A study to evaluate the effect of manual therapy and exercise on the levator plate in women with pelvic organ prolapse.

AUTHOR(S)

Maeve Whelan

CITATION

Whelan, Maeve (2013): A study to evaluate the effect of manual therapy and exercise on the levator plate in women with pelvic organ prolapse.. Royal College of Surgeons in Ireland. Thesis. https://doi.org/10.25419/rcsi.10819169.v1

DOI

10.25419/rcsi.10819169.v1

A Study to Evaluate the Effect of Manual Therapy and Exercise on the Levator Plate in Women with Pelvic Organ Prolapse

Maeve Whelan SMISCP
Dip Obs & Gyn (Physio)

School of Physiotherapy
Royal College of Surgeons in Ireland
123 St Stephens Green
Dublin 2

MSc (Research)
Submitted March 2013

Supervisors: Ruth Jones PhD MCSP and Louise Keating BPhysio, MPhtySt (Manip)

DECLARATION

I declare that this thesis, which I submit to RCSI for examination in consideration of the award of a higher degree of MSc by research is my own personal effort. Where any of the content presented is the result of input or data from a related collaborative research programme this is duly acknowledged in the text such that it is possible to ascertain how much of the work is my own. I have not already obtained a degree in RCSI or elsewhere on the basis of this work. Furthermore, I took reasonable care to ensure that the work is original, and, to the best of my knowledge, does not breach copyright law, and has not been taken from other sources except where such work has been cited and acknowledged within the text.

Signed Maeve Whelan

RCSI Student Number 11100796

Date May 17th 2013

TABLE OF CONTENTS

SUMMARY

Introduction
Pelvic organ prolapse (POP) symptoms, severity and pelvic floor muscle (PFM) strength have been shown to improve significantly with pelvic floor muscle training (PFMT). In this study, a new approach to conservative treatment of POP was investigated by the addition of manual physiotherapy to conventional PFMT.

Aim & Objectives
The aim of this study was to investigate the effect of internal manual therapy and PFMT on the levator plate angle (LPA) in women with stage I or II POP and to investigate the effect of this intervention on stage of POP, POP symptoms and quality of life (QoL). A further objective was to examine inter-tester reliability for MRI measurement in POP.

Methods
A same-subject pre and post test experimental study was undertaken with a sample of 12 subjects with stage I or II POP. MRI measurements as well as POP-Q score, symptom and QoL questionnaires were used as outcome measures before and two weeks after treatment. All subjects received the same intervention including internal manual therapy to the levator plate and muscles and a pelvic floor exercise programme. Pre and post intervention means were analysed using paired t tests for MRI measurements and for POP-Q anterior vaginal wall point, Aa and posterior vaginal wall point, Ap. Wilcoxon signed rank test was used for all other POP-Q measurements. Questionnaire data were analysed using non parametric Wilcoxon signed rank test due to the presence of an outlier. Reliability was calculated using intra-class correlation coefficients (ICC) and Bland and Altman plots were performed.

Results
There was no change in the LPA following the intervention. However, the H line significantly widened by mean 6.98mm ($p=0.01$). There was a significant improvement in POP-Q stage ($p=0.02$), with anterior wall point Aa of the POP-Q showing the greatest improvement; becoming higher by 1.75 cm ($p=0.00$). Point Bp showed a significant change in the opposite direction, demonstrating greater descent on valsalva after treatment by -0.67 cm ($p=0.00$). The predominant leading edge of prolapse changed from cystocele before treatment to rectocele after treatment. The overall result was an improvement in prolapse stage in a positive direction. The International Consultation Incontinence Questionnaire-Vaginal Symptoms score (ICIQ-VS), ICIQ - Sexual Matters score and QoL score were significantly improved ($p=0.01$, $p=0.02$, $p=0.00$). Inter-rater reliability for LPA measurement was moderate-strong for LPA (ICC 0.80) and for bladder (ICC 0.76). Bland and Altman plots revealed acceptable mean differences for LPA, bladder neck and H line.

Conclusions & Implications

Manual therapy and PFMT intervention did not change the LPA in women with stage I or II POP but significant improvements in POP-Q score, point Aa, ICIQ–VS and QoL were found. These changes are highly clinically significant in the light of the importance of patient's symptoms in clinical evaluation of POP. Inter-rater reliability of MRI measurements was moderate-strong for two of the six measures. Clinical application of these LPA and bladder neck measures cannot be recommended at this time and further psychometric testing is required. The improvement seen in POP-Q, symptoms and QoL in this small group warrants further investigation of this novel intervention in a randomised controlled trial.

ACKNOWLEDGEMENTS

Thank you to my supervisor, Louise Keating whose patience, help and guidance carried me through and to whom and I am indebted for all I have learnt. I am very grateful. To my co-supervisor Ruth Jones who did it all before me and still encouraged me to do this – even though she knew what I was letting myself in for – thank you for your words of wisdom.

Thank you to Kelvin Boos, Rohna Kearney and Niall McEniff and to Qiyu Peng and to Kolbe Mooney. Thank you to Hermitage Medical Clinic, to UPMC Beacon Hospital and to Euromedic. Thank you to RCSI statistician, Ronan Conroy.

Thank you to my subjects for their cooperation and trust both in the study and in their physiotherapist.

To all of the Women's Health physiotherapists in Ireland and in the United Kingdom whom I have worked with over the years and who have believed in what I do and have encouraged me.

To all my patients who are of course the people that I learn from and who have always trusted in me even while I am learning, it is always an honour.

To my colleagues at Milltown Physiotherapy who had to work with me and listen to me for this two years!

Thank you to the Continence Foundation of Ireland who funded the MRIs for this study.

Thank you to Jeanette Haslam who offered so kindly to proof read and then gave so much more.

Finally to my family – my parents who got me to physiotherapy in the first place and to my Andy, Alex and Victor who support me always even when they have had enough of me – thank you.

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

Aa - Anterior point 3 cm inside introitus on anterior wall
Ap - Posterior point 3 cm inside introitus posterior wall
ARA - Ano-rectal angle
Ba -Anterior point between Aa and anterior fornix
BMI- Body Mass Index
Bp - Posterior point between point Ba and posterior fornix
C - Cervix
CC – Correlation Coefficient
CPP - Chronic Pelvic Pain
CRADI - Colorectal-Anal Distress Inventory
CRAIQ - Colorectal-Anal Impact Questionnaire
D - Posterior fornix
EMG - Electromyography
GH - Genital hiatus
GRA- Global Response Assessment
GSI -Genuine Stress Incontinence
H line - Hiatus line
HEP - Home Exercise Programme
IC - Interstitial Cystitis
ICC – Intraclass Correlation Coefficient
ICIQ-UI - International Consultation on Incontinence Questionnaire – Urinary Index
ICIQ-VS - International Consultation on Incontinence Questionnaire -Vaginal Symptoms
IIQ - Incontinence Impact Questionnaire
INIT - Integrated Neuromuscular Inhibition Technique
LP - Levator plate
LPA - Levator Plate Angle
M line - Muscular relaxation line
MOS - Modified Oxford Scale
MRI - Magnetic Resonance Imaging
MUH - Measurement of Urinary Handicap
MVC - Maximum Voluntary Contraction
OLS - O'Leary Sant Scale
OR – Odds Ratio
PB - Perineal Body
PCL - Pubococcygeal Line
PFDI - Pelvic Floor Distress Inventory
PFDI-20 - Pelvic Floor Distress Inventory – 20
PFE - Pelvic Floor Exercise
PFIQ-7 - Pelvic Floor Impact Questionnaire –7
PFM - Pelvic Floor Muscles
PFMT - Pelvic Floor Muscle Training
POP - Pelvic Organ Prolapse
POPDI - Pelvic Organ Prolapse Distress Inventory
POPIQ - Pelvic Organ Prolapse Impact Questionnaire

POP-Q - Pelvic Organ Prolapse Quantification
POP-SS - Pelvic Organ Prolapse Symptom Score
PPSS – Pelvic Pain Symptoms Survey
QoL - Quality of Life
RCT - Randomised Controlled Trial
RR – Relative Risk
RTUS - Realtime Ultrasound
RX - Treatment
SCIPP - Sacrococcygeal inferior pubic point
SF-12 - Short Form 12
SPI – Symptom and Problem Index
SUI - Stress Urinary Incontinence
TVL - Total Vaginal Length
UDI - Urinary Distress Inventory
UI - Urinary Incontinence

INTRODUCTION

Pelvic organ prolapse (POP) is highly prevalent, affecting 43 - 76% of women in a routine gynaecologic population (Samuelsson et al., 1999, Swift et al., 2005b). Some degree of loss of support is present in most adult women who have given birth with one study showing that in a gynaecologic population only 24% of all women had normal support and the rest had some degree of prolapse (Swift et al., 2005b). However not all women with POP are symptomatic and many may have a significant prolapse without it being bothersome or without them even being aware of its presence (Ellerkmann et al., 2001, Tan et al., 2005).

The risk factors for either asymptomatic or symptomatic POP are childbirth, with instrumental birth carrying the greatest risk and large baby and small mother being a further risk. However caesarean section does not completely protect against prolapse (Glazener et al., 2013). Multiple births, obesity and previous surgery for POP are also risk factors (Mant et al., 1997, Moalli et al., 2003, Dallenbach et al., 2007). So the problem of prolapse will continue as long as women continue to have children.

As anatomical prolapse does not always correlate with clinical findings, it is important to measure various domains in research, including anatomy and symptom profile. Measurement of pelvic organ prolapse can be reliably done through clinical examination using the pelvic organ prolapse quantification (POP-Q) staging system (Bump et al., 1996). Descent is measured on valsalva where the maximum extent of the protrusion is demonstrated and good reliability and validity has been shown for this measure (Hall et al., 1996).

Symptoms are the most important indication of prolapse bother and remain one of the key outcome measures in POP research, and include vaginal, bowel and urinary symptoms(Ellerkmann et al., 2001, Tan et al., 2005). The most reliable measure of improvement in POP in clinical practice and in research is the measure of improvement of the symptom of seeing or feeling a bulge (Swift et al. 2005, Broekhuis et al., 2009a).

As diagnostic imaging has progressed over the years and become more accessible and less expensive, researchers and clinicians have explored the role of both real-time ultrasound (RTUS) and MRI in POP. RTUS is useful in evaluating compartmental prolapse and levator ani tears and is ever more accessible clinically (Dietz et al., 2010b, Dietz, 2011). However RTUS does not adequately capture the complete anatomy of the pelvic floor and MRI may be preferable when visualising the posterior compartment, in particular where anatomy is altered, as in the case of POP (Majida et al., 2010). MRI adds to the understanding of pelvic floor anatomy and offers a way to measure anatomical change, although to date it has not been shown to add any more clinical value to what can be measured by manual POP-Q measurement (Broekhuis et al., 2009a).

Surgery is a solution for many women for POP when their symptoms are severe or when the level of prolapse is so low that it has become obstructive and developments in surgery continue with research contributing to successful outcomes (Maher et al., 2010). However repeat surgery may be necessary after failures and recurrent prolapses and there is an increased incidence where there are existing levator muscle tears (Mant et al., 1997, Dietz et al., 2010b).

Conservative therapy has developed in recent years and includes provision of pessaries, which can be inserted into the vagina to support the descended organ, oestrogen therapy and physiotherapy. Pessaries provide relief from symptoms when successful and are a very important alternative to surgery when surgery is not an option (Handa and Jones, 2002, Jones et al., 2008). They are also used in conjunction with exercise, in the form of pelvic floor muscle training (PFMT) (Hagen et al., 2011a).

Since 2003, physiotherapy researchers have started to investigate the effects of PFMT on pelvic organ prolapse, challenging the idea that physiotherapy would not have an effect on pelvic organ descent. Many studies have shown positive effects with PFMT; Piya-Anant et al. (2003) found a much slower rate of anterior wall prolapse over two years versus controls; Ghroubi et al. (2008) found improvement in urinary scores and quality of life; Stupp et al. (2011) found greater improvement in anterior wall position versus posterior wall between groups, when measured using POP-Q staging. Hagen et al. (2009b) found improvements in symptom score and objective measurements in organ position and Braekken et al. (2010) found improvements in all of the above as well as morphological changes using RTUS. Further studies showing favourable results are ongoing over 12 month and 24 month periods (Hagen et al., 2011b, Frawley et al., 2012). However a Cochrane review on conservative management of POP concluded that there is still little evidence from large well-conducted randomised controlled trials (RCTs) and a need for more long term follow up (Hagen and Stark, 2011).

In the light of this inconclusive evidence this study will investigate a novel approach in conservative treatment of POP. Manual therapy is another physiotherapy intervention that more commonly is considered part of musculoskeletal physiotherapy. It has application in women's health physiotherapy in the treatment of chronic pelvic pain. The term manual therapy can be defined as procedures by which the hands directly contact the body to treat the soft tissues increasing range of motion, reducing or eliminating soft tissue inflammation, inducing relaxation of tissue improving contractile and non-contractile tissue repair, extensibility and/or stability, facilitating movement and improving function (Gatterman and Hansen, 1994). A skilled physiotherapist with training in both women's health and musculoskeletal physiotherapy can apply manual therapy techniques to the pelvic floor, both externally and internally. Research involving manual therapy as an intervention has mainly involved patients with bladder pain and many of the techniques in these studies cross over between external and internal techniques (Weiss, 2001, Anderson et al., 2005, Fitzgerald et al., 2012). There are no research studies to date examining the use of manual therapy in the treatment of pelvic organ prolapse although researchers have acknowledged the presence of negative muscle tension in the pelvic floor as a result of POP (Dietz, 2009, DeLancey et al., 2012).

The researcher, in a single case study using MRI, observed that the levator plate angle in the pelvic floor of a woman with POP became more cranial by 8 degrees, following one thirty minute manual therapy and exercise treatment session. Treatment during this session included deep palpation and trigger point massage to the pelvic floor muscles, as well as specific breathing techniques and pelvic floor muscle training. This single case study led to the development of this study to establish whether manual therapy has an effect on the levator plate in a group of women with POP.

CHAPTER 1 LITERATURE REVIEW

1.1 Pelvic Organ Prolapse (POP)

1.1.1 Definition

Pelvic Organ Prolapse is a gynaecologic problem that affects mainly parous women and is, for the most part, a consequence of childbirth. It is the downward descent of the pelvic organs from their resting position. Any one of the organs or any part of the pelvic floor can descend. Descent of the bladder is termed a "cystocele" and of the urethra is "urethrocele". Descent of the uterus is simply "prolapse of uterus"; the bladder and uterus will commonly prolapse together. The term "anterior wall descent" is frequently used to describe any one or a combination of cystocele, urethrocele or prolapse of uterus. Descent of the posterior wall in the vagina is a "rectocele". A rectocele is distinct from a "rectal prolapse", where the bowel protrudes through the back passage. When support at the apex of the vagina is lost this may result in an "enterocele" (descent of the small intestine into the vaginal space) or "sigmoidocele" (descent of the colon into the vaginal space).

Prolapse is staged according to how far the anatomical part has descended. In brief, stage I prolapse is when the leading edge of the prolapse is less than or equal to 1 cm inside the vagina, in stage II the leading edge is more than stage I but not more than 1cm outside the vagina and in stage III the leading edge is more than 1cm outside the vagina. In stage IV the descended part is for the most part outside the vagina and inverted to at least 2 cm less than the total vaginal length. The descent is visualised on maximal strain or valsalva and is measured by the Pelvic Organ Prolapse Quantification (POP-Q) system (Bump et al., 1996).

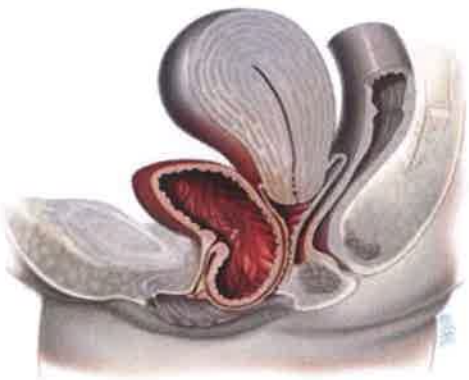


Figure 1-1 Cystocele (illustrations copyright Dr. Levent Efe)

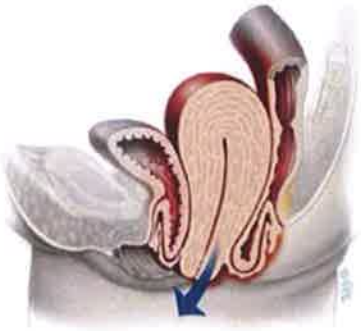


Figure 1-2 Prolapse of the uterus

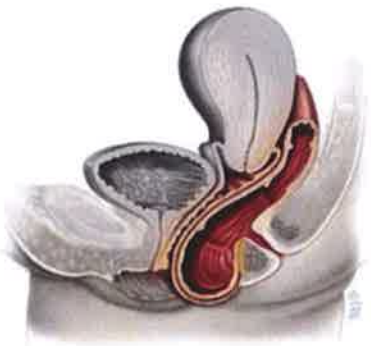


Figure 1-3 Rectocele

1.1.2 Incidence of POP

Some reports of incidence of POP are from either clinical populations or from databases identifying surgically treated prolapse rather than being reflective of the general population. Forty-three to 76% of women presenting for routine gynaecological care will have loss of vaginal or uterine support (Samuelsson et al., 1999, Swift et al. 2005). The figures are lower (20%) when there are symptoms present as reported in a study of women on a waiting list for major gynaecological surgery (Cardozo, 1995). So while there may be prolapse present it is not always symptomatic.

