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# Assessing muscle function of the male pelvic floor using real-time ultrasound

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### Abstract

Following surgical removal of the prostate, there may be compromise to the function of the pelvic floor muscles (PFMs) causing continence problems. Assessing the PFMs of male patients can be an invasive process that causes discomfort, making it worthwhile to evaluate alternatives to the conventional method of digital rectal examination (DRE). Real-time ultrasound (RTUS) has been used with female patients as an alternative to internal assessments. This paper examines the reliability and validity of assessing the male pelvic floor using abdominal RTUS. Twenty-eight men (mean age=66.2 years) with a history of treatment for prostate cancer were recruited to the study. They were assessed via DRE and RTUS. Findings from the procedures were correlated for evaluation of validity, and the RTUS readings were repeated by different therapists to assess reliability. Measurements on screen correlated moderately with DRE findings ( $r=0.57$ ,  $P=0.002$ ), and RTUS was found to have good reliability (intra-class correlation coefficient=0.90). Continent men had more movement of the bladder wall on RTUS than those who were incontinent ( $P=0.043$ ). Scar tissue and an inability to maintain a moderately full bladder were found to cause the most difficulty in getting a complete picture of pelvic floor movement. Real-time ultrasound can be used clinically to examine male pelvic floor function, and its use would be enhanced once it has been established by DRE that a true pelvic floor contraction is occurring. Real-time ultrasound can give an indication of pelvic floor function as an alternative measurement method when DRE is contraindicated.

*Keywords:* assessment, male, pelvic floor muscles, real-time ultrasound, validation.

### Introduction

The pelvic floor muscles (PFMs) forming a hammock at the base of the pelvis are important in the support of the abdominopelvic viscera. A number of methods of assessment of the func-

tion of this muscle group have been described, including clinical observation, digital palpation, electromyography, manometry, dynamometry and magnetic resonance imaging (Bø & Sherburn 2005; Frawley *et al.* 2006). Currently, the standard clinical method for assessing the PFM function in males is by digital rectal examination (DRE). However, this examination can

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only be performed by clinicians trained in pelvic floor assessment and may be personally invasive for the patient. In a recent study on prostate cancer screening, 8.2% of men rejected the use of a DRE, with shame being the most frequently reported reason (Romero *et al.* 2008). Ultrasound may be an alternative to DRE. Rehabilitative ultrasound is becoming more common in physiotherapy, and it has been proposed as a method to evaluate the morphology and function of the PFMs (Whittaker *et al.* 2007). The use of transabdominal ultrasound for assessment of the muscle function of the pelvic floor has been described and employed previously with females (Bø *et al.* 2003; Sherburn *et al.* 2005; Thompson *et al.* 2005; Thompson & O'Sullivan 2003). Transabdominal ultrasound records the movement of the levator plate by the levator ani, which moves the bladder neck anteriorly while elevating the levator plate, thereby closing the urethra (DeLancey 1988). The use of bladder displacement as a marker for levator plate movement has been described by Thompson & O'Sullivan (2003).

Real-time ultrasound (RTUS) in assessment of the PFMs can be applied transabdominally, transperineally or anally, and with females, there is also the option of transvaginal application. One of the main reasons RTUS has become widely used in pelvic floor rehabilitation for female patients is that it is well-tolerated and seems to eliminate the need to intimately examine the pelvic floor, which can be a barrier for both the client and the therapist. Transabdominal RTUS is the only assessment option that does not require the removal of underwear, and this reason alone may be why it is the method most preferred by clients.

Since the greater proportion of continence issues have been described in females, assessment in most of the pelvic floor RTUS studies available in the literature was performed with women. Indeed, only one published study that included men when describing assessment of pelvic floor function using ultrasound was found (Kelly *et al.* 2007). In this study, young males (mean age=23 years, SD=5 years) were assessed to determine whether their pelvic floor showed more elevation in standing rather than in crook-lying. To date, there have not been any studies that consider older men's pelvic floor function, nor have there been any studies examining whether there is a difference in pelvic floor function between those who have incontinence problems and those who do not. Furthermore,

ultrasound imaging as an assessment method after surgery such as radical prostatectomy has not been evaluated. Therefore, the aim of the present study was to examine the reliability and validity of assessment of the pelvic floor conducted by transabdominal ultrasound in a group of men that included those with post-surgery continence problems, and to compare RTUS with the standard clinical assessment made by DRE.

