected to a manometer in order to measure the intravaginal pressure from the PFM in millimeters of mercury (mmHg). Since then, several types of pressure probe with different shapes and technical properties have been developed and studied (Dougherty, 1986; Bo, 1990b; Laycock, 1994). These tools can measure pressure in mmHg or cm H_2O.

Good intra-rater (test-retest) reliability has been demonstrated for maximal squeeze pressure and resting pressure (tone) (Bo, 1990b; Kerschan-Schindl, 2002; Hundley, 2005; Frawley, 2006b; Frawley, 2006a). However, the study of Frawley et al. (2006b), found the endurance measurement to be unreliable. One advantage of the pressure measurement is the possibility to perform the assessment in different positions (lying, sitting and standing). Overall, the parameters proved to be reliable in these positions with the exception of the resting pressure, which was less reliable in the sitting and standing positions. Acceptable inter-rater reliability was found by Ferreira et al. (2011).

The validity of the measurement was studied by comparing the maximal squeeze pressure to other measurements. It was correlated with vaginal palpation, for instance, using the Oxford scale (r=0.703-0.814) (Riesco, 2010) and the Brink scale (r=0.68) (Hundley, 2005). The correlation was good (ICC=0.72) when comparing the maximal pressure to the bladder base movement evaluated with transabdominal US (Chehrehrazi, 2009) but moderate when comparing the maximal pressure to bladder neck movement assessed by transperineal ultrasound (r=0.43) (Thompson, 2006). The validity of the measurement is also supported by the capacity of the measurement to detect changes following treatment (Aksac, 2003) and to discriminate between groups, e.g. continent and incontinent women (Thompson, 2006).

There are a few known precautions to bear in mind regarding the uses of the pressure perineometry. Increases in intra-abdominal pressure, occurring if a patient co-contracts the abdominal muscles (rectus abdominis), or strain instead of contracting the PFM can interfere with pressure measurements. Some recommendations can be applied to ensure the validity of the measurement: 1-performing vaginal palpation before using the perineometer to make sure the woman is able to correctly contract her PFM; 2-observing the cranial movement of the vaginal probe during measurement of the muscle contraction; 3- not considering the contractions associated with the Valsalva maneuver or retroversion of the hip (Bo, 1990a; Bump, 1996). It should be pointed out that the use of perineometry is therefore difficult when a patient has a really low PFM strength, since no inward movement of the probe is possible in this case. The size of the probe and the brand of the device were also demonstrated to influence the measurement (Bo, 2005; Barbosa, 2009). The placement of the probe is another factor reported to be important. It was recommended to position the probe at the level of the PFM which corresponds to the high-pressure zone within the vagina (Guaderrama, 2005; Jung, 2007).

Electromyography

Electromyography (EMG) is basically the recording of the electrical activity traveling in the muscle fibers during a contraction. In this presentation, we will focus on surface EMG or kinesiological electromyography for evaluating the pelvic floor muscle function. To date, most pelvic floor EMG studies have used the amplitude of the signal for quantifying the PFM function (Workman, 1993; Glazer, 1999; Romanzi, 1999; Sapsford, 2001; Botelho, 2010). However, the EMG amplitude should be interpreted with caution since many confounding factors can compromise the PFM force estimation. Among other confounding variables, factors related to the detection such as the contact between the electrodes and the mucosa, vaginal lubrication and the thickness of the vaginal tissue can greatly affect the EMG signal. Moreover, the presence of crosstalk, i.e. contamination from neighboring muscles, should be considered when interpreting the force from the EMG (Peschers, 2001). It should be emphasized that EMG is not a direct force measure. The nature of the relationship between EMG amplitude and force (linear or nonlinear (Woods, 1983)) remains unknown in the context of the PFM. These factors were discussed by Auchincloss et al. (2009) who found a generally poor reliability (ICC=0.08-0.84). They argue that, although it is acceptable to use PFM surface EMG as a biofeedback tool for training purposes, it is not recommended for making between-subject comparisons or for using as an outcome measure between-days when evaluating the PFM function.