Glazener et al. (2013) in a 12 year longitudinal study evaluated questionnaires of 3,763 women and 762 of these women underwent a POP-Q examination. The mean age of

this group was 42 years and incidence of POP with a leading edge at the hymen or beyond was 24%. This was similar to the incidence found in an older group of 270 women in a centre of the Women's Health Initiative Hormone Replacement Therapy Clinical Trial in the United States where 25.2% of women with a mean age of 68.3 years had prolapse with a leading edge to the hymen or beyond (Nygaard et al., 2004).

In the Women's Health Initiative Hormone Replacement Therapy Clinical Trial 27,342 women underwent a baseline pelvic examination for assessment of prolapse. In the women who had a uterus, the rate of cystocele was 34.3%, the rate of uterine prolapse was 14.2% and the rate of rectocele was 18.3% (Hendrix et al., 2002).

Swift et al. (2003) examined 1,006 women between the ages of 18 and 83; 24% of whom had normal support, 38% had stage I prolapse, 35% had stage II and 2% had stage III. In this multicentre study the authors concluded that some loss of uterine support was present in most adult women. This concept forms a large part of the difficulty in evaluating prolapse and highlights the relevance of how bothersome a prolapse is as one of the main measures prior to any intervention.

1.1.3 Risk Factors

Risk factors for prolapse include vaginal childbirth, increasing parity, increasing age and increasing body mass index. Hendrix et al. (2002) found that single childbirth was associated with raised odds of uterine prolapse (Odds Ratio (OR) 2.1; 95% CI 1.7-2.7), cystocele (OR 2.2; CI 1.8-2.7) and rectocele (OR 1.9; CI 1.7-2.2) and every additional birth increased the risk of prolapse by 10-20%. More recently Glazener et al. (2013) found that those who had exclusive caesarean section deliveries were less likely to have prolapse (OR 0.11, 95% CI 0.03-0.38) and those who had at least one forceps delivery (OR 0.64, 95% CI 0.42-0.96) or at least one each of spontaneous vaginal delivery and caesarean deliveries (OR 0.48, 95% CI 0.22-0.97) were also less likely to have prolapse relative to those who had all their deliveries by spontaneous vaginal delivery.

A substantial number of women who have gone through a pregnancy but not given birth vaginally will still show progression from stage 0 or I in the first trimester to stage I or II in the third trimester and will not return to normal post-partum. This group of women will most likely fall into the category of the majority of women who do not need surgery for POP (Moalli et al., 2003, Swift et al., 2003).

Gyhagen et al. (2013) in a registry based national cohort study in Sweden of 5,236 women who returned a postal questionnaire 20 years after childbirth, found that mothers of maternal height $\leq$ 160 cm who delivered a child vaginally with birthweight $\geq$ 4000 g, had a higher prevalence of symptomatic POP compared with short mothers who delivered an infant weighing <4000 g. This same effect of birthweight was not observed for mothers >160 cms.

The prevalence of POP rose by 40% for every decade in a cross-sectional study of 1,004 US women aged 18-83 who presented for their yearly examination (Swift et al. 2005). In the Women's Health Initiative, women in the USA age range of 60-69 (OR 1.2; 95%

CI 1.1-1.3) and 70-79 (OR 1.4; 1.2-1.6) had a higher risk of prolapse than those aged 50-59 years (Hendrix et al., 2002).

Moalli et al. (2003) found women with a body mass index (BMI) of greater than 26 Kg / m^2 were more likely to undergo surgery (OR 3.0; CI 1.6-5.7) for prolapse than those with a lower value. Gyhagen et al. (2013) found that a combination of one or more forceps deliveries (OR 1.20, 95% CI 1.04-1.38) and a BMI 25-29.9 Kg/m^2 defined as overweight (OR 1.31, 95% CI 1.15-1.50) or a BMI ≥30 Kg/m^2 defined as obese (OR 1.59, 95% CI 1.36-187) were associated with worse POP-Symptom Score (POP-SS). However, Shalom et al. (2012) found no correlation between BMI and any POP-Q data point. They evaluated 311 patients with a mean age of 63.4 years, mean parity of 2.6 and mean BMI of 26.6 kg /m^2. Increasing age was correlated with worsening scores on POP-Q upper anterior wall point Ba ($r = 0.33$, $p < 0.0001$), uterine point C ($r = 0.14$, $p < 0.02$), apical point D ($r = 0.14$, $p = 0.02$) and upper posterior wall point Bp ($r = 0.13$, $p = 0.02$), while parity was only correlated with worsening scores on lower anterior wall point Aa ($r = 0.12$, $p = 0.04$). The lack of correlation between BMI and any specific POP-Q points is perhaps not surprising as it is not specific to type of birth or number of births. POP-Q points are described in section 1.6.1 and Appendix 1.

Previous hysterectomy is a risk factor for POP as is previous surgery for incontinence (Mant et al., 1997, Olsen et al., 1997, Swift, 2000, Hendrix et al., 2002). Dallenbach et al. (2007) found the risk of needing pelvic floor surgery after hysterectomy was 4.7 times higher in women whose initial hysterectomy was for genital prolapse.

1.2 Symptoms

There are two aspects of pelvic organ prolapse that prompt a woman to seek medical advice. The first is the visual aspect of having seen or palpated something coming down without having a sensation of anything coming down and secondly the symptoms, which can vary greatly. Bump et al. (1996) described the symptoms that can be frequently associated with prolapse. Urinary symptoms may be stress incontinence, frequency, urgency, urge incontinence, hesitancy, weak or prolonged urinary stream, feeling of incomplete emptying, needing to manually reduce the prolapse to start or complete bladder emptying and positional changes to start or complete voiding.

Bowel symptoms may include difficulty with defecation, incontinence of flatus, incontinence of liquid stool, incontinence of solid stool, faecal staining of underwear, urgency of defecation, discomfort with defecation, digital manipulation of vagina, perineum or anus to complete defecation, feeling of incomplete evacuation and rectal protrusion during or after defecation (Bump et al., 1996).

Further symptoms may include vaginal pressure or heaviness, vaginal or perineal pain, sensation or awareness of tissue protrusion from the vagina, low back pain, abdominal pressure or pain. If a woman is sexually active coitus may be painful, there may be incontinence during coitus and prolapse may affect frequency of coitus or sexual satisfaction (Bump et al., 1996).

The behaviour of prolapse over time may be impacted by multiple factors. DeLancey et al. (2008) outlined aspects over a lifespan that may affect pelvic floor behaviour; (1) predisposing factors such as genetic, nutritional and toileting (2) inciting factors of childbirth including size and shape of the mother's pelvic floor, type of birth and mechanism of injury and (3) intervening factors including normal aging, lifestyle, medications and mechanical stresses. Where a pelvic floor may be asymptomatic following childbirth, over time the intervening factors may result in the onset of symptoms.

The correlation of stage of POP to symptoms has been the subject of many research studies. Changes in vaginal anatomy are very common especially in parous women and symptoms are very non-specific. Women may be more aware of their symptoms with a stage I prolapse than with a stage II prolapse and prolapse is commonly found on physical examination in women without any pelvic symptoms (Swift, 2000, Hendrix et al., 2002).

Ellerkmann et al. (2001) evaluated type of prolapse and related symptoms in 237 consecutive women. Stage II was the most common POP encountered in 51% of women. Anterior compartment prolapse was the most common at 33%, 19% of women had posterior compartment prolapse and 11% of women had apical prolapse. Overall women with POP experienced symptoms that did not necessarily correlate with compartment-specific defects.

The main symptom of prolapse and the one that is found to have the best correlation with presentation of prolapse is "vaginal bulging" (Swift 2005, Tan et al., 2005). Broekhuis et al. (2009a) evaluated urinary and faecal symptoms and quality of life in 69 women with POP using three different disease-specific questionnaires (Urogenital Distress Inventory, Defecatory Distress Inventory and Incontinence Impact Questionnaire). The sensation or visualization of a bulge in the vagina was the only symptom that correlated positively with the degree of pelvic organ prolapse on Magnetic Resonance Imaging (MRI) (Spearman's rho 0.27, p=0.05) and with clinical POP-Q measurement (Spearman's rho 0.64, p=0.001). Although both MRI and POP-Q correlated with this symptom, POP-Q correlated more strongly and authors concluded that in comparison with clinical examination dynamic MR imaging had no additional value in the prediction of symptoms with increasing degree of POP (Broekhuis et al. 2009a). This statement is important in the light of other studies that claim the importance of dynamic versus static MRI in demonstrating the full extent on a prolapse (Yang et al., 1991, Goodrich et al., 1993, Hsu et al., 2006, Song et al., 2009). The current study will attempt to justify the use of clinical POP-Q evaluation only to demonstrate full extent of a prolapse (sections 1.6.1, 1.6.2.2).

Lakeman et al. (2012) in a cross-sectional study with 10 symptomatic subjects with POP, 10 symptomatic subjects without POP and 10 nulliparous asymptomatic women assessed inter-observer agreement of MRI-based PO-Q staging and quantified association with pelvic examination of POP-Q staging and with pelvic floor symptoms. Data was analysed using Spearman's rank correlation. In women with less than stage II

or greater POP the correlation of dynamic MRI with findings during physical examination was poor (r=0.22-0.33 anterior compartment; r= -0.43-0.17 middle compartment; r=0.51-0.70 posterior compartment). In women with at least stage II POP, this correlation was moderate (r=0.34-0.64 anterior compartment; r=0.36-0.67 middle compartment; r=0.52-0.84 posterior compartment). The correlation of both dynamic MRI and POP-Q with the wide number of pelvic floor symptoms in anterior middle and posterior compartments was poor for most symptoms in both prolapse and control groups. Therefore, there does not seem to be correlation between MRI and clinical POP-Q staging in the measurement of POP symptoms.

Glazener et al. (2013) surveyed 3,763 women 12 years after childbirth and also examined 762 of the respondents by POP-Q measurement. They used the Pelvic Organ Prolapse Symptom Score (POP-SS) as an outcome measure and found that women with their first birth under the age of 25 had significantly more prolapse symptoms POP-SS mean 3.4 (SD ± 4.1) by comparison to 25 to 29 years (2.2 ± 2.9, OR 0.63 (0.53-0.74), < 0.001) and 30 to 34 years (2.2 ± 2.9, OR 0.63 (0.53-0.74), <0.001) but when examining the 762 women found that it was the women over the age of thirty who had significantly greater prolapse scores as measured by POP-Q (OR 2.49 (1.49-4.18), p=0.001). The authors postulated that symptoms might improve with time after delivery as women recovered from the trauma of childbirth. They concluded that they were particularly interested in the fluctuation of symptoms of pelvic floor dysfunction and in women's needs to access treatment and its outcomes.

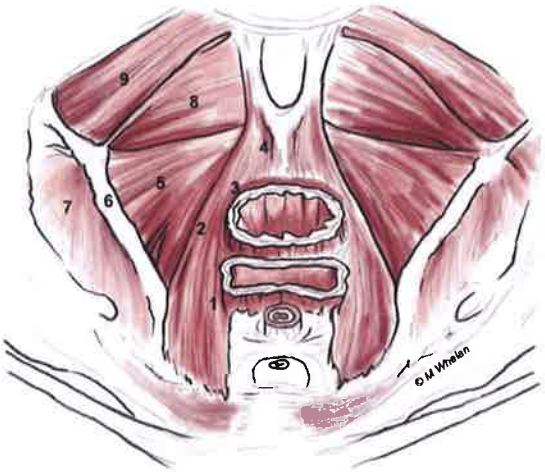
1.3 Anatomy

Hjartardottir et al. (1997, p.567) described the pelvic floor as 'a dome – not a basin', the title of an article that addresses the complex nature of anatomy of the pelvic floor with its overlying fascia and organs. The pelvic floor can be simplistically divided into the superficial and deep pelvic floor; the superficial pelvic floor muscles include the bulbospongiosus, ischiocavernosus and tranversus perineii. Other anterior pelvic floor muscles are the urethral urethrovaginal sphincter and compressor urethra muscles, which will not be referred to in this study but would be included in pelvic floor muscle training. The pelvic floor referred to in this study will be the deep pelvic floor; it extends from front to back and to the sidewalls of the pelvis supporting the entire contents of the pelvis. The main muscle group of the pelvic floor is the levator ani, comprised of the pubovisceralis and the iliococcygeus muscles. Other muscles in the pelvic floor are the ischiococcygeus attaching from the coccyx to the ischial spine and the obturator internus attaching from the sidewall of the pelvis extending at a 90º angle inserting into the lesser trochanter. These two muscles will not be discussed further as they do not play a role in pelvic organ support. The function of the pelvic floor is to support the organs, control micturition, control bowel movements and they play a role in sexual function.

The pubovisceralis part of the levator ani muscle is made up of different portions named by way of anatomical attachment. The most superficial part is the puboperineal portion attaching from the pubic bone to the perineal body, the pubovaginalis muscle attaches from the pubic bone to the posterior vaginal wall and

the puboanal portion inserts into the anal canal and skin. They were previously referred to as the pubococcygeus muscle but were renamed to reflect the orientation of the different parts of the muscle in the pelvic floor (Lawson, 1974, Kearney et al., 2004). The puborectalis is distinct from the other pubovisceralis muscles as it attaches to the pubic bon
e and forms a sling behind the rectum. It creates an angulation of the rectum whereas the other muscles elevate the anus, perineal body and vagina (DeLancey and Ashton-Miller, 2007).

The iliococcygeus is a fan shaped muscle extending from the tendinous arch of the levator ani along the sidewall of the pelvis and the ischial spine to the coccyx and is joined by the iliococcygeus from the opposite side in the midline forming the levator plate (LP) anterior to the coccyx. Some fibres of the iliococcygeus also arise from the external anal sphincter although this is not always documented (Law and Fielding, 2008). The levator plate has also been described as the flat region between the anus and the coccyx where the levator ani muscles unite with the same muscle group on the opposite side and intertwine with each other reinforcing the support behind the rectum (Hsu et al., 2006). Singh et al. (2001) described the levator plate as the horizontal shelf support of the pelvic floor. In healthy women the upper axis of the vagina is horizontal and should lie parallel to the levator plate, however it is more caudally inclined in women with prolapse (Hsu et al., 2006, Ginath et al., 2011). The levator plate rises with muscle contraction to support the pelvic contents when intra-abdominal pressure is increased (Zacharin, 1980).



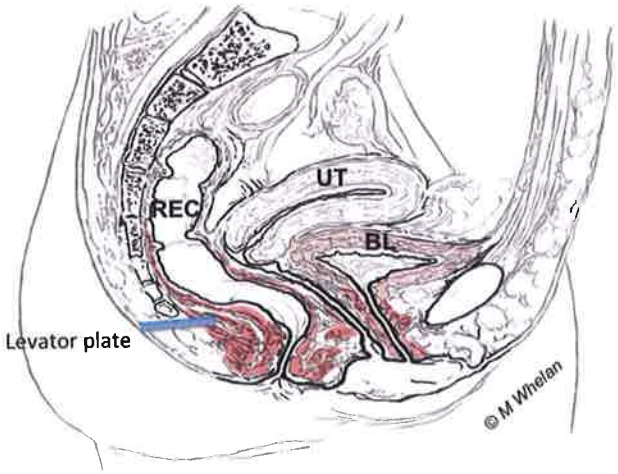
Key:

1. Pubovaginalis
2. Pubococcygeus
3. Puborectalis
4. Levator plate
5. Iliococcygeus
6. Tendinous arch of levator ani
7. Obturator internus
8. Ischiococcygeus
9. Piriformis

Figure 1-4 The deep pelvic floor muscles (copyright of author)

The pelvic floor contracts in a cranioventral direction towards the pubic bone. The direction of contraction is slightly different depending on the muscle attachments; the puboanalis and pubovaginalis portions of the pubovisceralis muscle elevate the anus and perineal body whereas the pubococcygeus and puborectalis portions compress the rectum, vagina and urethra behind the pubic bone. The iliococcygeus muscle elevates the central region of the posterior pelvic floor (Ashton-Miller and DeLancey, 2009).

