Physiotherapy Assessment and Management of Post-Prostatectomy Urinary Incontinence

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A thesis submitted in fulfilment of the requirements for the degree of Masters by Research at the University of Sydney

Discipline of Physiotherapy
Faculty of Health Sciences
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ABSTRACT

Aim: To determine the reliability of scoring real-time ultrasound (RTUS) record during an exercise protocol aimed at developing pelvic floor motor control in men with prostate cancer, and to determine predictors of acquiring control. **Methods**: 91 men diagnosed with prostate cancer attending physiotherapy for pelvic floor exercises. Detailed pelvic floor motor control exercises were taught by a physiotherapist to participants using trans-abdominal RTUS for biofeedback. A new protocol to measure skill attainment was developed. Three independent physiotherapists assessed skill attainment by viewing RTUS videos of the exercise. Reliability was evaluated using intraclass correlation coefficients. Logistic regression analysis was conducted to identify predictors of successful skill attainment. Acquisition of the skill was compared between pre and post-operative participants using an independent-groups t-test. **Results**: There was good reliability for scoring the outcome method (ICC 0.73 (95%CI 0.59 - 0.82)) for experienced therapists. Having low BMI and being seen pre-operatively predicted motor skill attainment, accounting for 46.3% of the variance. Significantly more patients trained pre-operatively acquired the skill of pelvic floor control compared with patients initially seen post-operatively (OR 11.87 95%CI 1.4 to 99.5 p = 0.02).

Conclusions: A new protocol to evaluate attainment of pelvic floor control in men with prostate cancer can be scored reliably from RTUS record, and is most effective delivered pre-operatively.

Future Studies: Based on the above research a proposed RCT has been

developed comparing current standard pelvic floor training protocols with a motor control led training protocol. This protocol is followed by development into a progressive resistance program that utilises progressively incremental intra-abdominal pressures as a resistance tool. Further discussion is made to evaluate optimal pelvic floor rehabilitative strategies.

PUBLICATIONS and PRESENTATIONS

Parts of the work presented in this thesis have been published and/or presented in the following formats:

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LIST OF ABBREVIATIONS

ADT	Androgen Deprivation Therapy
AS	Active Surveillance
BC	Bulbocavernosus
BPH	Benign Prostatic Hyperplasia
RTUS	Real Time Ultrasound
EUS	External Urethral Sphincter
RP	Radical Prostatectomy
QoL	Quality of Life
ICIQ	International Consultation on Incontinence Questionnaire
IIEF	International Index of Erectile Function
PSA	Prostate Specific Antigen
DRE	Digital Rectal Examination
EBRT	External Beam Radiation Therapy
RALP	Robot Assisted Laparoscopic Prostatectomy
SUI	Stress Urinary Incontinence
ED	Erectile Dysfunction
VLLP	Valsalva Leak Point Pressure
MVC	Maximal Voluntary Contraction
PVR	Post Void Residual
PRE	Progressive Resistance Exercise
TURP	Transurethral Resection of the Prostate
MAPS	Men After Prostate Surgery

CHAPTER ONE: Introduction

One form of incontinence that poses management problems for the physiotherapist and men with prostate cancer is the incontinence that can arise following prostatectomy. This incontinence, caused from unavoidable sphincteric injury during surgery for prostate cancer, needs research attention. Potentially, a more efficient rehabilitation strategy may make significant improvements in patients' quality of life outcomes for these men.

1.1 The problem of Prostate Cancer; prevalence and cost

Symptoms of prostatic disease including urinary retention have been reported as early as the first Century. In ancient Chinese and Roman times, such urinary retention was reported to be managed by crude catheterization techniques using hollow reeds[1]. In the last 500 years, compression from prostate growth has also been attributed to cancer of the prostate gland, which may also cause urinary dysfunction[1]. One of the first solutions offered to reduce urinary dysfunction was surgical removal of the prostate gland which was described for the first time in the 1850's[2]. At this time, prostate cancer was considered rare and a condition affecting only aged men. In the early 20th century, with the advent of improved histopathology techniques, prostate cancer was found to be more prevalent in men than was previously thought[3].

Currently, prostate cancer is regarded as the most common form of cancer in the world. In 2003, 33% of newly-diagnosed male cancers in the USA were identified as prostate cancer[4]. Based on 2010-2012 data, it is considered that approximately 14% of men will be diagnosed with prostate cancer at some point during their lifetime.[5] Although highly prevalent, cancer of the prostate is not always directly responsible for mortality. There were 19,821 new cases of prostate cancer in Australia in 2010, but only 3,294 deaths were reported, giving an 84% survival rate[6].

The annual government-determined cost for prostate cancer care in Australia in 2013 was reported as $25,000 - 30,000 per case[7]. Economists have recently estimated total costs for prostate cancer in 2012 as $1.4billion[8]. Of this amount, side effects from treatment accounted for $14 million; lost wellbeing for $222 million; lost productivity due to treatment for $156 million and the cost of caring for patients with prostate cancer for $15 million. There is therefore a need to investigate strategies to improve quality of life outcomes for men following prostate cancer treatment.

1.2 Approaches to the Management of Prostate Cancer

Prostate cancer management can be broken into two clearly distinct phases. The first phase is an assessment of the extent of the cancer which establishes the staging process. The second phase is a targeted management pathway based on the stage or grade of the cancer. Thus prostate cancer management depends on accurate diagnosis and grading of cancer initially in order to determine the optimal management strategy for each individual patient[9].

1.2.1 Assessment and Staging of Prostate Cancer

Assessment or diagnosis of prostate cancer is made by a process of blood markers, clinical examination, MRI and then biopsy. The first diagnostic test is a combination of blood test for prostate specific antigen (PSA) and digital rectal examination (DRE). There is still debate as to what constitutes a normal PSA reading. The PSA cutoff is currently considered to be 4.0-ng/mL in the blood[9], however, a raised PSA level is not always indicative of a cancerous pathology as it often increases with age and may indicate the presence of benign prostatic hyperplasia (BPH)[10] and is also found to be elevated for up to 48 hours post ejaculation[11]. Raised PSA has been shown to have specificity and sensitivity ranges of 20 to 40% and 70 to 90% respectively depending on the cutoff value used (e.g. 3 or 4 ng/mL)[12]. Hence the PSA alone is not sufficient for diagnosis given the low specificity and sensitivity. Since 1992, PSA velocity (the rate of change of PSA levels over time) has been shown to improve cancer detection and a PSA velocity of 0.75 ng/mL or greater per year is more accurately suggestive of cancer (72% sensitivity, 95% specificity)[13]. This improved test is now routinely utilised by urologists.

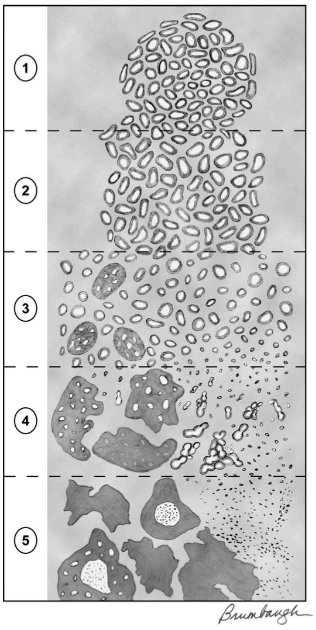
When combined with DRE, the accuracy of these combined tests (PSA velocity + DRE) improve. Digital rectal evaluation (DRE) of the prostate allows the physician to grade the feel of the prostate. When using a 4.0-ng/ml cutoff PSA value, the positive predictive value (PPV) of DRE alone is 17.7% with sensitivity and specificity of 27.1% and 49% respectively. However when combined with PSA testing the PPV increases to 56% with sensitivity and specificity increasing to 38% and 88%[14] respectively. Combined DRE and PSA testing is therefore recommended for screening processes[9].

Once abnormal markers are detected, MRI and prostate biopsy may further assist in evaluating the extent of the cancer and in planning the appropriate intervention[15]. Multiparametric magnetic resonance imaging (MRI) uses anatomic T2 weighted imaging combined with two functional techniques: diffusion weighted imaging and dynamic contrast enhanced MRI. A recent meta-analysis of MRI accuracy showed a specificity of 88% and sensitivity of 74% for prostate cancer detection[15]. In addition, MRI has been shown to lead to more accurate sampling during biopsy[16].

Thompson (2014) reports that MRI guided biopsies displayed higher sensitivity; specificity, negative predictive values and positive predictive values (>90%) compared to standard biopsy results[17].

Once the prostatic tissue is biopsied, it is evaluated histopathologically and assigned a score known as the Gleason score[18]. This is a combined score of the primary and secondary grades of tumor found in the specimen (Figure 1.1)

Figure1.1: Gleason's Histological Pattern



Pattern 1*: Circumscribed nodule of closely packed but separate, uniform, rounded to oval, medium sized acini (larger glands than pattern 3)*

Pattern 2*: Like pattern 1, fairly circumscribed, yet at the edge of the tumor nodule there may be minimal infiltration. Glands are more loosely arranged and not quite as uniform as Gleason pattern 1*

Pattern 3*: Discrete glandular units. Typically smaller than seen in pattern 1 or 2. Infiltrates in and amongst non-neoplastic prostate acini. Marked variation in size and shape. Smoothly circumscribed small cribriform nodules of tumor*

Pattern 4*: Fused microacinar glands. Ill-defined glands with poorly formed glandular lumina. Cribriform glands with an irregular border. Hypernephromatoid*

Pattern 5*: Essentially no glandular differentiation, composed of solid sheets, cords, or singe cells. Comedocarcenoma with central necrosis surrounded by papillary cribriform, or solid masses*

Reproduced from Epstein et al 2005[18]

Generally, the lower the score, the less concerning the findings[18], however a Gleason 3+4=7 finding would be considered less concerning than a Gleason 4+3=7 due to the presence of the primary tumor being a higher grade score in the second case[9].

The Gleason score generally predicts the aggressiveness of management. For example a Gleason score between 2 to 4 would potentially be managed with an active surveillance approach (watch and wait), whereas cancer with a Gleason score of 5 to 7 would be more likely to encourage intervention with a surgical management strategy, such as prostatectomy. Gleason scores of 8-10 are associated with more advanced neoplastic type cellular activity and would tend to be managed primarily with hormone therapy, as surgery would be unlikely to completely remove the cancerous prostatic tissue[9].

The Gleason score is combined with a Tumor Nodes Metastasis (TNM) staging system[19] to determine the best course of management. The TNM is reported following trans-rectal ultrasound guided biopsy of the prostate and/or multi-parametric MRI scans. It classifies the extent of the primary tumor, the spread to any localized lymph nodes and the presence or absence of any distant metastasis, (see Table 1.1).

Table 1.1 TNM Staging System

Localised disease	
Tx	*Primary tumor cannot be assessed*
T0	*No evidence of primary tumor*
T1	*Clinically inaparrent tumor neither palpable nor visible by imaging*
T1a	*Tumor incidental histologic finding in ≤ 5% of resected tissue*
T1b	*Tumor incidental histologic finding in >5% of resected tissue*
T1c	*Tumor identified by needle biopsy (e.g., because of elevated PSA level)*
T2	*Tumor confirmed within prostate*
T2a	*Tumor involves one-half of one lobe or less*
T2b	*Tumor involves more than one-half of one lobe but not both lobes*
T2c	*Tumor involves both lobes*
Local extension	
T3a	*Extracapsular extension (unilateral or bilateral)*
T3b	*Tumor invades seminal vesicles*
T4	*Bladder invasion, fixed to pelvic side wall, or invasion of adjacent structures*
Metastatic disease	
N1	*Positive regional lymph nodes*
M1	*Distant metastasis*

Reproduced from Edge et al (2010)[20]

Urologists consider both the Gleeson score and the TNM staging system in order to determine the best course of management[20].

1.2.2 Management Approaches

There are three main approaches to managing prostate cancer. Firstly, active surveillance, this is a watch-and-wait process of monitoring PSA velocity and intermittent MRI scanning. It is recommended for lower grade cancers. This is followed by medical management, which can be either monotherapy or combination therapy that utilizes hormone, radiation and chemotherapy interventions. This is often recommenced for cancers that have a higher grade and are no longer clinically localized as within the prostatic capsule. Finally, surgical removal (prostatectomy) is offered to patients with more clinically localized prostate cancer[21].

1.2.3 Active Surveillance

Prostate cancer is a relatively indolent cancer, not always resulting in mortality. Given this, the choice of management depends on the extent of the cancer and projected survival rates. Accordingly, the first course of action often recommended to patients over 70 years old who have a life expectancy of >10yrs when presenting with a new diagnosis of localized prostate cancer is a wait-and-watch approach called Active Surveillance (AS)[9]. During this process, repeat biopsy results and PSA-based tests will assist in stratifying the risk of cancer progression throughout the monitoring period[22]. Active surveillance has been shown to be a durable option as 64% of men at 5 years post commencement of monitoring may remain on active surveillance thereby avoiding unnecessary overtreatment for their cancer[23]. A recent critical review of active surveillance by Zargar et al (2015) commented that active surveillance has been shown to reduce overtreatment without compromising overall and cancer-specific survival rates[24]. Therefore AS should be recommended as a first line treatment if the following factors are present: low volume intraprostatic non-aggressive disease: Gleason 6, when specified < 2 - 3 positive cores with < 50% cancer involvement of every positive core, a clinical T1c or T2a, a PSA < 10 ng/mL and a PSA density < 0.15 ng/mL/cc[9].

1.2.4 Medical Management

Medical management of prostate cancer includes hormone, radiation and chemotherapy. Historically, hormone therapy was conceived from scientists noting that castration of the testes in animals often led to smaller-sized prostate glands[25]. In 1893, doctors began utilizing castration in the USA as a method of improving urinary retention symptoms with a poor degree of success[3]. It was not until the 1930's that administration of estrogen to men resulted in androgen ablation and subsequent prostatic glandular atrophy, thereby improving obstructive urinary retention symptoms[25].

Later, in the 1960's it became clear that although androgen ablation therapy improved patients with advanced prostate cancer, it rarely cured the condition[25]. In addition, many adverse side effects were reported, including hot flushes, gynecomastia, metabolic changes (some of which increase risk of cardiovascular disease), osteoporosis, anemia, psychiatric and cognitive problems, and fatigue [26]. In addition there was significant loss of potency and libido reported[27]. Despite these side effects, androgen deprivation therapy continues to be the most widely used treatment for systemic metastatic prostate cancer to date[28]. As hormones are transported via the blood stream it remains the ideal vessel for delivery of interventional therapy for more widespread metastatic disease.

Radiation therapy commenced in the early 20th century with good success rates and less adverse side effects. Techniques used included radio-isotopic seeds implanted into the prostate (brachytherapy), an approach that continues to be effectively utilized for localized prostate cancer[9]. Potter et al (2005) reported on a 12-year outcomes study of brachytherapy which showed a 93% disease-specific survival rate[29]. It is reported that compared to surgical intervention, brachytherapy offers the best quality of life outcomes for men with low or intermediate risk prostate cancer[30]. Brachytherapy's impact on quality of life was shown to cause moderately less continence and significantly less erectile dysfunction issues than radical prostatectomy. Notwithstanding this, radical prostatectomy has been shown to have a small but significant improvement over radiation in overall and cancer-specific survival rates. The adjusted 10-year overall survival after radical prostatectomy, external beam radiotherapy and brachytherapy was 88.9%, 82.6% and 81.7%, respectively[31]. Given this prostatectomy is often preferred by patients, however for patients who are more sexually active, and thus place a higher priority on recovery of erectile function, radiation is often selected.

An alternative radiation strategy is external beam radiation therapy. Due to improvements in Computerized Tomography and data processing capabilities improving accuracy of delivery of treatment[25], the prostate is now able to be targeted more efficiently with less radiation damage caused to surrounding tissues.

Often, the combination of two therapies has a better effect than either therapy alone. Some studies have reported beneficial effects of combining both hormone and radiation therapies to achieve a curative outcome for prostate cancer sufferers.[32-34] In a recent 10 year RCT comparing ADT alone to ADT plus EBRT involving 1205 patients survival was significantly improved in the combined group (hazard ratio [HR], 0.70; 95% CI, 0.57 to 0.85; $P < .001$)[35]. This suggests that combination therapy should also be considered for patients selecting to be treated with radiation.

Overall however, medical management of prostate cancer is completely dependent on the severity of the cancer. In general focal lesions are recommended to be managed with brachytherapy or EBRT, whilst more neoplastic lesions respond better to combined hormone and EBRT and/or chemotherapy[9]. Men with prostate cancer therefore need to consider all these factors and discuss carefully with both a urologist and radiation oncologist to obtain a non-biased view as to the best course for their individual management.

1.3 Surgical Management

Surgical removal of the cancerous prostate gland, radical prostatectomy (RP), has excellent curative rates and therefore is the preferred option for many men with prostate cancer. For example, a large observational study with a 15 year follow up reports double the survival rates for non metastatic prostate cancer patients in the surgery group (n=697), compared with radiotherapy group (n=339)[36]. Radical prostatectomy therefore has emerged as the treatment of choice over time as techniques have become more precise with fewer side effects.

Prostatectomy for cancer was first performed utilizing a perineal approach by Hugh Hampton-Young in 1904, and this was the preferred surgical approach until the 1930's[25]. Subsequent to this, surgeons in the UK pioneered a suprapubic approach, which has been continued to be utilized to the present day[2]. It should be noted that the outcomes for prostatic surgery at this time involved significant incontinence and almost guaranteed loss of potency. In fact, prostate surgery was infrequently performed throughout Europe from 1950-1980 for these reasons[37]. Fortuitously, advances in endocrinology during this time meant that hormone therapy took over for a period as the treatment of choice for men with prostate cancer.

Improvements in anatomical dissection pioneered by Walsh in the late 1970's meant that it was possible to operate and still preserve the erectile nerves, and this led to significant improvements in erectile recovery post-operatively[25]. With the advent of laparoscopic surgery in the early 1980's, and Robotic Assisted Laparoscopic Prostatectomy (RALP) in the late 1990's/early 2000's, better continence and erectile function outcomes were noted[38]. Cumulative analyses showed a better 12-month urinary continence recovery after RARP in comparison with RRP (OR: 1.53; p=0.03) or laparoscopic surgery (OR: 2.39; p=0.006). The better outcomes were attributed to better lighting, an improved field of view, and robotic instruments with 7 degrees of freedom of movement (the same as the human wrist). Other recent analysis of operative outcomes between RALP and RP interestingly report that although there was a reduction in length of hospital stay, and less intra-operative blood loss with RALP, overall outcomes in terms of cancer control and quality of life outcomes were similar[39]. RALP is a relatively new technique and many surgeons are still developing their skills with this technology. One 2014 study notes that RALP has a long learning curve of >300 RALP's with inferior outcomes initially, but then superior sexual and early urinary outcomes are noted[191]. I believe therefore that in the future RALP will be the intervention of choice for surgeons in high volume centres.

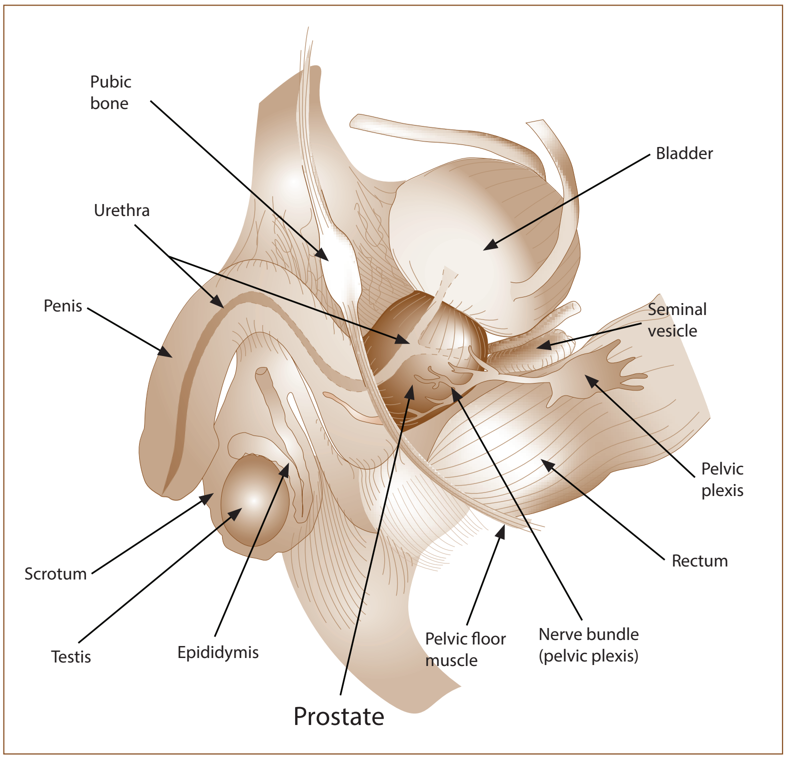
Further post-operative continence improvements have been reported recently, with the addition of a bladder base reconstructive surgical technique. This technique employs the use of a peri-urethral suspension stitch, called the Rocco stitch, to reconnect the dissected DeVillneuve fascia on the posterior aspect of the external urethral sphincter muscle to the outer fascial covering of the bladder[40]. This enables the external urethral sphincter to have a more effective and stable mechanical origin[41] improving early continence outcomes further. One study reports significantly greater continence rates at 3 months post RALP (p=0.013) utilising the suspension technique[192]. For this reason, this Rocco stitch is now considered a routine component of the RALP technique.

In summary, therefore Prostatectomy is often considered a first line approach to cure localized prostate cancer and it has impressive curative rates[42]. However post operative problems with continence and erectile function can have significant impact on quality of life outcomes[43]. At the present time, effective management of prostate cancer depends on accurate diagnosis and staging of the cancer. Interventions can vary from minimal (e.g. AS) to monotherapies such as Brachytherapy or RP for localized prostate cancers, to combination hormone, radiation and chemotherapy for metastatic cancers[9]. Patients are therefore encouraged to review guidelines[44] and to discuss their individual treatment strategy with their specialists in order to develop an effective management strategy.

1.4 Male Pelvic Anatomy

The relevant anatomical structures in the male pelvic floor are essential to its function and in the reduction of complications post prostatectomy. These structures are the prostate, pelvic floor muscles, bladder, urethra, endopelvic fascia, and local nerve supply. Firstly, in considering anatomy, the prostate itself is positioned just inferior to the bladder in the peritoneal cavity, with the bladder neck blending intimately with the membranous urethra which passes between the two lobes of the prostate as the prostatic urethra (Figure 1.2).

Figure 1.2: Male pelvic anatomy



As the prostatic urethra exits the inferior end of the prostate, it is immediately surrounded by the muscular rhabdospincter, or external urinary sphincter

(EUS) muscle. The rhabdosphincter at this level contains both smooth (autonomic) muscle fibres in its deepest layer as well as more superficial skeletal muscle fibres, which are organized in a horseshoe-shaped loop around the urethra and innervated by the deep branch of the pudendal nerve[45].

Also present in the male pelvic floor is a larger muscle complex called levator ani. It is comprised of three distinct muscle groups, iliococcygeus, pubococcygeus and puborectalis. Together they loop from the ischium and coccyx around the rectum and function as a support structure for the pelvic viscera[45]. However, the more anterior portion of the puborectalis, the puboperinealis (PP) muscle is positioned in an opposite omega-shaped orientation around the urethra to the EUS. The combined voluntary contraction of both EUS and PP leads to increased urethral closure pressure generation[193].

Interestingly a 2009 foetal study of the anatomical components of urinary continence showed that in females the EUS and levator ani shared a common tendinous attachment whereas in males the EUS had no anatomical fixation to the levator ani muscle[197]. This would suggest that in men, training to improve urinary continence may have to be more specific than in women.

Superior to the prostate is the bladder, which is a muscular sac called the detrusor muscle. The bladder acts as a storage depository for urine. It is innervated by the autonomic nervous system, which controls the bladder's functional phases. The bladder and urethra are suspended within the peritoneal cavity by connective tissue called endopelvic fascia. This fascial system supports the bladder and further assists in stabilizing the bladder base as the bladders volume is constantly changing[46]. Endopelvic fascia is also believed to have a role in offering stability to the sacroiliac joints assisting with optimizing force closure[47].