Despite these limitations, EMG is promising for plenty of clinical applications. It can be useful, for example, when proper normalization to maximal strength is done (Lehman, 1999). Moreover, EMG can also be interesting for assessing the muscle activation and co-activation with other surrounding muscles (Sapsford, 2001; Neumann, 2002; Barbic, 2003; Madill, 2008), as well as the innervation zone (Enck, 2004; Merletti, 2004).

Dynamometry

In the past 20 years, several versions of PFM dynamometer have been developed (Caufriez, 1993; Rowe, 1995; Ashton-Miller, 2002; Dumoulin, 2003; Verelst, 2004; Constantinou, 2007; Saleme, 2009; Nunes, 2011). They differ in terms of size and shape, the force vector recorded (anteroposterior force, latero-lateral or multi-directional) and other technical issues. Overall, during a PFM contraction, the lengthening or shortening of strain gauges glued on the speculum causes its electrical resistance to change. Voltage values from the strain gauge are then amplified, digitized and converted into units of force.

Dynamometers have shown good linearity, repeatability and ability to measure the resultant force independently of its point of application on the branch of the speculum in in-vitro calibration studies (Rowe, 1995; Dumoulin, 2003; Verelst, 2004). Some versions offer the advantage of evaluating multidirectional forces originating from the PFM (Constantinou, 2007; Saleme, 2009). Other dynamometers can be adjusted to measure the PFM function at different vaginal apertures (Dumoulin, 2003; Verelst, 2004; Morin, 2010). The test-retest reliability of PFM strength was found to be good (ICC=0.83-0.89) (Dumoulin, 2004; Verelst, 2004; Miller, 2007; Nunes, 2011). Other parameters such as endurance, speed of contraction and tonicity (passive forces and stiffness) of the PFM also showed good test-retest reliability (Morin, 2007; Morin, 2008). Finally, dynamometers have been shown to discriminate between stress urinary incontinent and continent women (Morin, 2004b; Dumoulin 2004). Various studies have been conducted to support the validity of dynamometric measurements. Maximal strength recorded with the dynamometer was correlated to vaginal palpation (Oxford scale, r=0.727) (Morin, 2004b). Moreover, dynamometric measurements have proven to be minimally influenced by increases in intra-abdominal pressure (Morin, 2006). Discriminant validity was also demonstrated since the dynamometer was able to distinguish between continent and incontinent women (Morin, 2004a). Furthermore, good sensitivity to detect changes following treatment was also demonstrated (Dumoulin, 2011).

The main limitation associated with PFM dynamometers is their lack of accessibility since these devices are mostly used by their designers and not commercially available.

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Ultrasound of Assessment of Pelvic Floor Muscle Function

ICS Conference Glasgow 2011

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Specialist Continence and Women's Health Physiotherapist
Body Logic Physiotherapy

PFM Function

Key to successful PFM training is accurate diagnosis of PFM dysfunction

PFM Assessment should include

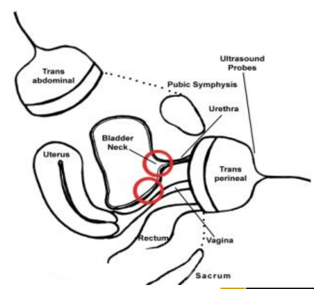
- Voluntary PFM contraction/relaxation
- Functional PFM with ↑ IAP
- Co-activation of PFM with other muscles of abdomino-pelvic cavity

Ultrasound -Advantages

- Non invasive (abdominal) or minimally invasive (perineal)
- Suitable for men, women and paediatric population
- Provides a dynamic assessment of PFM function in as close to "real-life" situation as possible
- Direct assessment PFM where VE/DRE not desirable
- Strong Biofeedback for therapist and patient
- Objective assessment "lifting" action of the pelvic floor
- Assessment of supportive function of pelvic floor during functional tasks