Fascia overlies the pelvic floor muscles extending up to and around the organs, which are in turn supported by this tissue and by strong ligaments with both bony attachments. On palpation along the anterior wall of the vagina, the end point is the anterior fornix where the anterior wall is attached to the cervix of the uterus. The posterior fornix is the area where the cervix is attached to the posterior wall of the vagina. The apex of the vagina should be well supported and normal total vaginal length (TVL) should be 10 cms. The paracolpium is the connective tissue surrounding the mid to upper vagina and uterus and fuses with the pelvic wall and fascia laterally. The cardinal and uterosacral ligaments were previously both described as strong and broad ligaments supporting the apex of the vagina anchoring the pelvic viscera over the levator plate (Herschorn, 2004). More recently, the existence of the cardinal ligament as a term has become controversial and it has been referred to as a visceral ligament which is a mesentery-like structure connecting the uterus to the pelvic sidewall implying that it does not contain the dense connective tissue of a broad ligament attaching two structures (Ramanah et al., 2012).



REC Rectum
UT Uterus
BL Bladder

Figure 1-5 Sagittal pelvis showing levator plate and organ position at rest (copyright of author)

The boundaries of the urogenital hiatus are defined by the pubic bones anteriorly, the medial margins of the levator ani muscles laterally and the perineal body dorsally. The levator ani muscles close the urogenital hiatus and the hiatus can be measured on MRI as the "H-line". Relaxation of the levator ani muscles posteriorly increases the levator hiatus. The descent of the organs and pelvic floor muscles as a result of loss of support is measured as the "M-line" (muscular relaxation). The levator plate loses its horizontal position in patients in association with enlargement of the hiatus and may predispose to prolapse (DeLancey and Hurd, 1998).

1.3.1 Biomechanics and Levator Injury

Ashton-Miller and DeLancey (2009) described how the anterior vaginal wall is fixed at its lower margin to the perineal membrane and is suspended from the cardinal and uterosacral ligaments at its upper margin. It rests against the rectum and posterior

vaginal wall supported by the levator ani muscles. Intra-abdominal pressure against the rectum and levator ani muscles pushes them backwards. If this force is not sufficiently counteracted then there will be a downward displacement of the anterior vaginal wall stretching the cardinal and uterosacral ligaments and the distal vaginal wall may protrude through the widened genital hiatus. The levator plate will have been rotated posteriorly under the action of the intra-abdominal pressure to expose the distal vaginal wall.

DeLancey et al. (2003) evaluated the pelvic floors of parous and nulliparous women on MRI and found that 32 of 160 women (20%) exhibited damage to the levator ani muscles. Twenty-nine of these were in the pubovisceral muscles and only three injuries occurred in the iliococcygeal portion. Within this group there was great variation in the amount of injury from a few fibres on one side of the levator to the entire pubovisceral muscle both with and without distortion of surrounding tissue.

Gearhart et al. (2004) evaluated 80 consecutive patients with pelvic organ prolapse and identified levator ani herniation in 12 patients (15%); eight unilateral and four bilateral. Abdool et al. (2009) retrospectively assessed the pelvic floor ultrasound images of 414 urogynaecologic patients; 21.1% of those having delivered vaginally had sustained an avulsion injury of the levator muscle and in 8.6% it was bilateral.

DeLancey et al. (2012, p.77) described "compensatory hypertrophy hypothesis" where damage to the ventral portion of the levator muscle results in compensatory hypertrophy of the dorsal intact portion, specifically the puborectalis. This compensatory hypertrophy may explain why a loss of less than 50% of the muscle is not associated with prolapse while a loss of greater than 50% has a significant association with prolapse (DeLancey et al., 2012). Furthermore where there is a lesser degree of injury the remaining muscle can hypertrophy to take over some of the lost function while greater degrees of injury exceed the capability of the remaining muscle to take over its activity (DeLancey et al., 2007, DeLancey et al., 2012).

It is known that there is a lesser rate of injury to the iliococcygeus (10%) as opposed to the pubovisceralis (90%) (DeLancey et al., 2003). If there is damage to the pubovisceral muscle it may result in an increased load on the iliococcygeal muscle and raphe, resulting in downward, more vertical displacement but not to the same degree as if the iliococcygeal muscle itself is damaged (Hsu et al., 2006).

1.4 Surgical Treatment

Pelvic organ prolapse is the leading indication for hysterectomy in post-menopausal women. It rarely results in severe morbidity or mortality but causes symptoms of the lower genital, urinary or gastrointestinal tract that can affect a woman's daily activities and quality of life (Jelovsek et al., 2007).

The incidence of surgery for prolapse is between 1.5 and 4.9 cases per 1000 woman-years (Mant et al., 1997, Olsen et al., 1997, Brown et al., 2002, Boyles et al., 2003). A woman's lifetime risk of surgery for POP by the age of 80 is seven to 11%

(Olsen et al., 1997, Brown et al., 2002). Fifty-eight per cent of procedures are undertaken in people younger than 60 years, however the peak is 60-69 years (Brown et al., 2002). The recurrence rate for pelvic organ prolapse following surgery is high with 13% of these women needing a repeat operation within 5 years (Olsen et al., 1997, Clark et al., 2003). Levator muscle avulsion is a risk factor for recurrence of prolapse; in a retrospective audit of 83 women who underwent surgery for cystocele, 40% had significant recurrence of their cystocele and 35% showed evidence of levator avulsion on ultrasound (Dietz et al., 2010a).

The types of repair surgery for POP vary depending on the type of prolapse and associated symptoms. The impact of pelvic organ prolapse surgery on bowel, bladder and sexual function can be unpredictable and may make symptoms worse or result in new symptoms, such as leakage of urine or problems with intercourse (Maher et al., 2010). A repeat UK national prolapse survey evaluating the surgical management among consultant gynaecologists showed trends in surgeries performed for prolapse in the UK over the preceding five years (Jha and Moran, 2011). There were 190 completed responses from 549 administered questionnaires and 218 returned responses. The useable response rate was 28% and 72% of these were either gynaecologists with a special interest in urogynaecology (52%) or urogynaecologists (20%), this is not surprising as this is the subspeciality with the greatest interest in pelvic floor surgery. The main procedures performed for anterior vaginal wall prolapse was anterior colporrhaphy (repair). The main procedure for uterovaginal prolapse was vaginal hysterectomy and repair. In women with posterior vaginal wall prolapse the procedure of choice was posterior colporrhaphy with midline fascial plication. For vault prolapse the procedure of choice was sacrocolpopexy; this is a procedure to correct the top of the vagina in women who have had a previous hysterectomy. It can be performed through an abdominal incision, using laparoscope or by robotic surgery. Sacrocolpopexy can be performed at the same time as surgery for incontinence or vaginal repair for bowel or bladder prolapse.

A recent Cochrane review concluded that abdominal sacrocolpopexy is associated with a lower rate of vault prolapse (Relative Ratio (RR) 0.23, 95% CI 0.07 – 0.77) and less dyspareunia (RR 0.39, 95% CI 0.18 – 0.86) than vaginal sacrospinous colpopexy but must be balanced against longer operating time and longer recovery time (Maher et al., 2010). However there were no statistically significant differences in re-operation rates for prolapse between these operations (RR 0.46, 95% CI 0.19 – 1.11). A further finding was that continence surgery at the time of prolapse surgery did not significantly reduce the rate of post-operative stress urinary incontinence (RR 1.39, 95% CI 0.53 to 3.70). In women with occult stress urinary incontinence before operation, the rate of de novo stress urinary incontinence may be reduced if women undergo continence surgery at the time of prolapse surgery. Approximately 20% of women will be prevented from developing de novo stress incontinence post-prolapse surgery if continence surgery is performed on all women who have occult stress incontinence pre-operatively, but 80% will have an unnecessary procedure (Maher et al., 2010). Overall the Cochrane review is useful in counselling women in specific surgical procedures where surgery is indicated and conservative therapy has failed.

1.5 Conservative Treatment

The high recurrence rates of POP after surgery are a cause for concern. However, the majority of women with findings of prolapse will not need surgical treatment (Weber and Richter, 2005). Jelovsek et al. (2007) stated that pessary was the only currently available, non surgical intervention for women with POP; however ongoing studies have shown the success of physiotherapy as a conservative treatment as well and the combination of both physiotherapy and pessary is under investigation; these will be explored under conservative treatment.

1.5.1 Pessary

A pessary is a device that can be inserted into the vagina to support the prolapsing organ alleviating symptoms of pressure in the vagina and in the rectum and keeping the organ inside the vagina. They are used for significant prolapses in women who opt for temporary relief going on to have surgery later, in women who decline surgery or women who are poor surgical candidates because of medical comorbidities. There are approximately 20 different types but the most frequently used are the Ring, Donut and Gelhorn pessaries. Pessaries are used by 98% of urogynaecologists in clinical practice (Cundiff et al., 2000, Pott-Grinstein and Newcomer, 2001).

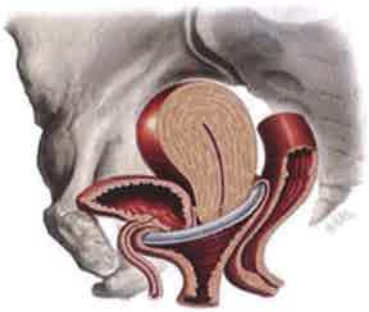


Figure 1-6 Ring pessary supporting uterus and bladder (Illustration © Dr Levent Efe)

Jelovsek et al. (2007) stated that at that time there had been no randomised controlled trails (RCTs) on effectiveness of pessaries to date. Jones et al. (2008) in an observational cohort study of 90 women reported a significant decrease in size of genital hiatus following removal of pessary after two weeks mean 4.1cm (SD ± 1.2) and three months 3.9cm (± 1.1) compared with baseline 4.8cm (±1.6) on strain ($p<.001$) but not at rest ($p=0.131$). There was no correlation between genital hiatus at rest or on strain with the Pelvic Floor Distress Inventory (PFDI) questionnaire that was used to evaluate symptoms from baseline to 3 months but there was a correlation with decreased genital hiatus on strain with the Pelvic Organ Prolapse Distress Inventory (POPDI) subsection of this from baseline to 3 months ($r=0.308$, $p=0.047$). In this same study POP-Q point Aa was positively associated with continued pessary use at 3 months mean +1.2cm (SD ± 1.9) versus discontinued use mean +0.3cm (SD ± 1.9),

p= 0.029 and was an independent predictor of continued use. Each 1cm increase in baseline point Aa was associated with a 26% decrease in the likelihood of a participant discontinuing pessary use. Of interest it was the POPDI questionnaire that was the one that correlated with the genital hiatus, which is the main questionnaire for POP symptoms of vaginal bulge and is used in the current study to evaluate the effect of manual therapy also as a method for off loading prolapse. Authors state that anterior predominant vaginal prolapse is more easily addressed with a pessary as compared with posterior predominant prolapse explaining the correlation with point Aa (Jelovsek et al. 2007).

Bo et al. (2012) in a pre-post test of 22 women looked at both vaginal resting pressure and maximum voluntary contraction (MVC) with and without ring pessary in situ. There was a significant difference in vaginal resting pressure ($p<0.01$) but not MVC ($p=0.68$). Results may have been different if the pessary had been in place for longer. Handa and Jones (2002) suggested there may be a therapeutic effect to pessary use over the course of one year. Thirty-three per cent of 56 women examined at baseline were followed up over the year. A significant improvement in the stage of prolapse was observed ($p=0.045$) in POP-Q examination. The authors commented on the mechanism of the observed improvement in prolapse. They speculated that the changes may have been due to alleviation of the prolonged stretch of perineal tissue which would in turn impair skeletal muscle strength. They stated that a further effect may be that the use of a pessary allows recovery from passive stretch and results in improved levator function.

Hagen et al. (2011a) carried out a multi-centre feasibility RCT to investigate the use of pessaries at the same time as physiotherapy. Sixteen women were randomised into one of two groups: pelvic floor muscle training, delivered by a physiotherapist at five appointments over 16 weeks in conjunction with pessary management of their prolapse or pessary management with lifestyle advice. All women had a nurse appointment six months after randomisation at which time their pessary was removed. A replacement pessary was not immediately re-fitted. At seven months after randomisation all women had a review appointment with their gynaecologist to have their prolapse assessed and the pessary re-fitted if indicated. Key outcomes were prolapse symptoms, prolapse-related quality of life and prolapse severity. The mean POP-SS disimproved from baseline and was worst in both groups at seven months indicating worse symptoms one month after removal of the pessary. Mean score was higher in the control group than the treatment group at 6 months (treatment 5.38 ± 4.72 v control 8.57 ± 9.65) but the reverse was true at 7 months (treatment 14.50 ± 5.46 v 12.67 ± 9.24). Overall apart from one woman who improved by two stages the differences in POP-Q scores between the two groups was comparable.

1.5.2 Physiotherapy

There is sufficient and growing evidence to suggest that muscle strengthening for the pelvic floor helps alleviate symptoms of pelvic organ prolapse (Piya-Anant et al., 2003, Ghroubi et al., 2008, Hagen et al., 2009b, Braekken et al., 2010, Stupp et al., 2011) with recent ongoing trials giving further evidence to support this (Hagen et al., 2011b, Frawley et al., 2012). However a Cochrane review of conservative management of POP

in 2011 included studies by Piya-Anant et al. (2003), Ghroubi et al. (2008) Braekken et al. (2010) and Hagen et al. (2009b) and authors concluded that there is still little evidence from large well-conducted randomised controlled trials, with a limited amount of pooling of results across trials possible due to different measures being used by different research teams. They suggested a need for more long term follow up and that further studies might explore the effect of biofeedback, electrical stimulation, lifestyle, weight loss and constipation (Hagen and Stark, 2011).

In five of the seven trials reviewed here, methodology was similar comparing a pelvic floor exercise group with controls, using measurement of symptoms score, POP-Q and pelvic floor muscle strength (Hagen et al. 2009b, Braekken et al. 2010, Stupp et al., 2011, Hagen et al. 2011b, Frawley et al. 2012). Two trials did not use baseline POP-Q for inclusion or as an outcome measure to assess pelvic organ position (Piya-Anant et al. 2003, Ghroubi et al. 2008). An outline of study design, participants, interventions, outcome measure and results is tabulated (table 1.1).

Table 1-1 Physiotherapy studies on pelvic organ prolapse

Author	PED-RO Score	Design	Participants	Intervention	Outcome Measures	Results
Piya-Anant et al. 2003	4/10	RCT	n= 654 (60 years+ community women) Rx. group n=330 Control group n=324 Anterior prolapse, baseline not measured	Rx. group: PFE 30 per day, no further description Control group: nil	Symptoms assessed visually at 6 month intervals over 24 months	72% controls worse prolapse visually measured vs. 27.3% intervention
Ghroubi et al. 2008	5/10	RCT	n=47 Rx. group n=27 Control group n=20, Stage I &II cystocele ± stage I rectocele	Rx. group: 24 sessions 30 mins each incl. digital facilitation, biofeedback and electrical stim., and HEP 20 reps per day from 10th session onwards Control group: nil	Measurement of Urinary Handicap Scale (MUH), Urodynamics test, Ditrovie QoL scale	Pelvic heaviness persisted in 19% vs. 70% control group (p<0.001). QoL imp in Rx. (p<0.001) vs. control group. MUH imp in Rx (p=0.001) vs. control.
Hagen et al. 2009(b)	6/10	Randomis-ed feasibility trial	n=47 Rx. group n=23 Control group n=24 Stage I or II anterior or posterior	Rx. group: 5 sessions with specialist physiotherapist at 0, 2, 6, 11, &16 weeks incl. education, lifestyle sheet, PFE and instruction in HEP: 6 sets of 8-12 reps daily Control group: Lifestyle sheet only	POP-Q stage Pelvic floor strength MOS, measured in Rx. group only, POP-SS, SF-12 ICIQ-UI, ICIQ bowel and vaginal symptom modules	MOS imp (p=0.008) baseline to 16 weeks. POP-Q stage imp at 20 weeks (p=0.038). POP-Q Aa imp (p=0.036)& Ba (p=0.007). POP-SS imp at 20 (p=0.08) and 26 weeks (p=0.021). No change in QoL /urinary /vagina /bowel
Braekken et al. 2010	8/10	RCT	n=109 Rx. group n=59 Control group n=50 Stage I, II & III anterior and posterior	Rx. group: 3 sets of 8-12 contractions x 3 per day recorded in exercise diary, weekly supervised session x 3 months, every second week x 3 months plus booklet & DVD. Control group: lifestyle advice and how to contract pelvic	POP-Q stage Pelvic floor contraction with vaginal balloon catheter Realtime ultrasound to measure muscle contraction 4-point symptom freq and bother scale ICIQ-UI SF	PFM strength imp in Rx. group vs. controls (p=0.035). POP-Q stage imp in 19% vs. 8% (p=0.035). Bladder neck (p<0.001) and rectal ampulla (p=0.022) lifted more on RTUS vs. controls. Urinary symptoms imp vs. controls (p=0.002). Less

				floor during incr. abd. pressure		frequency (p=0.015) and bother (p=0.04) of symptoms vs. controls.
Stupp et al. 2011	5/10	RCT	n=37 Rx. group n=21 Control group n=16 Stage II anterior or posterior compartment prolapse	Rx group: 7 sessions with specialist therapist over 14 weeks at 0, 1, 2, 6, 10 and 14 weeks incl, breathing, manual facilitation, strengthening, timing control & HEP: 3 sets per day 8-12 reps x 6-10 secs. Control group: how to perform PFE, no specific programme, lifestyle advice	Modified Oxford Squeeze, maximum voluntary contraction on EMG Prolapse –QoL questionnaire	MOS imp vs. controls (p<0.001). MVC imp vs. controls (p=0.008). POP-Q anterior compartment imp (p<0.001) more than posterior (p=0.025). P-QoL imp (p<0.01) in 4 out of 9 domains. Key symptom Q.s imp vs. controls: Lump in vagina (p<0.001), SUI (p=0.002) & straining to empty bladder (p=0.031).
Hagen et al 2011		Multi-centre RCT, 6 &12 month data, 24 month study ongoing	n= 447 (1 withdrawal) Rx. group: n=224 Control group n=222 23 UK centres, 2 international centres Stage I, II or III anterior or posterior	Rx. group: 5 sessions with specialist physiotherapist, 0, 2, 6, 11, &16 weeks incl. education, lifestyle sheet, PFE and instruction in HEP: 6 sets daily Control group: Lifestyle sheet only	POP-Q stage Pelvic floor strength MOS, measured in Rx. group only, POP-SS	POP-SS imp vs. controls at 6 mo (p<0.001) and at 12 mo (p=0.005). POP-Q stage (p=0.052). Self reported imp at 6 mo (p<0.001) at 12 mo imp (p=0.012); MOS imp compared to baseline (p<0.001).
Frawley et al. 2012		Multi-centre RCT, 12 month data as above	N= 168 Rx. group n=84 Control group n=84 Stage I, II and III anterior and posterior	Rx. group: 5 sessions with specialist physiotherapist, 0, 2, 6, 11, &16 weeks incl. education, lifestyle sheet, PFE and instruction in HEP: 6 sets daily Control group: Lifestyle sheet only	POP-Q stage ICS digital strength scale Manometry Peritron unit measured in both groups at 6 and 12 months POP-SS	POP-SS imp at 6 mo (p<0.000) and at 12 mo (p=0.006). MOS imp at 6 mo vs. Rx (p=0.04) but not at 12 mo. POP-Q Ap and Bp imp vs. control at 6 mo and 12 mo (p=0.03, p=0.02).