### Participants and methods

Twenty-eight men with a history of prostate cancer treatment were recruited via newsletters and flyers posted at local prostate cancer support group meetings (age range=46–80 years, mean age=66.2 years, SD=7.9 years). Of this number, 10 (mean age=68.9 years, SD=9.8 years) had stress urinary incontinence and 18 (mean age=64.7 years, SD=6.6 years) were dry. No exclusions were made on the grounds of medical or surgical history. The presence of stress urinary incontinence was diagnosed by history and observation. Treatments received included radical and laparoscopic prostatectomy, radiation therapy and active surveillance. Ethics approval was obtained from the University of Canberra Human Research Ethics Committee, Canberra, ACT, Australia.

A DP-6600 Digital Ultrasonic Diagnostic Imaging System (Mindray Medical International Limited, Shenzhen, China) with a 35C50EA convex array transducer head was used to image the pelvic fascia with a 3.5-MHz transducer. The position of the transducer head was monitored to avoid angular motion of <math><10^\circ</math> and inwards/outwards motion of <math><8\text{ mm}</math> in order to increase the reliability of the imaging technique (Whittaker *et al.* 2009).

A bladder-filling protocol was adopted to ensure optimum visualization of the bladder in the image. Men were asked to present with a moderately full bladder, to be achieved by drinking three or four glasses of water one hour before measurement. Subjects were asked not to void thereafter to ensure that they would have a moderately full bladder.

Men were positioned in crook-lying, in supine with the head supported on a pillow, the lumbar spine in neutral, and with hips and knees flexed comfortably at 60°, one knee supported by a wall and the other by the therapist. The ability to contract the pelvic floor was ascertained by visual inspection and standard DRE by a



**Figure 1.** Picture from a real-time ultrasound screen: pelvic floor relaxed on the left and contracted on the right.

physiotherapist trained in trained pelvic floor assessment. Standardized instructions were given to all participants, as follows: “Tighten your pelvic floor muscles as best you can whilst breathing normally.” The ability to contract the PFMs was judged by the tester after looking at auxiliary muscle use, breath-holding and bearing down manoeuvres, discriminating between the upward drawing feel of PFM activity and the squeeze sensation arising from anal sphincter muscle activity (Messelink *et al.* 2005).

After completion of the DRE, the ultrasound head was placed in the transverse plane suprapubically and angled in a posterior/caudal direction. The transducer head was adjusted to obtain the clearest image of the inferior–posterior aspect of the bladder. As a result of this, significant subject-to-subject variation was found in the resulting angle of the transducer head.

Each participant was asked to contract his pelvic floor three times. The displacement of the posterior bladder wall was measured by placing a marker “X” on the monitor at the central portion of the bladder base. The junction of the hyper- and hypo-echoic structures in the region where the greatest displacement was visualized at the beginning and at the end of the contraction was used for measurement (see Fig. 1). Proprietary measurement software, supplied with the ultrasound imaging equipment, was used to determine the extent of any perceived movement, as described by Sherburn *et al.* (2005). The investigator was blinded to the measurement value until after the three measurements were taken. The transducer head was held in the same position to ensure a constant picture between the three measurements. For statistical analysis, the mean of the three measures was used.

#### Validation study

Digital rectal examination is current standard clinical practice for assessing male PFMs. Some

information can be obtained by visual inspection and by perineal palpation, but DRE was considered here to be the standard against which to validate the RTUS assessment of pelvic floor activity. The physiotherapist first assessed the ability of the subject to correctly activate his pelvic floor using the five-point grading scale, then after a 5-min rest, assessed the muscle contractions with the RTUS. A validity check was carried out on the two forms of measurement using the group classification of continent/incontinent with the expectation that, when compared using a *t*-test, both the DRE and RTUS values would be significantly higher for the group of continent males than for those who were not continent.

Pelvic floor muscle function was graded with the Modified Oxford Scale component of the validated tripartite assessment score (Wyndaele & Van Eetvelde 1996). Because the RTUS procedure cannot measure the endurance and exhaustion scales of the tripartite assessment, these were not used.

#### Reliability study

To examine the reliability of the measures of PFM activity taken on the screen, three physiotherapists specializing in continence management were asked to measure the displacement of the pelvic floor. Loops of ultrasound images with two or three contractions were recorded and saved to be replayed for review at a later time. The continence physiotherapists then used the ultrasound software to measure the displacement with callipers. Each was asked to view the loops, pick the best contraction and then measure the amount of displacement of the bladder as they would clinically. No advice was provided as to the end points of where to measure. The physiotherapists were blinded to the section of the loop they were viewing and to the measurement of the callipers. Note was

taken of which contraction on the loop was used in order to determine consistency between therapists as to the contraction that was deemed the best. Consistency was measured as per cent exact agreement for clip selection. The measurements recorded by each assessor were analysed to obtain intra-class correlation coefficients (ICCs) as the intra- and inter-rater reliability statistics.