The nerve supply around the prostate, also known as the Veil of Aphrodite, is not a single nerve but a neurovascular bundle wrapped intimately in the fascial outer layer of the prostate gland. Preservation of this delicate neural web is critical in optimising potency post-operatively. Menon and Hemal (2004)[48] described a technique of preserving the lateral prostatic fascia that Menon et al (2003) had called the 'Veil of Aphrodite' (p.615)[49]. Nerve sparing surgical approaches have been linked to improved continence outcomes, for example, Wei et al (2000) states that a 40 year old man undertaking nerve sparing surgery is 3.8-fold more likely to achieve continence that a similar 40 year old man who did not undergo that technique[50]. Given this, considerable care is taken during surgery to limit trauma to the endopelvic fascia[51], as this structure is responsible for stabilizing the bladder base. There is also care taken by surgeons to avoid resecting too deeply at the apical prostatic region, as this may cause excessive trauma to the external urethral sphincter muscle and its neuromotor connections[52]. In this regard, surgeon experience has been found to be an important variable in relation to post-operative continence and erectile function outcomes[53].

1.5 Function of the Male Pelvic floor

The function of the bladder can be summarized by its two distinct phases, a storage phase and an elimination phase. During the urinary storage phase, the sympathetic nervous system predominates, thereby causing the bladder wall (detrusor muscle) to relax and allow storage of urine to occur without increasing intra-bladder pressure. Simultaneously, constant tone is provided to the urethral smooth muscle of the rhabdosphincter to increase urethral closure pressure. During elimination, parasympathetic system stimulation causes the detrusor muscles to contract and the smooth urethral muscles to relax. The EUS must then be allowed to consciously relax to allow urine to pass[54]. Voluntary contraction of both the external urethral sphincter and the bulbocavernosus muscle at this point will prevent urination from occurring[55].

The function of the male pelvic floor is to provide postural support and generate voluntary increases in both urethral closure pressure and anal sphincteric closure. The urethral and anal sphincteric closure pressures are key to voluntarily controlling urination and defecation thereby maintaining continence. Research by Stafford et al (2015) indicates that elements of the more anterior musculature (bulbocavernosus and external urethral sphincter muscles) are more mechanically suited to voluntarily generating urethral closure pressure than the more posteriorly located levator ani muscle[56]. Given this it appears that voluntary control of the external urethral sphincter may play an important role in continence following prostatectomy.

During surgical resection of the prostate, the prostatic apex has to be dissected away from the muscular external urethral sphincter. This procedure typically causes localized tissue trauma and may potentially induce reflex inhibition of the striated external urethral sphincter and autonomic internal sphincter deep to it[49]. In turn, this leads to an inability to effectively retain urine within the bladder under increasing intra-bladder pressure[57]. This condition is known as stress urinary incontinence (SUI). Trans-rectal 3D ultrasound studies have shown that post-operative SUI is associated with a significant reduction in urethral retraction during voluntary EUS contractions[58]. When considered together therefore, there may be a need to develop motor control techniques that target the EUS for development into rehabilitation programs.

1.6 Common complications following prostatectomy

1.6.1 Urinary Incontinence

Urinary incontinence remains a common sequella related to prostatectomy, is costly and results in considerable health burden. Despite the previously mentioned advances in surgical techniques, there is still evidence to suggest that these interventions lead to weakening of the external striated urethral sphincter muscle[59] and levator ani complex. For example, radical prostatectomy has been associated with an increased relative risk of urinary incontinence (RR 4.3; 95%CI 2.6-7.3)[60]. By 2018 it is projected that 423 million people will be affected by some form of urinary incontinence worldwide[61].

Furthermore, incontinence results in considerable loss of quality of life. Avery (2013)[62] noted that deteriorating quality of life and depression are commonly reported alongside incontinence, and the prevalence of major depressive disorders for men with prostate cancer is reported to be 19.2%[63]. Even though their cancer may have been well treated, men can feel emasculated and suffer significant social embarrassment due to the sequelae of prostate cancer management[64]. Given both the cost and poor quality of life related to incontinence, improving continence outcomes needs to be urgently addressed by treating physiotherapists.

1.6.2 Erectile Dysfunction

Erectile dysfunction (ED) is also common post prostatectomy and is associated with poor health outcomes. Erectile dysfunction is reported to occur in between 30-70% of post prostatectomy patients[65],[66]. Further, McCullough et al. (2001) found that less than 10% of patients return to their pre operative erectile capacity following prostate surgery[67]. Tomlinson and

Wright (2004) noted that an online survey by the Impotence Association in 1997 found that 62% of participants felt that their ED affected their self esteem[68].

Erectile dysfunction arises due to the proximity of the prostate gland to the surrounding erectile nerve plexus. This proximity means surgical excision can induce neuropraxic and vascular trauma causing potency issues[49]. The more extensive the surgical trauma, the more likely that axonotmesis or neourotmesis will be the predominant neural pathology[69]. This in turn may result in permanent impotency. More extensive surgical trauma may arise either through necessity in order to completely remove extensive cancerous prostatic material, or through surgeon inexperience or error. It would appear therefore that if extensive surgery can be avoided, then it is less likely that ED would arise. Surgical experience therefore becomes an important factor for men to consider when undertaking prostatic surgery.

1.7 Factors associated with Incontinence Post Prostatectomy

There are a number of factors that can affect continence outcomes following prostate surgery. These include obesity, urethral membranous length and the muscle morphology of the external urethral sphincter. For example, Wolin et al. (2010) reported that men who were not obese and physically active were 26% less likely to be incontinent than men who were obese and inactive (RR 0.74, 95%CI 0.52-1.06)[70]. Further, Coakley et al. (2002) reported that preoperative longer membranous urethral length was associated with improved time to stable continence. In this study, men with a urethral length of less than 11mm were more likely to be partially incontinent at 12 months (23%), compared with those with a urethral length of more than 12mm (11%)[71]. Of these 2 factors, only obesity is modifiable highlighting that weight loss prior to surgery could be important when attempting to optimise continence outcomes.

A greater proportion of skeletal muscle resected within the external urethral sphincter is also associated with greater incontinence. For example, a recent study by Skelton et al. (2014) found a significant correlation between the amount of skeletal muscle (EUS) within the excised prostatic apex and continence outcomes post prostatectomy. Histological evaluation of the excised prostate tissue revealed that men with skeletal muscle occupying more than 10% of the apical margin were 11.7 times more likely to be incontinent than men who had less skeletal muscle resected[69]. Hence there is a clear need for improved accuracy from the surgeon during apical prostatic resection.

Surgical experience has been discussed to date as a factor that could improve continence outcomes by resulting in less surgical trauma and or less excision of skeletal muscle. In addition to this, there is now direct evidence that surgical volume is related to better post-operative outcomes. For example, being operated on in surgical centers with high volumes has also been shown to result in reduced post-operative complications. Post-operative morbidity was lower in very high volume centers than in low volume centers (27% vs. 32% P=0.03), and more experienced surgeons noted significantly less post-operative complications (26% vs. 32% P>0.001).[72] It would appear therefore that both surgeon experience and high volume/specialized prostate cancer centers are essential in optimising outcomes.

1.8 Measurement of Incontinence

Currently, there is no agreed-upon standard to measure incontinence, with several subjective and objective methods proposed. Firstly, subjective methods of measuring incontinence include patient self- report during surgeon interview or self-report by completing the International Consultation on Incontinence Questionnaire (ICIQ). Although the ICIQ has been evaluated and been shown to have high validity, reliability and sensitivity,[73] these scores only reflect the patient's opinion as to their continence levels. Patients have very personalized opinions as to how 'bothered' they are by their continence status. For example, some are devastated by small leaks but are relatively pad free, whereas others are leaking considerably but are content to use pads. This subjective analysis is therefore only useful to compare each individual's response to their own continence and cannot be compared between patients.

There is also disagreement between these self-report measures. For example, Litwin et al. (1995) reported significant variability between patient reported quality of life outcomes and a surgeon's impression of a patient's urinary bother. For this cohort, patient self reported bother was 97% whereas the physician rating was averaged at 21%. Due to this large variation between surgeon and self-report measures they are not useful as an outcome measure for research, instead a more objective measure of continence would allow for better comparisons.

More objective methods of evaluating continence include number of pads utilized per day, and 24-hour pad weight scores. One such objective method was a ranking system developed by Lantz et al (2010). This system ranks incontinence as follows: none (0-1 pad/day) mild (1-2 pads/day), moderate (3pads/day) and severe (>3 pads/day)[74]. The limitation of this system however, is that pads themselves come in a range of sizes and absorbency ratings, with absorbency ranging from 100g to >1000g of urine per pad. Further, as patients can change pads before they are fully filled and for 'hygienic' purposes, it is clear that this rating system may be inconsistent between patients.

Pad weight testing is a more objective way to evaluate incontinence. The one-hour pad weight test is a standardized one wherein the bladder is filled by drinking 500ml of water and then a pad is worn for one hour throughout a series of predefined activities[75]. Although analysis has allowed for classification of mild incontinence (1-10g), moderate (11-50g) and severe exists. Twigg et al (2007) in his male study validated the use of the 24-hour pad weight test in male continence however it has no formal standardised protocol and therefore it too has its limitations[76]. For example, more physically active people will have more incidence of SUI and therefore report higher pad weight scores than those who are less active. But percentage change in 24-hour pad weight scores could be considered a good assessment of incontinence if reviewed over a period of time – thereby taking into account variations in activity levels. O'Sullivan et al. (2004) defined grades of incontinence depending on 24 hour pad weight scores, (1.3-20g – mild, 21-74g – moderate, and >75g – severe) and argued that these should be considered when evaluating continence outcomes[77]. Given this, researchers and clinicians should consider the 24-hour pad weight test rather than number of pads/24 hours for measuring change in continence outcomes over time[167].

1.9 Assessment of pelvic floor function

There are numerous methods to evaluate pelvic floor function including urodynamic studies, clinical (manual) assessment and evaluation through real time ultrasound. It is therefore important to evaluate which method would appear optimal when managing male incontinence.

1.9.1 Urodynamic assessment of pelvic floor function

The most commonly utilized test to assess pelvic floor function usually performed by urologists is a Urodynamic study[78]. During this test the patient arrives with a full bladder and is encouraged to urinate into a flow rate monitor, in order to assess whether there is any obstruction present. Patients are then catheterized to evaluate whether there is any residual urine left within the bladder at the end of voluntary urination (post void residual – PVR). The bladder is then filled via the catheter and the volume recorded at the point that initial urge to urinate is experienced. Thereafter, the bladder continues to be filled until the point at which leakage occurs (valsalva leak point pressure (VLPP)).

Despite urodynamic testing being commonly used, there is some debate as to its association with incontinence. For example one small study in 1996 (n=27) showed that there was virtually no correlation between VLPP and SUI in men post prostatectomy (Pearson correlation = 0.14, p=0.49)[79] whist another larger study in 2005 (n=146) indicated that SUI post prostatectomy is due to intrinsic sphincter deficiency[80] and has found a statistically significant correlation between leak point pressure and urethral pressure (r=0.46, P<0.0001). Due to a larger sample size and better urethral pressure profilometry, the more recent data would appear to be a more robust study to construct upon.

Logically it can be argued that urodynamic testing does not directly evaluate continence, as it does not require the patient to voluntarily resist urination and it is questionable therefore as to whether it accurately assesses the functionality of the pelvic floor muscles. Rather, urodynamic testing evaluates passive features such as obstruction, overall bladder compliance and maximal bladder volume/capacity[81]. Given this, urodynamic studies may fail to give a clear picture of the external urethral sphincters functional ability to voluntarily cease urination, and there is limited evidence that pre operative urodynamic testing predicts surgical outcomes[81]. It would appear therefore that urodynamic testing should not be utilised routinely post-prostatectomy and that clearly a test that more closely evaluates pelvic floor function is required.

1.9.2 Clinical assessment of pelvic floor function

Assessment of pelvic floor function in females has always placed great emphasis on the validity of internal vaginal palpation/manometric testing[82]. Internal digital vaginal palpation is utilized in some studies[82-84] to evaluate the efficacy of pelvic floor muscle control in women. Other studies use surface electrodes[85], or internal manometric devices such as the Peritron to evaluate pelvic floor activity. For females these testing procedures have been shown to be reliable and valid measures of pelvic floor strength. For example, Pereira et al. (2014) showed a strong positive correlation between pelvic floor muscle function and manometric pressure (Pearson correlation = 0.90) and a moderate correlation between function and both electromyographic assessment (Pearson correlation = 0.59) and ultrasound assessment

(Pearson correlation = 0.51)[82]. Given this vaginal manometric pressure is recommended as a valid method to assess pelvic floor function in women, however cannot be done in men.

Notwithstanding this the philosophy of testing pelvic floor muscle strength via internal palpation has been adapted to men following prostatectomy. Some studies evaluate the efficacy of the male pelvic floor by assessing internal squeeze pressure via digital rectal examination (DRE)[86-90] and anal manometry[87, 91]These assessments are however invasive for patients and there appears to be only moderate correlation with DRE and Trans-abdominal RTUS motion (r=0.57, P=0.002)[86]. Furthermore, work by Stafford et al.[56] brings into question the effectiveness of any assessment protocol involved with evaluating an anal dominant contraction. They suggest that urethral closure pressures in men are more likely to be achieved by a coordinated contraction of the more anteriorly located bulbocavernosus and external urethral sphincter muscles. Hence there may be a need to target these more anterior muscles for assessment when evaluating the male continence mechanism.

Other less invasive methods such as sub-scrotal digital palpation techniques[92] or surface EMG[93] have also been utilized. However, neither of these studies report on the validity or reliability of these techniques in the assessment of the male continence mechanism. Given this and the question regarding the validity of DRE in relation to pelvic floor function, it appears therefore that a valid, reliable and less invasive method of assessing male pelvic floor function is required.

1.9.3 Real Time Ultrasound (RTUS) assessment of pelvic floor function.

Real time ultrasound (RTUS) has also been used as a method to assess pelvic floor muscles with both trans-perineal and trans-abdominal methods advocated. In females there is good correlation between internal perinometry and trans-abdominal ultrasound scanning[94] ($r=0.72$, $R^2=0.52$, $P<0.0001$). Furthermore, both trans-perineal and trans-abdominal RTUS have been shown to have significant correlation with digital internal vaginal palpation in women[95] ($rho=0.58$, $P<0.0001$ and $rho=0.58$, $P<0.0001$ respectively). These data suggest that both trans-perineal and trans-abdominal RTUS could substitute for internal perinometry in women.

Furthermore, trans-abdominal RTUS has shown to be reliable method to evaluate pelvic floor function in women. For example, Sherburn et al. (2005) found good to excellent reliability for both inter- rater (ICC range 0.86 to 0.88 (95%CI 0.68 to 0.97)) and intra-rater (ICC range 0.81 to 0.89 (95%CI 0.51 to 0.96)) evaluation of female pelvic floor function using trans-abdominal RTUS. This led the authors to comment that it was a personally non-invasive tool to assess female pelvic floor function[84]. Accordingly, trans-abdominal RTUS assessment should be recommended as the most valid assessment tool to utilize in women.

In males, however, only one study has evaluated the reliability and validity of trans-abdominal RTUS[86]. Here RTUS was shown to have moderate correlation to DRE assessments (r=0.57*, P*=0.002) and good reliability (ICC 0.90). However, the basis of this study was utilizing anal assessments and there was still no means to evaluate whether the intrinsic motor skill of pelvic floor muscle isolation had occurred. Therefore, the reliability of an improved protocol for using RTUS in men needs to be evaluated.

1.10 Current physiotherapy management of post-prostatectomy patients

Pelvic floor exercises (initially known as Kegel exercises) were first proposed as a conservative strategy for addressing stress urinary incontinence in women in the 1950's[96, 97]. Such exercises are now recommended as standard management for women with SUI post childbirth[98-100]. Marques et al. (2010) in their review paper identified that there was a lack of consensus on the amount of exercise necessary to improve pelvic floor muscle function and listed a range of protocols which were all designed to strengthen and improve pelvic floor function[99, 101]. They concluded that further research was needed to evaluate the efficacy of specific training protocols.

The role of pelvic floor muscle training to improve continence outcomes for men following radical prostatectomy has conflicting results. Randomized controlled trials advocating for pelvic floor muscle training have demonstrated[91, 92, 102] that pre-operative pelvic floor training reduces post-operative incontinence severity[91, 92, 102] and that early post-operative pelvic floor exercises improve continence recovery[103, 104]. On the other hand one study concluded that pelvic floor muscle training has no effect on continence recovery[88] the protocols in all of these studies did not clearly identify how the pelvic floor exercises were taught to the patient. This variability in continence outcomes following pelvic floor training is possibly due to the fact that there is no standardised protocol by which the male pelvic floor is assessed or delivered to the patient.

1.11 The need to develop a progressive training protocol to improve SUI in men post prostatectomy

The lack of a standardized protocol to assess and then progress pelvic floor function in men is hypothesized here to be the key challenge to improving SUI post prostatectomy. Progression of muscle function in other skeletal muscles follows a skill acquisition, endurance then strength model[194].

1.11.1 Skill Acquisition/Muscle Targeting

The first phase of muscle training is termed motor learning or skill acquisition phase. During this phase, the emphasis is on careful targeting of the muscle that it is desired to develop and repeating gentle contractions to develop an engram of motor recruitment within the brain[105]. Training requires high repetition and an awareness as to why the motion is necessary[105] and this need for awareness is seen in other aspects of therapy such as gaze retraining to improve neck control in the management of whiplash patients[106]. There is a need, therefore, as suggested by Pedraza et al. (2014)[107], to be more specific in the way in which patients selectively recruit the muscles to train. To date there is no documented protocol for the skill acquisition phase of pelvic floor muscles training.

The key to skill acquisition in the male pelvic floor would seem to be how this skill is taught and practiced. Recent research[108] indicates that different verbal cues can have a significant effect on altering the pattern of activation of male pelvic floor muscles. A verbal cue to 'shorten the penis' produces a greater displacement of the mid urethra (EUS motion) than 'elevating the bladder' and cues to 'tighten around the anus' produced significantly less puboperinealis and EUS co-concomitant activity. Just as skill acquisition in sport progresses with practice[109] these studies suggest that specificity of cues and practice are important components to incorporate into a standardized model for assessing and teaching the skill of effective pelvic floor muscle control.

Pelvic floor muscles are skeletal muscles and thus contain four types of muscle fibers. These fiber types include type 1,IIa, IIx and IIb (Table 1.2). In all forms of efficient and effective muscle training, the muscles must be exposed to training specific to their fiber type[110]. As the pelvic floor muscles contain both fast-twitch phasic muscle fibers (type II) and slow-twitch fibers (type I). It is argued that training should be directed at both fast twitch fibers to develop strength and slow twitch fibers to develop endurance capacity specifically.

Table 1.2: Differences in Skeletal Muscle Fiber Types

	Type 1 Fibers	***Type IIa Fibers***	***Type IIx Fibers***	***Type IIb Fibers***
Contraction time	*Slow*	*Moderately fast*	*Fast*	*Very Fast*
Resistance to fatigue	*High*	*Fairly high*	*Moderate*	*Low*
Activity used for	*Aerobic activity*	*Long-term anaerobic activity*	*Short-term anaerobic activity*	*Short-term anaerobic activity*
Maximum duration of use	*Hours*	*< 30 minutes*	*< 5 mins*	*< 1min*
Power produced	*Low*	*Medium*	*High*	*Very high*
Mitochondrial density	*Very high*	*High*	*Medium*	*Low*
Capillary Density	*High*	*Intermediate*	*Low*	*Low*
Oxidative density	*High*	*High*	*Moderate*	*Low*
Major storage fuel	*Triglycerides*	*Creatine phosphate, glycogen*	*ATP, creatine phosphate, glycogen (little)*	*ATP, Creatine phosphate*
Properties	*Consumes lactic acid*	*Produce lactic acid and creatine phosphate*	*Consume creatine phosphate*	*Consume creatine phosphate*

Reproduced from Zatsiorsky et al. (2006)[110]

1.11.2 Strength training of the male pelvic floor

The reported strength training undertaken in male pelvic floor studies to date have often not been constructed to target strength gains. Physiological studies define strength training as requiring maximal force generation to be achieved by the targeted muscle in 3-4 sets of 8-12 repetitions[110]. This has been shown to increase hypertrophic change within the Type IIa muscle fibres themselves on muscle biopsy testing[111]. Mcdonald et al. (2007) in their systematic review of male pelvic floor rehabilitation, highlighted the fact that treatment regimens were not standardized and that the type, intensity and duration of pelvic floor training was often not specified within individual studies[112] . Some studies had patients performing exercise volumes ranging from 2x30 contractions/day[89] to 3 sets of 10 maximum effort repetitions held for 5 seconds each[103] to 10-15 repetitions of 5-10 second hold contractions 4x/day[93] The high repetitions employed by these studies is not consistent with a strength protocol. Given this, and assuming that weakness is the reason for incontinence, it is argued that the pelvic floor muscle training implemented in these studies[89, 93, 103]did not accurately target strength gains and therefore may explain the lack of efficacy for continence outcomes in these trials.

It is proposed therefore, that there is a need to challenge the pelvic floor urethral closure mechanism against a form of resistance in order to optimally stimulate hypertrophic change. One such training method may be to use progressive increments in intra-abdominal pressure, which will cause intra-bladder pressure rises. In turn this is hypothesized as the resistive force used to challenge the urethral closure mechanism. This training method is proposed as the basis of a future RCT described in Chapter 4.

1.11.3 Endurance training of the male pelvic floor

Endurance gains are characterized by individuals being able to sustain lower intensity muscular contractions for progressively longer periods[110]. Pedraza et al. (2014) documented a standardized protocol for pelvic floor rehabilitation including endurance training, however their endurance training consisted of maximal effort sustained pelvic floor muscle holding[107]. Conversely, Dorey et al. (2009) in their Men After Prostate Surgery (MAPS) trial notes that the patient's pelvic floor should be advised to be sub-maximally active and sustained during functional endurance activities such as walking[113] . Further suggestions for endurance were made by Quartly et al. (2010) where the authors measured pelvic floor endurance as the time to failure below 60% of MVC[114]. Once again this diversity in the methodology of training to improve endurance brings into question whether pelvic floor endurance capacity was directly targeted in these studies.

It is reported that the pelvic floor has a role in core stability[115] and it has been shown that there is a correlation between pelvic floor function and deep abdominal muscle co-activation[116]. Interestingly some smaller female studies[117, 118] focus on improving postural control by implementing a Pilates type approach to training, have been found to have a positive effect on continence outcomes. Therefore, it may be beneficial to consider integrating postural advice to patients post RRP to improve endurance capacity of the pelvic floor.

Taken together, it is argued that the ideal protocol to improve pelvic floor function should encompass skill acquisition, progressing to strength and endurance/postural training. If a protocol can be developed and shown to be reliable and valid, then assessment and management of male pelvic floor function could be improved and ultimately result in reduced SUI post prostatectomy.

1.12 Thesis aims

The aims of this thesis therefore are:

- To develop an outcome measure using trans-abdominal RTUS as a biofeedback tool to evaluate whether skill acquisition of the male pelvic floor has been acquired.
- To evaluate whether such a motor learning strategy is optimal if delivered pre-or post-prostatectomy
- To evaluate whether physiotherapists teaching male pelvic floor exercises can reliably interpret RTUS images.
- To propose a future RCT evaluating whether motor learning followed by intra-abdominal pressure resistance training induces greater hypertrophic change in pelvic floor muscles as compared to standard pelvic floor (isometric) training.

CHAPTER TWO: Development of an outcome measure using trans-abdominal RTUS as a biofeedback tool

2.1 Introduction

There is debate in the literature as to whether pre or post-operative pelvic floor training is superior in terms of improved continence outcomes for men post prostatectomy. Some studies have investigated the efficacy of pre-operative pelvic floor training[89, 91-93, 119-121], whilst others have investigated post-operative training[87, 102, 112, 122-127], with the outcomes widely varied. For example, a critical review by Nahon et al [128] reported only level III evidence in favour of pre-operative training in hastening time to continence. Whereas, Burgio et al (2006) in their RCT showed a significant benefit in time to return to continence and a significantly reduced incidence of men with severe leaking issues at 6 months post op (5.9% vs. 19.6% p=0.04)[91] in men randomized to receive pre-operative training compared with controls.