Rx – treatment ; MOS - Modified Oxford Grade ; MUH – Measurement Urinary Handicap; POP-SS – Pelvic Organ Prolapse Symptom Score: ICIQ –UI International Consultation Incontinence; Questionnaire – Urinary Index; MVC maximum voluntary contraction; P-QoL – Prolapse Quality of Life; PFE – pelvic floor exercise; HEP - home exercise programme; SUI – stress urinary incontinence

Piya-Anant et al. (2003) assessed 654 elderly women with anterior prolapse, 330 in the intervention group and 324 in the control group. Stage of prolapse was not measured objectively and there were no baseline inclusion criteria. POP was assessed visually at six-month intervals over 24 months. Validated subjective outcome measures were not used in this study. At 24 months authors reported that 72.2% of controls demonstrated worse prolapse compared with only 27.3% of the intervention group, however there were major methodological flaws in this trial as assessors were not blinded and measurement would have been highly subjective. This was a sizeable study and visually there were reports of improvements but researchers failed to show any objective changes by using any symptom scores or POP measurements and therefore failed to show any changes that could add comparatively to current research with no statistical values reported.

Ghroubi et al. (2008) recruited 47 women with stage I and II cystocele, with or without concurrent grade I rectocele. Subjects were randomized to a pelvic floor muscle exercise intervention group (n=27) and a control group (n=20). "Pelvic heaviness" was the main symptom measure and was reported to persist in five (19%) of the intervention vs. 14 (70%) in the control group ($p<0.001$). QoL improved with intervention ($p<0.001$) compared with no significant changes in the control group. Measure of Urinary Handicap (MUH) and all urodynamic parameters significantly improved ($p<0.001$) in the intervention group. It is not possible to comment on stage of prolapse as it was only used at the start for inclusion in the study. Outcome measures were unusual with "pelvic heaviness" being the most relevant. Other outcome measures were more urinary related which is unusual in a POP study indicating it may have been part of a wider urinary study and so not being as useful for comparison. It should also be noted that 24 physiotherapy sessions was a significantly larger physiotherapy dose in comparison with other studies.

Hagen et al. (2009b) carried out a randomised feasibility trial for women with stage I and II prolapse involving a physiotherapy treatment group (n=23) and a control group (n=24). The treatment group demonstrated an improvement in Modified Oxford Squeeze (MOS) pressure ($p=0.008$) between base-line and 16 weeks and in POP-Q grade ($p=0.038$). Women in the control group received a lifestyle intervention sheet only. The change in Oxford grade before and after intervention in the control group was not measured as it was thought that there would be a treatment effect, altering results in comparison of POP-Q stage by taking a baseline measurement. Sixteen weeks was the period of time attending the specialist physiotherapist and was sufficient time to create a training effect in muscle and will later be compared to other training periods (Bø, 1995).

POP-Q stage was significantly improved at 20 weeks ($p=0.038$). The POP-Q showed significantly more improvement in the intervention group in the Aa and Ba measurements ($p=0.036$) and ($p=0.007$) respectively. The authors commented that this improvement may have been expected due to the large proportion of women in the study with cystocele (85%). The treatment group demonstrated statistically significant improvements in POP symptoms at 20 weeks ($p= 0.08$) and at 26 weeks ($p=0.021$) versus controls using the POP-SS (Hagen et al., 2009a). There were no significant

differences between groups in urinary, bowel or vaginal symptoms. There were no statistically different changes in QoL between groups using the generic Short Form-12.

This feasibility trial has now been followed by a multicentre RCT (Hagen et al., 2011b). Four hundred and forty eight women were recruited over 30 months from 23 UK centres and two international centres. Results in prolapse severity showed there was a marginally significant difference in prolapse stage between trial groups; 20% in the intervention group had an improved stage versus 12% in the control group (Mann-Whitney test p=0.052). The majority of women in both groups had no change in their prolapse stage. Results in prolapse symptoms were measured by the POP-SS. There were significantly lower symptoms in the intervention group compared to the control group. The estimate of difference between groups in change was 2.84 (95% Confidence Interval (CI) 2.05, 3.63, p<0.001) from baseline at 6 months and 1.52 (95% CI 0.46, 2.59, p=0.005) from baseline at 12 months. Further significant changes in the intervention group were that women were more likely to report that their prolapse felt better compared to the start of the study, both at 6 months (52% intervention vs. 17% control, p<0.001) and 12 months (57% intervention vs. 45% control, p=0.012). There was a significant increase in squeeze pressure for those who attended the fifth appointment (n=143) from baseline on the Modified Oxford Scale (mean increase 0.6, 95% CI 0.5, 0.7, p<0.001). Similar to the last design, squeeze pressure was not measured in controls.

Braekken et al. (2010) measured pelvic floor contraction using a vaginal balloon catheter and used real time ultrasound to assess muscle contraction as well as other morphological measures including muscle length, diameter of the hiatus and muscle thickness. They recruited 59 women in the treatment group and 50 in the control group and found pelvic floor muscle strength improved significantly in the treatment group (p<.001) compared with controls.

Significantly more women in the treatment group (19%) compared with the control group (8%) improved by one POP stage (p=0.035). There were however no significant correlations between increase in PFM strength and change in POP-Q values. This has never been proven in a pelvic floor study and as one is a measure of the function of a muscle and the other is a measure of the passive descent of the organ on valsalva they are not likely to correlate even with improvements. There were no significant correlations between increase in pelvic floor muscle strength and symptom improvement, authors state that pelvic floor strengthening is merely supportive to the organs as a mechanism for changing pelvic floor symptoms. There were improvements in the cranial elevation of the bladder (difference 3 mm; 95% CI 1.5-4.4; p<0.001) and the rectum (difference 5.5 mm; 95% CI; 1.4-7.3; p=0.022) between treatment and control groups after 6 months of intervention. There were positive correlations between increased PFM strength and cranial elevation of the bladder (r=0.23; p=0.024) and rectum (r=0.027; p=0.019). Subgroup analysis of the 40 women with prolapse below the hymen did not show a statistically significant change in prolapse stage but did demonstrate a reduction in frequency of prolapse symptoms in 56% (14/25) of the treatment group compared with 15% of the control group (p=0.008). Although this was

a well randomised controlled trial, it was not powered to do a sub group analysis (stage I: 19, stage II: 65, stage III: 24).

Stupp et al. (2011) recruited 37 women with stage II prolapse, 21 women randomised to the treatment group and 16 to the control group. After 14 weeks of intervention there was a significant change in strength in the treatment group as measured by Modified Oxford Scale ($p<0.001$) and maximum voluntary contraction as measured by surface electromyography (EMG) ($p=0.008$).

Symptoms measured using the Prolapse-QoL questionnaire improved across the intervention group and POP-Q stage improved in both anterior compartment and posterior compartment although greater improvement was seen in the anterior compartment ($p<0.001$) than the posterior ($p=0.025$). Thirteen of the 21 had improved by one stage in the anterior compartment versus four in the posterior compartment. Correlation between stage and strength and symptoms was not reported. One of the strengths of this study was that all women at baseline had stage II prolapse and that measurement of muscle function and EMG was taken from the same stage of prolapse.

Frawley et al. (2012) reported on a multicentre RCT forming part of the extended international trial by Hagen et al. (2011b) looking at 6 and 12 month data and following the same protocol. One hundred and sixty eight women with symptomatic POP of stage I, II or III, were recruited.

POP-SS was significantly lower in the PFMT group compared to the control group at 6 ($p<0.000$) and 12 months ($p=0.006$). There were no overall differences in POP-Q stages between groups at 6 ($p=0.98$) and 12 months ($p=0.90$). There were significant differences in points Ap and Bp in favor of PFMT group at 6 ($p=0.03$, 95% CI -0.79 – -0.03) and 12 months ($p=0.02$, 95% CI -0.86 – -0.08). MOS squeeze was significantly greater in the PFMT group compared to the Lifestyle group at 6 months (OR 2.2, $p=0.04$, 95% CI 1.04 – 4.79) and stronger but not significantly at 12 months (OR 1.87, $p=0.12$, 95% CI 0.85 – 4.15). Other manometry findings were non-significant between groups.

Reduction in PFM function has been found to be independently related to pelvic organ prolapse. Braekken et al. (2009a) as part of their study recruited 49 women with POP and 49 controls and showed that reduced PFM strength (OR 7.5; 95% CI 1.5-36.4) and endurance (OR 11.5; 95% CI 2.0-66.9) were independently related to POP using vaginal pressure transducer measurements. However Frawley et al. (2011) reported on a study of 170 women from 3 centres internationally where prolapse symptoms were measured; POP was staged and pelvic floor muscle function was measured using both digital pressure and manometry. They found no relationship between symptom score and POP-Q stage and no relationship between strength and POP symptoms or POP-Q. This seems to be the case throughout all of the studies despite showing improvements in strength and POP-Q stage, no correlation can be found. It seems reasonable over a period of strength training greater than 16 weeks that strength as measured by digital squeeze or manometry should improve consistent with principles of muscle training (Bø, 1995). Consistent with these same principles it would seem reasonable that this

same muscle contraction would be more supportive to the organs day to day and provide the patient with more awareness of her pelvic floor though this exercise. Therefore over time there should be less loading and straining of her organs where they should spend more time in a position or rest and when tested on valsalva should not descend as low. However as one is a test of the function of the muscle and the ability, awareness, control and practice of the patient and the other is a test of the passive supports, they should not necessarily correlate.

The clinical implications for the length of these studies are important. Ghroubi et al. (2008) had the largest treatment dose at 24 individual sessions, then Braekken et al. (2010) with a total of 18 sessions over 26 weeks, Hagen et al. (2009, 2011b) and Frawley et al. (2012) with 5 sessions over 16 weeks, and Stupp et al. (2011) with 7 sessions over 14 weeks. There are a number of issues that are important as clearly this would mean significantly greater cost with more individual physiotherapy sessions. It needs to be ascertained whether it is necessary to invest the significantly greater time of 18 and 24 individual sessions relative to the less expensive 5-7 sessions. Braekken et al. (2010) were able to demonstrate the morphological changes in bladder and rectal ampulla for prolapse position with RTUS and showed a statistically significant change in POP-Q stage vs controls ($p=0.035$) with significantly reduced frequency ($p=0.015$) and bother ($p=0.04$) of symptoms versus controls. However Stupp et al. (2011) were able to demonstrate improvement in POP-Q stage in anterior compartment ($p<0.001$) and posterior compartment ($p=0.025$) after only 14 weeks by comparison to 26 weeks in the previous study. Without being able to demonstrate a correlation for these morphological changes it is difficult to justify the cost and time of 26 weeks intervention.

Hagen et al. (2011b) showed improvement in POP-SS after 6 months ($p<0.001$) versus controls after only five intervention sessions as did Frawley et al. (2012) over the same time period and same number of sessions ($p<0.000$) showing that improvements may be achieved over time and that the number of intervention sessions may not be the most important factor. The improvement by Hagen et al. (2011b) in POP-Q was just marginally improved ($p=0.052$) at 16 weeks and had worsened by 6 months ($p=0.98$) and 12 months ($p=0.90$) versus controls when measured by Frawley et al. (2012). This was by comparison to Braekken et al. (2010) where 11 women improved by one stage in the treatment group (19%) vs. four in the control group (8%) ($p= 0.035$). This was a far smaller sample size than that in the study by Hagen et al. (2011b) and Frawley et al (2012). Clinically interpreted, these improvements in POP-Q stage are not that much greater for the increased amount of input over that period of time. Furthermore, relative to the input the symptom improvement over 6 months seems a better outcome with just five intervention sessions and POP-Q stage is clinically less important than symptom change. However the best objective improvement was by Stupp et al. (2011) where manual facilitation is described and POP-Q stage was significantly improved (anterior $p=0.001$, posterior $p=0.025$). The difference between facilitation and manual therapy as techniques between this study and the current study will be clarified in section 2.8.1 on Manual Therapy.

It seems therefore that from five to seven sessions over a six month period is enough

time with a therapist and enough time to train the pelvic floor muscle to create change. However a recent Cochrane report stated that in women with stress urinary incontinence, 10% of those who received weekly or twice-weekly group supervision in addition to individual appointments with the therapist did not report improvement post-treatment compared to 43% of the group who had individual appointments only (RR for no improvement 0.29, 95% CI 0.15 to 0.55). This was for four trials only and authors suggested in conclusion that women are offered reasonably frequent appointments during the training period. The data provided consistently showed that women receiving regular (e.g. weekly) supervision were more likely to report improvement than women doing pelvic floor muscle training with little or no supervision (Hay-Smith et al., 2012).

Hagen et al. (2011b) were able to report that the average improvement in the POP-SS was associated with a cost of £127 per woman and on the assumption that women in the intervention group women gained 10% on their QoL for a year as a result of the intervention, the estimated cost per quality adjusted life year gained was approximately £16,000. A finding such as this would obviously have huge implications for national clinical guidelines. Overall the shorter time frame is more representative of what may be afforded to a patient in a private clinic setting or in a public service.

1.5.2.1 Manual Therapy

In the current study manual therapy was used as a direct intervention to the levator plate. The term manual therapy can be defined as "procedures by which the hands directly contact the body to treat the soft tissues increasing range of motion reducing or eliminating soft tissue inflammation, inducing relaxation of tissue improving contractile and non-contractile tissue repair, extensibility and/or stability, facilitating movement and improving function" (Gatterman and Hansen, 1994, p.302). A skilled physiotherapist with training in both women's health and musculoskeletal physiotherapy can apply manual therapy techniques to the pelvic floor. The techniques used can vary according to the clinician's background, training and the findings at the time of examination.

It can be noted clinically that the pelvic floor muscles become inhibited with the load of supporting descended organs and this has also been noted in previous research (Hsu et al., 2006, Beco, 2008, Dietz, 2009). Palpation techniques described by Travell & Simons (1999) are well recognised in musculoskeletal physiotherapy and were first documented as techniques for any part of the body and then specifically for the muscles in the pelvic floor. They are flat palpation, pincer palpation and deep palpation and form the basis of manual therapy for the pelvic floor, they are further described in section 2.8.1. The researcher has adapted and further developed these pelvic floor manual therapy techniques and they are used in the intervention in this study (Whelan, 2006, Whelan, 2008, Whelan, 2012). They include identifying taut bands and trigger points in the levator ani and the iliococcygeus muscles as well as identifying restrictions in the surrounding fascia. Once identified, modified techniques of ischaemic pressure adapted from the above are used to release them, the pressure may reveal an acute trigger point referring pain to another part of the pelvic floor, vagina or rectum or may just feel like a pressure by the nature of the taut band (Travell

and Simons, 1993). General treatment of central and attachment trigger points has been well documented and the timing in Integrated Neuromuscular Inhibition Technique (INIT) has been found by the author to be effective (Chaitow, 1994, Chaitow and DeLany, 2002). A pressure sufficient to activate the trigger point is maintained for 5-6 seconds or longer followed by 2-3 seconds release and repeated for up to 2 minutes on each restriction until the patient reports that the local or referred symptoms have reduced. Importantly the ischaemic pressure is stopped if there is an increase in pain or if the pain has ceased.