Real Time Ultrasound

- Transperineal
  2-D, 3/4D
- Transabdominal



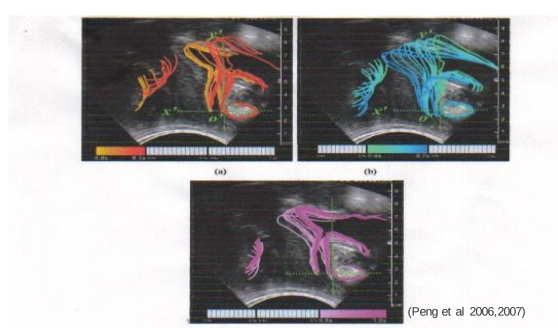
Transperineal Ultrasound

Good intra/inter rater reliability for
- Rest position bladder
- BN movement during PFM contraction/Valsalva
- Levator hiatus dimensions
- PFM thickness/length

Correlation BN movement PFM contraction with strength of PFM
- MMT (r = 0.62)
- VP (r = 0.52)

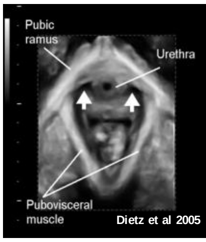
(Schaer 95, Peschers 96, Dietz 2001, 2004, 2010, Hoff Braekken 2009)

Measurement



(Peng et al 2006,2007)

Assessment of Levator 3 /4 D

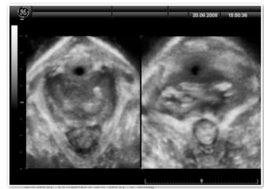


http://web.mac.com/hpdietz1/Site/Welcome.html

Curtin University

Levator trauma

Avulsion injuries
- Occur in 10-30% normal vaginal deliveries
- Uni/bilateral (Dietz 2005,2006)



- Ultrasound more reliable than palpation at detecting defects (Dietz 2006,2008)

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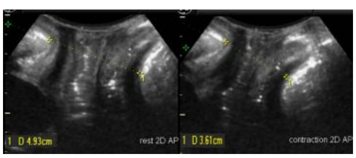
Levator Hiatus

- At rest
- During PFM
- During Valsalva



(Dietz 2010)

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Pelvic Organ Prolapse

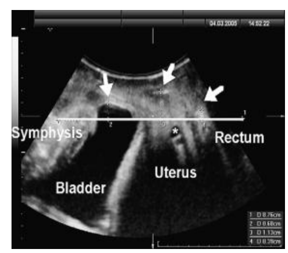
Differential diagnosis POP

Anterior compartment

- Cystocele
  - Open RV angle and funneling
  - Intact RV angle and kinking

Posterior compartment

- Rectocele
  - Defect in recto vaginal septum
  - Distensible recto vaginal septum
  - Recto-entrocele
  - Entrocele
  - Rectal intersussectption (Dietz 2010)



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Outcome measure

RCT PFMT for POP (Hoff Braekken et al 2010)

Compared with control group (difference between groups)

- Increased pelvic floor muscle thickness (1.9mm p<.001)
- Decreased hiatal area (1.8cm p=0.026)
- Shortened pubovisceral muscle length (6.1 mm P=.007)
- Elevated resting position of bladder (4.3 mm P<.000)

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Transabdominal Ultrasound

- Totally non invasive patient does not need to undress
- Easy to apply in different positions
- Good intra/inter rater reliability PFM contraction and low level tasks (ASLR) (ICC 0.81- 0.98)
- Mod/good intra rater reliabilityabd curl & Valsalva(ICC 0.51-0.86)
- Disadvantage no fixed bony landmark/probe movement

(Sherburn 2005,Thompson 2006, O'Sullivan et al 2002)

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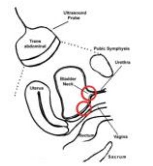
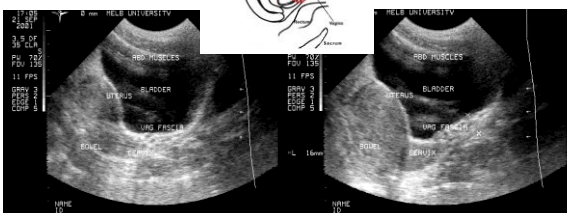
Sagittal View