Centemero et al (2010) in their RCT demonstrated a 0.41 fold lower risk of incontinence at 1 month post-operation and 0.38 fold lower risk of incontinence at 3 months post-operation[92] when comparing pre to post-operatively trained patients. These studies therefore would appear to indicate that pre-operative pelvic floor muscle training improves continence outcomes for men compared with those undertaking training post-operatively.

In contrast to the above, there is equal evidence that pre-operative training does not deliver better outcomes, however these studies have some limitations. For example; Dijkstra-Eshuis et al (2015) demonstrated in their RCT (n=122 patients) that no significant difference was noted with respect to incidence of stress urinary incontinence (SUI) and quality of life (QoL) scores at 1 year post op in pre- or post-operatively trained patients[89]. Similarly Bales et al (2000) reported a similar proportion of people with minimal incontinence at 6 months post operatively whether training was delivered pre operatively (94%) or post operatively (96%)[93]. However both these aforementioned studies had methodological flaws; one utilizing anal probes to evaluate urethral pelvic floor function[89] and the other using surface electrodes to ascertain pelvic floor function[93]. Anal probes direct the patient to bias the more posterior musculature (external anal sphincter) rather than the urethral mechanism and therefore should be excluded when considering prior research outcomes. Given that the higher quality studies using more valid outcome measures have reported better outcomes with pre vs. post operative programs, it appears that pre-operative training should be of greater benefit compared with post operative training.

Real time ultrasound (RTUS) has emerging evidence as a valid measure of determining if the pelvic floor is functioning and providing adequate urethral closure. Several studies by Stafford et al[55, 56, 108] have used RTUS and have proposed that the more anterior pelvic floor muscles are mechanically more suited to developing efficient urethral closure pressures. However, this work utilizes a trans-perineal approach to ultrasound scanning which is more awkward for the patient and more technically challenging for the physiotherapist to perform. Furthermore, the RTUS image analysis requires sophisticated measurement analysis software. Therefore, such an approach has less clinical utility than an alternative method such as a trans-abdominal approach.

Missing therefore is an approach to assessment of male pelvic floor function that is clinically feasible and reliable. Trans-abdominal ultrasound has been documented to be a valid and reliable tool in assessing pelvic floor function[84, 94, 95, 130-132] in female populations. Its advantage is that feedback about the motor skill can be given in real time and that hypothetically change can be facilitated within a reasonable amount of clinical time. To date however the reliability and feasibility of such an approach in the male pelvic floor has not been established.

Effective isolation of correct muscles to achieve urethral closure pressure would appear to be the skill patients should aspire to acquire. Specific skill acquisition may be dependent on a number of physical factors such as age[133] (older ages correlate to poorer new skill acquisition), BMI[134] (higher BMI correlating with poor motor skill performance), and possibly pre-operative urinary continence status. Hence measurement of these parameters is necessary to determine whether there are confounding factors affecting continence outcomes.

The primary aim of this study therefore was to develop a novel, clinically useful protocol and outcome measure that would utilize simple trans-abdominal RTUS scanning techniques. The secondary aim was to investigate the number of therapy sessions necessary to reach the motor learning outcome measure, and to determine factors associated with skill acquisition including whether this should be delivered to the patient prior to surgery.

Having a visual biofeedback tool such as RTUS would enable clinicians to evaluate whether adequate motor learning is occurring in real time. Potentially such a tool is hoped to improve continence outcomes for men post prostatectomy.

2.2 Methods

2.2.1 Study participants

Participants were men with prostate cancer who had or were soon to undergo radical prostatectomy, who were referred by their urologist or general practitioner to a physiotherapy clinic in Sydney, Australia to improve their pelvic floor function. Participants were excluded from this study if they had had a previous transurethral resection of the prostate (TURP) and/or prior radiotherapy, as this has been shown to adversely affect continence mechanisms.[135, 136] Further exclusion criteria were other factors such as prior incontinence, a history of chronic pelvic pain[132] and a history of pre-existing neurological conditions.

Ethical approval to conduct the study was obtained from the University of Sydney Human Research Ethics Committee (protocol number 14286)

Participants completed a baseline questionnaire comprising demographic data such as age, height, weight and Body Mass Index (BMI). Additional baseline data collected included the timing of the initial assessment (pre- or post-operatively), and the referring urological surgeon. Participants also were also screened for the presence of pre-existing erectile dysfunction or urinary dysfunction (such as frequency, urgency, incontinence or nocturnal).

2.2.2 The Protocol

Participants were educated on the anatomy and function of the pelvic floor muscles, then positioned in a crook lying position with their abdomen exposed.

A Mindray RTUS machine (Model DP-50) was used in conjunction with a curvilinear transducer (35C50EA - 2-5 MHz R50mm broadband Convex Array) to image the pelvic floor trans-abdominally. Images were recorded using a handheld video recorder. We adapted the protocols of Khorosani et al (2012) and Thompson et al (2005) to obtain a consistent image for our data collection. The transducer was placed in the transverse plane immediately suprapubically, angled at 15-30 degrees from the vertical, until an optimal view of the bladder base was achieved[95, 132] (see Figure 2.1).

Figure 2.1 RTUS Probe orientation on patient

The participant was asked for a voluntary pelvic floor muscle contraction using a standard instruction “show me how you would contract your pelvic floor muscles.” This ensured no verbal or tactile cueing from the physiotherapist, so that baseline skill and natural compensation strategies could be observed.
The physiotherapist then commenced training to facilitate isolated pelvic floor muscle (PFM) contractions.

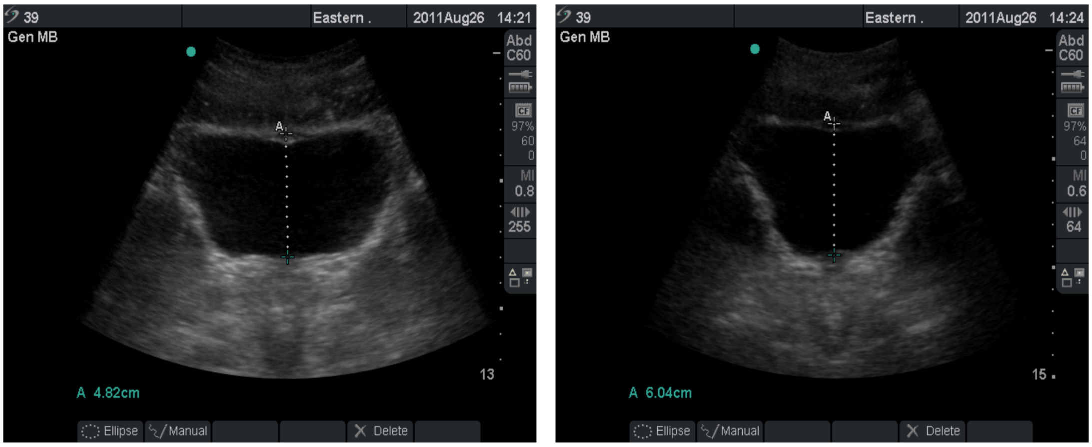
Training included specific cues to elicit isolated pelvic floor contractions with a bias to the anterior pelvic floor (penis), middle pelvic floor (testicles) and posterior pelvic floor (anal) regions (or ‘zones’). Cues included; “stopping the flow of urine midstream” (anterior bias), “lifting your testicular sack upwards” (mid zone bias) and “stopping oneself from defecating” (posterior bias). These differing verbal cues have been shown to alter the pattern of motor recruitment in men.[108] During this time the trans-abdominal RTUS image was used as a form of biofeedback.

Throughout training, suboptimal or indirect strategies, such as breath holding, valsalva, superficial muscle co-activation (especially abdominal, adductor, gluteal and hamstring) were discouraged and a lower effort was encouraged, to achieve a more isolated, accurate contraction. Patients were prompted to attend to slightly different sensations during each zone isolation exercise and to focus on how each zone was subtly different to its neighbour. The physiotherapist observed whether the patient was using any suboptimal strategies, and provided feedback as necessary. Patients continued until the optimal learning outcome for the session was achieved. The number of individual physiotherapy sessions was recorded until the learning outcome has been achieved. A handheld stopwatch was also used to record the time of exposure to RTUS training.

The patient was encouraged to continue with low effort (20% MVC) practice of these isolated motor control exercises at home until the next therapy session. At the next physiotherapy session the process was repeated until the outcome was achieved, or until a maximum of eight sessions had been reached.

During correct contraction of the pelvic floor muscles an upward and inward moment is produced[84]. This is observable on the RTUS screen as an upward deflection of the bladder base (muscles causing a lift of the bladder towards the probe). One common type of incorrect pelvic floor activation strategies tends to create an increased intra-abdominal pressure change (also known as a valsalva manouvre), which causes a downward deflection of the bladder base (forcing the bladder base away from the probe)[95, 137]. (Figure 2.2)

Figure 2.2 RTUS images showing PFM contraction (L) and Valsalva Manouvre (R)



(Images taken from study footage NOTE Distance measurements are recorded in green at the bottom left hand screen corner)

<u>*2.2.3 Defining the Outcome Measure*</u>

Acquisition of the skill of an isolated pelvic floor muscle contraction was defined as a notable bladder base lift with initial effort that was sustained throughout three normal respiratory cycles, followed by a similar sized drop in bladder base level on release of pelvic floor muscle effort. The patient was deemed to have attained this outcome through having achieved the following three components:

1) **LIFT PHASE:** An initial observable rise in the bladder base as observed on RTUS (>1mm but usually less than 1cm) with all pelvic zone cues (anterior, mid and posterior)
2) **SUSTAIN PHASE:** Ability to maintain this rise for three normal breaths (usually between 3 and 8 seconds) for all pelvic zones, with failure of this criterion defined as a loss of more than 25% of the original bladder base rise.
3) **DROP PHASE:** An observable fall of the bladder base after completion of component 2 as observed on RTUS determined to be equal to the rise (>1mm but usually less than 1cm)

Each component was rated on a 4-point Likert scale; 0 (definitely no), 1 (no (maybe)), 2 (yes (maybe)), 3 (definitely yes). Hence skill quality ranged from lowest skill quality 0 to highest skill quality 9. A total score of 6 or greater was used to determine acquisition of the skill in each of the pelvic floor zones (penile/anterior, testicular/mid and anal/posterior).

Time to skill acquisition was determined as the number of therapy sessions taken to attain the motor outcome measure as greater than 6/9 on the previously described Likert scale.

The minimum was considered to be one physiotherapy session and a maximum of 8 physiotherapy sessions was considered adequate time to attain the skill. If the outcome had not been reached by 8 sessions, the participant was considered as not having attained the skill.

2.2.4 Statistical Analysis

Patients were grouped into pre- or post-operative groups as indicated by their status upon initial physiotherapy assessment. For the purposes of power calculation, Cohen (1988) argues that the artithmetic mean of two unequal group sizes is affected by the larger sample size, and that the harmonic mean, which in the two group case is 2.N1.N2/(N1+N2), is preferable because it is less weighted by the larger value[138]. Therefore, it was determined apriori that a harmonic mean sample size of 32 patients per group was required to detect a difference between groups as large as 0.7 standard deviation units (Cohen's d = 0.7) with 80% power and a Type 1 error rate of 0.05.

Independent t-tests were used to determine whether there was any baseline difference between the pre- and post-operative groups, and to compare between-group differences in time to skill acquisition.

A logistic regression analysis was conducted to identify predictors of skill attainment and multiple regression was conducted to assess predictors of time to skill acquisition. Independent variables entered into the regression models included BMI, age, history of pre-operative erectile dysfunction, history of pre-operative urinary dysfunction, and whether the patients were initially seen pre- or post-operatively.

2.3 Results

Ninety-six consecutive patients who presented to the physiotherapy clinic were invited to participant in the study. Of these 91 (95%) consented to participate and were included in the study. Fifty patients (50/91=55%) presented pre-operatively and 41/91 (45%) post-operatively. There were no significant differences in demographic data between groups (Table 2.1).

Table 2.1: Demographic data for Study Participants

Factor	Initially trained Pre op (n=50)	Initially trained Post op (n=41)
Age (years) Mean (SD)	63.54 (7.6)	67.72 (7.2)
BMI (kg/m^2) Mean (SD)	27.96 (3.3)	27.25 (3.6)
Pre existing UD* n(%)	15 (30%)	11 (27%)
Pre existing ED^ n(%)	14 (28%)	8 (20%)
Surgeon A n(%)	29 (29.7%)	24 (26.4%)
Surgeon B n(%)	18 (19.7%)	10 (11.0%)
Others n(%)	3 (3.3%)	7 (7.7%)

*UD – Urinary Dysfunction
^ED – Erectile Dysfunction

2.3.1 Time to Skill Acquisition

Patients seen initially pre-operatively achieved the skill with a mean RTUS exposure time of 10.0 minutes (SD 8.3), whereas patients seen post operatively took 11.9 minutes (SD11.8) to achieve skill acquisition, however this difference in RTUS exposure time not significant (p=0.36). However, the proportion of patients who were unable to acquire the skill of pelvic floor control within the allocated time constraints were significantly less in the group initially seen pre-operatively compared to those initially seen post-operatively (see Table 2.2; OR 11.87 95%CI 1.4 to 99.5) p = 0.02). In addition, patients seen pre-operatively achieved the skill in significantly fewer therapy sessions than those seen post-operatively (mean difference -1.30 (95%CI -2.1 to – 0.5) p = 0.002.)

Table 2.2: Skill attainment of patients seen pre- and post-operatively

	Initially trained Pre-op	Post-op	Sig
Did not attain the skill n(%)	1(1.1%)	8(8.8%)	P= .005*
Attained the skill n(%)	49 (53.8%)	33 (36.3%)	
Time to skill acquisition Mean (SD)	9.97 (8.3)	11.89 (11.8)	P= 0.36^
Mean therapy sessions	1.5 (1.0)	2.88 (2.6)	P= 0.02^
Key: * Pearson Chi Square value 7.752, 1 degree of freedom ^ Independent t-test			

2.3.2 Factors related to skill acquisition

Independent variables found to be significant predictors of skill attainment were low BMI and initial visit occurring pre-operatively (see Table 2.3). Together, these two predictors accounted for 46.3% of the variance. No variables were found to be predictive of time to skill acquisition.

Table 2.3: Forward stepwise regression of predictors of skill acquisition

Variable	B value	sig
BMI	-0.427	P=.002
Initially seen preoperatively	-3.097	P=.009

2.4 Discussion

This study describes a novel outcome measure for using trans-abdominal RTUS to evaluate motor skill acquisition for men undergoing radical prostatectomy for prostate cancer. It demonstrated that the protocol can be delivered in a clinically feasible amount of time and therefore it should be able to be incorporated easily into clinical physiotherapy practice. It also highlights a potential benefit for combining weight-loss advice with pre-operative pelvic floor muscle training to successfully achieve improved motor control learning outcomes.

This study showed that many men seen post-operatively failed to achieve a baseline level of skill acquisition within a clinically reasonable period of time (Table 2.2: 8.8% post-op vs. 1.1% pre-op, p=0.005). This would further support a recommendation for pre-operative pelvic floor training for men over post-operative training.

This research infers that teaching men targeted motor control pelvic floor exercises is faster if delivered pre-operatively. Previous studies have not evaluated the time it takes to teach early motor patterning skills. We demonstrated that early motor control could be effectively taught over an average of 1.5 therapy sessions if delivered pre operatively, as opposed to 2.9 sessions if performed post operatively. Other studies have reported varied therapy interventions from a single session[91], to 2-4 sessions per week[93],[119],[89]. Logically it is argued that one session is inadequate to ensure that motor training has been taught and retained. Following this up with another consult therefore seems reasonable in some cases to ensure skill is retained. It is noted that in latter studies[89, 91, 93, 119] no specification has been made as to whether there has been a motor learning component in the teaching phase. It is therefore reasonable to offer 1-2 pre-operative physiotherapy sessions, which is not unduly expensive, but will enhance the possibility that motor learning has been adequately addressed.

One potential reason for skill acquisition to be notably more efficiently achieved pre-operatively is the fact that motor learning is known to be compromised in the presence of significant stress[139]. The mechanism here is suggested to be a reduction in available attention during skill learning. Parvizi et al.[140] notes that there is evidence that pressure-induced anxiety causes shifts in attention that lead to decrements in performance and learning. The stress of active incontinence is significant and is reported in Quality of Life (QoL) studies.[43] Motor skill acquisition may therefore be impeded in the presence of the stress arising when a person is suffering from incontinence. The present study corroborates this by demonstrating improved outcomes when training is delivered pre-operatively. In such a situation, learning can take place in a calmer, more relaxed environment.

Previous studies have also reported numerous extrinsic factors associated with better continence outcomes following RP[71, 141, 142]. For example longer membranous urethral length (the distance from prostatic apex to entry of the urethra into the penile bulb), is associated with significantly improved continence outcome ($p=0.02$)[71]. Other factors such as younger age (<70yrs), better pre-operative sexual dysfunction scores, lower cancer stage, shorter operative time, lower blood loss during surgery, and smaller prostate volume (<40cc) were all shown to be independent predictors of improved continence outcomes after RP ($P<0.05$)[141]. Taken together therefore, future studies should assess each of the known extrinsic factors together with the factors demonstrated by our research (BMI and pre vs. post operative training) to determine which are the better predictors of incontinence outcomes.

It is unclear as to why BMI should affect motor learning outcomes as demonstrated in our study. One suggestion may be that men with higher BMI scores are arguably less familiar with exercise in general, and may have had poorer general muscular coordination. Another theory may be that larger men have higher resting intra-abdominal pressures[143], which may adversely affect the pelvic floor muscles length/tension relationship. The relationship between excess accumulation of adipose tissue (obesity) and prostate cancer aggressiveness has been highlighted in a previous study[144] as well as correlation between continence outcomes and obesity[70]. The inference arising is that weight loss/management programs should be encouraged by any, and all, treating health professionals, because these may not only ameliorate the aggressiveness of the cancer, but also may assist in improving the likelihood of pelvic floor muscle motor control skill acquisition.

In regards to the clinical application of RTUS in the management of men following RP our study shows that trans-abdominal RTUS is a clinically acceptable approach. Emerging studies utilising a trans-perineal approach[108, 145-147] infer that this altered view enables the clinician to observe the muscles more directly involved in urinary continence and may of more benefit in teaching early motor control. Future studies may be needed to compare motor learning outcomes with both approaches.

Another point to consider is that patients presenting to physiotherapy post-operatively may have been suffering from more severe levels of incontinence.

This could introduce some systematic bias between pre- and post- operative groups. Future studies should consider randomly allocating the intervention to teach motor skills prior to surgery with the results of this RCT proving the hypothesised benefits of pre-operative training.

In conclusion prior to surgery, trans-abdominal RTUS can be utilised to teach early motor control of the male pelvic floor within a clinically acceptable time period. This may have future implications in the way that pelvic floor exercises are delivered to optimise pelvic floor health post radical prostatectomy and improve outcomes.

The results of this study show that a lower BMI and being seen pre-operatively may be associated with improved pelvic floor motor skill attainment, however it is still unknown whether this is in turn related to better continence outcomes. This may need to be proved in a prospective study or future RCT.

It needs to be noted that motor control is only the first step in a sequence of a proposed pelvic floor training protocol. In order to be synthesised with previous regimens/studies, correct isolation of the muscles responsible for urethral closure should precede training protocols in future studies in order to evaluate their role in affecting changes in continence outcomes post RP. This method is proposed in Chapter 4 as part of a RCT with motor control training preceding strength and endurance training for men post-prostatectomy.

CHAPTER THREE: To evaluate whether physiotherapists teaching male pelvic floor exercises can reliably interpret RTUS images.

3.1 Introduction

In the previous chapter I have documented a protocol for measuring pelvic floor motor control using trans-abdominal RTUS, there is thus a need to evaluate whether this protocol is reproducible amongst other physiotherapists. Inter-rater reliability is essential when evaluating interventions such as RTUS which has been shown to be highly user dependant[148]. For a protocol to be efficiently utilized in patient management it is essential that the images used to assess motor skill acquisition are reliably interpreted by a number of independent physiotherapists. Shrout and Fleiss (1979) reported that intra-class correlation coefficients (ICC) would give an indication as to the level of reliability achieved during a scientific study[149]. Inter-rater reliability for this study was considered poor (ICC >0.4), good (ICC range 0.4-0.75) or excellent (ICC > 0.75) as per Fleiss et al (1999)[150]

The reliability of real time ultrasound imaging in evaluating the presence of disease or muscle performance has been established in other conditions. For example radiologists were reliably able to detect the presence of deep vein thrombosis (DVT) using ultrasound with an overall sensitivity of 94.2% for proximal DVT and a specificity of 93.8%[151]. Similarly, cardiologists utilize

RTUS to determine the presence of pericardial effusions and it has been shown to increase diagnostic accuracy in 90% of cases[152]. However, the establishment of the reliability of RTUS to assess muscle performance is in its infancy. For example in assessing deep abdominal muscle cross sectional thickness Hides et al (2007) noted a very high ICC (>0.97) even in novice RTUS users, however in the same study low ICC's were reported for assessment of fascial slide across images (ICC = 0.44) and across 2 days (ICC = 0.36)[153] indicating that the repeatability of the US measure is poor for assessors with limited training. A study by Wallwork et al (2007) shows that RTUS has very high intra-rater (ICC = 0.96, 95%CI: 0.84-0.99) and good inter-rater reliability (ICC = 0.85, 95%CI: 0.51-0.96) when assessing lumbar multifidus thickness. In the cervical spine RTUS has been shown to have good intra-tester reliability in evaluating the size of the cervical multifidus muscle, however the inter-tester reliability was questionable[154]. As intra-rater reliability in these cases is consistently well reported, if pelvic floor RTUS images can be shown to have good inter-rater reliability it may indeed be a promising tool for quantifying pelvic floor motor skill acquisition.

Good repeatability of measure of male pelvic floor contraction with trans-perineal RTUS imaging has been shown[146] and Sherburn (2005) showed that RTUS was valid and reliable in evaluating pelvic floor muscle function in non-pregnant adult female subjects which suggests that it may be a potential tool for evaluating pelvic floor function in men.

Familiarity in using and assessing RTUS images requires some skill and training. Indeed, in other conditions such as low back pain, people with less skill in reading US images were less reliable[153], It is unknown how much training is required to familiarize clinicians with the skill to use and measure pelvic floor function reliably. Hence comparing novice users with experienced users may determine the level of training required to establish reliability.

It may also be efficacious to also study the RTUS images during different phases of contraction and with a bias to different muscles within the male pelvic floor. It may therefore be of interest to evaluate the RTUS images during the differing motor phases (activation, sustain and relaxation) that are integral in a muscle contraction in each of the various pelvic floor ‘zones’ (i.e. penile – anterior, testicular – mid, and anal - posterior). This may highlight how RTUS imaging could best be used to evaluate pelvic floor muscle motor control in each of these anatomical regions.

The male pelvic floor is made up of a number of individual muscles that work together in a synchronized fashion and recent research by Stafford et al. (2015) has shown that differing verbal cues can illicit varying pelvic floor muscle activation patterns. A cue to ‘shorten ones penis’ causes more activity in the more anterior musculature than a cue to ‘stop breaking wind’ – a more posterior cue[108]. It would appear therefore that there is a need to evaluate whether RTUS images are reliable regardless of the specific muscle being targeted for motor recruitment.

The aim of this study therefore was to evaluate inter-rater reliability for the use of RTUS images in evaluating pelvic floor motor skill acquisition, and whether, like in other previously mentioned studies, there is a difference between novice and experienced RTUS clinicians. Secondary aims were to determine which verbal cues and which motor phases were more reliably viewed by novice and experienced physiotherapists. In doing so it is hoped that we can improve the way in which we can use RTUS and improve reliability in RTUS image interpretation.

3.2 Methods

3.2.1 Participants

In this study there were three physiotherapist raters. Two raters were considered experienced, with more than 5 years post-graduate experience in men's health and in viewing trans-abdominal RTUS images (one was the author and the other a colleague in a men's health practice in Western Sydney) and one rater was considered a novice, with standard undergraduate physiotherapy training in RTUS who was a titled-member of the musculoskeletal physiotherapy association (MPA). All physiotherapy raters worked in different locations across Sydney.