Thiele (1963), a medical doctor, was the first to describe massage of the pelvic floor performed rectally. He recommended rubbing the fibres of the levator ani along their length, with a stripping motion from attachment at the pubic bone to insertion at the coccyx. Levator ani massage was further described in treatment of low back pain attributed to coccygeal spasm (Grant et al., 1975, Malbohan et al., 1989). However although there are studies dating back to 1963, there are few studies in the last five years and any studies using manual therapy of the pelvic floor relate to chronic pelvic pain, interstitial cystitis (IC) and bladder pain and not POP (Anderson et al. 2005, Fitzgerald et al. 2009, Fitzgerald et al. 2012). These are for the most part observational studies in which manual therapy is used where it is often combined with other therapies making any treatment effect for manual therapy difficult to estimate.

Weiss (2001) applied a transvaginal or transrectal approach to manual therapy in 10 subjects with interstitial cystitis and 42 subjects with urgency-frequency syndrome. Subjects were treated one to two times weekly for 8 to 12 weeks with pelvic floor muscle compression, stretching and strumming (repetitive and deep stroking across at right angles) the muscle, with the simultaneous use of external muscle stretching or heat application to facilitate greater muscle relaxation. Subjects also received intramuscular injections (1 to 2 mL of 0.5% bupivacaine/1% lidocaine) to discrete trigger points remaining after 6 to 8 weeks of therapy. Seven (70%) of those with IC were noted to have moderate (51% to 75%) to marked (76% to 99%) improvement in their symptoms as determined by patient-completed score sheets. Of the 42 with urgency-frequency, 35 (83%) reported moderate to marked improvement. Ten patients underwent EMG resting pelvic floor tension indicating a mean decrease from 9.73 to 3.61 microvolts (65%) improvement. There was no statistical analysis reported. This paper is frequently cited in the literature as it is descriptive regarding pelvic floor manual therapy, however it is not useful in determining which treatment technique is effective as there were no specific treatment groups, interventions were variable between subjects and there were no control groups. It may also have been of research interest to evaluate what happened to these patients over six month and twelve month follow up.

Another study that is worth consideration in relation to the use of pelvic floor manual therapy is that by Anderson et al. (2005) who treated 138 men with Chronic Pelvic Pain (CPP) using myofascial trigger point therapy and paradoxical relaxation techniques according to their "Stanford protocol". Internal manual therapy, as well as external, included deep tissue mobilisation, stripping, strumming, skin rolling and effleurage. Treatment was weekly for 4 weeks and biweekly for 8 weeks. Symptoms were

assessed with a Pelvic Pain Symptoms Survey (PPSS) and National Institute of Health-CP Symptom Index. Overall there was a 72% improvement in symptoms (marked 46% or moderate 26%). Pain scores significantly decreased in those with marked ($p<0.001$) and moderate ($p= 0.001$) improvement. There was no control group for comparison with another intervention although this would have contributed to their study. This particular group could have compared their Stanford Protocol plus external manual therapy to a Stanford protocol plus internal manual therapy group plus a possible Stanford Protocol only.

The only RCTs to date using manual therapy for pelvic symptoms, albeit not in POP, have been by Fitzgerald et al. (2009) and Fitzgerald et al. (2012). In a feasibility trial published in 2009, 48 men and women with chronic pain or painful bladder syndrome or prostatitis, were randomized into two groups, 23 received myofascial physical therapy both internally and externally and 24 received global therapeutic massage as a control. The myofascial therapy in this study included connective tissue manipulation, which is skin rolling to the connective tissue layer, over the thighs, buttocks and entire pelvic floor area. The primary outcome was the proportion of responders defined as *moderately improved* or *markedly improved* in overall symptoms compared to baseline on a 7-point global response assessment scale. There was an overall higher global response assessment rate (GRA) of 57% in the myofascial physical therapy group versus 21% in the global massage group, which was statistically significant ($p=0.03$). There was a statistically significant improvement ($p<0.001$) in physician's baseline examination of right and left sided pelvic floor muscle tenderness before (17.78) and after treatment (10.96) on a scale of 0-6 per muscle group across four muscle groups. This was however not a validated scale of measurement.

In the full RCT a total of 81 women with Interstitial Cystitis (IC)/painful bladder syndrome with demonstrable pelvic floor tenderness on physical examination were randomized to the two treatment groups, pelvic floor myofascial physical therapy and global therapeutic massage (Fitzgerald et al. 2012). Subjects received a trial of 10 scheduled treatments, internally to pelvic floor muscle and connective tissue and externally to muscles and connective tissue of hips, thighs, pelvis and abdomen. The primary outcome was the GRA score. Secondary outcomes included ratings for pain, urgency and frequency, the O'Leary-Sant (OLS) IC Symptom and Problem Index (SPI), and reports of adverse events. The GRA was 26% in the therapeutic massage group and 59% in the myofascial physical therapy group ($p = 0.012$). Pain, urgency and frequency ratings, and OLS IC SPI decreased in both groups during follow up, and were not significantly different between the groups. Pain was the most common adverse event, occurring at similar rates in both groups. One of the limitations in this study in demonstrating differences between the groups in the global response was that it was not possible to blind the patient as to which group they were in and therefore the effect that this might have had on their response. Although there was a significant difference between groups it was interesting to note that there was a therapeutic effect from the non specific techniques and therefore from the effect of general musculoskeletal relaxation as well as the contact with the therapist.

Pelvic floor manual therapy has not been described for pelvic organ prolapse. While the studies above have described symptom and pain questionnaires as outcome measures with pelvic floor manual therapy none have used pelvic floor position as a measure. The current study will be the first known study to use internal manual therapy to treat prolapse and to use pelvic floor position measured with MRI as an outcome measure.

1.5.2.2 Single case study

The researcher has previously carried out a single case study evaluating the effect of manual therapy on the position of the pelvic floor of a 30 year old with visualised stage II uterine prolapse (the uterus extends to the introitus on valsalva). MRI was performed pre treatment and within 30 minutes post treatment. Treatment consisted of trigger point treatment where taut bands were identified and ischaemic pressure was applied until tension eased and the patient performed breathing release techniques prior to contracting and relaxing the levator ani muscles. The levator plate angle (LPA) of this single case study was subsequently blindly measured by the urogynaecologist, who also measured all before and after scans in the current study. Cordonics Clarity Viewer (Cordonics Incorporated, Ohio, USA) MRI software was used for evaluation. The LPA measured 37 ° from horizontal pre treatment and changed to 29° post treatment (at rest) becoming more cranial by 8° (Fig 1.7); the context of these angles of change are discussed in MRI Imaging of Levator Plate below. These observed changes as well as the need to observe whether these changes were sustained over time led to the development of this research study and to determine if there was consistency in these findings among women with stage I and II POP.

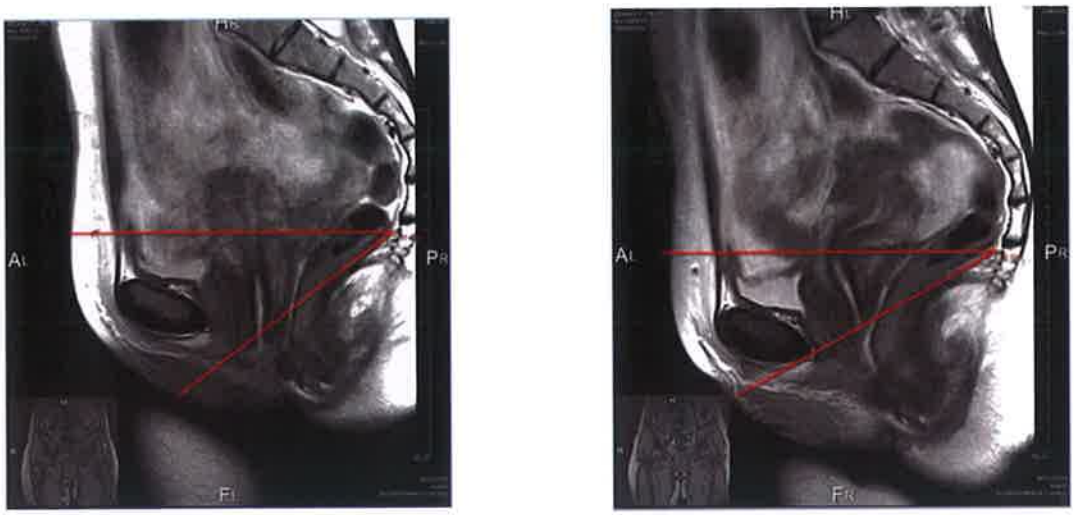


Figure 1-7 MRI before (left) and immediately after (right) treatment in single case study

1.6 Measurement

1.6.1 Pelvic Organ Prolapse Quantification (POP-Q)

POP-Q is an objective, site-specific system for describing, quantifying, and staging pelvic organ support in women. It provides a standardized means for documenting, comparing, and communicating clinical findings with proven inter-observer and intra-observer reliability and was published for the International Continence Society (ICS) Committee on Standardization of Terminology and is recommended by the ICS for clinical use (Bump et al., 1996).

The examiner places the patient in the standardised lithotomy position i.e. lying down at 45 degrees and asks the patient to bear down repeatedly to visualise the maximum protrusion. Once the examiner is satisfied that the protrusion is at its maximum the examiner then measures the extent of the protrusion with a disposable measuring stick (Appendix 1).

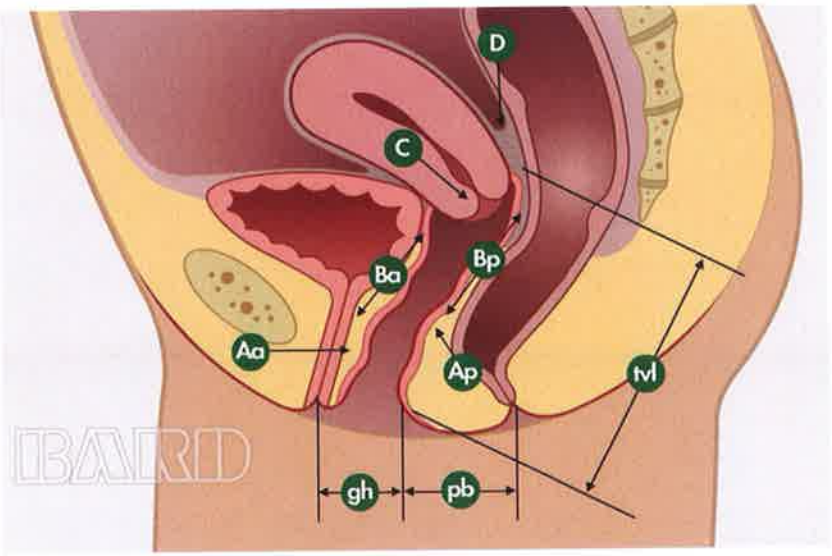


Figure 1-8 Bard POP-Q (Image under copyright reprinted with the kind authorization of CR Bard Inc.)

There are six defined points internally, two on the anterior vaginal wall (Aa, Ba), two in the superior vagina (C, D) and two on the posterior wall (Ap, Bp). There are 2 external points; the genital hiatus (GH) and the perineal body (PB). Finally the total vaginal length (TVL) is measured and this is the only value measured at rest when the prolapse is reduced as all of the other points are measured on valsalva (Fig 1.6). A full description of POP-Q points is listed in Appendix 1.

Bump et al. (1996) stated that measurements are acceptable to the nearest 0.5cms, it is doubtful that any further precision is possible and because of the many possible combinations the variations are too numerous to permit useful analysis and comparisons when populations are studied. Therefore ordinal stages are assigned using these values according to the most severe portion of the prolapse when the full extent of the protrusion has been demonstrated (Bump et al., 1996).

Stage 0: No prolapse is demonstrated
Stage I: The criteria for stage 0 are not met but the most distal portion of the prolapse is > 1 cm above the level of the hymen
Stage II: The most distal portion of the prolapse is ≤1cm proximal to or distal to the plane of the hymen (i.e. ≥ -1 cm but ≤ +1cm)
Stage III: The most distal portion of the prolapse is > 1cm below the plane of the hymen but protrudes no further than 2cms less than the total vaginal length in cms
Stage IV: This is complete eversion of the total length of the lower genital tract. The distal proportion protrudes to at least 2 cms less than the total length of the vagina (TVL)

Hall et al. (1996) determined the interobserver and intraobserver reliability of the POP-Q staging system. Forty-eight women underwent examination by two investigators, approximately half had stage II prolapse and half had stage 0, I, III or IV. Correlations for each of the nine site specific points were highly significant when analysed with Spearman's correlation coefficient. The values for the anterior wall and apical prolapse were: Aa r=0.81, p<0.0001; Ba r=0.89, p=0.0001; C r=0.52, p=0.0003; TVL r=0.04, p=0.0008. In 69% of subjects the stage was identical on the two examinations and in no subject was there a variation by more than one stage.

Twenty-five subjects underwent examinations on two different occasions by the same examiner under the same conditions. Correlations for each of the same site-specific measurements were highly significant (Aa r=0.78, p=0.0003; Ba 0.934, p<0.0001; r=0.76, p=0.0003, TVL r=0.43; p=0.04). In 64% of subjects the stages were identical.

When measuring POP it is important to document all variables including position of the patient, instruments used and contents of the rectum (Bump et al., 1996). Barber et al. (2000) evaluated 189 consecutive women and examined them in the lithotomy as well as the upright position. Seventy per cent had the same stage of prolapse in both positions whereas 26% had a higher stage and 4% had a lower stage in standing. There was a significant increase in the degree of prolapse in all of the POP-Q measurements in standing (p<0.001) except for apical point D (p<0.04) and the total vaginal length because it is only measured when reduced passively. However, the degree of pelvic organ prolapse assessed with the patient in the lithotomy position correlates well with assessment in the upright position even though there is a higher degree of prolapse with upright examination. It is therefore acceptable to measure in lying.

Ali-Ross et al. (2009) measured prolapse in 54 women already admitted to hospital for surgery for prolapse after one hour of prescribed activity and compared again after a night of sleep. There were significant changes in all parameters between rest and

activity (p=0.001) except for point D in POP-Q staging, which was not measured in women who had previous hysterectomy. The greatest differences between the rest and activity values occurred in the upper anterior point Ba and the apical points, both had median value at rest of +0.5 cms to +1.3 cms on activity (p=0.001). Therefore time of day should be considered with measurement and consistency of time of day documented.

Auwad et al. (2004) issued an online questionnaires to 667 doctors and received completed responses from 380 which was a reasonably high 57% response rate. They found that only 40.2% of the respondents routinely used POP-Q in their clinical practice and 33.5% never used it. Furthermore only 60% used it in research. The responders were members of the International Continence Society (ICS) and the American Urogynecology Society (AUGS) and the authors concluded that it is unlikely that general gynaecologists would use this system in practice if only 40.2% of a subspecialist interest group use it. They recommended that a simpler user-friendly system could be devised for routine clinical use.

1.6.2 Diagnostic Imaging in POP

MRI provides additional information in POP and has a staging system of its own but is expensive and neither practical nor indicated for evaluation of pelvic organ prolapse prior to surgery. It is therefore generally only used in POP research rather than routine care. There are no official recommendations for use from the International Continence Society in the same way that there are for bladder ultrasound (Carter and Tubaro, 2001). It does however increase our understanding of structures involved in descent and reference lines can be easily visualized where this is clearly not possible in manual measurement.

Realtime ultrasound (RTUS) is used extensively for measuring pelvic floor muscle defects (Dietz et al., 2010b). Although visualization of the levator plate is possible using RTUS the spectrum is not as wide as it is with MRI, therefore the anterior compartment extending to the pubic bone and the posterior compartment extending back to the coccyx cannot be visualised at the same time. Dietz (2011) has described the levator plate on RTUS as the angle between the symphyseal axis and the levator hiatus in the midsagittal plane; a change in the angle is measured on contraction or relaxation where an increase in angle would be seen if the levator muscle contracted cranioventrally away from the axis of the pubic symphysis. This is somewhat different from a take-off angle of the iliococcygeus from the coccyx bone that is described on MRI. It is also possible on RTUS to measure the reduction of the levator hiatus to the pubic symphysis on muscle contraction and bladder neck displacement is measured on muscles contraction where there is an approximation of the neck of the bladder to the pubic symphysis.

Morin et al. (2011) using RTUS imaging described the LPA as an angle between the horizontal reference line and the line from the pubic symphysis to the anorectal angle. Beco (2008) described a "retro-anal ultrasound" approach to measuring the levator plate positioning the probe between the anus and the coccyx and in initial unpublished

data in a control group of 40 women found mean LPA of 19.7° (±8.8°) at rest and 30.5° (±10.7°) during valsalva.