## Results

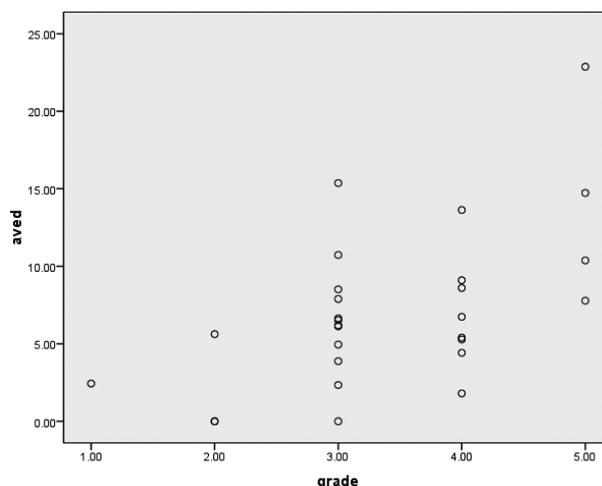
### Validation study

Twenty-five of the 28 men were able to activate their PFM when assessed by DRE. Two more managed to do so after some instruction. The mean DRE score was 3.39 (range=1–5, SD=0.99) and the means for the distance moved on screen are given in Table 1.

Movement assessed manually was correlated with what was observed on the ultrasound screen. The determining criterion for a correct PFM contraction was that it produced a vertical displacement of the bladder floor in a cephalad direction on the monitor.

Real-time ultrasound measurements of image movement were found to be correlated moderately with the digital rectal assessment ( $r=0.57$ ,  $P=0.002$ ) (see Fig. 2). This moderate correlation between DRE and calliper measurement on the RTUS suggests that only some of what is felt manually is visible on the ultrasound image. Three of the subjects had a palpable contraction on DRE, but movement could not be discerned on the RTUS screen. All three had a well-defined bladder on the screen. Two of the subjects had no continence problems, and had a grade 2 and a grade 3 on DRE, respectively. The other scored a grade 2 and still experienced some leakages.

The subgroup of 10 males with continence problems had a mean RTUS reading of 5.1 mm (SD=3.3 mm) compared to the subgroup of 18 who were continent (mean=8.2 mm, SD=5.7 mm), and when a *t*-test was conducted, this difference was significant [ $P=0.043$ , 95%



**Figure 2.** Scatter plot showing the average distance moved on real-time ultrasound (aved) and digital rectal examination grade.

confidence interval (95% CI)=0.14–5.94]. Although the DRE scores for the incontinent group (mean=3.10, SD=1.10) were lower than for the continent group (mean=3.56, SD=0.92), this difference was not statistically significant ( $P=0.14$ , 95% CI=–0.24 to 1.16). Thus, the mean DRE grade difference between continent and incontinent of 0.46 was not significant, whereas, on the RTUS, the 3.1-mm difference between continent and incontinent men in the distance moved for a contraction is significantly different, with the continent men showing greater PFM movement than those in the incontinent group.

Movement could also be seen when the transducer head was placed in a sagittal plane. This view was not used where the men had a mid-line incision from their surgery because of interference from scar tissue in the viewing field. Where the quality of the image was good, a pelvic floor contraction resulted in movement of the posterior wall of the bladder in an anterocephalic direction. This movement had both vertical and horizontal components that can be interpreted as the vertical component reflecting the anterior draw of the levator ani and the horizontal component reflecting the lift felt on palpation.

### Reliability study

Fourteen clips of data were measured by the three physiotherapists, all of whom were currently working in the continence field with varying RTUS experience (1–5 years). Testers were asked to measure the bladder displacement on what they considered the best pelvic floor contraction in each of the 14 loops (see Table 2).

**Table 1.** Range and mean digital rectal examination scores for the pelvic floor displacement of the 28 participants: (SD) standard deviation

Distance	Minimum	Maximum	Mean	SD
1	0.00	28.00	7.67	5.74
2	0.00	20.10	6.91	4.86
3	–1.20	20.50	6.63	5.22

**Table 2.** Range and mean displacement values for the three therapists across the three measures: (SD) standard deviation

Measure	Minimum	Maximum	Mean	SD
<i>Physiotherapist A</i>				
1	2.65	31.00	11.23	7.29
2	2.35	26.00	12.05	6.57
3	3.49	29.00	11.36	6.96
<i>Physiotherapist B</i>				
1	2.22	28.80	11.99	7.90
2	2.18	31.40	11.98	8.51
3	3.05	29.70	12.01	8.10
<i>Physiotherapist C</i>				
1	3.52	26.20	12.62	7.17
2	3.95	26.30	11.99	6.82
3	3.18	26.60	12.23	6.95

Each rater rated every loop three times. Coefficients for intra-rater reliability were found to be high. As measured by the ICC (3.1), reliability was 0.93 (95% CI=0.87–0.97), 0.98 (95% CI=0.95–0.99) and 0.94 (95% CI=0.85–0.98) for the three raters, respectively.