3.2.2 Study sequence

A total of 48 individual video clips of RTUS screen images of 16 patients were randomly selected from the previous study to evaluate reliability. Video clips were de-identified and copied onto a DVD and sent to all 3 raters. Raters were asked to rate each component of the pelvic floor muscle contraction (lift/sustain/drop) using the 4-point Likert scale described below.

1. Did you see a rise in the bladder base?

Definitely Yes (3) / Maybe Yes (2) / Maybe No (1) / Definitely No (0)

2. Was the rise maintained?

Definitely Yes (3) / Maybe Yes (2) / Maybe No (1) / Definitely No (0)

3. Did you see a fall in the bladder base at the release of the contraction similar in amplitude to the initial lift?

Definitely Yes (3) / Maybe Yes (2) / Maybe No (1) / Definitely No (0)

Hence the total skill quality was ranged from lowest skill quality (0) to highest skill quality (9).

3.2.3 Statistical analysis

Inter-rater reliability was assessed using the ICC (2,1 statistic). In addition, the ICC was determined for the different verbal cues (anterior/ middle/posterior) zones) as well as for the different phases of contraction (lift/sustain/drop).

The significance level for all tests was set as $p=0.05$. When describing ICC's, the following reliability classifications were given. Reliability was considered poor (ICC <0.4) good (ICC range 0.4-0.75) or excellent (ICC > 0.75)[150]

3.3 Results

3.3.1 inter-rater reliability

The inter-rater reliability between all raters was poor (ICC 0.26, 95%CI: 0.11-0.43). However, once the novice data was removed, the ICC was good and improved significantly (ICC 0.73, 95%CI: 0.59-0.82), see Table 3.1.

Table 3.1: Combined ICC and 95%CI for image interpretation

	ICC (95%CI)
All Reviewers	0.262 (0.11-0.43)
Experts Only	0.73 (0.59-0.82)

3.3.2 Inter-rater reliability for cues and phases

When evaluating the reliability with respect to the phase of muscle action, good inter-rater reliability was demonstrated for the lift phase (ICC 0.69, 95%CI: 0.53-0.8). The lift phase scored good reliability (ICC 0.6, 95%CI: 0.47-0.72) even with the novice data included (see Table 3.2).

Table 3.2: ICC and 95%CI Reliability data for pelvic floor skill acquisition

	Lift	**Sustain**	**Drop**
All Reviewers	0.6 (0.47-0.72)	0.06 (-0.081-0.22)	0.17 (0.02-0.33)
Experts only	0.69 (0.53-0.8)	0.66 (0.49-0.78)	0.55 (0.35-0.7)

Once the novice data was removed, it was revealed that amongst experienced raters that the anterior and middle cues demonstrated good reliability, whilst the posterior cue demonstrated excellent reliability (ICC 0.81, 95%CI: 0.54-0.93), see Table 3.3.

Table 3.3: Experienced clinician reliability for pelvic floor zone

Verbal Cue	**ICC** (95%CI)
Anterior (Penile cue)	0.74 (0.4-0.9)
Middle (Testicular cue)	0.67 (0.28-0.87)
Posterior (Anal cue)	0.81 (0.54-0.93)

3.4 Discussion

This study demonstrated that this protocols 4-point Likert scale can be reliably used to interpret trans-abdominal real time ultrasound images in the assessment of pelvic floor function for men undergoing prostatectomy. There is good reliability between expert physiotherapists regardless of the phase or cue used. When a novice physiotherapist was included, image interpretation was most reliable when assessing the lift phase and was poor when assessing both the sustain and drop phases. When considering the verbal cues, the posterior (anal) cue was more reliably visualised on RTUS across physiotherapists than the mid or anterior cues. This suggests, similar to previous RTUS studies, that physiotherapists should be experienced in RTUS use in order to reliably interpret trans-abdominal RTUS screen images when assessing pelvic floor muscle action.

These are similar findings that Hides (2007) made in their study on physiotherapists experience level and RTUS use[153]. In his study of reliability in RTUS assessment of cervical muscle thickness, Kristjansson (2004) used a similar approach of assessing reliability between two experienced physiotherapists and found the mean difference between the trials was not significantly different from zero[154]. Although our study was not as impressive as these results and only reported good inter-tester reliability between experienced physiotherapists this may be due to the increased complexity of qualitatively assessing moving RTUS images rather than a review of a static screenshot of cross sectional muscle thickness measurements.

This study is unable to comment as to the extent of training necessary to qualify a physiotherapist to accurately interpret RTUS images. The novice therapist within this study was 5 years post-graduate trained but had minimal bladder scan trans-abdominal RTUS exposure. The more experienced therapists had 5 and 20 years bladder scanning experience respectively. It would appear from our study training time can only be estimated as being within the 0-5 years timeframe. Further studies may look at physiotherapist training times to optimise RTUS assessment reliability. Consideration should also be given to our conclusions as only one novice physiotherapist was used. Future studies should include multiple novice clinicians in order to confirm our initial observations.

The lift phase (activation/initial muscle recruitment phase) demonstrated good inter-rater reliability when assessed by both experienced and novice therapists compared with both sustain and drop phases. This is most likely due to the fact that mechanically it produces the most convincing elevation of the bladder base, the more anteriorly orientated muscles being unable to achieve this as directly. Due to the lack of similar type studies there is no other data to compare this to, however the initial lift phase may be the clearest to observe for a number of reasons. Firstly, pelvic floor muscle activation causes a clear displacement (cephlad deflection) in the resting bladder base level, whereas in the sustain phase during respiratory effort the descent and ascent of the diaphragm causes changes in intra-abdominal pressure which can be viewed on the RTUS images as a bladder base drop and rise respectively[198]. This, to a novice physiotherapist, may compromise their judgement as to whether the initial lift has actually been sustained. Recent research by Smith et al (2014) provides evidence of a relationship between back pain, incontinence, respiratory problems and GI symptoms[155] and the bladder base motion observable during the sustain phase further highlights an association between respiration and continence.

Likewise, during the drop phase at the cessation of voluntary muscle activation if pelvic floor motor control has not been sustained throughout normal respiration there is often not a clearly visualised drop in the bladder base level. This is again hard for a novice physiotherapist to reliably interpret, but expert inter-rater reliability remains good.

In conclusion the lift phase of pelvic floor control should therefore be recommended to be assessed in preference to either the sustain or drop phases of pelvic floor muscle action as it is more reliably assessed by our 4-point Likert scale.

Interestingly the posterior (anal) cue was the most reliably visualised by experienced physiotherapists. Anecdotally patients often report that this anal indrawing sensation is a more familiar and it is hypothesized that this may be because patients are more familiar with the sensation. It has been well established that repetition creates stronger motor patterns over time[134], and arguably the posterior 'levator ani' contraction is commonly and frequently used by men to inhibit the release of flatus and is practiced more frequently than either ceasing the flow of urine midstream or lifting one's testicular sac.

Notwithstanding this, just because the posterior cue is the most reliably viewed, does not necessarily mean that this should be the one recommended to cue pelvic floor motion. The aim of a pelvic floor contraction in men post-prostatectomy is to increase urethral closure pressure and inhibit the passage of urine. Much of the Levator ani complex, (the muscle responsible for the anal indrawing sensation), is not optimally suited biomechanically to achieve this outcome. Instead the cue to 'shorten ones penis' has been shown to recruit optimal EUS activity and provide better biomechanical advantages[145]. Future studies may be warranted utilising urethral pressure catheters to test which cues are actually responsible for generating optimal urethral closure pressures.

This study did not test intra-rater reliability, which is a possible limitation to this study. It was considered that as RTUS has often been shown to have excellent intra-rater reliability[95, 154, 156, 157] however inter-rater reliability is often poor[153, 157]. As our study showed good inter-rater reliability amongst expert physiotherapists it is my opinion that intra-rater reliability testing was not necessary. The lack of formal data in this area though may be considered as a limitation and future studies may wish to include this to evaluate the repeatability of the assessment – including image capture.

A secondary limitation was that the raters commented and observed on the RTUS images that were collected by a single clinician. Further studies may be warranted assessing whether RTUS images are reliable when a number of physiotherapists perform assessments of the same patient this would significantly improve the construct validity.

In conclusion this 4 point Likert scale can reliably assess trans-abdominal RTUS images to evaluate bladder base motion in the male pelvic floor if performed by experienced physiotherapists. The initial activation phase is most reliably observed and should therefore be considered as the best marker for evaluating male pelvic floor muscle activation. Future studies may be warranted evaluating which verbal cues result in generating optimal urethral closure pressures. This may then allow optimal targeting of specific muscles for rehabilitation post prostatectomy. Future RCT's may then be performed to evaluate continence outcomes in patients exposed to targeted training as opposed to standard pelvic floor muscle training. The construct validity of RTUS image interpretation can also further be enhanced by evaluating whether a number of therapists performing pelvic floor RTUS scans produce comparable outcomes.

CHAPTER FOUR: Evaluating the effectiveness of using progressive valsalva pressure as a resistance tool to develop sphincteric hypertrophy in men with prostate cancer. Protocol for a randomised controlled trial.

4.1 Introduction

Prostatectomy for prostate cancer induces trauma to both the skeletal external urethral sphincter (rhabdosphincter) muscle and the internal (autonomic) smooth muscle sphincter[69], which are in close proximity to, and intimately blended with, the prostatic apex. Studies have shown that scarring and atrophy of the sphincter is evident in trans-rectal and trans-urethral real time ultrasound (RTUS) assessments of incontinent men post Radical Prostatectomy (RP)[58, 59]. The scarring and atrophy in both smooth and striated muscles have been highlighted as a potential cause of post prostatectomy stress urinary incontinence[59]. In turn, stress urinary incontinence is associated poor post operative quality of life scores[62]. Given this, physiotherapy-led rehabilitation programmes that address atrophy of the external urethral sphincter through developing hypertrophy should improve continence post-prostatectomy.

To date, however, physiotherapy led rehabilitation of pelvic floor muscles has shown equivocal results, with one explanation for this being that true hypertrophic change of the sphincter has not been achieved. For example, a post operative intervention using the Men After Prostate surgery (MAPS) protocol[113] found no significant difference in rates of incontinence at 12-months post RP between one-on-one formal (MAPS) training (76%) and usual care (77%) (Absolute risk difference [RD] -1.9%, 95% CI: -10-6)[88]. Such poor outcomes, together with other trials, have led authors of systematic reviews to question the role of PFM training[120]. Pooled data from these trials showed that there were no significant differences in continence status at the early (1 month – RR 1.21, 95% CI = 0.71-2.08,Œ p=0.48), interim (6 month – RR 0.98, 95%CI = 0.93-1.04, p=0.59) or late recovery stage (RR 0.93, 95%CI _0.93, 95%CI = 0.67-1.29, p=0.66)[120]. Both Dorey et al's MAPS trial[113] and the studies evaluated in Wang et al's meta-analysis[120] failed to utilise progressive resistance with their exercise program, although this is a construct that is required to induce hypertrophy of muscles. This may explain why outcomes were poor in these trials and highlights the need to introduce an alternate form of exercise more conducive to facilitating hypertrophic change. Together these data suggest that physiotherapy-led training for pelvic floor muscles (with a urethral more than anal bias) should be revised.

There is some preliminary evidence that muscle-training protocols can induce hypertrophy of the sphincter. For example, a recent study by Ocampo-Trujilloa et al (2014) demonstrated that pre-operative pelvic floor muscle training induced both histologic evidence of hypertrophy and increased cross sectional area measurements of the pelvic floor muscles[195]. While this preliminary finding has demonstrated that hypertrophy of the external sphincter muscle is possible with training, to date it is unknown whether this hypertrophy is associated with improved continence outcomes.

Progressive resistance exercise (PRE) has demonstrated muscle hypertrophy in other conditions and has been described from the 1950's as a way to develop skeletal muscle fibres.[110] A more recent systematic review of PRE demonstrated moderate to large effect sizes (lower limit of the 95% CI = 0.6-1.28) of patients global assessment of effect on hip and knee OA symptoms[158]. If PRE has been shown to facilitate a change in patients functional capacity, then such effects in other conditions should logically predict a similar effect in men with prostate cancer.

Progressive resistance loading is difficult to induce on the rhabdosphincter, however one loading mechanism that has been proposed is utilizing intra-abdominal pressure (IAP) as a means of resistance. Following RP, the rhabdosphincter is often observed to fail during periods of suddenly increasing IAP[159], such as a cough or a sneeze, resulting in a stress urinary incontinence incident. IAP can therefore be viewed as a loading force on the sphincteric mechanism. If the sphincter is voluntarily contracted, an inspiratory breath taken and then a breath hold/valsalva manoeuvre performed, IAP will be increased. If continence is maintained, then the sphincter can be viewed as being challenged at a level above that which would have been experienced during a voluntary isometric pelvic floor muscle contraction. This process is proposed to be incorporated into a periodised progressive resistance-training program.

However, in order to evaluate whether hypertrophy has occurred at the rhabdosphincter as a result of this progressive resistance training, it is necessary to evaluate this change. Several methods utilising RTUS have shown to be valid and reliable means to measure muscle cross sectional area in the trunk and abdominal muscles[157] and both internal trans-urethral and 3D trans-rectal RTUS and external trans-abdominal and trans-perineal RTUS have been effectively utilised to evaluate pelvic floor muscular anatomy[58, 59,131,147]. With the advent of improved scanning technology over the last 10 years the newer 3D trans-rectal RTUS scans offer a more detailed 3D view of the rhabdospincter[58]. It should therefore be possible to utilise this trans-rectal 3D RTUS as a good method to evaluate whether volumatic changes have occurred in the pelvic floor muscles as a result of progressive IAP resistance training.

Notwithstanding the above, hypertrophy programmes should logically be prescribed following early motor control training. This approach is seen commonly in athletic training where a motor skill is taught slowly with low impact initially, then speed and power are developed subsequently[110]. Early motor control training of the external sphincter would be achieved by selectively biasing the muscles that are more mechanically suited to generating urethral closure pressures[145]. It has been noted that rhabdosphincter (skeletal EUS) muscle fibres are observed to contract effectively when a ‘penile shortening’ verbal cue is given[108]. Further more, the prior work in Chapter 1 of this thesis has demonstrated that early pelvic floor motor training seems to be acquired faster when delivered pre-operatively. It is argued therefore that these factors should precede the hypertrophy training when designing an optimal pelvic floor training program post RP.

There are other extraneous factors that may also have a bearing on continence post RP. To date these factors have been demonstrated as age, BMI, experience of surgeon, pre-existing continence or erectile dysfunction issues, prostatic size/weight and blood loss during surgery[71, 160-162]. Finally, motor learning has shown to be compromised in the presence of stress and anxiety[139]. Given this, such factors should be considered as confounders when explaining continence outcomes.

In summary, it is proposed that an optimal pelvic floor rehabilitation program to be utilised by men following RP for localised prostate cancer should comprise all of the elements outlined above. It should commence with a pre-operative motor control training program to develop a keener sense of the muscles more intimately associated with biomechanically generating urethral closure pressure. This should then be followed by implementation of a progressively demanding training program utilising IAP as a form of internal pelvic floor muscle resistance.

Accordingly, the aim of this study therefore is to evaluate whether targeted motor control training followed by a progressive IAP hypertrophy program for men following radical prostatectomy improves continence outcomes compared with standard pelvic floor training protocols. Secondary aims are to evaluate whether this programme results in hypertrophy of the sphincter compared with the standard programme.

4.2 Methods

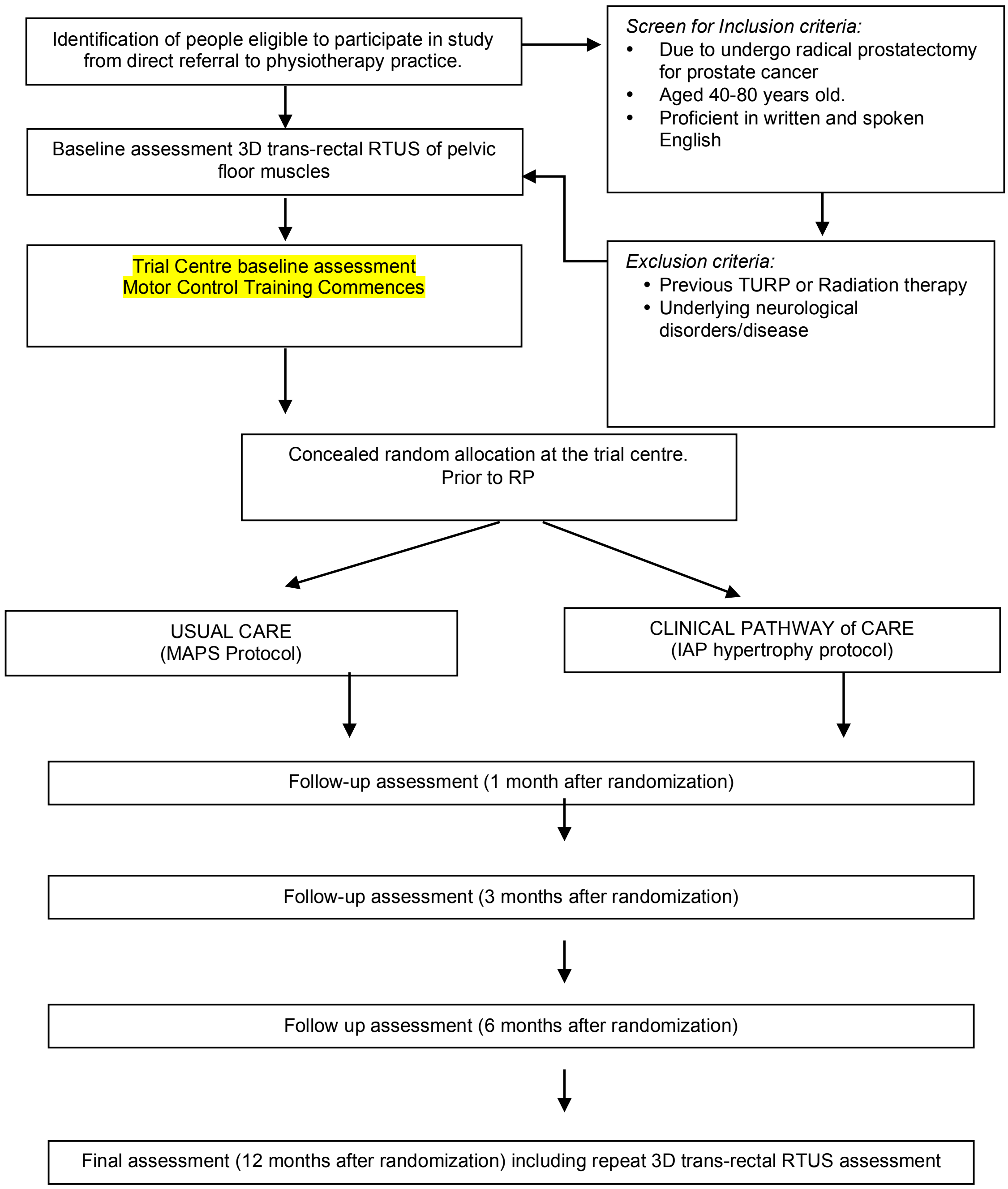
4.2.1 Participants

Participants will be men recently diagnosed with clinically localised prostate cancer aged from 40 to 80 years, who have elected to undergo radical prostatectomy (RP). Participants will be recruited from a physiotherapy clinic specialising in male pelvic floor muscle training. Exclusion criteria are non-English speaking, men with pre-existing neurological disorders, pre-operatively existing SUI and men who have had prior TURP and/or radiation therapy.

Participants will be recruited by an advertisement in the practice. All potential participants will be provided with the participant information statement and consent form. After consenting to enter the study, participants will be randomly allocated to either the standard (MAPS intervention) therapy (Group A – discussed later) or progressive IAP training program (Group B).

Randomisation will be achieved by random number generator allocation to group and the patients will be blinded to group allocation. The proposed flow of participants throughout the trial is given in Figure 4.1.

Figure 4.1 Proposed RCT Study design



4.2.2 Baseline data

Demographic data to be collected will include age, BMI, occupation, surgeon performing the procedure, and marital status. Patients will also document their time from initial assessment to surgery.

Baseline questionnaires completed will include the Calgary Symptoms of Stress Inventory (C-SOSI). A 2007 study showed it to have excellent Cronbach's alpha reliabilities for its subscales (range from 0.80 to 0.95) and concluded that is a reliable tool with converging validity for assessing stress symptoms in an oncology population[163].

The International Consultation on Incontinence Questionnaire (ICIQ) and International Index of Erectile function (IIEF) questionnaires will be used to evaluate pre operative urinary and sexual function. The ICIQ has been shown to have good reliability with moderate to very good stability in test retest analysis and a Cronbach's alpha of 0.95[73]. The IIEF has also been well evaluated by Rosen (1997) who reported a high degree of sensitivity and specificity to the effects of treatment. It was also shown to have high internal consistency with a Cronbach's alpha of 0.91[166].

The consultant urologist prior to therapy referral will complete pre-operative urological assessment. This will comprise an initial trans-rectal 3D RTUS evaluation of their external urethral sphincter muscle (as per Strasser et al (2004)[58]) which will be performed at the time of their biopsy. Sphincteric muscular cross section/volume measurements will be taken of the external urethral sphincter.

4.2.3 Interventions

All men will be taught pelvic floor motor training using RTUS as a form of biofeedback pre-operatively as per the protocol outlined (Chapter 2; Doorbar-Baptist et al 2015). Men will then be randomly allocated to either Usual care or Intervention Groups. The intervention tested is a novel IAP hypertrophy program whilst usual care is a standard care pelvic floor rehabilitation (MAPS[113]) .

The initial pre-operative pelvic floor motor control training will consist of 2 physiotherapy sessions. At the first session, participants will be taught low MVC pelvic floor contractions using RTUS for biofeedback, as per the previous protocol (Chapter 2: Doorbar-Baptist 2015). Each contraction will be encouraged to be a targeted lift, followed by three respiratory efforts whilst sustaining the lift and then a let go /relaxation phase. Anterior cues will include ‘shortening the penis.’ Mid zone cues will include ‘lifting the testicular sac’ and posterior cues will include ‘anal indrawing’ Participants will be encouraged to perform these exercises for 10 mins 4 times a day at home every day for 7-10 days. At the second physiotherapy session, there will be a re-evaluation of motor learning outcomes via RTUS and if skill acquisition has been sustained (score of >6/9 on the previously noted Likert scale) they will continue with motor training pre-operatively.

4.2.4 Immediate post-operative rehabilitation protocol

Immediately post operatively patients will be instructed to not perform any pelvic floor muscle exercise with the catheter in situ. They will be encouraged to resume light motor training gently once the catheter is removed at 6-10 days post-operatively and continue with light motor training for 2 further weeks. This is to allow time for natural healing to occur within the traumatised sphincteric muscles prior to the commencement of hypertrophy training.

4.2.5 Group A: Usual Care/Standard Intervention Program

Patients randomised to usual care will receive motor control training followed by the standard MAPS protocol[113]. The initial motor control training will be the same as for the intervention group. The standard MAPS protocol will commence two weeks post catheter removal and will consist of an initial single intervention to explain the daily home exercise protocol, followed by fortnightly reviews to check for patient compliance and quality of exercise.

The MAPS protocol consists of a total of 18 contractions per/day broken down as below:

- 2 sets of 3 maximal contractions each lasting 10 seconds in lying
- 2 sets of 3 maximal contractions each lasting 10 seconds in sitting
- 2 sets of 3 maximal contractions each lasting 10 seconds in standing

plus 50% Maximum Voluntary Contraction (MVC) effort sustained during walking

Patient reviews will be performed in the clinic fortnightly and trans-abdominal RTUS scanning will be used as a biofeedback tool during this time. RTUS should show a bladder base lift that is sustained for a period of 10 seconds.

4.2.6 Group B: Novel IAP hypertrophy program

Participants in the intervention group will undergo a novel IAP hypertrophy programme consisting of initial pelvic floor motor training followed by a periodised hypertrophy program. Again, note the IAP hypertrophy program will not commence until 2 weeks post catheter removal.

Once commenced, the periodised hypertrophy programme will be performed on alternate days (e.g. Mon/Wed/Fri only) to give adequate rest and recovery to the targeted training muscles. The programme will progress through minimal to maximal Valsalva manoeuvres as the means to increase resistance. Increased IAP/valsalva pressure will be achieved by increasing the size of the inspiratory effort – (i.e. one third of total lung capacity as an inspiratory effort will be considered enough to generate a minimal valsalva pressure, two thirds of total lung capacity inspiratory effort will generate a moderate valsalva pressure and a full inspiratory effort will create a maximal valsalva pressure). The exact degree of inspiratory volume can be ascertained by using simple handheld spirometry which will be supplied to the patient.