Majida et al. (2010) examined the pubovisceral muscles of 18 volunteers at rest using realtime ultrasound and MRI in a validation study. They measured the levator hiatus in the sagittal pane as well as measuring muscle thickness, transverse diameters and attachments at the pubic bone on axial images. Overall the intraclass correlation coefficient (ICC) values showed good agreement (range, 0.80-0.97), however they commented that RTUS could be used instead of MRI only when evaluating static pelvic floor anatomy in women without pelvic organ prolapse because they said that women with pelvic organ prolapse might have tissue that is more difficult to visualise on ultrasound. They did not attempt to measure the levator plate.

In a test re-test reliability study Braekken et al. (2009b) evaluated the pelvic floor muscles with RTUS in 17 normal subjects i.e. subjects without any pelvic floor dysfunction. Each woman performed three pelvic floor muscle contractions in the standing position on two separate occasions. In this study the LPA was defined as the angle between a horizontal reference line and a line from the infero-posterior margin of the pubic symphysis to the anorectal angle. The authors commented that there was a high technical failure rate for measurement of the rectal ampulla and back sling of the puborectalis muscle and that the cervix was identified in only three out of 17 patients. They also recommended that data should not be extrapolated to women with pelvic floor dysfunction, as the variability in anatomy and larger hiatus would make it even more difficult to capture both anterior and posterior measurements. For these reasons RTUS was not considered for the current study.

1.6.2.1 MRI imaging of Levator Plate

The levator plate (LP) can be best visualised in the mid-sagittal plane on MRI. Hsu et al. (2006) in a study to quantify the LPA compared normal and abnormal pelvic organ support in 68 controls and 74 patients. A "best-fit" line was placed at the initial take off portion of the iliococcygeus muscle from the coccyx on mid-sagittal MRI. An angle between this and a horizontal reference line was measured as the LPA. The perineal body position and the width of the levator hiatus were measured in relation to another reference line the sacrococcygeal inferior pubic point (SCIPP) as distinct from the PCL. Results showed that the LPA in normal women on strain was a mean of 44.3°±15.2° relative to horizontal compared with 53.4°±16° in patients; this was a 9.1° more caudally inclined levator plate ($p < .0008$). At rest patients also had significantly larger LPAs compared with controls, 45.8° ±12.4 compared with 36.2°±12.3°, a difference of 9.6° ($p < 0.0001$). The authors commented that they would expect a greater angle difference if the LPA was a primary indicator of prolapse.

Fielding (2003) proposed that in evaluation of pelvic floor position the angle of the LP should be measured and that in healthy women it should be parallel to the pubococcygeal line (PCL). Furthermore this relationship to the PCL should be irrespective of whether at rest or during strain and an increased caudal inclination of greater than 10° is an indicator of loss of posterior muscular support. Fielding (2003)

referenced this 10° angle to a study by Hoyte et al. (2001) who with 10 women in each group compared levator ani muscle structure, integrity and volume on MRI in normal women, women with genuine stress incontinence (GSI) and women with POP. Hoyte et al. measured the LPA to the PCL and found no statistically significant difference at rest but did find a difference during strain. In asymptomatic patients the difference was -4.3° ± 18°, in GSI patients -11.5° ± 15.5° and in prolapse patients -30° ± 21.6° (p=0.01). A difference from normal subjects of greater than 10° can be seen in both the GSI and the POP groups.

Fielding (2003) also referenced the study by Ozasa et al. (1992) citing the 10° angle of clinical significance. The authors found in an MRI study that in 19 patients without POP and 14 with uterine or vaginal prolapse a reference line extrapolated from the LP crossed the pubis each time when there was no prolapse and did not cross the line in each case with prolapse. This happened irrespective of the stage of prolapse. They also noted that backward bending of the upper vagina noted in non-prolapse patients was usually absent in prolapse patients. They did not however measure any specific angles apart from noting the extrapolated line from the levator plate. It may have been more difficult to measure an angle or reference line on various MRI models in 1992 due to MRI technology hence the decision to look at the extrapolation of a line in a study instead of measuring an angle or being more specific with measurement for purposes of statistical differences. It would seem therefore that the reference to a 10-degree angle in this study is a best guess of clinical significance.

However Ginath et al. (2011) more recently demonstrated differences at rest. In a group of 17 women, six nulliparous without prolapse and 11 parous with prolapse a larger LPA was found at rest, 14.5° ± 22° in the prolapse group compared with -9.8° ± 14.1° in the control group (p=0.004). These LPAs are relative to the PCL and not the horizontal and are therefore smaller in value. Good correlation was shown between the LPA at rest on MRI and clinical POP-Q staging of point C (cervix) (r=0.64, p=0.005) and this correlation was better than with the position of the cervix at rest (r=0.35, p=0.17). This meant that the position of the LPA at rest (on MRI) was more likely to predict what would happen to the uterus on strain (on POP-Q) than the position of the uterus itself (on MRI).

1.6.2.2 Static and Dynamic MRI

Most literature refers to dynamic measurement of POP either with manual POP-Q staging or with MRI. Dynamic MRI is where the subject strains during the MRI sequence so that the extent of the prolapse can be captured on the images. It has been frequently stated that MRI must be performed dynamically to be of any value (Yang et al., 1991, Goodrich et al., 1993, Hsu et al., 2006, Song et al., 2009) and differences either before or after surgery and between controls and case groups are primarily evaluated on strain.

However Ginath et al. (2011) more recently demonstrated differences at rest. In a group of 17 women, six nulliparous without prolapse and 11 parous with prolapse they found a larger LPA at rest, 14.5° ± 22° in the prolapse group compared with -9.8° ± 14.1° in the control group (p=0.004). These LPAs are relative to the PCL and not the

horizontal and are therefore smaller in value. Good correlation was shown between the LPA at rest on MRI and clinical POP-Q staging of point C (cervix) (r=0.64, p=0.005) and this correlation was better than with the position of the cervix at rest (r=0.35, p=0.17). This meant that the position of the LPA at rest (on MRI) was more likely to predict what would happen to the uterus on strain (on POP-Q) than the position of the uterus itself (on MRI).

Ansquer et al. (2006) evaluated the static and dynamic MRI scans of 40 women who were referred for prolapse surgery. Associations between static and dynamic MRI were assessed using correlation tests for quantitative variables and found that bladder neck descent on valsalva correlated with LPA at rest (correlation coefficient CC 0.51, p=0.001) and with hiatus length at rest (CC 0.48, p=0.02) in the prolapse group. A paradoxical inverse correlation was observed between the anterior rectal bulge and the hiatus width at rest (CC-0.32, p=0.04). Thinning of the iliococcygeus muscle was not associated with an increased severity of prolapse and uterine descent was greater for those women with normal thickness of the iliococcygeus. There was no correlation for uterine descent and any tested variables.

Hsu et al. (2010) analysed the scans of 10 women with normal pelvic support and nine women with anterior compartment prolapse. Anterior wall compliance and bladder position at rest and with strain were evaluated. Compliance was measured on MRI by calculating the displacement of the anterior wall in cms and increase of abdominal pressure in cms H_20. The degree of anterior vaginal wall descent on strain was associated with resting anterior vaginal wall position with correlation of r=0.74 (p<0.001). These studies are increasing highlighting the value of measuring resting pelvic organ position and not just measuring POP on strain.

A physiotherapy study by Dumoulin et al. (2007) used MRI to evaluate PFM morphological changes in 5 subjects before and after 2.5 months and 7 group intervention sessions of PFM training in a group of women with urodynamically proven stress urinary incontinence. They used axial images to evaluate changes at rest and on PFM contraction. Levator ani surface area at rest was found to be significantly smaller than before physiotherapy, decreasing from 677.11 ± 45.00mm to 620.48 ± 36.14mm (p=0.04) and levator ani surface retraction during a voluntary contraction increased significantly from 65.61% ± 17.07 % to 81.70% ± 16.30% (p=0.02). The authors concluded that PFM training resulted in anatomical changes in the levator ani and reduction of pubic movement. The current study is the first known physiotherapy study to use MRI in a POP group and to use sagittal images measuring the levator plate.

1.7 Conclusion

Forty three to 76% of women presenting for routine gynaecological evaluation have loss of vaginal support but less present with symptoms due to their prolapse (Cardozo, 1995, Swift et al., 2005b). The correlation of symptoms to anatomical prolapse severity is not consistent and decisions to intervene are determined by how bothersome the prolapse is rather than pelvic organ or pelvic floor position. Current intervention

strategies are surgery and conservative treatment. A woman's lifetime risk of surgery for POP is seven to 11% and re-operation rates can be as high as 13% within five years (Olsen et al., 1997). The Cochrane review of surgical management of pelvic organ prolapse outlines how when the correct procedure is chosen and the woman is well counselled surgery can be highly successful (Maher et al., 2010). Indication for surgery is not related to stage of prolapse but to symptoms. Physiotherapy treatment is most likely to be beneficial in stages I, II & III and is not likely to be very beneficial in stage IV (Hagen et al., 2009b, Braekken et al., 2010, Stupp et al., 2011, Hagen et al., 2011b, Frawley et al., 2012). A woman will not necessarily be advised to go for surgery just because she has a prolapse beyond the hymen (stage II or III) but would be advised to go for surgery with a stage IV prolapse regardless of the symptoms.

The improvements in physiotherapy studies have been in POP-Q stage (Braekken et al. 2010, Stupp et al. 2011), symptoms scores (Ghroubi et al. 2008, Hagen et al. 2009, Braekken et al. 2010, Hagen et al. 2011b, Frawley et al. 2012) and strength (Stupp et al. 2011, Hagen et al. 2009, Braekken 2010, Hagen et al 2011b, Frawley 2012). There is no correlation between strength and prolapse stage or organ position in any of the physiotherapy studies (Frawley et al., 2011). The improved muscle strength appears to have a supportive effect on the organs but when muscle function is tested by squeeze pressure and when the passive descent of the organs is tested with POP-Q it is the passive fascial system that is being tested. It is therefore not surprising that there is not a correlation when additionally the different prolapse stages are considered.

POP is measured using POP-Q staging by visual observation of descent of the prolapse in centimetres relative to the hymen (Bump et al., 1996). It has been shown to have excellent inter and intra-observer reliability (Hall et al., 1996). It is recommended by the International Continence Society (ICS) for clinical use although in reality only 40% of subspecialists use it in clinical practice (Auwad et al., 2004). MRI and realtime ultrasound (RTUS) can be used to measure bone, organ and muscle position by reference points in centimetres or by angles to chosen reference lines. The LPA cannot as effectively be measured by RTUS and so MRI was chosen in the current study as an outcome measure measure. Outcome of intervention is measured by organ position as well as by symptom and quality of life questionnaires. As there is a the lack of correlation between POP-Q stage and symptoms, both were chosen as outcome measures in the current study in an effort to improve the understanding of correlation of symptoms and POP where the correlation with strength training does not exist.

A single case study by the researcher showed that the levator plate angle could be immediately changed after internal manual therapy and previous studies have shown that the levator plate is important for shelf support of the organs (Strohbehn et al., 1996, Singh et al., 2001, Herschorn, 2004, Law and Fielding, 2008). It may be that the aims of physiotherapy are expanded beyond strength training alone, as outlined in the previous pelvic organ prolapse studies, and should include the manual facilitation of the levator plate as a direct support for the organs. The clinical significance of this may be that with more targeted intervention, the number of treatments and period of time over which improvements take place may be shortened and the expected level of improvement may be increased when compared with current physiotherapy practice

for pelvic organ prolapse. This study quantified the effect of a novel physiotherapy treatment programme that combined manual therapy and PFM training, in several domains such as prolapse stage, symptoms and quality of life. The main aim of the study was however, to investigate the effect of this intervention on the LPA in women with stage I or II POP, to establish whether the levator plate could be changed with this treatment and if it is a valid consideration for physiotherapy intervention.

CHAPTER 2 METHODOLOGY

2.1 Aim and Objectives

The aim of this study was to evaluate the effect of a novel physiotherapy intervention involving internal manual therapy and pelvic floor muscle training on the levator plate angle in women with stage I and II pelvic organ prolapse (POP).
The objectives were:

- To evaluate the effect of this intervention on
  - the anorectal angle, bladder neck, cervix, H line and M line on MRI
  - pelvic organ position through the use of POP-Q staging and
  - POP symptoms and POP-related quality of life (QoL).

- To examine inter-tester reliability for MRI measurement in POP.

2.2 Hypothesis

The null hypothesis was that there would be no change in the levator plate angle following internal manual therapy and pelvic floor muscle training intervention.

The research hypothesis was that following internal manual therapy and pelvic floor muscle training intervention, the levator plate angle would change by approximately 10 degrees.

2.3 Study Design

This study was an experimental same subject pre and post-test design.

2.4 Subjects

In view of the unknown efficacy of the intervention, it was proposed to analyse outcomes for ten subjects in the first instance. Therefore 12 women were recruited in order to allow for drop out over the period of intervention. Should no subject achieve a successful outcome (10 degree decrement in angle), a sample of 10 subjects would place an upper confidence interval of 37% on the probability of success. That is, if no subject benefited in a sample of ten, it was unlikely that the intervention would be successful in more than one subject in every three. Likewise if there were no intervention failures, the sample size would place an upper confidence limit of 37% on the failure rate. If there was 50% success rate, the associated confidence interval would run from 24% to 76%, while an 80% success rate would have a confidence interval of 50% to 94%. It was felt that although these confidence intervals are wide, they would greatly inform the understanding of the therapeutic potential of the

intervention, and a pilot study such as this is ethically appropriate before planning larger studies (Personal communication R. Conroy 23rd September 2011). Calculations based on mean differences of the LPA resulted in large sample sizes that were prohibitively expensively for the use of MRI and were not justified in these early stages of a novel intervention where changes in LPA as an outcome were not yet proven.

2.5 Recruitment

Mr Kelvin Boos (consultant urogynaecologist) acted as study gatekeeper recruiting symptomatic patients who had presented with POP from private clinics in Hermitage Medical Clinic and UPMC Beacon Hospital. A second pathway of referral was via physiotherapy colleagues from public hospitals and private clinics where they were asked to refer patients they thought filled the criteria. In order to be included in the study the extent of the prolapse needed to be measured using POP-Q staging and this was done for all subjects by Mr Boos. The procedure was different depending on whether patients were recruited through Mr Boos's clinic in the first place or were recruited through physiotherapy colleagues and then attended Mr Boos for POP-Q measurement (Table 2.1, 2.2).

Figure 2-1 Pathway of referral by consultant

Figure 2-2 Pathway of referral by physiotherapy colleagues

Recruitment and treatment took place from January 2012 to December 2012.

2.5.1 Inclusion Criteria

Women aged between 18 and 70 years presenting with POP were included. The age limit of 18 years was set to include all women from age of consent and the age limit of 70 years was to be conservative with the skin condition of women tolerating pelvic floor manual therapy (women's skin can become thinner and more delicate over time due to reduced oestrogen).

Women who presented with an anterior compartment prolapse (bladder or uterine) or posterior compartment prolapse as determined by POP-Q staging, measured by the recruiting consultant were included. POP stages I and II were included and stages III and IV were excluded. Stage I prolapse is descent from the normal resting position to within 1 cm inside the hymen on strain. Stage II prolapse is descent from 1 cm inside the hymen to descent beyond the hymen by no greater than 1 cm. It was the researcher's clinical observation that stage III POP is not as responsive to internal manual therapy as the pelvic floor muscles are less likely to mobilise possibly due to becoming constantly re-inhibited by the load of the larger prolapse.

Women chosen were parous so although pelvic organ descent is not exclusive to parity (Dietz et al., 2003) there was the consistency of some degree of trauma to the pelvic floor within the study.

2.5.2 Exclusion Criteria

The commencement of oestrogen therapy at the same time as the study as another form of conservative treatment for POP by the consultant was one of the exclusion criteria as this could lead to improvement in symptoms without any other intervention and could therefore be a confounder. Subjects were also excluded if they had a ring pessary in place.

Subjects within six months of childbirth or still breastfeeding were excluded due to possible additional hormonal contributing factors.

Subjects with a history of any previous pelvic floor surgery were also excluded. The reasons were (1) that it would be difficult to control for type of surgery (2) that the possibility of pelvic floor manual therapy employed in the study may break down any weak or particularly inelastic tissue (3) there may be limited access to the area to be treated due to restrictions caused by scar tissue.

Any subjects with vulvar skin conditions or history of pelvic carcinoma were also excluded. Cognitive impairment or inability to understand the English language similarly led to exclusion. Any woman who was pregnant or who had a desire to become pregnant over the following four months was excluded as MRI is contraindicated in pregnancy.

Subjects who had an inability to tolerate MRI scans or had any MRI contraindications (metal implants, aneurysm clip, heart valve, pacemaker, stent) were also excluded.

2.6 Ethical Considerations

Ethics approval was received from RCSI Research Ethics Committee (REC 684) on 23rd December 2011 (Appendix 2).