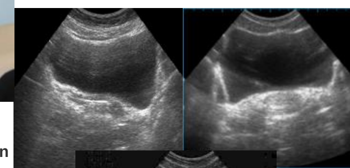


PFM relaxed

PFM contracted



Transverse View



- Asymmetry at rest and during PFM contraction
- PF elevation
- Relaxation to rest position
  - Quick contraction
  - Sustained hold

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Ultrasound Assessment

- Objective assessment of elevating PFM contraction
- RTUS more sensitive than digital palpation for the "lifting" action of the PFM (Frawley et al, 2005)
- 30-43% women with UI and POP depress PF (Thompson and O'Sullivan 2003, Thompson et al 2006)

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Functional PFM Activation

- Asymptomatic women PFM contracts as an unconscious reflex activity in response to changes in IAP
- PFM ↑ activation as a response to ↑ IAP
- RTUS measures supportive function of pelvic floor during activities which ↑ IAP

Abdominal curl up manouevre

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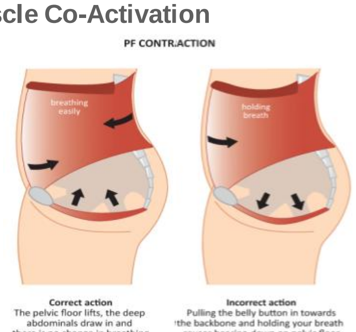
Muscle Co-Activation



CFA Fit :http://www.pelvicfloorfirst.org.au /

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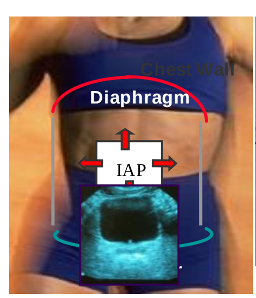
Correct PFM Contraction

Elevation bladder base: ↑ PFM, IO, min ↑ IAP



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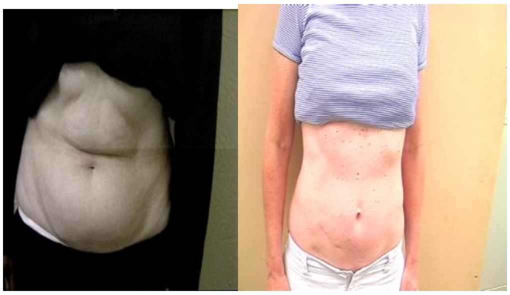
Incorrect PFM Contraction



Paediatrics

- BFB PF elevation and relaxation
- Relaxed voiding
- Defaecation dynamics

Bladder Function

Storage

- Bladder capacity

Emptying

- Post void residual

Ultrasound

Advantages

- Non-invasive(TA) minimally(TP)
- Dynamic assessment of PFM
- Strong Biofeedback
- Objective measure of
  -PFM contraction
  -Valsalva
  Good/mod intra and inter-rater reliability TP>TA
- PFM morphology/POP TP
- PVR- check for dysfunctional void
- No radiation

Disadvantages

- More expensive than VE/DRE
- No assessment of rest tone
- No assessment of pain/trigger points
- Not a direct measure of force of PFM
- Requires experience to interpret images TP>TA
- TA -lack of fixed reference point
- TA -confounding variables (probe movement and presence of prolapse)
- TA requires full bladder
- TA difficult with abdominal scar tissue

Comparison of Methods for Physiotherapy

TP US

- Direct assessment of the BN and proximal urethra
- Assessment of levator/levator hiatus
- Assessment of POP
- Measurement made from bony landmark
- Smaller measurement error
- More suitable for comparisons between subjects

TA US

- Less invasive
- Does not limit functional movements
- Quicker and easier for biofeedback in a clinical situation
- Precaution-movement visualized may not reflect PF movt may be abdominal wall movt