The proposed training programme is outlined in Table 4.1 below.

Table 4.1: Outline of the proposed IAP hypertrophy programme.

Week #	***Day***	***Reps x Sets***	***Level of Valsalva***
1	Monday	8 x 4	Min
	Wednesday	8 x 4	Min
	Friday	10 x 4	Min
2	Monday	10 x 4	Min
	Wednesday	12 x 4	Min
	Friday	12 x 4	Min
3	Monday	8 x 4	Mod
	Wednesday	8 x 4	Mod
	Friday	10 x 4	Mod
4	Monday	10 x 4	Mod
	Wednesday	12 x 4	Mod
	Friday	12 x 4	Mod
5	Monday	8 x 4	Max
	Wednesday	8 x 4	Max
	Friday	10 x 4	Max
6	Monday	10 x 4	Max
	Wednesday	12 x 4	Max
	Friday	12 x 4	Max

At the first session the patient will be lying in a crook lying position with their abdominal region exposed and Trans-abdominal RTUS applied as per our previous protocol (Chapter 2: Doorbar-Baptist 2015).

The patient will be given anterior and mid zone cues in order to perform strong (100% MVC) targeted pelvic floor contractions sufficient to cause a rise in bladder base on the RTUS screen. This will be sustained whilst a slow steady inspiratory effort is made. Closure of the glottis will be encouraged once 1/3 inspiratory lung volume has been achieved to ensure IAP is increased. During this period of time there should be no caudad deflection of the bladder base on RTUS screen as the pelvic floor muscles are encouraged to continue to function voluntarily. It is important to advise the patient to cease this training should they note increasing incontinence as a result of this extra pressure. The key with this form of training is to expose the patient to a force where the sphincter is successful at withstanding increasing IAP changes. This force therefore increases the demands on muscles preventing incontinence.

Once the patient has sufficiently mastered this sensation they will be sent home to perform this program as per the table above. Patients will be reviewed every 2 weeks to progress to the next valsalva level under RTUS biofeedback.

4.3 Outcomes

Outcomes will be assessed at 1,3,6 and 12 months after surgery. The primary outcome measure will be 24-hour pad weight at 12 months. Secondary outcome measures will be self reported incontinence and sphincteric muscle volumes.

24-hour pad weight will be obtained by recording the wet weight of all pads used during a 24-hour period, then subtracting off the combined dry weight of the number of pads used in that period. It has been shown to have excellent validity and reliability in the assessment of male continence[76].

The International Consultation on Incontinence Questionnaire (ICIQ) will assess self-reported incontinence. As has been previously stated this is a very simple, valid and reliable method for evaluation of urinary incontinence[73].

Sphincteric muscle volumes will be evaluated at 12-months post RP by 3D trans-rectal RTUS. The data will be compared to the pre-operative muscle volume to evaluate for signs of initial loss of volume and changes with exposure to IAP training.

4.4 Statistical analysis

The primary and secondary outcomes will be analysed independently, using cross-sectional analyses, at 12 weeks, 6, and 12 months post-intervention using generalised linear models methods, with an appropriate link function, to test for an intervention effect adjusted for the baseline values. Effect sizes in terms of measure standard deviation units will be calculated for all measures with an effect size of 0.2 considered small, 0.5 medium and 0.8 large. Alpha will be set at 0.05. Dylewski et al (2007) report the standard deviation for the 24 hour pad weight test (24PWT) for incontinent males to be 464 grams[167], so a medium effect size would correspond to a difference between groups of 232 grams on the 24PWT. If there is a statistically significant treatment effect, we will also calculate number needed to treat (NNT) to achieve a significant effect in terms of change in 24-hour pad weight.

4.4.1 Sample size

With the outcome being change in 24-hour pad weight pre-post, based on detecting a medium effect size of 232grams pad weight, with a power of .80 and an alpha rate of 0.05, the required number of participants is calculated as 32 per group (Cohen (1992))[138].

4.5 Discussion

Prostate cancer is a highly prevalent cancer and its post-operative incontinence is a costly burden to Australia. There is a need to evaluate new and novel ways to improve pelvic floor training in men, given the poor effects with post-operative training seen to date. The method of utilising progressive resistance training following accurate motor control training is novel and is hypothesised to improve continence outcomes for men post prostatectomy. This proposed trial has a number of significant benefits, as it will highlight whether motor training and progressive IAP hypertrophic training can optimise physiological change within the male continence mechanism. It will also contribute to the knowledge as to whether this improved strategy of male pelvic floor training can lead to improved continence outcomes if commenced pre operatively.

It is important to note however that hypertrophy training requires loading of muscles to a certain percentage of MVC. Prior to the implementation of this study work must be done to develop understanding of the percentage activation of the pelvic floor muscles which is achieved/required with the tasks selected for providing resistance with intra-abdominal pressure changes.

The outcomes of this study will potentially have a dramatic impact as to whether physiotherapy should be advocated pre-operatively by urological surgeons and may also influence the time needed between diagnosis of prostate cancer and surgery itself in order to instigate training and optimise patient quality of life outcomes.

CHAPTER 5: Clinical Relevance and Future Research

5.1 Overview of Findings

This study has documented an outcome measure that can be reliably utilised to document a patient's ability to activate their pelvic floor muscles. The reliability is greater when assessed by physiotherapists experienced in RTUS use. The data also shows that pelvic floor muscle training in men is more successful and time/cost efficient if delivered pre-operatively. This study therefore adds to the existing literature by establishing a reliable and clinically pragmatic way to assess the male pelvic floor using trans-abdominal real-time ultrasound.

Future studies should establish how this new protocol compares to a trans-perineal protocol when evaluating construct validity. Furthermore, it remains to be determined whether utilising this protocol on its own or when added to other endurance and strength regimens, improves continence outcomes for men post-prostatectomy.

5.2 Clinical Implications

An outcome measure using trans-abdominal RTUS has been designed to evaluate early motor control of the male pelvic floor. The protocol was developed and shown to be reliable when used by experienced therapists.

This study suggested a need for postgraduate physiotherapists to develop their experience in RTUS use and to undergo additional training in order to reliably interpret trans-abdominal RTUS screen images of the male pelvic floor. These observations compare to those of Hides et al (2007), where physiotherapists with less training also had lower reliability when evaluating transversus abdominus images with RTUS, (ICC (3,4) = 0.44)[153]. Similarly, Orrom et al (1990) in their study using ultrasound to evaluate rectal cancer reported an improvement in diagnostic accuracy from 74% to 86% with increasing experience[168]. Further, a study by Hoy et al (1992) also concluded that, due to the significant presence of false positive tests, assessment of shoulder rotator cuff pathology by inexperienced sonographers was of little, if any, diagnostic value[169]. This present study appears to support the need for training and experience in RTUS use to improve reliability when assessing the male pelvic floor.

This study demonstrated the lift phase was more reliably evaluated than the sustain and drop phases. During voluntary male pelvic floor muscle activation, the lift phase (initial muscle recruitment phase) was reliably detected by both experienced and novice therapists. In contrast, it was observed that the sustain and drop phases, (maintaining pelvic floor activation during normal respiratory activity and relaxing after contraction), were less reliable markers of motor control, and are therefore of questionable clinical use to evaluate pelvic floor function. Given this, the lift phase is recommended to be used by clinicians as the most reliable component of the assessment protocol. Further studies may however wish to investigate whether the sustain and drop phases provide more important clinical information.

The reliability of verbal cues to more specifically recruit more anterior muscles within the pelvic floor has been well documented[108, 145]. It is argued that the more anterior pelvic floor muscles are biomechanically better suited to generating urethral closure pressure than the posterior levator ani muscles[108]. This study highlighted that a posterior (anal indrawing) cue was the most reliably visualised on RTUS by physiotherapists. However, caution is needed before interpreting this as an indication to encourage development of the more posterior muscles during training. The motor pattern of anal indrawing may just be a more familiar action in men and as such is more easily visualised on trans-abdominal RTUS. The subtler motion observed on trans-perineal RTUS during prompting with penile shortening cues may be more important to teach and to strive for when localising the muscles more involved with improving continence post prostatectomy. It is suggested here that future work therefore investigates the reliability of the more anterior cues proposed by Stafford et al as those needed to generate urethral closure pressure.

The present study also highlights the benefits of pre-operative physiotherapy assessment and treatment for men awaiting surgery for prostate cancer.

Efficient learning has been shown to be compromised in the presence of stress, and incontinence has been shown to be a significant stressor in QOL studies post operatively[30]. Pre-operative training may potentially reduce the cost of overall therapy intervention as motor learning was shown to occur more rapidly in the pre-operative group indicating a need for fewer overall therapy sessions. Despite the finding that motor training appears to be more successfully implemented pre-operatively (Chapter 2: Doorbar-Baptist 2015) and a systematic review which indicates that there is benefit to pre-operative physiotherapy[170], men are often not routinely referred to physiotherapists preoperatively[171]. Our study suggests that there would be a benefit if this were the case and the current data adds to the body of evidence to be considered by consultant Urologists in the management of their patients.

The study reported here was able to identify that pre operative high BMI and pre-operative PFM training were collectively useful in predicting the outcome of skill acquisition. The identification of high BMI as a negative feature highlights a need for urologists and general practitioners to instigate both weight management programs and pelvic floor training programs as early as possible following diagnosis of prostate cancer. To date however, it is unknown whether this motor skill acquisition correlates with post-operative continence outcomes. This would be a further interesting future study topic.

5.2.1 Establishing further predictors of male SUI

This study established two predictors of faster motor skill acquisition, namely pre-operative motor training and lower BMI, it is acknowledged that there may be additional factors that may predict motor skill acquisition in men with prostate cancer, which therefore may be associated with male stress urinary incontinence. Such factors may include pre-existing low back pain and/or sacroiliac joint dysfunction, respiratory dysfunction and gastrointestinal issues.

In relation to this, in removing the prostate, surgical trauma occurs during RP to the internal endopelvic fascia[51]. A reduction in endopelvic fascial tension may possibly have an effect on SIJ stability[172] and it may be hypothesised that such trauma could potentially reduce the stability of the sacroiliac joint complex. Lee et al (2004)[173] hypothesised that incontinence may be due to laxity causing failed load transfer though the pelvis. Concurrently, Huri et al (2014) documented a recent fascial sparing approach to radical prostatectomy. Their approach demonstrated improved potency outcomes, as well as sparing more endopelvic fascia to continue to stabilise the bladder base[196]. Similarly Ashton-Miller et al (2001) report that bladder neck stabilisation may be compromised if the endopelvic fascial support system is stretched or damaged[174]. Taken together, these studies suggest that the endopelvic fascia plays an important role in support of the bladder base and also assists in SIJ stability. It may therefore be worth looking at the incidence of SIJ symptoms/dysfunction in patients with persistent SUI post-prostatectomy, to determine if this is related to SUI.

It may also be useful to evaluate whether there is a correlation between posture and continence post RP. In the clinic we often observe improvements in continence, especially towards the end of the day, with a targeted attention to improving global posture over time. Dorey et al (2009) encourages a low-grade awareness of pelvic floor function during extended functional activities to improve PFM endurance capacity[113], whereas other studies report maximal effort contractions sustained for longer periods e.g. 6-7 seconds[90], 6-8 seconds[175], 10 seconds[91] and even up to 30 secs[89]. Again, as with our argument regarding strength training, one must question whether PFM endurance is actually targeted with these training interventions. It may need to be considered that, if a correlation between pre-operative postural presentation and post operative continence outcomes can be shown, that a functional postural rehabilitation program such as Pilates[118] or some other form of global postural re-education[117] may have a more effective role at improving the pelvic floors postural tone/endurance of the male pelvic floor, thereby optimising post-prostatectomy recovery.

The forgoing consideration implies that future studies investigating predictors of male SUI and/or male pelvic floor control post RP should not only investigate whether training was given pre operatively or not and investigate the role of BMI, but also consider other factors such as the incidence of LBP/SIJ dysfunction and pre-operative postural presentation on post-operative continence outcomes.

5.3 Directions for Future Research

There is a need to evaluate which RTUS approach is optimal for retraining the male pelvic floor. To date both the trans-abdominal approach and the trans-perineal approach have been described, however as yet, they have not been directly compared in relation to their efficacy in producing improved continence outcomes for men following RP.

5.3.1 Trans-Abdominal and Trans-Perineal RTUS approaches

There are two main approaches utilised when performing RTUS scans of the male pelvic floor; trans-abdominal and trans-perineal. Thus far, only one study has compared the two approaches for intra-rater reliability finding that the percentage agreement between approaches was excellent (85% during contraction and 100% during valsalva)[95]. This study however only utilised one experienced sonographer and so did not evaluate inter-rater reliability. It was also a female only population study. It may therefore be beneficial to look at comparative studies of both scanning strategies to compare their relative reliability in men.

One possible advantage of trans-abdominal scanning is that it can be considered that the patient more easily tolerates it, as it is less invasive.

Furthermore, the reliability of this method has been established in this thesis (Chapter 3) and by other authors (Sherburn et al 2005). For example Sherburn et al (2005) showed that the ICC for within session inter-rater reliability ranged between 0.86 and 0.88 (95% CI 0.68-0.97) and inter session intra rater reliability ranged between 0.81 and 0.89 (95%CI .051-0.96)[84]. Given both the potential clinical tolerance and established reliably, it could be argued that trans-abdominal scanning should be the preferred method to retrain the male pelvic floor.

Alternatively, trans-perineal scanning would appear to have an advantage in that the individual muscles within the pelvic floor can be clearly identified[56] and their relative contribution to continence may be able to be evaluated in future studies. This contrasts with trans-abdominal RTUS images, which is able to reliably evaluate whether a pelvic floor muscle contraction (bladder base rise) has occurred or whether increasing IAP/valsalva has occurred (bladder base drop)[95] but is not able to identify specifically which muscle is predominately responsible for the bladder base motion.

Trans-perineal RTUS has also been shown to be a reliable measurement tool for the male pelvic floor. Roll et al (2015) report intra-rater reliability coefficients ranging from 0.50 – 0.98 when evaluating specific anatomical pelvic floor structures[176]. Hence the counter argument to trans-abdominal RTUS is that trans-perineal is potentially more accurate as the muscle identified for training (namely the EUS skeletal fibres) can be directly imaged.

Given the equal reliability, trans-perineal scanning may be the method that is used more frequently in the future.

The decision as to the preferred method can only really be made if both methods are compared and related to continence outcomes. Both methods have not yet been correlated with pelvic floor strength and or continence outcomes. In addition, future studies should also compare patient satisfaction using both scanning techniques to determine if one method is more satisfactory. Such a study may inform the debate on the preferred method.

5.3.2 Relationship of pelvic floor training protocols with continence outcomes

There is also a need to establish whether accurate isolation of pelvic floor muscle activation pre operatively assists in improving continence outcomes post radical prostatectomy. As previously discussed, there have been studies that have evaluated pre-operative training[89, 91-93, 104, 119, 120], however none of these protocols have focussed on accurate motor learning as a pre-requisite prior to commencing strength or endurance training. It is argued that as a result of this, the continence outcomes in these strengthening studies[88, 90-92, 103, 118, 119] have been varied.

Notwithstanding, it is unlikely that motor training alone will result in adequate strength gains for the pelvic floor muscles. Strength gains necessitate the addition of resistance to the muscles in contrast to motor learning where high volume, low MVC contractions are needed. All protocols of pelvic floor training within the literature pertaining to men [88, 90-92, 103, 118, 119] rely on maximal effort contractions to develop strength. Despite this, none of these studies offer, or report, a means of resistance in order to achieve strengthening. This leads to the question as to whether hypertrophy is ever achieved.

One way to offer resistance to the pelvic floor is to progressively increase intra-abdominal pressure challenges (i.e. using valsalva pressures as a resistance tool. It is theoretically possible to observe the lift phase, add in a valsalva pressure and incrementally increase the IAP until the bladder base is seen to descend. This would be considered the 'failure point' for the pelvic floor to continue sustaining its upward moment and could thereby be utilised to ensure exercise at the edge of physical capacity. It is argued here that this level of resistance would be necessary to stress the muscle enough to cause hypertrophic change.

In Chapter 4, the protocol for a randomised controlled trial is proposed to evaluate the effect of such a programme on continence outcomes as well as to determine the presence of hypertrophic change

5.3.3 *Relationship of pelvic floor training protocols with erectile dysfunction*

Erectile dysfunction is a commonly reported side effect following RP, and has been reported to be observed in 70-75% of men following surgery[177]. In order to improve quality of life scores post RP, it may be necessary therefore attend to the issue of both continence and erectile function. A previous RCT by Dorey et al (2004) for non-cancerous men suffering erectile dysfunction noted a significant benefit in erectile function with pelvic floor training. Although most erectile dysfunction occurs due to neurological trauma during the surgical process of prostatic excision, there may be potential to improve outcomes utilising pelvic floor muscle training. Through the mechanical orientation of its fibres, bulbocavernosus may be suited to functioning as having a both a pumping effect to increase penile blood flow and also as a tourniquet compressing the dorsal vein of the penis and sustaining erectile function. Future studies therefore should assess erectile dysfunction outcomes with pelvic floor training for men following radical prostatectomy.

5.3.4 A proposed sub-classification System of Incontinence in men post-prostatectomy

As is the case with other musculoskeletal disorders, it is proposed here that a sub-classification system may arise out of future research, which identifies different types of incontinence and different responders to pelvic floor training regimens. For example, in non-specific low back pain, O'Sullivan et al[178] have identified different types of impairments that can occur with back muscles. These were sub-classified into different motor control impairments. Subsequent work then identified that when treated according to the specific sub-classification, health outcomes improved (Fersum et al[179]), compared with when the group was treated homogeneously. Similarly, it is proposed that a sub-classification system may arise for males with pelvic floor dysfunction.

One such sub-classification system may be to identify males based on the type of incontinence observed. In the authors' experience, it is observed clinically that patients' post-prostatectomy appears to have four different types of incontinence issues. These four observed incontinence types are:

1) Patients who have had larger surgical resections and leak heavily even at rest (heavy incontinence),

2) Patients who have intermittent stress type urinary incontinence (Intermittent incontinence),

3) Patients who tend to note leaking mainly towards the end of the day (light incontinence), and

4) Patients who suffer with bladder irritability post operatively and have incontinence predominately associated with urinary urgency.

Patients with heavy incontinence appear to have significantly weaker pelvic floor muscles due to traumatic muscular and neurological damage post surgery. Such men would more likely benefit from both an accurate motor control exercise program to target the more traumatised striated urethral sphincter muscle, followed by a progressive strength program.

Patients with intermittent incontinence, who suffer stress urinary leakage but don't lose frank bladder control, appear to have a delay in muscle activation. It is proposed that this group would more likely benefit from accurate motor training followed by faster speed rapid muscle activation strategies followed by a functional 'knack' based program where voluntary pelvic floor muscle activation is encouraged just prior to activities that usually result in an incontinence episode.

Finally, patients with light incontinence, who tend to leak more towards the end of the day, appear to be suffering from an endurance based issue. Logically these men would more likely benefit from combined bladder training and postural rehabilitation to improve the ability of the pelvic floor muscles to function over more sustained periods.

This classification-based approach to pelvic floor rehabilitation post prostatectomy is one that could be considered as a future avenue for study.

5.4 Concluding Remarks

Pelvic floor training is considered a first line intervention for women with SUI post childbirth. In contrast, the evidence for pelvic floor training in men post prostatectomy is poor, leading to this approach not currently being recommended for men in this situation. This apparent paradox led to the work undertaken for this thesis, with the primary line of enquiry being to consider how training of the male pelvic floor may have to be changed in order to improve outcomes.

As a result, findings here have indicated that it may be worthwhile to re-evaluate pelvic floor training for men post prostatectomy and commence training with a bias towards preoperative motor training. Theoretically this would allow targeting and isolation of the more anterior pelvic floor muscles, which are more biomechanically suited to achieve increasing urethral closure pressures. Furthermore, trans-abdominal RTUS was shown to be of benefit in objectifying whether early motor control has been achieved and it was found that it could be reliably utilised by experienced physiotherapists.

In addition, this thesis has proposed that evaluation of continence and erectile dysfunction outcomes in future studies is important. Further, a protocol where training progresses from early motor training of the male pelvic floor into effective strength/hypertrophy and endurance protocols. Conducting this work should result in determining whether this approach can assist in improving quality of life following radical prostatectomy.

Future evaluation of a classification-based treatment approach should be considered in the effective management of incontinence following radical prostatectomy. The outcomes of future cohort studies will show whether classifying incontinence and developing more patient-specific clinical pathways for management improve physiotherapy management of the incontinent male post radical prostatectomy.

REFERENCES:

1. Shackley D. A century of prostatic surgery. *BJU international* 1999; **83**(7): 776-82.
2. Nahon I, Waddington G, Dorey G, Adams R. The history of urologic surgery: from reeds to robotics. *Urologic nursing* 2011; **31**(3): 173-80.
3. Murphy L. A history of urology. . Springfield, IL: Charles C Thomas.; 1972
4. Crawford ED. Epidemiology of prostate cancer. *Urology* 2003; **62**(6 Suppl 1): 3-12.
5. Howlader N NA, Krapcho M, Garshell J, Miller D, Altekruse SF, Kosary CL, Yu M, Ruhl J, Tatalovich Z,Mariotto A, Lewis DR, Chen HS, Feuer EJ, Cronin KA (eds). . SEER Cancer Statistics Review, 1975-2012, National Cancer Institute. Bethesda, MD. 2015.
6. (AIHW) AIoHaW. Australian Cancer Incidence and Mortality (ACIM) books. Canberra: Australian Government; 2015.
7. Gordon LG RS, Mervin C. . The Financial Impact of Prostate Cancer in Australia. Final Report In: Centre for Applied Health Economics GHI, Griffith University. , editor. Meadowbrook Queensland.; 2013. .
8. Searles AaD, C. ECONOMISTS UNCOVERING THE COST OF PROSTATE CANCER. 2013. https://hmri.org.au/2013/02/economists-uncovering-the-cost-of-prostate-cancer/.
9. Heidenreich A, Bastian PJ, Bellmunt J, et al. EAU guidelines on prostate cancer. part 1: screening, diagnosis, and local treatment with curative intent-update 2013. *European urology* 2014; **65**(1): 124-37.
10. Lilja H, Ulmert D, Vickers AJ. Prostate-specific antigen and prostate cancer: prediction, detection and monitoring. *Nature reviews Cancer* 2008; **8**(4): 268-78.
11. Rajaei M, Momeni A, Kheiri S, Ghaheri H. Effect of ejaculation on serum prostate specific antigen level in screening and non-screening population. *Journal of research in medical sciences : the official journal of Isfahan University of Medical Sciences* 2013; **18**(5): 387-90.
12. Brawer MK. Prostate-specific antigen: current status. *CA: a cancer journal for clinicians* 1999; **49**(5): 264-81.
13. Carter HB, Pearson JD, Metter EJ, et al. Longitudinal evaluation of prostate-specific antigen levels in men with and without prostate disease. *Jama* 1992; **267**(16): 2215-20.
14. Crawford ED, Leewansangtong S, Goktas S, Holthaus K, Baier M. Efficiency of prostate-specific antigen and digital rectal examination in screening, using 4.0 ng/ml and age-specific reference range as a cutoff for abnormal values. *The Prostate* 1999; **38**(4): 296-302.
15. de Rooij M, Hamoen EH, Futterer JJ, Barentsz JO, Rovers MM. Accuracy of multiparametric MRI for prostate cancer detection: a meta-analysis. *AJR American journal of roentgenology* 2014; **202**(2): 343-51.