Mr Kelvin Boos (consultant urogynaecologist) provided a letter of support for the study acting as Gatekeeper (Appendix 3). Hermitage Medical Clinic gave approval for patient recruitment to be carried out from outpatient clinics and a letter of approval was provided (Appendix 4). To boost recruitment, permission was also sought from UPMC Beacon Hospital and approval for recruitment to be undertaken from outpatient clinics was forthcoming at UPMC Beacon Hospital (Appendix 5). A confirmation letter from Dr. Sam Hamilton Medical Director of Euromedic was obtained (Appendix 6) stating that there were no safety issues with MRIs, that scans would be performed without referral letter from a consultant, that Euromedic did not have a REC committee and that the researcher had permission to carry out the study.

Further approval of protocol amendments was required and obtained from RCSI REC to change the upper age limit from the initial proposal (REC684b) (Appendix 7) and the inclusion criteria of type of pelvic organ prolapse (REC684bb) (Appendix 8).

The researcher kept all study documentation in a locked filing cabinet at Milltown Physiotherapy Clinic where access was restricted. Patient reference numbers only and not their names were kept on a laptop where research data were stored. The lap top was password protected and used only by the researcher. Patients were assigned a number in the order that they presented for initial MRI scan. This number appeared on the MRI disc as the identification for that patient. There was no patient name or date of birth on the disc. The Euromedic MRI radiographer was the only other personnel that had access to both patient name and reference number. This and the documentation in Milltown Physiotherapy were the only two locations where both reference and patient name were stored.

2.7 Procedure

The initial patient assessment included POP-Q measurement by the gatekeeper, physiotherapy assessment by the researcher, MRI scan and self-report questionnaires. As there were two different pathways of recruitment the order differed for both groups. If the gate-keeping consultant gynaecologist had referred the patient, the POP-Q measurement was conducted before the physiotherapy assessment and if a physiotherapist had referred the patient then the physiotherapy assessment by the researcher was undertaken before the POP-Q measurement.

If patients presented with symptoms of POP and on initial examination the consultant thought they met inclusion criteria, he informed them of the study and proceeded to measure their prolapse using the POP-Q staging to confirm their eligibility. This was recorded on a form prepared by the researcher (Appendix 9). Following the examination the consultant provided the patient with a study patient information

sheet (Appendix 10). The consultant then included the POP-Q sheet in a letter of referral for physiotherapy and documented that the patient had been informed of the study, had been given an information sheet and consented to being contacted by the researcher. The consent form however, was only signed following the initial physiotherapy assessment.

If the patient was referred first to the researcher then the initial physiotherapy assessment took place before the assessment by the consultant. The researcher evaluated the patient as described below and if satisfied that they reached the inclusion criteria she referred them to the consultant for confirmation of their eligibility to be included in the study. In this case the study consent form was given to the patient following the physiotherapy assessment by the researcher and consent was already signed before attending the consultant (Appendix 11).

Hagen et al. (2009b) compiled a gynaecologist's guide to completing POP-Q listing examination conditions, POP-Q measurements and staging of prolapse. This guide was used in this study with permission by the authors (Appendix 12). The gatekeeper was also provided with the American Urogynecological Society's POP-Q training DVD.

POPstix®, a narrow wooden "popsicle" stick with 0.5 cm increments up to 12 cms, were used for POP measurement avoiding the necessity of equipment that needs sterilizing (Appendix 1). The consultant was provided with these measurement sticks and the printed guide to the points measured.

The first contact in both pathways with the researcher was by phone. The researcher provided as much information as possible and once the patient was satisfied with the information and agreed to participate, they were offered an appointment at Milltown Physiotherapy. They were given a further explanation of the study and an opportunity to discuss any concerns.

As part of the physiotherapy assessment subjects were given an explanation of the anatomy of the pelvic floor and the anatomy of prolapse with diagrams shown. A full history was taken and if satisfied they agreed to an internal assessment by informed consent as is usual practice in Milltown Physiotherapy. An objective physiotherapy assessment was performed but no treatment was provided during this first hour session. The assessment included recording of degree of prolapse, resting tone, pelvic floor muscle tension, Modified Oxford Squeeze (MOS) and ability to release the muscle contraction. Additionally, abdominal muscle activity was assessed and breathing coordination was assessed (Appendix 13). Once the assessment had taken place and the presence of a prolapse was confirmed the subject signed the consent form and questionnaires were filled out before leaving the clinic on that day (Appendix 14a-d). Subjects were informed of the MRI procedure and were informed of MRI contraindications prior to proceeding.

A letter of referral was sent by the researcher to Euromedic (Dundrum) to arrange the first MRI scan (Appendix 15). MRI clinical specialist radiographer Kolbe Mooney set up the protocol with the researcher and performed all of the scans. It was agreed that

reference numbers would be in the sequence that patients attended and the reference number only was copied to the disc. The subject's name was retained in Euromedic for reference to the number on the scan for their records. Subjects filled out a registration and safety questionnaire on arrival at the clinic (Appendix 16) and were cleared for any contraindications to scan by the radiographer. Subjects were instructed to empty their bladders prior to the scan and were scanned in supine with support under their knees. Scans were taken in the sagittal and axial planes. All scans took place in the evening which provided consistency in appointment time for scans so that prolapse would be measured at a consistent time of day. Three copies of the scan were made per subject.

The researcher was on site for most scans, the reason for this was purely for security purposes i.e. to have two people on the Euromedic premises after hours. The researcher collected the anonymous discs from Euromedic at the time and securely stored them at Milltown Physiotherapy before sending the discs by registered post and in random order to urogynaecologist Dr. Rohna Kearney for blinded assessment. Dr. Kearney who had publications in research of the pelvic floor muscles using MRI and was based in Oxford, UK had agreed to measure all scans (Kearney et al., 2004, Kearney et al., 2006).

The levator plate angle and anorectal angle, the bladder neck, the cervix and H and M lines as well as the pubococcygeal reference line were all measured and recorded on a data sheet (Appendix 17). The description of these angles and lines is provided in section 2.9.2. Scans and results were returned by email to the researcher for data collation. Inter-rater reliability for these measurements was evaluated separately and this procedure is outlined in section 2.9.2.6.

Once the MRI scan had been scheduled the patient was contacted to arrange five physiotherapy treatment sessions at approximately two-week intervals. Patients were treated with manual therapy, instructed in breathing exercises, pelvic floor exercise and received a written home exercise programme and advice on posture. In some cases treatment intervals extended beyond the two weeks because of the holiday period and lack of availability of the subjects.

Approximately two weeks after finishing the fifth treatment session, the consultant repeated the POP-Q measurement and MRI was repeated. It was attempted to have these two measurements carried out as close to each other as possible. The POP-Q measurements were made at the same time of day as the first assessment and were carried out in Hermitage Medical Clinic or UPMC Beacon Hospital.

The symptom and QoL questionnaires were provided by the consultant on the same day as the repeat POP-Q measurement and completed on that day before being posted back to the researcher in Milltown Physiotherapy either by the subject or by the secretary in the respective clinic. The data were not entered or analysed before unblinding; the finishing dates of the subjects following treatment were sufficiently far apart that it was impossible to be blinded to the identity of the returned questionnaires. The researcher entered all the data and random checks were undertaken.

The researcher sent a referral letter for repeat MRI scan at Euromedic on completion of the subject's last physiotherapy session. It was attempted to have this scan at approximately two weeks after finishing treatment. This period of time was however five weeks for one subject due to difficulty planning and four weeks for another subject due to holidays. Subjects were scanned using the same protocol as before. The scans continued to be numbered sequentially so that scans could not be identified as repeat scans to protect blinded assessment. Discs were sent in random order by registered post to Dr. Kearney for measurement.

2.8 Intervention

2.8.1 Manual therapy

The manual therapy techniques used during each of the five treatment sessions with each of the subjects employed the following techniques as described by Travell and Simons (1999):

Flat palpation: the fingertip slides the overlying fascia aside and palpates across the fibres to be examined
Pincer palpation: grasping the muscle between the fingertip and thumb and pressing the fibres or rolling forwards and backwards to locate taut bands; this technique will be for the superficial or more accessible tissue
Deep palpation: the intervening tissue overlies the muscle containing the trigger point and palpation through tissue is necessary; more suitable for deeper levator ani muscles

It could be noted clinically that the pelvic floor muscles became inhibited with the load of supporting descended organs. General treatment of central and attachment trigger points has been well documented and the timing in Integrated Neuromuscular Inhibition Technique (INIT) has been found by the author to be effective (Chaitow, 1994, Chaitow and DeLany, 2002). The amount of time spent on mobilising restricted tissue and the amount of pressure exerted varied according to the sensitivity of the tissue. Each person who presented with pelvic organ prolapse required this type of treatment regardless of the position of the muscles whether short or long and whether presenting with higher or lower tone. However the presentation in the prolapse patient was mostly of lower tone muscle, which had become taut and inhibited. A pressure sufficient to activate the trigger point was maintained for 5-6 seconds or longer followed by 2-3 seconds release and repeated for up to 2 minutes on each restriction until the patient reported that the local or referred symptoms had reduced. Importantly the ischaemic pressure was stopped if there was an increase in pain or if the pain had ceased.

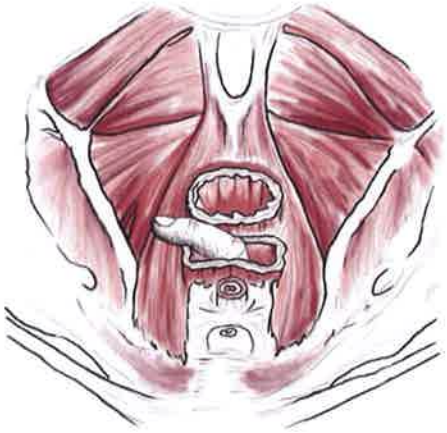


Figure 2-3 Deep palpation release technique of levator sling (copyright of author)

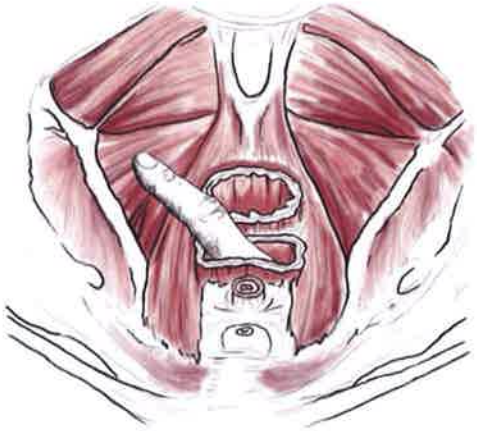


Figure 2-4 Deep palpation release technique of iliococcygeus muscle (copyright of author)

In each treatment session, timing varied according to the subjects's sensitivity. Generally, pelvic floor manual therapy treatment was tolerated well for 15 to 20 minutes per half hour session with good effect varying between the palpation techniques described above and the "sniff, flop and drop" breathing exercise described below and PFM exercise. The pressure of the palpation technique always eased after a few minutes of treatment and gradually the muscle became more mobile. It is one of the aims of treatment that when the subject attempts to activate the muscles following this treatment there is more palpable movement, resulting in better excursion of the muscle. In general this was always palpable at the end of a session.

At each session the resting tone, grade of contraction and ability to release as a percentage of contraction was recorded as well as the excursion of the contraction. This was compared between right and left and the dominance of the superficial or the deeper muscles were recorded for comparison from week to week for improvements (Appendix 18).

2.8.2 Breathing ("Sniff, Flop & Drop")

The author has developed a breathing technique found to be clinically useful in releasing pelvic floor tension, that has developed as a result of unwanted pelvic floor holding patterns (Whelan, 2012). Subjects were instructed in this technique on their first intervention session and it was reviewed at each session for correct performance. The instruction was to breathe in with a "sniff" to make the diaphragm descend and to relax the stomach completely as the sniff filled up the stomach with a "flop" and there should then be a corresponding "drop" of the pelvic floor. This exercise was performed in the lying position with the knees bent and the spine in a neutral position or could be performed in side lying. The subjects were instructed that they should feel a maximal relaxation over the 5-10 minutes of performing the exercise without at any time pushing the pelvic floor downwards as this would push the organs downwards exacerbating the prolapse. If the abdomen was tense, then the subject was instructed to palpate the tense muscles in an effort to release. The aim was to soften the abdomen and therefore allow better abdominal relaxation (Appendix 19).

2.8.3 Pelvic Floor Muscle Training

Participants were instructed to squeeze in starting from the back passage and then pull in the whole pelvic floor from the back upwards and forwards to the front in the direction of the pubic bone. The researcher has observed in clinical practice on both palpation and using RTUS imaging that to instruct the pelvic floor contraction engaging from behind first is most effective in contracting the pelvic floor and in using the levator plate (Appendix 20). The researcher palpated vaginally in each case to evaluate the quality of the pelvic floor contraction and to ensure optimum performance to the subject's ability. Ten repetitions of the prescribed exercise were to be performed three times per day, in accordance with published recommendations (Dumoulin et al., 2011). The exercises were instructed with verbal prompts and by manual palpation facilitation, where the subject was required to concentrate completely on the sensation of the targeted area of the levator plate in the pelvic floor. Further concentration was required to coordinate breathing and abdominal control as part of the pelvic floor control.

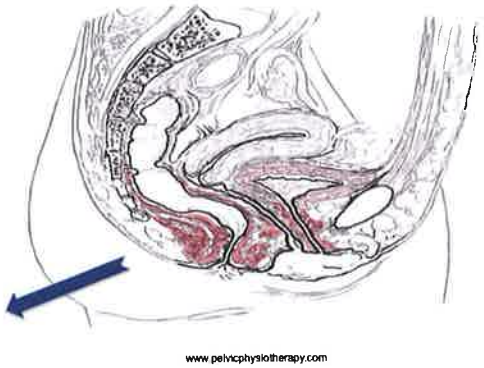


Figure 2-5 The pelvic floor at rest or releasing down and backwards (copyright of author)

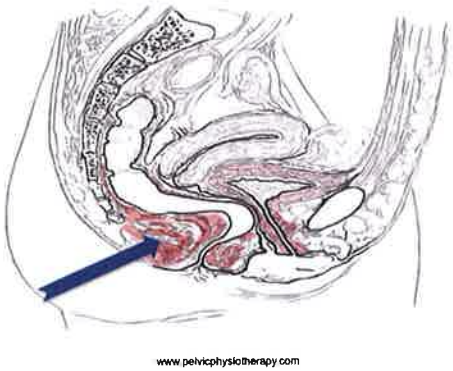


Figure 2-6 The pelvic floor contracting upwards and forwards (copyright of author)

The exercise was prescribed according to the level of ability of the subject. Subjects were instructed only to do what they were able to and not to perform to a degree that was too difficult for them. If they could hold the pelvic floor for 5 seconds then this was the level at which they were instructed to start. Otherwise they would hold for 3 seconds and then release. If they could not contract their pelvic floor at all then they were instructed to practice their breathing technique and manual therapy was used to facilitate the pelvic floor muscles. Similarly if they could not release their pelvic floor at all then this was the main focus.

Abdominal muscle activity was assessed by palpation to determine if either appropriate transversus abdominis activity or other unwanted abdominal muscle action was taking place. Subjects were not allowed to incorporate the abdominal muscle into exercise practice if they braced their abdominal muscles instead of contracting transversus abdominis muscles correctly. If they could not contract their pelvic floor muscles without tilting the pelvis posteriorly or without bracing their abdominals they had to wait until they had sufficient isolation by way of practice and intervention manual therapy in order to start contract/relax exercises.

Progression of exercises was by increasing holding time, increasing repetitions, increasing strength and changing position of practice from lying to sitting to standing. Exercise technique and progression was reviewed at each session (Appendix 21).

Participants were instructed to perform 5-10 minutes of breathing ("sniff, flop and drop") twice daily. At this time they were also instructed to perform 10 repetitions of their prescribed exercise and to perform 10 more repetitions at two other times every day, this could be done in lying or standing to optimize compliance.

Participants were given an exercise diary to record their home exercise programme and an advice sheet on exercise and lifestyle (Appendix 22 & 23). Participants were given exercise diaries to monitor compliance with their home programme. They were also asked to bring these exercise diaries to each of their appointments and adherence was monitored by the researcher. Advice in the lifestyle sheet, which is routine physiotherapy care, included teaching defecation techniques i.e. how to correctly pass a bowel movement without straining incorrectly and incorporating the 'knack' of holding the pelvic floor in the case of coughing or increases in intra abdominal pressure were explained in particular to the subjects (Miller et al., 1998).

2.9 Outcome Measures

2.9.1 POP-Q

POP-Q staging was used to establish eligibility for inclusion, to measure stage before treatment and to measure any improvement after treatment. It is an objective, site-specific system for describing, quantifying, and staging pelvic organ support in women. The examiner places the patient in the lithotomy position and asks the patient to bear down repeatedly to visualise the maximum protrusion and proceeds to measure the protrusion in cms. There are six internal reference points, two at the front vaginal wall (Aa, Ba), two at the apex (C,D) and two at the back (Ap,Bp). There are two external points measuring the length of the perineum, the genital hiatus and the perineal body (GH, PB) and one point that is not measured on strain but measured when organs are returned to resting position, the total vaginal length (TVL) (Appendix 1).