Conclusion

RTUS

- TP more reliable TA for comparisons between subjects
- TP accurate measure of levator morphology
- TP the way forward for diagnosis of POP
- TA valuable non invasive PFM assessment in wider population
- TA/TP assessment PVR

Real time Ultrasound Assessment of Pelvic Floor Muscle Function

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Evaluation of pelvic floor muscle (PFM) function is necessary to teach PFM exercises and to evaluate the effectiveness of PFM training programs. An accurate diagnosis of the PFM dysfunction is essential to allow targeted intervention. Assessment of the PFM should include both the voluntary and functional activation of PFM as the conscious contraction of PFM is not always reflective of the automatic PFM activation in response to changes in intra abdominal pressure(IAP) (Devreese, Staes et al. 2004; Thompson, O'Sullivan et al. 2007). A 'correct' PFM contraction has been defined as lift and squeeze around the pelvic opening with an increase in urethral pressure without significant Valsalva or straining effort (Bump, Hurt et al. 1991). The pelvic floor does not work in isolation co-activates with the abdominal muscles and diaphragm to generate and maintain IAP (Sapsford, Hodges et al. 2001; Neumann and Gill 2002; Thompson, O'Sullivan et al. 2006), therefore any assessment of a 'correct' lifting PFM contraction must take into account the activity in other muscles of the abdomino-pelvic cavity.

Ultrasound has the advantage for physiotherapists in that it allows a dynamic real-time assessment of both the voluntary and functional activation of the PFM in as close as "real life" situation as possible. It is non invasive (abdominal) or minimally invasive (perineal) and the images generated have a strong biofeedback effect for both therapist and patient. Ultrasound is suitable for use in men, women and children and Transabdominal (TA) ultrasound is particularly useful to give direct objective assessment of PFM function in populations where vaginal examination (VE) or digital rectal examination(DRE) may not be desirable such as children and adolescents and women that have suffered sexual abuse (Thompson, O'Sullivan et al. 2005).

Ultrasound has the advantage over all other clinical methods of PFM assessment in that it objectively measures the lifting aspect of a PFM contraction and is more accurate that digital assessment (Frawley, Galea et al. 2005). It is also useful for the assessment of the supportive function of the pelvic floor during Valsalva manoeuvre (Dietz 2004, Thompson, O'Sullivan et al. 2007). In asymptomatic women the pelvic floor muscles contract as a reflex during increases in IAP(Constantinou and Govan 1982) this functional activation of the PFM and co-activation with the abdominal muscle is essential for continence and pelvic organ support. A delay in PFM activation during increases in IAP has been demonstrated in women with stress urinary incontinence (Smith, Coppieters et al. 2007; Smith, Coppieters et al. 2007). Ultrasound can be used to assess the reflex activation of the PFM and as biofeedback to retrain this supportive action during functional tasks (Thompson, O'Sullivan et al. 2007).

The most common methods of ultrasound used by physiotherapists in the clinic are 2D Transperineal (TP) and Transabdominal (TA) ultrasound. TP ultrasound is an established reliable method of evaluating women with incontinence (Dietz 2004), the advantages are that it allows good visualization of bladder neck, urethra and vagina and measurements of bladder neck movement during PFM contraction and Valsalva manoeuvre are made from a fixed bony landmark, the pubic symphysis, making it more reliable for comparisons between subjects. The disadvantages of TP are that it requires specific training and practice to perform the technique consistently, the measure is more complex and time consuming to calculate, the images rendered require experience to interpret and the location of the probe on the perineum is more invasive than TA approach and may limit some functional manouevres.