The mean for each rater was calculated and this was then used to determine the inter-rater reliability across the 14 measurements. The inter-rater reliability given by the ICC (2.1) was 0.90 (95% CI=0.77–0.96).

The same part of the clip was used by each rater for measurement on all the measurement occasions and per cent exact agreement for contraction identification was 71% since the raters agreed with each other as to the best contraction in 10 out of 14 contractions.

## Discussion

The present study suggests that the assessment of PFM function in males using RTUS is a reliable technique. The RTUS measure was able to show that there was significantly more movement of the pelvic floor in men who did not have any continence problems than for those who did leak. In the current group, males who had large amounts of urine loss from bladder leakage were the hardest to image, as were those who had a large waistline. Scar tissue from the surgery also made viewing the bladder more difficult. However, acceptable assessments were able to be obtained in all cases. Whilst RTUS can be used to diagnose other forms of muscle dysfunction, such as in the transversus abdominis or multifidus, and can even replace palpation of these muscles, this is not the case in the pelvic floor, where abdominal RTUS is a useful component

but does not constitute a complete assessment of the PFMs in the male.

The variation in the angle of the transducer head was different to that found by Sherburn *et al.* (2005). The female subjects in that study all required the head to be between 15° and 30° from the vertical in a cephalad direction, whereas, in the present study, no such regularity was found. There was a substantial variance in body shape between the subjects, with several having the pronounced abdominal curvature associated with increased body weight. The shape of the lower abdomen of these (older) males is likely to be the reason for the difference in the placement of the transducer head needed for the best image.

For the evaluation of inter-rater reliability, three experienced physiotherapists viewed and then measured the movement of the pelvic floor. Some of the men tested were unable to hold any significant amount of urine in their bladder, and this resulted in a less-clear edge of the bladder wall on the image. Scar tissue for those who had had a radical prostatectomy was another issue affecting the quality of the images in that some men had dense scar tissue that cast a shadow over the bladder and this interfered with effective visualization of the bladder where the sagittal view was used. In one clip, there was apparent movement of the tissue under the bladder, which was surmised to be from the levator ani; nevertheless, the activation of the PFM seemed to be correct. When the bladder was full, a clear image of the bladder wall could be obtained and measurement correlations were good. Differences of <0.4 mm between the three therapists, and <0.1 mm within the therapists' recorded values, were obtained, confirming the consistency of use of the measurement protocol.

Real-time ultrasound is a widely used clinical tool because it enhances the visual feedback available to the patient regarding the appropriate muscle movement response required of them. The present study suggests that, for men, it can be a useful and visually convincing tool in teaching PFM contractions, particularly in the situation where more feedback is needed to attain a PFM contraction. However, the current findings suggest that, in cases where men are unable to retain urine, have significant scar tissue or have larger abdomens, RTUS needs to be supplemented with other assessment methods.

Overall, the present study shows that RTUS can be used reliably and validly to measure the amount of vertical displacement of the male

pelvic floor during a contraction. Some features of the particular patient group involved required adaptations. Accurate quantification of the movement within the pelvic floor was optimized with a clear image of the bladder wall since RTUS only measures part of the movement of the base of the bladder. Movement can be seen in a cephalic direction with transverse scanning and in an anterocephalic direction in the sagittal plane view, representing movement of the bladder base in a lift as well as an anterior draw of the PFMs. In making these measurements, the level of any accessory muscle movement was checked since the use of abdominal muscles may distort the available field of view, and the operator needs to monitor these muscles while simultaneously looking at the screen. Checking for use of thigh and buttock muscles needs additional care, so the patient should be adequately disrobed for visualization.

This is the first time RTUS has been assessed for use in a male population over 45 years of age. Significant findings in this small group need to be tested in a larger sample to confirm that RTUS can be used reliably in men who have had prostate surgery. The effect of scar tissue, fascial integrity and resting muscle tone after differing prostate cancer treatments such as surgery versus radiation also needs to be further investigated.

### Conclusion

The present findings suggest that RTUS can be used clinically as a measure of PFM function. Ideally, this would be once it has been established by DRE that the patient is using the PFMs correctly. Real-time ultrasound could also function as a biofeedback tool and help to progress exercises. If a perineal assessment or a visual assessment is possible, RTUS could effectively be used in conjunction with these assessments to ensure that correct pelvic floor contractions are being trained. In patients in whom DRE is contraindicated immediately after rectal or prostatic surgery, or where consent for DRE is not given, RTUS could provide an effective alternative as an indication of pelvic floor function.

### Acknowledgement

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### Conflicts of interest

None.

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