16. Hambrock T, Hoeks C, Hulsbergen-van de Kaa C, et al. Prospective assessment of prostate cancer aggressiveness using 3-T diffusion-weighted magnetic resonance imaging-guided biopsies versus a systematic 10-core transrectal ultrasound prostate biopsy cohort. *European urology* 2012; **61**(1): 177-84.
17. Thompson JE, Moses D, Shnier R, et al. Multiparametric magnetic resonance imaging guided diagnostic biopsy detects significant prostate cancer and could reduce unnecessary biopsies and over detection: a prospective study. *The Journal of urology* 2014; **192**(1): 67-74.
18. Epstein JI, Allsbrook WC, Jr., Amin MB, Egevad LL, Committee IG. The 2005 International Society of Urological Pathology (ISUP) Consensus Conference on Gleason Grading of Prostatic Carcinoma. *The American journal of surgical pathology* 2005; **29**(9): 1228-42.
19. Schroder FH, Hermanek P, Denis L, Fair WR, Gospodarowicz MK, Pavone-Macaluso M. The TNM classification of prostate cancer. *The Prostate Supplement* 1992; **4**: 129-38.
20. Edge SB, Compton CC. The American Joint Committee on Cancer: the 7th edition of the AJCC cancer staging manual and the future of TNM. *Annals of surgical oncology* 2010; **17**(6): 1471-4.
21. Scher HI, Kelly WM, Zhang ZF, et al. Post-therapy serum prostate-specific antigen level and survival in patients with androgen-independent prostate cancer. *Journal of the National Cancer Institute* 1999; **91**(3): 244-51.
22. Loeb S, Bruinsma SM, Nicholson J, et al. Active surveillance for prostate cancer: a systematic review of clinicopathologic variables and biomarkers for risk stratification. *European urology* 2015; **67**(4): 619-26.
23. Loeb S, Folkvaljon Y, Makarov DV, Bratt O, Bill-Axelson A, Stattin P. Five-year nationwide follow-up study of active surveillance for prostate cancer. *European urology* 2015; **67**(2): 233-8.
24. Zargar H, Giannarini G, Loeb S, Dasgupta P, Murphy DG, Ficarra V. Active surveillance in prostate cancer: a critical review. *Minerva urologica e nefrologica = The Italian journal of urology and nephrology* 2015; **67**(3): 247-61.
25. Denmeade SR, Isaacs JT. A history of prostate cancer treatment. *Nature reviews Cancer* 2002; **2**(5): 389-96.
26. Chen AC, Petrylak DP. Complications of androgen deprivation therapy in men with prostate cancer. *Current oncology reports* 2004; **6**(3): 209-15.
27. Smith MR. Changes in body composition during hormonal therapy for prostate cancer. *Clinical prostate cancer* 2003; **2**(1): 18-21.
28. Sharifi N, Gulley JL, Dahut WL. Androgen deprivation therapy for prostate cancer. *Jama* 2005; **294**(2): 238-44.
29. Potters L, Morgenstern C, Calugaru E, et al. 12-year outcomes following permanent prostate brachytherapy in patients with clinically localized prostate cancer. *The Journal of urology* 2005; **173**(5): 1562-6.
30. Ferrer M, Guedea F, Suarez JF, et al. Quality of life impact of treatments for localized prostate cancer: cohort study with a 5 year follow-up. *Radiotherapy and oncology : journal of the European Society for Therapeutic Radiology and Oncology* 2013; **108**(2): 306-13.

31. Kibel AS, Ciezki JP, Klein EA, et al. Survival among men with clinically localized prostate cancer treated with radical prostatectomy or radiation therapy in the prostate specific antigen era. *The Journal of urology* 2012; **187**(4): 1259-65.
32. Pilepich MV, Krall JM, al-Sarraf M, et al. Androgen deprivation with radiation therapy compared with radiation therapy alone for locally advanced prostatic carcinoma: a randomized comparative trial of the Radiation Therapy Oncology Group. *Urology* 1995; **45**(4): 616-23.
33. Pilepich MV, Caplan R, Byhardt RW, et al. Phase III trial of androgen suppression using goserelin in unfavorable-prognosis carcinoma of the prostate treated with definitive radiotherapy: report of Radiation Therapy Oncology Group Protocol 85-31. *Journal of clinical oncology : official journal of the American Society of Clinical Oncology* 1997; **15**(3): 1013-21.
34. Lawton CA, Winter K, Byhardt R, et al. Androgen suppression plus radiation versus radiation alone for patients with D1 (pN+) adenocarcinoma of the prostate (results based on a national prospective randomized trial, RTOG 85-31). Radiation Therapy Oncology Group. *International journal of radiation oncology, biology, physics* 1997; **38**(5): 931-9.
35. Mason MD, Parulekar WR, Sydes MR, et al. Final Report of the Intergroup Randomized Study of Combined Androgen-Deprivation Therapy Plus Radiotherapy Versus Androgen-Deprivation Therapy Alone in Locally Advanced Prostate Cancer. *Journal of clinical oncology : official journal of the American Society of Clinical Oncology* 2015; **33**(19): 2143-50.
36. Sooriakumaran P, Nyberg T, Akre O, et al. Comparative effectiveness of radical prostatectomy and radiotherapy in prostate cancer: observational study of mortality outcomes. *Bmj* 2014; **348**: g1502.
37. Gil-Vernet JM. Prostate cancer: anatomical and surgical considerations. *British journal of urology* 1996; **78**(2): 161-8.
38. Ficarra V, Novara G, Mottrie A, Wilson TG, Zattoni F, Montorsi F. Reply to Michael Froehner and Manfred P. Wirth's letter to the editor re: Vincenzo Ficarra, Giacomo Novara, Raymond C. Rosen, et al. systematic review and meta-analysis of studies reporting urinary continence recovery after robot-assisted radical prostatectomy. Eur Urol 2012;62:405-17. *European urology* 2013; **63**(3): e39-40.
39. Alemozaffar M, Sanda M, Yecies D, Mucci LA, Stampfer MJ, Kenfield SA. Benchmarks for operative outcomes of robotic and open radical prostatectomy: results from the Health Professionals Follow-up Study. *European urology* 2015; **67**(3): 432-8.
40. Gautam G, Rocco B, Patel VR, Zorn KC. Posterior rhabdosphincter reconstruction during robot-assisted radical prostatectomy: critical analysis of techniques and outcomes. *Urology* 2010; **76**(3): 734-41.
41. Rocco B, Cozzi G, Spinelli MG, et al. Posterior musculofascial reconstruction after radical prostatectomy: a systematic review of the literature. *European urology* 2012; **62**(5): 779-90.
42. Ward JF, Slezak JM, Blute ML, Bergstralh EJ, Zincke H. Radical prostatectomy for clinically advanced (cT3) prostate cancer since the advent of prostate-specific antigen testing: 15-year outcome. *BJU international* 2005; **95**(6): 751-6.

43. Johansson E, Steineck G, Holmberg L, et al. Long-term quality-of-life outcomes after radical prostatectomy or watchful waiting: the Scandinavian Prostate Cancer Group-4 randomised trial. *Lancet Oncol* 2011; **12**(9): 891-9.
44. Network NCC. NCCN Guidelines for Patients: Prostate Cancer. 2015. http://www.nccn.org/patients/guidelines/prostate/index.html.
45. Fowler CJ, Griffiths D, de Groat WC. The neural control of micturition. *Nature reviews Neuroscience* 2008; **9**(6): 453-66.
46. Herschorn S. Female pelvic floor anatomy: the pelvic floor, supporting structures, and pelvic organs. *Rev Urol* 2004; **6 Suppl 5**: S2-S10.
47. Grewar H, McLean L. The integrated continence system: a manual therapy approach to the treatment of stress urinary incontinence. *Manual therapy* 2008; **13**(5): 375-86.
48. Menon M, Hemal AK, Team VIP. Vattikuti Institute prostatectomy: a technique of robotic radical prostatectomy: experience in more than 1000 cases. *Journal of endourology / Endourological Society* 2004; **18**(7): 611-9; discussion 9.
49. Menon M, Tewari A, Peabody J, Team VIP. Vattikuti Institute prostatectomy: technique. *The Journal of urology* 2003; **169**(6): 2289-92.
50. Wei JT, Dunn RL, Marcovich R, Montie JE, Sanda MG. Prospective assessment of patient reported urinary continence after radical prostatectomy. *The Journal of urology* 2000; **164**(3 Pt 1): 744-8.
51. Huri E. Novel anatomical identification of nerve-sparing radical prostatectomy: fascial-sparing radical prostatectomy. *Prostate international* 2014; **2**(1): 1-7.
52. Khanna RV, Bratslavsky, G., Stein, R.J. Surgical Techniques for Prostate Cancer: Springer New York; 2015.
53. Walsh PC. Patient-reported urinary continence and sexual function after anatomic radical prostatectomy. *The Journal of urology* 2000; **164**(1): 242.
54. de Groat WC, Fraser MO, Yoshiyama M, et al. Neural control of the urethra. *Scandinavian journal of urology and nephrology Supplementum* 2001; (207): 35-43; discussion 106-25.
55. Stafford, R. E., J. A. Ashton-Miller, C. E. Constantinou and P. W. Hodges (2012). Novel insight into the dynamics of male pelvic floor contractions through transperineal ultrasound imaging. J Urol **188**(4): 1224-1230.
56. Stafford RE A-MJ, Constantinou C, Hodges PW. A New Method to Quantify Male Pelvic Floor Displacement From 2D Transperineal Ultrasound Images. *Urology* 2013; **81**: 685-9.
57. Fraser MO, Chancellor MB. Neural control of the urethra and development of pharmacotherapy for stress urinary incontinence. *BJU international* 2003; **91**(8): 743-8.
58. Strasser H, Pinggera GM, Gozzi C, et al. Three-dimensional transrectal ultrasound of the male urethral rhabdosphincter. *World journal of urology* 2004; **22**(5): 335-8.
59. Strasser H, Frauscher F, Helweg G, Colleselli K, Reissigl A, Bartsch G. Transurethral ultrasound: evaluation of anatomy and function of the rhabdosphincter of the male urethra. *The Journal of urology* 1998; **159**(1): 100-4; discussion 4-5.

60. Shamliyan TA, Wyman JF, Ping R, Wilt TJ, Kane RL. Male urinary incontinence: prevalence, risk factors, and preventive interventions. *Rev Urol* 2009; **11**(3): 145-65.
61. Irwin DE, Kopp ZS, Agatep B, Milsom I, Abrams P. Worldwide prevalence estimates of lower urinary tract symptoms, overactive bladder, urinary incontinence and bladder outlet obstruction. *BJU international* 2011; **108**(7): 1132-8.
62. Avery JC ea. Identifying the quality of life effects of urinary incontinence with depression in an Australian population. *BMC Urology* 2013; **13**(11).
63. White AJ, Reeve BB, Chen RC, Stover AM, Irwin DE. Coexistence of urinary incontinence and major depressive disorder with health-related quality of life in older Americans with and without cancer. *Journal of cancer survivorship : research and practice* 2014; **8**(3): 497-507.
64. Nahon I, Dorey G, Waddington GS, Adams R. Perceptions of embarrassment for men with and without urinary incontinence. *Urologic nursing* 2009; **29**(3): 164-70.
65. Wilt TJ, MacDonald R, Rutks I, Shamliyan TA, Taylor BC, Kane RL. Systematic review: comparative effectiveness and harms of treatments for clinically localized prostate cancer. *Annals of internal medicine* 2008; **148**(6): 435-48.
66. Vale J. Erectile dysfunction following radical therapy for prostate cancer. *Radiotherapy and oncology : journal of the European Society for Therapeutic Radiology and Oncology* 2000; **57**(3): 301-5.
67. McCullough AR. Prevention and management of erectile dysfunction following radical prostatectomy. *The Urologic clinics of North America* 2001; **28**(3): 613-27.
68. Tomlinson J, Wright D. Impact of erectile dysfunction and its subsequent treatment with sildenafil: qualitative study. *Bmj* 2004; **328**(7447): 1037.
69. Skeldon SC ea. Striated Muscle in the Prostatic Apex: Does the Amount in Radical Prostatectomy Specimens Predict Postprostatectomy Urinary Incontinence? *Urology* 2014; **83**: 888-92.
70. Wolin KY LJ, Sutcliffe S, Andriole GL, Kibel AS. Risk of Urinary Incontinence Following Prostatectomy: The Role of Physical Activity and Obesity. *Journal of Urology* 2010; **183**(2): 629-33.
71. Coakley FV, Eberhardt S, Kattan MW, Wei DC, Scardino PT, Hricak H. Urinary continence after radical retropubic prostatectomy: relationship with membranous urethral length on preoperative endorectal magnetic resonance imaging. *The Journal of urology* 2002; **168**(3): 1032-5.
72. Begg CB, Riedel ER, Bach PB, et al. Variations in morbidity after radical prostatectomy. *The New England journal of medicine* 2002; **346**(15): 1138-44.
73. Avery K, Donovan J, Peters TJ, Shaw C, Gotoh M, Abrams P. ICIQ: a brief and robust measure for evaluating the symptoms and impact of urinary incontinence. *Neurourology and urodynamics* 2004; **23**(4): 322-30.

74. Lantz AG, Saltel ME, Cagiannos I. Renal and functional outcomes following cystectomy and neobladder reconstruction. *Canadian Urological Association journal = Journal de l'Association des urologues du Canada* 2010; **4**(5): 328-31.
75. Krhut J, Zachoval R, Smith PP, et al. Pad weight testing in the evaluation of urinary incontinence. *Neurourology and urodynamics* 2014; **33**(5): 507-10.
76. Twiss CO, Fischer MC, Nitti VW. Comparison between reduction in 24-hour pad weight, International Consultation on Incontinence-Short Form (ICIQ-SF) score, International Prostate Symptom Score (IPSS), and Post-Operative Patient Global Impression of Improvement (PGI-I) score in patient evaluation after male perineal sling. *Neurourology and urodynamics* 2007; **26**(1): 8-13.
77. O'Sullivan R, Karantanis E, Stevermuer TL, Allen W, Moore KH. Definition of mild, moderate and severe incontinence on the 24-hour pad test. *BJOG : an international journal of obstetrics and gynaecology* 2004; **111**(8): 859-62.
78. Leach GE, Trockman B, Wong A, Hamilton J, Haab F, Zimmern PE. Post-prostatectomy incontinence: urodynamic findings and treatment outcomes. *The Journal of urology* 1996; **155**(4): 1256-9.
79. Gudziak MR, McGuire EJ, Gormley EA. Urodynamic assessment of urethral sphincter function in post-prostatectomy incontinence. *The Journal of urology* 1996; **156**(3): 1131-4; discussion 4-5.
80. Kielb SJ, Clemens JQ. Comprehensive urodynamics evaluation of 146 men with incontinence after radical prostatectomy. *Urology* 2005; **66**(2): 392-6.
81. Lucas MG, Bosch RJ, Burkhard FC, et al. EAU guidelines on assessment and nonsurgical management of urinary incontinence. *European urology* 2012; **62**(6): 1130-42.
82. Pereira VS, Hirakawa HS, Oliveira AB, Driusso P. Relationship among vaginal palpation, vaginal squeeze pressure, electromyographic and ultrasonographic variables of female pelvic floor muscles. *Brazilian journal of physical therapy* 2014; **18**(5): 428-34.
83. Frawley HC, Galea MP, Phillips BA, Sherburn M, Bo K. Reliability of pelvic floor muscle strength assessment using different test positions and tools. *Neurourology and urodynamics* 2006; **25**(3): 236-42.
84. Sherburn M, Murphy CA, Carroll S, Allen TJ, Galea MP. Investigation of transabdominal real-time ultrasound to visualise the muscles of the pelvic floor. *The Australian journal of physiotherapy* 2005; **51**(3): 167-70.
85. Sapsford RR, Richardson CA, Maher CF, Hodges PW. Pelvic floor muscle activity in different sitting postures in continent and incontinent women. *Archives of physical medicine and rehabilitation* 2008; **89**(9): 1741-7.
86. Nahon I, Waddington G, Adams R, Dorey G. Assessing muscle function of the male pelvic floor using real time ultrasound. *Neurourology and urodynamics* 2011; **30**(7): 1329-32.
87. Marchiori D, Bertaccini A, Manferrari F, Ferri C, Martorana G. Pelvic floor rehabilitation for continence recovery after radical prostatectomy: role of a personal training re-educational program. *Anticancer Res* 2010; **30**(2): 553-6.

88. Glazener C, Boachie C, Buckley B, et al. Urinary incontinence in men after formal one-to-one pelvic-floor muscle training following radical prostatectomy or transurethral resection of the prostate (MAPS): two parallel randomised controlled trials. *Lancet* 2011; **378**(9788): 328-37.
89. Dijkstra-Eshuis J, Van den Bos TW, Splinter R, et al. Effect of preoperative pelvic floor muscle therapy with biofeedback versus standard care on stress urinary incontinence and quality of life in men undergoing laparoscopic radical prostatectomy: a randomised control trial. *Neurourology and urodynamics* 2015; **34**(2): 144-50.
90. Abrams P, Andersson KE, Birder L, et al. Fourth International Consultation on Incontinence Recommendations of the International Scientific Committee: Evaluation and treatment of urinary incontinence, pelvic organ prolapse, and fecal incontinence. *Neurourology and urodynamics* 2010; **29**(1): 213-40.
91. Burgio KL, Goode PS, Urban DA, et al. Preoperative biofeedback assisted behavioral training to decrease post-prostatectomy incontinence: a randomized, controlled trial. *The Journal of urology* 2006; **175**(1): 196-201; discussion
92. Centemero A, Rigatti L, Giraudo D, et al. Preoperative pelvic floor muscle exercise for early continence after radical prostatectomy: a randomised controlled study. *European urology* 2010; **57**(6): 1039-43.
93. Bales GT, Gerber GS, Minor TX, et al. Effect of preoperative biofeedback/pelvic floor training on continence in men undergoing radical prostatectomy. *Urology* 2000; **56**(4): 627-30.
94. Chehrehrazi M, Arab AM, Karimi N, Zargham M. Assessment of pelvic floor muscle contraction in stress urinary incontinent women: comparison between transabdominal ultrasound and perineometry. *International urogynecology journal and pelvic floor dysfunction* 2009; **20**(12): 1491-6.
95. Thompson JA, O'Sullivan PB, Briffa K, Neumann P, Court S. Assessment of pelvic floor movement using transabdominal and transperineal ultrasound. *International urogynecology journal and pelvic floor dysfunction* 2005; **16**(4): 285-92.
96. Kegel AH, Powell TO. The physiologic treatment of urinary stress incontinence. *The Journal of urology* 1950; **63**(5): 808-14.
97. Kegel AH. Physiologic therapy for urinary stress incontinence. *Journal of the American Medical Association* 1951; **146**(10): 915-7.
98. Chen HY, Chang WC, Lin WC, et al. Efficacy of pelvic floor rehabilitation for treatment of genuine stress incontinence. *J Formos Med Assoc* 1999; **98**(4): 271-6.
99. Dumoulin C, Hay-Smith J. Pelvic floor muscle training versus no treatment, or inactive control treatments, for urinary incontinence in women. *The Cochrane database of systematic reviews* 2010; (1): CD005654.
100. Borello-France DF, Zyczynski HM, Downey PA, Rause CR, Wister JA. Effect of pelvic-floor muscle exercise position on continence and quality-of-life outcomes in women with stress urinary incontinence. *Phys Ther* 2006; **86**(7): 974-86.
101. Marques A, Stothers L, Macnab A. The status of pelvic floor muscle training for women. *Canadian Urological Association journal = Journal de l'Association des urologues du Canada* 2010; **4**(6): 419-24.

102. Tienforti D, Sacco E, Marangi F, et al. Efficacy of an assisted low-intensity programme of perioperative pelvic floor muscle training in improving the recovery of continence after radical prostatectomy: a randomized controlled trial. *BJU international* 2012; **110**(7): 1004-10.
103. Filocamo MT, Li Marzi V, Del Popolo G, et al. Effectiveness of early pelvic floor rehabilitation treatment for post-prostatectomy incontinence. *European urology* 2005; **48**(5): 734-8.
104. Sueppel C, Kreder K, See W. Improved continence outcomes with preoperative pelvic floor muscle strengthening exercises. *Urologic nursing* 2001; **21**(3): 201-10.
105. Lee TD, Swanson LR, Hall AL. What is repeated in a repetition? Effects of practice conditions on motor skill acquisition. *Phys Ther* 1991; **71**(2): 150-6.
106. Jull G, Falla D, Treleaven J, Hodges P, Vicenzino B. Retraining cervical joint position sense: the effect of two exercise regimes. *Journal of orthopaedic research : official publication of the Orthopaedic Research Society* 2007; **25**(3): 404-12.
107. Pedraza R, Nieto J, Ibarra S, Haas EM. (2014) Pelvic muscle rehabilitation: a standardized protocol for pelvic floor dysfunction. *Advances in Urology*: 487436.
108. Stafford, R. E., J. A. Ashton-Miller, C. Constantinou, G. Coughlin, N. J. Lutton and P. W. Hodges (2016). Pattern of activation of pelvic floor muscles in men differs with verbal instructions. *Neurourol Urodyn* 35*(*4): 457-463.
109. Williams AM, Hodges, N.J. Skill Acquisition in Sport: Research, Theory and Practice: Routledge; 2004.
110. Zatsiorsky, V. M., Kraemer, W.J. (2006). Science and the practice of strength training. Human Kinetics, New York.
111. Campos GE, Luecke TJ, Wendeln HK, et al. Muscular adaptations in response to three different resistance-training regimens: specificity of repetition maximum training zones. *European journal of applied physiology* 2002; **88**(1-2): 50-60.
112. MacDonald R, Fink HA, Huckabay C, Monga M, Wilt TJ. Pelvic floor muscle training to improve urinary incontinence after radical prostatectomy: a systematic review of effectiveness. *BJU international* 2007; **100**(1): 76-81.
113. Dorey G GC, Buckley B, Cochran C, Moore K. Developing a pelvic floor muscle training regimen for use in a trial intervention. *Physiotherapy* 2009; **95**: 199-208.
114. Quartly E, Hallam T, Kilbreath S, Refshauge K. Strength and endurance of the pelvic floor muscles in continent women: an observational study. *Physiotherapy* 2010; **96**(4): 311-6.
115. Akuthota V, Ferreiro A, Moore T, Fredericson M. Core stability exercise principles. *Current sports medicine reports* 2008; **7**(1): 39-44.
116. Sapsford RR, Hodges PW, Richardson CA, Cooper DH, Markwell SJ, Jull GA. Co-activation of the abdominal and pelvic floor muscles during voluntary exercises. *Neurourology and urodynamics* 2001; **20**(1): 31-42.
117. Fozzatti C, Herrmann V, Palma T, Riccetto CL, Palma PC. Global Postural Re-education: an alternative approach for stress urinary incontinence? *Eur J Obstet Gynecol Reprod Biol* 2010; **152**(2): 218-24.

118. Pedriali FR, Gomes CS, Soares L, et al. Is pilates as effective as conventional pelvic floor muscle exercises in the conservative treatment of post-prostatectomy urinary incontinence? A randomised controlled trial. *Neurourology and urodynamics* 2015.
119. Geraerts I, Van Poppel H, Devoogdt N, et al. Influence of preoperative and postoperative pelvic floor muscle training (PFMT) compared with postoperative PFMT on urinary incontinence after radical prostatectomy: a randomized controlled trial. *European urology* 2013; **64**(5): 766-72.
120. Wang W, Huang QM, Liu FP, Mao QQ. Effectiveness of preoperative pelvic floor muscle training for urinary incontinence after radical prostatectomy: a meta-analysis. *BMC Urol* 2014; **14**: 99.
121. Zhang AY, Strauss GJ, Siminoff LA. Effects of combined pelvic floor muscle exercise and a support group on urinary incontinence and quality of life of postprostatectomy patients. *Oncology nursing forum* 2007; **34**(1): 47-53.
122. Mariotti G, Sciarra A, Gentilucci A, et al. Early recovery of urinary continence after radical prostatectomy using early pelvic floor electrical stimulation and biofeedback associated treatment. *The Journal of urology* 2009; **181**(4): 1788-93.
123. Moore KN, Valiquette L, Chetner MP, Byrniak S, Herbison GP. Return to continence after radical retropubic prostatectomy: a randomized trial of verbal and written instructions versus therapist-directed pelvic floor muscle therapy. *Urology* 2008; **72**(6): 1280-6.
124. Overgard M, Angelsen A, Lydersen S, Morkved S. Does physiotherapist-guided pelvic floor muscle training reduce urinary incontinence after radical prostatectomy? A randomised controlled trial. *European urology* 2008; **54**(2): 438-48.
125. Ribeiro LH, Prota C, Gomes CM, et al. Long-term effect of early postoperative pelvic floor biofeedback on continence in men undergoing radical prostatectomy: a prospective, randomized, controlled trial. *The Journal of urology* 2010; **184**(3): 1034-9.
126. Sighinolfi MC ea. Potential Effectiveness of Pelvic Floor Rehabilitation Treatment for Postradical Prostatectomy Incontinence, Climacturia, and Erectile Dysfunction: A Case Series. *Journal of Sexual Medicine* 2009; **6**: 3496-9.
127. Van Kampen M, De Weerdt W, Van Poppel H, De Ridder D, Feys H, Baert L. Effect of pelvic-floor re-education on duration and degree of incontinence after radical prostatectomy: a randomised controlled trial. *Lancet* 2000; **355**(9198): 98-102.
128. Nahon I, Martin M, Adams R. Pre-Operative Pelvic Floor Muscle Training--A Review. *Urologic nursing* 2014; **34**(5): 230-7.
129. Stokes IA, Henry SM, Single RM. Surface EMG electrodes do not accurately record from lumbar multifidus muscles. *Clinical biomechanics* 2003; **18**(1): 9-13.
130. Arab AM, Behbahani RB, Lorestani L, Azari A. Correlation of digital palpation and transabdominal ultrasound for assessment of pelvic floor muscle contraction. *J Man Manip Ther* 2009; **17**(3): e75-9.