The technological advancements in ultrasound scanning are rapid and progressive. Three and four Dimensional (D) ultrasound allow detailed assessment of the levator muscle and the dimensions of the levator hiatus (Dietz 2004; Dietz 2010). Valid and reliable methods to assess the morphology of the pelvic floor and the diagnosis of levator trauma post childbirth have been established (Dietz and Lanzaronne 2005; Dietz and Steensma 2006; Braekken, Majida et al. 2009; Braekken, Hoff Braekken et al. 2010; Braekken, Majida et al. 2010) and more recently in the differential diagnosis of pelvic organ prolapse (Dietz, Haylen et al. 2001; Dietz 2010). These methods have been used as valuable outcome measures to demonstrate changes in pelvic floor muscle thickness, length resting position of the bladder and hiatal dimensions as a response to PFM training (Braekken, Hoff Braekken et al. 2010) and offer some exciting research prospects to evaluating the effects of physiotherapy programs in the future.

Transabdominal ultrasound is totally non invasive method of PFM assessment and has become popular clinically and is used by physiotherapists worldwide. TA ultrasound has been used in several studies to observe the movement of the bladder base as a marker for pelvic floor movement (Bo, Sherburn et al. 2003; Thompson and O'Sullivan 2003; Sherburn, Murphy et al. 2005; Thompson, O'Sullivan et al. 2005), and good reliability for the measurement of bladder base movement has been reported (Sherburn, Murphy et al. 2005; Thompson, O'Sullivan et al. 2005). There are several advantages of TA ultrasound for physiotherapists; the technique involves only one measure and therefore it is quick and easy in a clinical situation, the probe placement does not restrict movement of the lower limbs, the technique is easy to perform in different functional positions and it is totally non-invasive so that the patient does not need to undress making it available to a wider population of clients- such as those attending Pilates or for musculo-skeletal physiotherapy. There are however some disadvantages; it does not always allow visualisation of the bladder neck directly, and cannot assess for prolapse directly, it requires a full bladder and it may be difficult to obtain a clear image in women with dense abdominal scar tissue. A confounding variable is that movement of the bladder base does not always reflect movement at the bladder neck and in some instances it may actually reflect outward movement of the abdominal wall instead due to lack of a bony reference point (Thompson, O'Sullivan et al. 2005). With TA ultrasound it is not possible to assess PFM strength or the resting tone of the PFM, the amount of movement of the bladder base does not correlate directly with PFM strength(Sherburn, Murphy et al. 2005). In situations where there is no or minimal movement of the bladder base it is difficult to assess if the muscle are weak or in fact overactive and not relaxing. It is not always possible to determine if relaxation after PFM contraction is partial or complete. However clinically incomplete PFM relaxation is associated with failure to return to the rest position either after repeated quick contractions or an endurance contraction. Where ever possible ultrasound assessment should be done in conjunction with a digital VE or DRE (with consent) to accurately assess the resting tone and strength of the PFM.

Transabdominal ultrasound is a quick easy method to evaluate bladder volume and for assessment of any post void residual in clients with dysfunctional voiding. Often clients will present to physiotherapy as first contact clients and may not have had voiding studies. It is important therefore to assess for good bladder emptying and eliminate a PVR before commencing bladder training.

Clinically, due to the non invasive properties, TA ultrasound is useful as a biofeedback tool in the evaluation of PFM function in children with bladder and bowel symptoms. The amount of movement occurring at the bladder base during PFM contraction in asymptomatic children is highly variable (Bower, Chase et al. 2006) and as yet there are no reports evaluating the use of TA ultrasound for PFM re-education in this population.

In conclusion, the use of ultrasound clinically for physiotherapists is growing: TP ultrasound is more reliable than TA ultrasound due to the fact that the measurements are taken from a fixed bony marker, make it more suitable for comparisons between subjects and a valuable outcome measure for research purposes. The many advances in assessment using 3 and 4 D images will surely be the way forward in the future. On the other hand TA ultrasound is a valuable non invasive biofeedback tool for PFM assessment in a wider population. It is quick and easy to use in a clinical situation however precaution should be taken to use firm probe placement and standardize the technique used to minimize errors, it is also a valuable tool to asses for the presence of a PVR.

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Website

Professor Hans Peter Dietz, Sydney Medical School: Pelvic floor Ultrasound teaching resources: http://web.mac.com/hpdietz1/Site/Welcome.html