131. Bo K, Sherburn M, Allen T. Transabdominal ultrasound measurement of pelvic floor muscle activity when activated directly or via a transversus abdominis muscle contraction. *Neurourology and urodynamics* 2003; **22**(6): 582-8.
132. Khorasani B, Arab AM, Sedighi Gilani MA, Samadi V, Assadi H. Transabdominal ultrasound measurement of pelvic floor muscle mobility in men with and without chronic prostatitis/chronic pelvic pain syndrome. *Urology* 2012; **80**(3): 673-7.
133. Kennedy KM, Raz N. Age, sex and regional brain volumes predict perceptual-motor skill acquisition. *Cortex; a journal devoted to the study of the nervous system and behavior* 2005; **41**(4): 560-9.
134. Gentile AM. A Working Model of Skill Acquisition with Application to Teaching. *QUEST* 1973; **17**(1): 3-23.
135. Rassweiler J, Teber D, Kuntz R, Hofmann R. Complications of transurethral resection of the prostate (TURP)--incidence, management, and prevention. *European urology* 2006; **50**(5): 969-79; discussion 80.
136. Petersen S, Jongen J, Petersen C, Sailer M. Radiation-induced sequelae affecting the continence organ: incidence, pathogenesis, and treatment. *Diseases of the colon and rectum* 2007; **50**(9): 1466-74.
137. Thompson JA, O'Sullivan PB, Briffa NK, Neumann P. Differences in muscle activation patterns during pelvic floor muscle contraction and Valsalva maneuver. *Neurourology and urodynamics* 2006; **25**(2): 148-55.
138. Cohen J. Statistical Power Analysis for the Behavioural Sciences, 2nd edn. New York: Routledge; 1988.
139. Conrad C, Konuk Y, Werner PD, et al. A quality improvement study on avoidable stressors and countermeasures affecting surgical motor performance and learning. *Annals of surgery* 2012; **255**(6): 1190-4.
140. Parvizi N, Daneshfar, A and Shojaei, M. Effect of attentional focus of self-talk on anxiety and learning under pressure *European Journal of Experimental Biology* 2012; **2**(6): 2303-9.
141. Kim JJ ea. Independent Predictors of Recovery of Continence 3 Months After Robot-Assisted Laparoscopic Radical Prostatectomy. *Journal of Endourology* 2012; **26**(10): 1290-5.
142. Novara G, Ficarra V, D'Elia C, et al. Evaluating urinary continence and preoperative predictors of urinary continence after robot assisted laparoscopic radical prostatectomy. *The Journal of urology* 2010; **184**(3): 1028-33.
143. Sugerman H, Windsor A, Bessos M, Wolfe L. Intra-abdominal pressure, sagittal abdominal diameter and obesity comorbidity. *Journal of internal medicine* 1997; **241**(1): 71-9.
144. Falk B, E. Sadres , N. Constantini , et al. . The Association Between Adiposity and the Response to Resistance Training Among Pre- and Early-Pubertal Boys. *Journal of Pediatric Endocrinology and Metabolism* 2011; **15**(5): 597-606.
145. Stafford RE, Ashton-Miller JA, Constantinou CE, Hodges PW. Novel insight into the dynamics of male pelvic floor contractions through transperineal ultrasound imaging. *The Journal of urology* 2012; **188**(4): 1224-30.

146. Stafford RE, Ashton-Miller JA, Constantinou CE, Hodges PW. A new method to quantify male pelvic floor displacement from 2D transperineal ultrasound images. *Urology* 2013; **81**(3): 685-9.
147. Stafford RE, Mazzone S, Ashton-Miller JA, Constantinou C, Hodges PW. Dynamics of male pelvic floor muscle contraction observed with transperineal ultrasound imaging differ between voluntary and evoked coughs. *J Appl Physiol (1985)* 2014; **116**(8): 953-60.
148. Smeenge M, Mischi, M., Laguna, M.P, de la Rosette, J.J.M.C.H., and Wijkstra, H. . Imaging and Focal Therapy of Early Prostate Cancer, Current Clinical Urology: Springer Science & Business Media; 2012.
149. Shrout PE, Fleiss JL. Intraclass correlations: uses in assessing rater reliability. *Psychological bulletin* 1979; **86**(2): 420-8.
150. Fleiss J. Reliability of Measurement, in The Design and Analysis of Clinical Experiments. . Hoboken, NJ, USA: John Wiley & Sons, Inc.; 1999.
151. Goodacre S, Sampson F, Thomas S, van Beek E, Sutton A. Systematic review and meta-analysis of the diagnostic accuracy of ultrasonography for deep vein thrombosis. *BMC medical imaging* 2005; **5**: 6.
152. Lapostolle F, Petrovic T, Lenoir G, et al. Usefulness of hand-held ultrasound devices in out-of-hospital diagnosis performed by emergency physicians. *The American journal of emergency medicine* 2006; **24**(2): 237-42.
153. Hides JA, Miokovic T, Belavy DL, Stanton WR, Richardson CA. Ultrasound imaging assessment of abdominal muscle function during drawing-in of the abdominal wall: an intrarater reliability study. *The Journal of orthopaedic and sports physical therapy* 2007; **37**(8): 480-6.
154. Kristjansson E. Reliability of ultrasonography for the cervical multifidus muscle in asymptomatic and symptomatic subjects. *Manual therapy* 2004; **9**(2): 83-8.
155. Smith MD, Russell A, Hodges PW. The relationship between incontinence, breathing disorders, gastrointestinal symptoms, and back pain in women: a longitudinal cohort study. *The Clinical journal of pain* 2014; **30**(2): 162-7.
156. Wallwork TL, Hides JA, Stanton WR. Intrarater and interrater reliability of assessment of lumbar multifidus muscle thickness using rehabilitative ultrasound imaging. *The Journal of orthopaedic and sports physical therapy* 2007; **37**(10): 608-12.
157. Hebert JJ, Koppenhaver SL, Parent EC, Fritz JM. A systematic review of the reliability of rehabilitative ultrasound imaging for the quantitative assessment of the abdominal and lumbar trunk muscles. *Spine* 2009; **34**(23): E848-56.
158. Taylor NF, Dodd KJ, Damiano DL. Progressive resistance exercise in physical therapy: a summary of systematic reviews. *Phys Ther* 2005; **85**(11): 1208-23.
159. Hoyland K, Vasdev N, Abrof A, Boustead G. Post-radical prostatectomy incontinence: etiology and prevention. *Rev Urol* 2014; **16**(4): 181-8.
160. Catalona WJ, Basler JW. Return of erections and urinary continence following nerve sparing radical retropubic prostatectomy. *The Journal of urology* 1993; **150**(3): 905-7.

161. Ficarra V, Novara G, Rosen RC, et al. Systematic review and meta-analysis of studies reporting urinary continence recovery after robot-assisted radical prostatectomy. *European urology* 2012; **62**(3): 405-17.
162. Finkelstein J, Eckersberger E, Sadri H, Taneja SS, Lepor H, Djavan B. Open Versus Laparoscopic Versus Robot-Assisted Laparoscopic Prostatectomy: The European and US Experience. *Rev Urol* 2010; **12**(1): 35-43.
163. Carlson, L. E. and B. C. Thomas (2007). Development of the Calgary Symptoms of Stress Inventory (C-SOSI). *Int J Behav Med* **14**(4): 249-256.
166. Rosen RC, Riley A, Wagner G, Osterloh IH, Kirkpatrick J, Mishra A. The international index of erectile function (IIEF): a multidimensional scale for assessment of erectile dysfunction. *Urology* 1997; **49**(6): 822-30.
167. Dylewski DA, Jamison MG, Borawski KM, Sherman ND, Amundsen CL, Webster GD. A statistical comparison of pad numbers versus pad weights in the quantification of urinary incontinence. *Neurourology and urodynamics* 2007; **26**(1): 3-7.
168. Orrom WJ, Wong WD, Rothenberger DA, Jensen LL, Goldberg SM. Endorectal ultrasound in the preoperative staging of rectal tumors. A learning experience. *Diseases of the colon and rectum* 1990; **33**(8): 654-9.
169. Hoy G, Hayes, M.G. Ultrasound imaging and arthroscopic diagnosis of rotator cuff tears. *J Bone Joint Surg Br* 1994; (Suppl. 2.): 110.
170. Nahon I, Dorey G, Waddington G, Adams R. Systematic review of the treatment of post-prostatectomy incontinence. *Urologic nursing* 2006; **26**(6): 461-75, 82.
171. Hirschhorn AD KG, Brooks AJ. Barriers and enablers to the provision and receipt of preoperative pelvic floor muscle training for men having radical prostatectomy: a qualitative study. *BMC Health Services Research* 2013; **13**(305).
172. Lukban J, Whitmore K, Kellogg-Spadt S, Bologna R, Lesher A, Fletcher E. The effect of manual physical therapy in patients diagnosed with interstitial cystitis, high-tone pelvic floor dysfunction, and sacroiliac dysfunction. *Urology* 2001; **57**(6 Suppl 1): 121-2.
173. Lee DaLLJ. Stress Urinary Incontinence –
A Consequence of Failed Load Transfer Through the Pelvis? 5th World Interdisciplinary Congress on Low Back and Pelvic Pain. Melbourne; 2004.
174. Ashton-Miller JA, Howard D, DeLancey JO. The functional anatomy of the female pelvic floor and stress continence control system. *Scandinavian journal of urology and nephrology Supplementum* 2001; (207): 1-7; discussion 106-25.
175. Bo K, Haakstad LA. Is pelvic floor muscle training effective when taught in a general fitness class in pregnancy? A randomised controlled trial. *Physiotherapy* 2011; **97**(3): 190-5.
176. Roll SC, Rana M, Sigward SM, Yani MS, Kirages DJ, Kutch JJ. Reliability of superficial male pelvic floor structural measurements using linear-array transperineal sonography. *Ultrasound in medicine & biology* 2015; **41**(2): 610-7.

177. Haglind E, Carlsson S, Stranne J, et al. Urinary Incontinence and Erectile Dysfunction After Robotic Versus Open Radical Prostatectomy: A Prospective, Controlled, Nonrandomised Trial. *European urology* 2015; **68**(2): 216-25.
178. O'Sullivan P. Diagnosis and classification of chronic low back pain disorders: maladaptive movement and motor control impairments as underlying mechanism. *Manual therapy* 2005; **10**(4): 242-55.
179. Fersum KV, Dankaerts W, O'Sullivan PB, et al. Integration of subclassification strategies in randomised controlled clinical trials evaluating manual therapy treatment and exercise therapy for non-specific chronic low back pain: a systematic review. *British journal of sports medicine* 2010; **44**(14): 1054-62.
180. AIHW. Incontinence in Australia: prevalence, experience and cost. . In: Wellbeing AIoHa, editor.; 2012.
181. Tutolo M ea. Optimizing postoperative sexual function after radical prostatectomy. *Therapeutic Advances in Urology* 2012; **4**(6): 347-65.
182. Bay R IS, Zhiruddin WM, Arifin WN. Effect of combined psycho-physiological stretching and breathing therapy on sexual satisfaction. *BMC Urology* 2013; **13**(16).
183. Gentile AM. A working model of skill acquisition with application to teaching. *Quest* 1972; **17**(1): 3-23.
184. Dorey G, Speakman M, Feneley R, Swinkels A, Dunn C, Ewings P. Randomised controlled trial of pelvic floor muscle exercises and manometric biofeedback for erectile dysfunction. *Br J Gen Pract* 2004; **54**(508): 819-25.
185. Painter EE, Ogle MD, Teyhen DS. Lumbopelvic dysfunction and stress urinary incontinence: a case report applying rehabilitative ultrasound imaging. *The Journal of orthopaedic and sports physical therapy* 2007; **37**(8): 499-504.
187. Liao C-M, and Richard SW Masters. Self-focused attention and performance failure under psychological stress. . *Journal of Sport & Exercise Psychology* 2002; **24**(3).
188. Du Toit DaP, A.E. Overweight and obesity and motor proficiency of 3- and 4-year old children. *South African Journal for Research in Sport, Physical Education and Recreation* 2003; **25**(2): 37-48.
189. Fleiss JL. Reliability of Measurement, in The Design and Analysis of Clinical Experiments. . Hoboken, NJ, USA: John Wiley & Sons, Inc.; 1999.
190. Capitanio U, Suardi N, Briganti A, et al. Influence of obesity on tumour volume in patients with prostate cancer. *BJU international* 2012; **109**(5): 678-84.
191. Thompson JE, Egger, S, Bohm, M et al. Superior quality of life and improved surgical margins are achievable with robotic radical prostatectomy after a long learning curve: a prospective single-surgeon study of 1552 consecutive cases. *European Urology* 2014; **65**(3):521-531.
192. Patel, VR, Coelho, RF, Palmer, KJ and Rocco, B. (2009) Periurethral suspension stitch during robot-assisted laparoscopic radical prostatectomy: description of the techniaue and continence outcomes. *European Urology*. **56**(3):472-478.

193. Walz, J, Burnett, AL, Costello, AJ, Eastham, JA et al. A critical analysis of the current knowledge of surgical anatomy related to optimisation of cancer control and preservation of continence and erection in candidates for radical prostatectomy. *European Urology*. 2010; 57(2):179-192.
194. Schmidt, R, and Lee, T (2013). Motor Learning and Performance, 5E with Web Study Guide: From Principles to Application. Human Kinetics. New York
195. Ocampo-Trujilloa, A., Carbonell-Gonzáleza,b, J., Martínez-Blancoa, A., Díaz-Hunga,c, A., Muñozd,C.A., Ramírez-Véleze, R (2014). Pre-operative training induces changes in the histomorphometry and muscle function of the pelvic floor in patients with indication of radical prostatectomy. *Actas Urologicas Espanolas (English Edition)* 38(6): 378-384.
196. Huri, E. (2014). Novel anatomical identification of nerve-sparing radical prostatectomy: fascial-sparing radical prostatectomy. *Prostate Int* 2(1): 1-7.
197. Wallner, C., N. F. Dabhoiwala, M. C. DeRuiter and W. H. Lamers (2009). The anatomical components of urinary continence. *Eur Urol* 55(4): 932-943.
198. Hodges, P. W., R. Sapsford and L. H. Pengel (2007). Postural and respiratory functions of the pelvic floor muscles. *Neurourol Urodyn* 26(3): 362-371.

APPENDIX i

Ethical Approval for Study

RESEARCH INTEGRITY
Human Research Ethics Committee
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Ref: MF/HW

22 November 2011

Dr Roger Adams
Discipline of Physiotherapy
Faculty if Health Sciences
University of Sydney
roger.adams@sydney.edu.au

Dear Dr Adams

Thank you for your correspondence dated **18 November 2011** addressing comments made to you by the Human Research Ethics Committee (HREC).

I am pleased to inform you that with the matters now addressed your protocol entitled **"Developing voluntary isolated Pelvic Floor Muscle contraction in men with prostate cancer during physiotherapy training sessions utilizing real time ultrasound (RTUS) biofeedback: Time taken and rater reliability for skill acquisition"** has been approved.

Details of the approval are as follows:

Protocol No.: **14286**

Approval Date: **22 November 2011**

First Annual Report Due: **30 November 2012**

Authorised Personnel: **Dr Roger Adams**
Stuart Baptist
Dr Trudy Rebbeck
Professor Gordon Waddington

Documents Approved:

Document	Version Number	Date
Patient Participant Information Statement	3	18/11/2011
Physiotherapist Participant Information Statement	3	18/11/2011
Physiotherapist Participant Consent Form	3	18/11/2011
Advertisement Letter	Nil	15/10/2011

HREC approval is valid for four (4) years from the approval date stated in this letter and is granted pending the following conditions being met:

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CRICOS 00026A

APPENDIX ii

Article approved for publication by Physiotherapy Theory and Practice Journal. Due for publication Feb 2017.

Manuscripts with Decisions

Manuscript ID	Manuscript Title	Date Submitted	Date Decisioned	Status	Actions
UPTP-2015-0177.R2	Ultrasound-based motor control training for the pelvic floor pre- and post-prostatectomy: Scoring reliability and skill acquisition [View Submission]	14-Mar-2016	20-Mar-2016	EOA: Hasson, Ellen • Accept (20-Mar-2016) • Awaiting Production Checklist view decision letter	

Decision Letter (UPTP-2015-0177.R2)

From: shasson@gru.edu

To: stuartbaptist@ssop.com.au, studb73@yahoo.com.au

CC:

Subject: Physiotherapy Theory and Practice - Decision on Manuscript ID UPTP-2015-0177.R2

Body: 20-Mar-2016

Stuart:

The review of your twice-revised manuscript is now completed. It is clear that you considered the recommendations from both Referees and that these were all addressed.

Congratulations, my decision is now to accept your paper. The next step is that you will get proofs from the publisher for you to review. It is likely that your paper will be published in the February issue – 2017. However we are now publishing manuscripts electronically ahead of hard print using e-pub in Med-Line/Pub-Med. This usually occurs about 3 to 6 months prior to hard copy publication, so we may see your article on Med-Line/Pub/Med by late 2016. I am attaching the Copyright form. Please fill this out, sign (only need your signature), and forward to me as a PDF file via e-mail as soon as possible.

I want to thank you for your addition to the journal. If you have questions please do not hesitate to contact me.

Sincerely yours,

Scott M. Hasson, EdD, PT, FACSM, FAPTA – Editor PTP

Date Sent: 20-Mar-2016

File 1: PTP-Copyright-Form.pdf

ABSTRACT
Aim: This study documents a protocol designed to evaluate pelvic floor motor control in men with prostate cancer. It also aims to evaluate the reliability of therapists in rating motor control of Pelvic Floor Muscles (PFM) using Real Time Ultrasound Imaging (RUSI) video clips. We further determine predictors of acquiring motor control. **Methods**: Ninety-one men diagnosed with prostate cancer attending a physiotherapy clinic for pelvic floor exercises were taught detailed pelvic floor motor control exercises by a physiotherapist using trans-abdominal RUSI for biofeedback. A new protocol to rate motor control skill acquisition was developed. Three independent physiotherapists assessed motor control skill attainment by viewing RUSI videos of the contractions. Inter-rater reliability was evaluated using intra-class correlation coefficients. Logistic regression analysis was conducted to identify predictors of successful skill attainment. Acquisition of the skill was compared between pre and post-operative participants using an independent-groups t-test. **Results**: There was good reliability for rating the RUSI video clips (ICC 0.73 (95%CI 0.59 - 0.82)) for experienced therapists. Having low BMI and being seen pre-operatively predicted motor skill attainment, accounting for 46.3% of the variance. Significantly more patients trained pre-operatively acquired the skill of pelvic floor control compared with patients initially seen post-operatively (OR 11.87 95%CI 1.4 to 99.5 p = 0.02).
Conclusions: A new protocol to evaluate attainment of pelvic floor control in men with prostate cancer can be assessed reliably from RUSI images, and is most effective delivered pre-operatively.

Introduction

Stress urinary incontinence (SUI) and erectile dysfunction (ED) are common sequelae following prostatectomy for prostate cancer and both constitute a significant and growing health burden in Australia. A recent report by the Australian Institute of Health and Welfare stated that the estimated costs of incontinence in Australia in 2003 totalled $1.5 billion, projected to increase to $4.5 billion in 2030-31(AIHW 2012). By 2018 it is projected that 423 million people will be affected by urinary incontinence worldwide (Irwin et al, 2011). Results from a 12-year randomized controlled trial (RCT) comparing radical prostatectomy (RP) with active surveillance (AS) (watchful waiting) and an age matched control group with no pathology showed significant differences in Quality of Life in RP and AS compared to the control group. Continence was reported problematic in 41%, 11%, and 3% respectively and erectile dysfunction reported in 84%, 80%, and 46% respectively (Johansson et al, 2011). Effective management of SUI in men is therefore a priority for both individual patients and national health.

Pelvic floor motor control is proposed here as an appropriate method to improve SUI in men. To date, most research investigating pelvic floor muscle training in men has focused on strength training. (Tutolo 2012; Bay, Zhiruddin and Arifin, 2013) to improve SUI outcomes. Data for outcomes of strength training of the pelvic floor for male SUI are conflicting, with some studies (Van Kampen et al, 2000; MacDonald et al, 2007) indicating an improvement, whilst others find no additional benefit (Glazener et al, 2011; Moore et al, 2008).

Given that strength training is dependent upon initially isolating the correct muscle activation strategies (Gentile 1972), this concept of motor training should be considered a logical precursor skill prior to engaging in strength training. A lack of teaching optimal 'early' motor control prior to strengthening may be a potential reason for variable outcomes from rehabilitation efforts seen in the literature to date.

To date there is no standardised protocol for measurement of this early pelvic floor motor control in men with prostate cancer. Measurement of motor recruitment has been performed previously using internal methods such as digital anal palpation (Dorey, Buckley, Cochran and Moore, 2009), anal probe biofeedback (Dorey et al, 2004) and trans-perineal RUSI (Stafford, Ashton-Miller, Constantinou and Hodges, 2013). However, each of these methods utilized different protocols, and the internal methods are invasive. In contrast, trans-abdominal Real Time Ultrasound Imaging (RUSI) has been identified as a non invasive tool that can effectively visualize structures (Sherburn et al, 2005) and teach patients to isolate pelvic floor muscle activation, (Painter, Ogle and Teyhen, 2007) and has been used to visually display pelvic floor muscle action in post-prostatectomy men (Nahon, Waddington, Adams and Dorey, 2011). There is a need therefore to define what contributes good 'early' motor control in the male pelvic floor and whether RUSI can be used to assist in establishing a reliable scoring system.

Several other biometric factors are known to influence attainment of a skill such as early motor control and therefore need to be considered in studies investigating skill attainment. For example, anxiety and stress levels have been shown to negatively affect skill acquisition (Liao and Masters 2002). Further studies have found that age and BMI also significantly impacted on skill acquisition (Du Toit and Pienaar 2003; Falk, Sadres and Constantini, 2011). Given that participants in this study have been diagnosed with prostate cancer and are undergoing surgery that may affect their continence, with the high level of stress and anxiety this impairment generates, it is necessary to evaluate the most effective time to instigate training, and to account for other biometric factors that may influence skill acquisition.

This study aims, therefore, to document a protocol for rating pelvic floor motor control. Furthermore, it will measure the reliability of therapists to assess motor control of PFM captured using RUSI video clips. It further aims to investigate factors that are related to the acquisition of these motor skills and to compare acquisition of this skill between patients trained pre- and post-operatively.

Materials and Methods

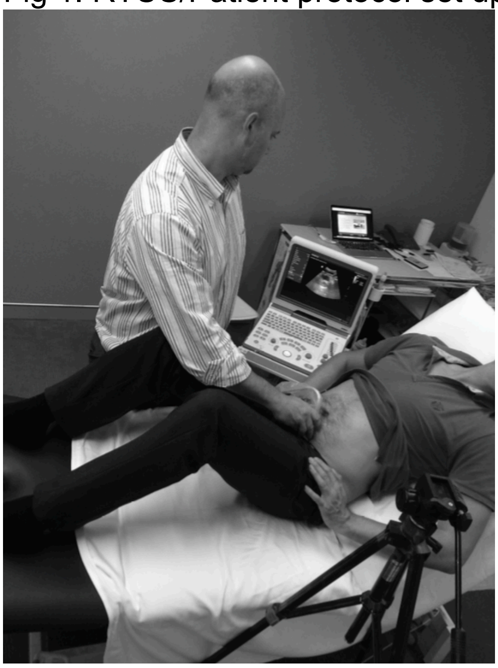
Participants were men with prostate cancer who were referred by their urologist or general practitioner for physiotherapy to improve their pelvic floor function between Nov 2011 and June 2012.

Consecutive patients who presented to a physiotherapy clinic and consented to participate were included in the study. Participants were excluded from this study if they had had a previous transurethral resection of the prostate (TURP) and/or prior radiotherapy, as this has been shown to adversely affect continence mechanisms (Rassweiler, Teber, Kuntz and Hofmann, 2006; Petersen, Jongen, Petersen and Sailer, 2007). Ethical approval to conduct the study was obtained from the University of Sydney Human Research Ethics Committee.

Demographic data collected included age, height, weight and Body Mass Index (BMI). Additional baseline data collected included the timing of the initial assessment (pre- or post-operatively), and the referring urological surgeon. Participants also were also screened for the presence of pre-existing erectile dysfunction or urinary dysfunction (such as frequency, urgency, incontinence or nocturia).

The protocol
Participants were educated on the anatomy and function of the pelvic floor muscles, then positioned in a crook lying position with their abdomen exposed. A Mindray™ ultrasound machine (Model DP-50) was used in conjunction with a curvilinear transducer (35C50EA - 2-5 MHz R50mm broadband Convex Array) to image the pelvic floor trans-abdominally. The transducer was placed in the mid-sagittal plane immediately suprapubically, angled at 15-30 degrees from the vertical, until an optimal view of the bladder base was achieved as per Thompson (Thompson et al, 2005 - See figure 1). RUSI screen images were recorded using a handheld video recorder and fixed tripod standardized set up. A hand held stopwatch was used to record the time as the participant was requested to contract the pelvic floor and sustain the contraction for 3 respiratory cycles before relaxing, for each of the three pelvic floor 'zones'.

Fig 1. RTUS/Patient protocol set up



The participant was educated in simple anatomy and muscle physiology and informed that the male pelvic floor is a collection of a number of individual muscles. We requested a voluntary pelvic floor muscle contraction using a standard instruction: “show me how you would contract your pelvic floor muscles.” This ensured no verbal or tactile cueing from the physiotherapist, so that baseline skill and natural compensation strategies could be observed. The physiotherapist then commenced motor control training to facilitate isolated PFM contractions. Training included specific cues to elicit isolated pelvic floor contractions with a bias to the anterior pelvic floor (penis), middle pelvic floor (testicles) and posterior pelvic floor (anal) regions (or ‘zones’). Cues included; “shortening the penis” (anterior bias), “lifting your testicular sack upwards” (mid zone bias) and “stopping oneself from defecating” (posterior bias). As with all motor training protocols, initial development of a skill needed to be performed slowly and gently and with due consideration as to the targeted outcome, in this case the zone of the pelvic floor we wished to recruit. The RUSI was used as a form of biofeedback and patients were encouraged to avoid sudden high maximal voluntary contractions, visualized on the RUSI screen as sudden changes in bladder base height, as they were deemed to lack specificity and thus more conducive to hypertrophy training not motor training.

Throughout training, suboptimal or indirect strategies, such as breath holding, valsalva, superficial muscle co-activation (especially abdominal, adductor, gluteal and hamstring) were discouraged and in most cases a lower effort was encouraged, to achieve a more isolated accurate contraction. Patients were prompted to attend to slightly different sensations during each zone isolation exercise and to focus on how each zone was subtly different to its neighbour. The physiotherapist observed whether the patient was using any suboptimal strategy, and provided feedback as necessary. Patients continued until the optimal learning outcome for the session was achieved. Time was recorded at the cessation of RUSI use within each individual physiotherapy session.

The patient was encouraged to continue with low effort (approximately 20% Maximal Voluntary Contraction effort), as initial motor unit activation had been shown in a previous study (Bigland and Lippold, 1954) to occur at 15% MVC, this was however unable to be officially standardised during this study. They were also encouraged to continue to practice these isolated motor control exercises at home until the next therapy session. Following 7 days of independent practice the RUSI assessment process was repeated until the outcome measure was achieved, or until a maximum of eight sessions had been reached.

The outcome

Acquisition of the skill of an isolated pelvic floor muscle contraction was defined as a notable bladder base lift with initial effort that was sustained throughout 3 normal respiratory cycles, followed by a similar sized drop in bladder base level on release of pelvic floor muscle effort.

The patient was deemed to have attained this outcome through having achieved the following three components:

LIFT PHASE: An initial observable rise in the bladder base as observed on RTUS (>1mm but usually less than 1cm) with all pelvic zone cues (anterior, mid and posterior)
SUSTAIN PHASE: Ability to maintain this rise for 3 normal breaths (usually between 3 and 8 seconds) for all pelvic zones, with failure of this criterion defined as a loss of more than 25% of the original bladder base rise.
DROP PHASE: An observable fall of the bladder base after completion of component 2 as observed on RUSI determined to be equal to the rise (>1mm but usually less than 1cm)
Each component was rated on a 4-point Likert scale; 0 (definitely no), 1 (maybe no), 2 (maybe yes), 3 (definitely yes). Hence skill quality ranged from lowest skill quality 0 to highest skill quality 9. A total score of 6 or greater was used to determine acquisition of the skill.

Time to skill acquisition was determined as the total time (seconds) taken to attain the skill. The time taken during each physiotherapy session was summed to give the total time. The minimum was considered to be one physiotherapy session and a maximum of 8 physiotherapy sessions was considered adequate time to attain the skill. If the outcome had not been reached by 8 sessions, the participant was considered as not having attained the skill.

Inter-Rater Reliability

The outcome measure was assessed for inter-rater reliability by three independent physiotherapy raters. Two raters were considered experienced, with more than five years post-graduate experience in men's health and in viewing trans-abdominal RUSI and one rater was considered a novice, with standard undergraduate physiotherapy training. A total of 64 individual video clips of RUSI screen images of 16 patients were randomly selected to evaluate reliability. The video clips were coded and de-identified. Raters were asked to measure each component of the pelvic floor muscle contraction using the 4-point Likert scale previously described.

Statistical Analysis

Images were only viewed and rated once, so no intra-rater reliability measure could be obtained. Because raters are regarded as more like themselves than they are like others with respect to the utilization of a rating protocol, intra-rater reliability values are typically higher, and do not constitute as generalizable a test of a measurement protocol as does the more conservative and more generalizable inter-rater reliability index. For these reasons inter-rater reliability only was evaluated.

Inter-Rater Reliability

ICC (2,1) values (Fleiss, 1999) were used to evaluate inter-rater reliability. In addition, the ICC was determined for the different cues (anterior/ middle/posterior zones) as well as for the different phases of contraction (lift/sustain/drop). Inter-rater reliability was considered poor (ICC <0.4) good (ICC range 0.4-0.75) or excellent (ICC > 0.75) (Fleiss, 1999).

Factors related to skill acquisition
A logistic regression analysis was conducted to identify predictors of skill attainment and multiple regression was conducted to assess predictors of time to skill acquisition. Independent variables entered into the regression models included BMI, age, history of pre-operative erectile dysfunction, history of pre-operative urinary dysfunction, and whether the patients were initially seen pre- or post-operatively.

Comparison of pre- and post-operative groups
Patients were grouped into pre- or post-operative groups as indicated by their status upon initial physiotherapy assessment. For the purposes of power calculation, Cohen (1988) argues that the arithmetic mean of two unequal group sizes is affected by the larger sample size, and that the harmonic mean, which in the two group case is 2.N1.N2/(N1+N2), is preferable because it is less weighted by the larger value. Thus a harmonic mean sample size of 32 patients per group was required to detect a difference between groups as large as 0.7 standard deviation units (Cohen's d = 0.7) with 80% power and a Type 1 error rate of 0.05.

Independent t-tests were used to determine whether there was any baseline difference between the two groups, and to compare between-group differences in time to skill acquisition.

Results
A total of 96 consecutive participants met the eligibility criteria for the study. Of these, 91 consented to participate: 50 men seen preoperatively and 41 post-operatively, giving a harmonic mean number per group of 45. The demographic data of participants is outlined in Table 1. There was no significant difference in age, BMI and baseline erectile or urinary dysfunction between groups.

Table 1: Demographic data for Study Participants

Factor	Initially trained Pre op (n=50)	Initially trained Post op (n=41)
Age (years) Mean (SD)	63.54 (7.6)	67.72 (7.2)
BMI (kg/m^2) Mean (SD)	27.96 (3.3)	27.25 (3.6)
Pre existing UD n(%)	15 (30%)	11 (27%)
Pre existing ED n(%)	14 (28%)	8 (20%)
Surgeon A n(%)	29 (29.7%)	24 (26.4%)
Surgeon B n(%)	18 (19.7%)	10 (11.0%)
Others n(%)	3 (3.3%)	7 (7.7%)

Inter-Rater Reliability data
Results showed poor inter-rater reliability (ICC 0.26 (95%CI 0.11-0.43)) between all raters. However, once the novice data was removed, the ICC was good and improved significantly (ICC 0.73 (95%CI 0.59 - 0.82)). See Table 2

When evaluating the inter-rater reliability with respect to the phase of muscle action, good reliability was demonstrated for the lift phase (ICC 0.69 (95%CI 0.53-0.8)) The lift phase scored good reliability (ICC 0.6 (95%CI 0.47-0.72)) even with the novice data included. See Table 2

Table 2: Inter-Rater ICC and 95%CI for image interpretation for pelvic floor skill acquisition components

	Lift	Sustain	Drop	Overall
All Reviewers	0.6 (0.47-0.72)	0.06 (-0.08-0.72)	0.17 (0.02-0.33)	0.26 (0.11-0.43)
Experts Only	0.69 (0.53-0.8)	0.66 (0.49-0.78)	0.55 (0.35-0.7)	0.73 (0.59-0.82)

The posterior lift cue was the most reliably consistent cue between experienced raters (ICC 0.81 (95%CI 0.54-0.93). See Table 3

Table 3: Experienced clinician reliability for pelvic floor zone cue

Verbal Cue	ICC (95%CI)
Anterior (Penile cue)	0.74 (0.4-0.9)
Middle (Testicular cue)	0.67 (0.28-0.87)
Posterior (Anal cue)	0.81 (0.54-0.93)

Factors related to skill acquisition
Independent variables found to be significant predictors of skill attainment were low BMI and initial visit occurring pre-operatively (see Table 4). Together, these two predictors accounted for 46.3% of the variance. No variables were found to be predictive of time to skill acquisition.

Comparison of pre- and post-operative groups
The proportion of patients who were unable to acquire the skill of pelvic floor control was significantly less in the group initially seen pre-operatively compared to those initially seen post-operatively (Table 4; OR 11.87 95%CI 1.4 to 99.5) p = 0.02). In addition, patients seen pre-operatively achieved the skill in fewer sessions than those seen post-operatively (mean difference –

1.30 (95%CI -2.1 to – 0.5) p = 0.002. Patients seen initially pre-operatively achieved the skill with a mean time of 10.0 minutes (SD 8.3), whereas patients seen post operatively took 11.9 minutes (SD11.8), however this difference in time to acquire was not significant (p=0.36).

Table 4: Skill attainment of patients seen pre- and post-operatively and predictors of skill acquisition

	Initially trained Pre-op	Post-op	Sig
Did not attain the skill n(%)	1(1.1%)	8(8.8%)	P= 0.005*
Attained the skill n(%)	49 (53.8%)	33 (36.3%)	
Time to skill acquisition Mean (SD)	9.97 (8.3)	11.89 (11.8)	P= 0.36^
Mean therapy sessions	1.5 (1.0)	2.88 (2.6)	P= 0.02^
Key: * Pearson Chi Square value 7.752, 1 degree of freedom ^ Independent t-test			

Variable	B value	sig
BMI	-0.427	P=0.002
Initially seen preoperatively	-3.097	P=0.009

Discussion

This study is the first to describe and evaluate the reliability of a protocol for pelvic floor muscle motor control training for men undergoing prostatectomy. It has demonstrated that motor control training can be successfully taught using trans-abdominal RUSI for biofeedback, within a clinically reasonable period of time for a majority of patients. Patients who were seen pre-prostatectomy and had a lower BMI were more likely to attain the skill of performing an isolated pelvic floor muscle contraction.

The outcome measure used to evaluate pelvic floor muscle control was more reliable amongst experienced physiotherapists, this study reveals similar findings to a previous study which shows improved ICC scores when more experienced clinicians utilize RUSI (Thompson et al, 2005).

We also demonstrate that reliability is optimized when giving a posterior (anal) recruitment cue. We hypothesize that this posterior (anal) cue may be more reliable because patients are more familiar with the instruction. It has been well established that repetition creates stronger motor patterns over time (Gentile, 1972). Arguably, the posterior ‘levator ani’ contraction is commonly used by men to inhibit the release of flatus and is practiced more frequently than either ceasing the flow of urine midstream or lifting one’s testicular sac.

Finally, we showed that clinicians regardless of their experience more reliably viewed the lift phase and, as this phase scored good reliability, it should therefore be recommended as the most clinically useful evaluation marker.

Patients with a higher BMI tended to be less likely to acquire the motor control involved in pelvic floor muscle activation. The relationship between excess accumulation of adipose tissue (obesity) and prostate cancer aggressiveness has been highlighted in a previous study (Capitano et al, 2012) as well as a positive correlation between continence outcomes and obesity (Wolin, Sutcliffe, Andriole and Kibel, 2010). The inference arising is that a plan to reduce BMI should instigated by GP's and treating urologists, because these may not only ameliorate the aggressiveness of the cancer, but also assist in improving the likelihood of pelvic floor muscle motor control skill acquisition. The impact of pelvic floor muscle motor control on post-operative function and quality of life has yet to be examined.

Participants who were assessed and given RUSI guided PFM exercises pre-operatively were more likely to obtain the skill of pelvic floor muscle contraction. This finding corroborates that of previous randomized controlled trials (Burgio et al, 2006; Centemero et al, 2010) where pre-operative PFM training improved post-operative return to continence outcomes in patients following prostatectomy. Furthermore, in this study participants who were taught pre-operatively acquired early motor control in fewer therapy sessions than patients instructed post-operatively. Initiating physiotherapy intervention pre-operatively translates to a potential cost saving to patients and the healthcare system by reducing the total number of visits required for successful motor learning to occur.

The less successful motor skill acquisition outcomes that were demonstrated in the post-prostatectomy group may be partially or even fully explained by the fact that motor learning is known to be less effective when the learner is anxious and under duress (more than likely given the outcomes of this surgery and the associated impact). A 2011 Quality of Life study reported that the stress of active incontinence is rated as significant in 61% of cases up to 9 years post-operatively (Johansson et al, 2011). Parvizi et al (2012) reported that there is evidence that pressure-induced anxiety causes shifts in attention that lead to decrements in performance and learning. Although our study did not actively screen for stress and anxiety throughout this study, this may be a weakness of this study and could be reviewed in future studies. Data from our study provides support to this theory in that that motor skill attainment occurs optimally pre-operatively. We hypothesize that by having a pre-operative consultation, more optimal learning can occur without linking the learning objective to the stress of incontinence.

Recent research by Stafford et al (2015) showed that verbal cues can alter the degree of motion observable in various pelvic floor muscles. They also postulate that the muscles closest to the urethra itself (the bulbocavernosus and striated urethral sphincter muscles) may have a mechanically more optimal role in developing urethral closure pressure than the more distant levator ani muscle.

Previous studies (Glazener et al, 201; Moore et al , 2008) noting poor outcomes from pelvic floor training strategies have focused on commencing strength training and may have not ensured adequate targeting of the muscles responsible for generating urethral closure pressure.

Our data shows motor learning can be taught utilizing trans-abdominal RSUI and if early motor learning can be optimized and a bias developed for the more anterior muscles more involved in affecting urethral closure pressure, there may be more potential for improved continence and erectile dysfunction outcomes. This study therefore, provides the rationale for a future RCT that evaluates the effect a motor learning component prior to the commencement of strength training on continence and erectile dysfunction.

Stafford et al (2013) also report on a novel trans-perineal RUSI approach for biofeedback to motor learning, which may be able to further improve the way in which pelvic floor exercises are taught. However, this technique is more invasive for patients than the trans-abdominal approach.

Conclusion

A new trans-abdominal RTUS protocol can be used reliably by experienced clinicians to score pelvic floor motor control skill acquisition in men with prostate cancer. Acquisition of early motor skills are achievable within a clinically reasonably amount of time and are more likely to be successful if conducted prior to prostate surgery and in combination with an attempt to reduce BMI.

Word count 3252

References:

1. AIHW (Australian Institute of Health and Wellbeing) 2012. Incontinence in Australia: prevalence, experience and cost, Australian Cancer Incidence and Mortality (ACIM) books. Canberra, Australian Government.
2. Bay RIS, Zhiruddin WM, Arifin WN 2013. Effect of combined psycho-physiological stretching and breathing therapy on sexual satisfaction. BioMed Central Urology **13**(16).
3. Bigland B and Lippold OC 1954. Motor unit activity in the voluntary contraction of human muscle. The Journal of Physiology **125**(2): 322-335.
4. Burgio K L, Goode PS, Urban DA, Umlauf MG, Locher JL, Bueschen A and Redden DT 2006. Preoperative biofeedback assisted behavioral training to decrease post-prostatectomy incontinence: a randomized, controlled trial. The Journal of Urology **175**(1): 196-201; discussion 201.
5. Capitanio U, Suardi N, Briganti A, Gallina A, Abdollah F, Lughezzani G Salonia A, Freschi M and Montorsi F 2012. Influence of obesity on tumour volume in patients with prostate cancer. British Journal of Urology International **109**(5): 678-684.
6. Centemero A, Rigatti L, Giraudo D, Lazzeri M, Lughezzani G, Zugna D, Montorsi F, Rigatti P and Guazzoni G 2010. Preoperative pelvic floor muscle exercise for early continence after radical prostatectomy: a randomised controlled study. European Urology **57**(6): 1039-1043.
7. Cohen J. 1988 Statistical Power Analysis for the Behavioral Sciences, 2nd edn. New York: Routledge.
8. Dorey G, Buckley B, Cochran C, Moore K 2009. Developing a pelvic floor muscle training regimen for use in a trial intervention. Physiotherapy **95**: 199-208.
9. Dorey G, Speakman M, Feneley R, Swinkels A, Dunn C and Ewings P 2004. Randomised controlled trial of pelvic floor muscle exercises and manometric biofeedback for erectile dysfunction. British Journal of General Practice **54**(508): 819-825.
10. Du Toit D and. Pienaar AE 2003. Overweight and obesity and motor proficiency of 3- and 4-year old children. South African Journal for Research in Sport, Physical Education and Recreation **25**(2): 37-48.
11. Falk B, Sadres E and Constantini N 2011. The Association Between Adiposity and the Response to Resistance Training Among Pre- and Early-Pubertal Boys. Journal of Pediatric Endocrinology and Metabolism **15**(5): 597-606.
12. Fleiss JL 1999. Reliability of Measurement. In: The Design and Analysis of Clinical Experiments. Hoboken, NJ, USA, John Wiley & Sons, Inc.
Gentile AM 1972. A working model of skill acquisition with application to teaching. Quest **17**(1): 3-23.
13. Glazener C, Boachie C, Buckley B, Cochran C, Dorey G, Grant A, Hagen S, Kilonzo M, McDonald A, McPherson G, Moore K, Norrie J, Ramsay C, Vale L and N'Dow J 2011. Urinary incontinence in men after formal one-to-one pelvic-floor muscle training following radical prostatectomy or transurethral resection of the prostate (MAPS): two parallel randomised controlled trials. Lancet **378**(9788): 328-337.

14. Irwin DE, Kopp ZS, Agatep B, Milsom I and Abrams P 2011. Worldwide prevalence estimates of lower urinary tract symptoms, overactive bladder, urinary incontinence and bladder outlet obstruction. British Journal of Urology International **108**(7): 1132-1138.
15. Johansson E, Steineck G, Holmberg L, Johansson JE, Nyberg T, Ruutu M and Bill-Axelson A 2011. Long-term quality-of-life outcomes after radical prostatectomy or watchful waiting: the Scandinavian Prostate Cancer Group-4 randomised trial. Lancet Oncology **12**(9): 891-899.
16. Liao CM, and Masters RSW 2002. Self-focused attention and performance failure under psychological stress. Journal of Sport and Exercise Psychology **24**(3).
17. MacDonald R, Fink HA, Huckabay C, Monga M and Wilt TJ 2007. Pelvic floor muscle training to improve urinary incontinence after radical prostatectomy: a systematic review of effectiveness. British Journal of Urology International **100**(1): 76-81.
18. Moore KN, Valiquette L, Chetner MP, Byrniak S and Herbison GP 2008. Return to continence after radical retropubic prostatectomy: a randomized trial of verbal and written instructions versus therapist-directed pelvic floor muscle therapy. Urology **72**(6): 1280-1286.
19. Nahon I, Waddington G, Adams R and Dorey G 2011. Assessing muscle function of the male pelvic floor using real time ultrasound. Neurourology and Urodynamics **30**(7): 1329-1332.
20. Painter EE, Ogle MD and Teyhen DS 2007. Lumbopelvic dysfunction and stress urinary incontinence: a case report applying rehabilitative ultrasound imaging. Journal of Orthopaedic Sports Physical Therapy **37**(8): 499-504.
21. Parvizi D, Koch H, Friedl H, Spendel S, Hubmer M, Parvizi I, Prandl E, Rappl T and Haas F 2012. Analysis of functional outcome after posttraumatic thumb reconstruction in comparison to nonreconstructed amputated thumbs at the proximal phalanx of the thumb ray: a mid-term follow-up with special attention to the Manchester-modified M2 DASH questionnaire and effect size of Cohen's d. Journal of Trauma Acute Care and Surgery **72**(2): E33-40.
22. Petersen S, Jongen J, Petersen C and Sailer M 2007. Radiation-induced sequelae affecting the continence organ: incidence, pathogenesis, and treatment. Diseases of the Colon and Rectum **50**(9): 1466-1474.
23. Rassweiler J, Teber D, Kuntz R and Hofmann R 2006. Complications of transurethral resection of the prostate (TURP) - incidence, management, and prevention. European Urology **50**(5): 969-979; discussion 980.
24. Sherburn M, MurphyCA , Carroll S, Allen TJ and Galea MP 2005. Investigation of transabdominal real-time ultrasound to visualise the muscles of the pelvic floor. Australian Journal of Physiotherapy **51**(3): 167-170.
25. Stafford RE, Ashton-Miller JA, Constantinou C and Hodges PW 2013. A new method to quantify male pelvic floor displacement from 2D transperineal ultrasound images. Urology **81**(3): 685-689.
26. Stafford RE, Ashton-Miller JA, Constantinou C, Coughlin G, Lutton NJ and Hodges PW 2015. Pattern of activation of pelvic floor muscles in men differs with verbal instructions. Neurourology and Urodynamics.
doi: 10.1002/nau.22745

27. Thompson JA, O'Sullivan PB, Briffa K, Neumann P, and Court S 2005. Assessment of pelvic floor movement using transabdominal and transperineal ultrasound. International Urogynecological Journal of Pelvic Floor Dysfunction **16**(4): 285-292.
28. Tutolo MEA 2012. Optimizing postoperative sexual function after radical prostatectomy. Therapeutic Advances in Urology **4**(6): 347-365.
29. Van Kampen M, De Weerdt W, Van Poppel H, De Ridder D, Feys H and Baert L 2000. Effect of pelvic-floor re-education on duration and degree of incontinence after radical prostatectomy: a randomised controlled trial. Lancet **355**(9198): 98-102.
30. Wolin KY, Sutcliffe LJ, Andriole GL, Kibel AS 2010. Risk of Urinary Incontinence Following Prostatectomy: The Role of Physical Activity and Obesity. Journal of Urology **183**(2): 629-633.