Bump et al. (1996) stated that measurements are acceptable to the nearest 0.5cms, it is doubtful that any further precision is possible and because of the many possible combinations the variations are too numerous to permit useful analysis and comparisons when populations are studied. Therefore ordinal stages are assigned using these values according to the most severe portion of the prolapse when the full extent of the protrusion has been demonstrated (Bump et al., 1996).

Hall et al. (1996) determined the inter-observer and intra-observer reliability of the POP-Q staging system, analysed with Spearman's correlation coefficient and established that both inter-observer (Aa $r=0.81$, $p<0.0001$; Ba $r=0.89$, $p=0.0001$; C $r=0.52$, $p=0.0003$; TVL $r=0.04$, $p=0.0008$) reliability as well as intra-observer (Aa $r= 0.78$, $p=0.0003$; Ba $r=0.93$, $p<0.0001$; C $r=0.76$, $p=0.0003$, TVL $r=0.43$; $p=0.04$) reliability was high.

It is important to measure subjects under the same conditions (Bump et al., 1996) and the same time of day (Ali-Ross et al., 2009). Although prolapse would be greater in the upright position the degree of prolapse in the lithotomy position correlates well with the degree of prolapse in the upright position so it is acceptable to measure in the lithotomy position (Barber et al., 2000). Subjects in this study were therefore measured by POP-Q at the same time of day both pre and post intervention and all subjects were measured in the lithotomy position.

2.9.2 MRI Measurement

All MRI scans were taken using Siemens Magnetom Avanto Syngo MR B15 1.5T Tesla system, Siemens AG, Erlangen, Germany. Static MRI was based on the acquisition of a multishot turbo spin echo (TSE) T2-weighted sequence in axial and sagittal planes, field-of-view 240mm, slice thickness 3 mm, slices 24, 20% distance factor, TR (relaxation time)/TE (echo time) 4050/101ms. The number of averages was three. No contrast gel was used in the vaginal or in the rectum.

The lines and angles analysed were the levator plate angle (LPA), the anorectal angle (ARA), the bladder neck, the cervix, the H line, the M line and the reference of the pubococcygeal line (PCL).

2.9.2.1 Levator Plate Angle (LPA)

A "best-fit" line was placed at the initial take off portion of the iliococcygeus muscle from the coccyx and an angle between this and a horizontal reference line was measured as the LPA, (fig 1-7, p.26) (Hsu et al., 2006). The measurement of the LPA has been described in various ways in the literature. Madill et al. (2011) described the LPA as the angle between the PCL and the H line. Ansquer et al. (2006) and Ginath et al. (2011) both defined the LPA as the angle between the LP and the PCL. The "take off" point best reflected the area treated by the researcher in this study and was therefore used in preference to other lines described. It is the researcher's opinion that the take off point was more likely to reflect the position of the iliococcygeus muscle and this has been shown by Hsu et al. (2006) and Fielding (2003) whereas the studies that took the posterior hiatus as representative of the LP were more likely to be measuring posterior sling position as well. Although the posterior portion of the sling muscle and the iliococcygeus portion of the levator plate are both part of the levator ani, they have different origins and insertions and different angles of contraction.

2.9.2.2 Pubococcygeal Line (PCL)

The pubococcygeal line is the reference line between the pubis and the coccyx, which was first described by Comiter et al. (1999) and has since been used in many other studies. The inferior pubic bone point is always the anterior aspect of the PCL but there has been some variation in the literature as to where to place the coccygeal point of the PCL. The variations have been the tip of the coccyx (El Sayed et al., 2008), the last joint of the coccyx (Fielding, 2002, Lockhart et al., 2008, Handa et al., 2009) or

the sacrococcygeal joint (Hsu et al., 2006). Madill et al. (2011) found that there was movement of the coccyx in 66% of women on both strain and pelvic floor contraction. They measured the PCL to the tip of the coccyx and to the sacrococcygeal joint in 47 women and found that with contraction the PCL to tip shortened and lifted ($p<0.001$) and the PCL to joint did not change ($p>0.05$). The sacrococcygeal joint should therefore be used to avoid measuring changes in coccygeal position (Madill et al., 2011). This is only a consideration if a pelvic floor contraction is being measured.

In the current study it was a consideration that reference lines closer to the sacrococcygeal line were also closer to the landmarks to be measured, therefore distances would have been smaller allowing more margin of error of measurement (Portney and Watkins, 2009). A point was therefore taken from the inferior pubic point and a line extended to the last joint of the coccyx, this reference line was the PCL. The PCL is reproducible independent of pelvic tilt as it includes the pubic bone and the coccyx, which are attachments for the pelvic floor and in healthy volunteers there is minimal movement of the pelvic organs with respect to the PCL (Colaicomo et al., 2009).

2.9.2.3 H and M Lines

The H line is the line that measures the distance between the pubis and the posterior anal canal, it measures the width of the hiatus and should normally be 5 cms on strain (Comiter et al., 1999). The M-line measures descent from the pubococcygeal line. It is a perpendicular line drawn from the PCL to the posterior anal canal and measures muscular descent; it should normally be 2 cms on strain (Comiter et al., 1999). These values were determined in a study of 39 women with pelvic pain and 125 consecutive women with POP who had presented in a urogynaecologic clinic and were evaluated with MRI (Comiter et al., 1999). In the pain group the H-line averaged 5.2 (±1.1) cm versus 7.5 (±1.5) cm in the prolapse group ($p<0.001$). The M-line averaged 1.9±1.2 cm in the pain group versus 4.1(±1.5) cm in the prolapse group ($p<0.001$). The pain group was taken as representative of normal.

2.9.2.4 Bladder Neck and Cervix

A perpendicular line was drawn from the most inferior border of the bladder to the PCL to measure the position of the bladder neck and the cervix position was measured by a perpendicular line between the most inferior border of the uterine cervix and the PCL (Ansquer et al 2006; Song et al 2009; Ginath et al 2011).

Yang et al. (1991) assessed 26 women with signs and symptoms of POP and 16 control subjects. The vertical distance from the PCL to the bladder base and to the most inferior position of the cervix were measured at rest and on strain. Bladder position of controls at rest was higher than prolapse patients (mean 2.23 cms SD ± 0.51 vs. 1.84 cms ± 0.79). On straining the bladder bases of patients descended more than controls (-1.88 ± 1.44 vs. 1.26 cm ± 1.12). Similarly at rest the cervix was higher in controls than patients (3.89 ±1.13 vs. 2.29 ± 0.99). On strain, the cervix of the patient group also descended more than the control group (-0.69 ±0.83 vs. 2.95 ±1.21). Minus values signified that the bladder base was below the PCL. Correlation coefficients (*r*) in this

study were provided for rest position to strain for each of the compartments: anterior or middle. In the control group the correlation coefficient was r=0.31 for the anterior compartment and r=0.59 for the middle compartment and for the prolapse group was r=0.34 and r=0.68 for the same compartments. Of interest is the stronger correlation in the more mobile middle compartment for both control and prolapse groups from rest to strain position versus the more fixed anterior compartment. Clearly this correlation is stronger in the prolapse group. Results from this study have been cited in other literature i.e. that with maximal strain the bladder base should not descend more than 1cm below the PCL, in a normal pelvic floor and the cervix should not descend more than 1cm above the PCL (Hsu et al., 2006, Ansquer et al., 2006, Ginath et al., 2011).

2.9.2.5 Anorectal Angle (ARA)

The ARA is defined as the angle between the posterior border of the distal part of the rectum and the central axis of the anal canal. It normally measures between 108° and 127° degrees at rest and changes as the puborectalis contracts or relaxes. It normally closes between rest and squeezing and opens between rest and defection by about 15-20° (Colaicomo et al., 2009). The ARA does not always form part of POP measurements in routine MRI/POP studies because it will usually be an area of interest in defaecation proctograms and colorectal studies, so forms a different area of interest(Healy et al., 1997). It is however an area of interest in muscle evaluation and was indirectly included in the real-time ultrasound study by Braekken et al. (2010). In this study the rectal ampulla was measured which was as they described also a measure for POP but was indirectly a measure for ARA as did measure before and after muscle contraction (Braekken et al., 2010). Colaicomo et al. (2009) stated that the ARA corresponds to the posterior impression of the transition between the puborectal muscle and levator plate and represents the point of reference for posterior compartment descent. It was included as an angle of measurement in the current study in an effort to distinguish, if possible, between puborectal and levator plate changes.

2.9.2.6 Reliability

To examine inter-tester reliability of MRI measurements used in this study, two raters were asked to blindly measure six measurements (LPA, bladder neck position, cervix, ARA, H Line and M line) and a reference line (PCL) on 10 consecutive MRI scans. The consultant urogynaecologist who measured all before and after scans, with significant research experience of MRI measurement in POP, was the first rater (*Rater 1*). The second rater (*Rater 2*) was a Dublin-based consultant radiologist, Dr Niall McEniff, with experience of gynaecological radiology intervention.

Both raters were sent a detailed pdf where a definition was clearly specified for each measurement with exact landmarks to be measured, a drawing provided according to the literature they were referenced from and an example of an MRI measurement in each case provided (Appendix 24). Raters were offered the opportunity to discuss all aspects with the researcher. In addition to this instruction file, raters were sent an excel document where the optimal scan frames were suggested for best visibility of structures; this was a choice of anywhere from 1 slice to 5 slices where it was possible

to scroll between slices in order to reference two anatomical points at one time and T2 filtered images were suggested as the best option (Appendix 17). Trufi scans (TrueFISP: True fast imaging with steady state precession) were an option for the ARA in particular as Trufi scans can show better soft tissue delineation. Measurements were returned on the Excel spread sheet.

2.9.3 POP Symptom Questionnaires

The most valid way of measuring the presence, severity and impact of a symptom or condition on a patient's activities and wellbeing is through the use of psychometrically robust self-administered questionnaires (Barber, 2007). The following questionnaires were chosen for this study to best reflect changes that may have occurred with the intervention and separately address symptoms specific to the anterior compartment, uterine and posterior compartment prolapses.

2.9.3.1 International Consultation Incontinence Questionnaire –Urinary Index (ICIQ-UI)

The ICIQ-UI (Avery et al., 2001) short form is a brief and psychometrically robust patient–completed questionnaire for evaluating the frequency, severity and impact of incontinence on quality of life. The ICIQ-UI was used to establish existence and changes in symptoms of urinary problems and bother in the study group. It assesses prevalence, frequency and perceived cause of urinary incontinence and its impact on everyday life. It is scored on a scale of 0-21. It has been psychometrically evaluated in a series of studies of 324 women. It had good construct validity, moderate to strong agreement with other questionnaires, good reliability and moderate to very good stability in test retest analysis with a Cronbach's alpha of 0.95 (Avery et al., 2001, Avery et al., 2004) (Appendix 14a).

2.9.3.2 International Consultation Incontinence Questionnaire – Vaginal Symptoms (ICIQ-VS)

The ICIQ-VS (Abrams et al., 2006) was used in the current study to evaluate vaginal symptoms, associated sexual matters and impact on quality of life. It is scored on a scale of 0-53 for vaginal symptoms, 0-58 for sexual matters associated with vaginal symptoms and 0-10 for impact on quality of life associated with vaginal symptoms. It had 27 items in its developmental version and has 14 items in its shortened version without compromising validity, stability or sensitivity. The internal consistency of the final reduced version was high with Cronbach's alpha 0.79 for vaginal symptoms and 0.84 for sexual symptoms (Price et al., 2006). The short version is used in the current study (Appendix 14b).

2.9.3.3 Pelvic Floor Distress Inventory – Short Form 20(PFDI-20) & Pelvic Floor Impact Questionnaire – Short Form 7(PFIQ-7)

The PFDI and PFIQ (Barber et al., 2005) were developed for use together to measure the extent to which pelvic floor symptoms affect the quality of life of women with a range of pelvic floor disorders, however the PFDI focuses more on symptoms and the PFIQ more on QOL. The PFDI and PFIQ have been shown to have good test-retest reliability (ICCs 0.86 and 0.87 respectively) and excellent internal consistency (Cronbach's alpha 0.88 and 0.97)(Barber et al., 2005). Both demonstrate significant

association with appropriate measures of symptom severity and pelvic floor diagnoses, demonstrating construct validity. Data for psychometric testing were taken from 100 forms used in development of long forms and tested against forms containing short forms and administered to 45 women pre and post operatively. Women had urinary incontinence, voiding dysfunctions, POP or defaecatory dysfunction and were stage II or greater. Correlation with the PFDI long form was tested in each of the subsections and was excellent for each of the subsections urinary distress index (UDI-6), r= 0.86; pelvic organ distress inventory (POPDI-6), r=0.92; colorectal anal distress inventory (CRADI-8), r=0.93. Correlation with PFIQ long form was also excellent for each of the subsections incontinence impact questionnaire (IIQ-7), r=0.96; pelvic organ prolapse impact questionnaire (POPIQ-7), r=0.94; colorectal anal impact questionnaire (CRAIQ-7), r=0.96. Overall condition specific measures for women with pelvic floor disorders have been shown to be more responsive than generic measures when measuring quality of life (Barber et al., 2011). These two questionnaires have been chosen to reflect changes in the variety of symptoms that may be present in pelvic organ prolapse (Appendix 14c&d).

2.10 Costing

The cost of the 24 pelvic MRI scans at €150 was €3,600. Further costs are estimated to be the treatment time taken with the patients (€5,880) and postage and stationary were in the region of €100. Grant funding of €3,600 was received from the Continence Foundation of Ireland to cover the cost of the MRI scans.

2.11 Statistical Analysis

The Statistical Package for Social Sciences (SPSS®), Released 2011, Version 20, Chicago, IBM Corporation® was used for all statistical analysis.

The Shapiro-Wilk test was chosen to test for normality of continuous data. The assumption of normality for all variables was assessed by Shapiro-Wilk test ($p>0.05$).

All MRI data were found to be normally distributed and were evaluated by comparing the mean values before and after treatment, using a parametric paired t test.

POP-Q staging is an ordinal scale and POP-Q stage data were not normally distributed, therefore a non-parametric Wilcoxon signed rank test was used to evaluate POP-Q stage. POP-Q points Aa, Ap, Ba and Bp were on a restricted numeric scale for the purposes of this study due to the inclusion criteria of only stage I and stage II prolapse. The genital hiatus (GH) and perineal body (PB) are normally on a narrower scale; in the study the range was 3 cm and 2 cm respectively. Apical points C and D are on a wider scale and could reach seven points but within the study the range of both was 3 cm. Similarly the total vaginal length (TVL), where it could be in excess of seven points, the range in this study was 3 cm. POP-Q points Ba, Bp, C, D, GH, PB and TVL were not normally distributed, therefore although they are numeric scales, they were evaluated using the Wilcoxon signed rank test. The only data that were normally distributed were

the POP-Q points Aa and Ap and they were evaluated using paired t tests.

Questionnaire data were also evaluated using the Wilcoxon signed rank test as a more robust non parametric test was needed due to the presence of an outlier. It was considered because of the small size of the study (n=12) it would not have been appropriate to remove one of the subjects from the analysis of the data.

Reliability was determined using a combination of intraclass correlation coefficients (ICC), with 95% Confidence Intervals (CI) and Bland and Altman plots of the difference between the two raters' measurements. Bland and Altman techniques are independent of the true variability in the observations and compliment the ICC values (Bland & Altman, 1990; Rankin & Stokes, 1998).

ICC were interpreted as follows: 0-0.2 indicates *poor* agreement: 0.3-0.4 indicates *fair* agreement; 0.5-0.6 indicates *moderate* agreement; 0.7-0.8 indicates *strong* agreement; and >0.8 indicates *almost perfect* agreement (Landis and Koch, 1977).

The significance level was set at a value of p=0.05.

CHAPTER 3 RESULTS

Twelve subjects were recruited and all subjects completed the course of physiotherapy. A further three subjects were referred but were excluded according to exclusion criteria.

1.1 Subject Characteristics

3.1.1 Demographics

The mean age of the subjects was 46.75 ±11.68 years and mean BMI was 24.9 K/m^2 ± 4.52 (table 3.1).

Table 3-1 Subject demographics

	Mean	*SD*	*Range*
Age	46.75	11.67	31-66
Body Mass Index	24.92	4.52	20-34
Number of children	2.67	1.30	1-4

Seven subjects had a monthly cycle, one had a Mirena coil in situ, one subject was peri-menopausal and four subjects were post-menopausal. Five subjects had given birth a year prior to the study and two had given birth six months before starting in the study.

Subjects included in the study had either cystocele or rectocele and some subjects presented with both, although it was either the cystocele or the rectocele that had the leading edge (table 3.2). There were no subjects with a uterine prolapse. Subjects had predominantly stage two prolapse with cystocele being the most common type. Only two subjects had rectocele without concurrent cystocele.

Table 3-2 Prolapse type at baseline

Subjects (n=12)	*Stage 1 prolapse (n=2)*	*Stage 2 prolapse (n=10)*
Cystocele (7)	2	5
Cystorectocele (3)	0	3
Rectocele (2)	0	2

As the predominant prolapse type was cystocele, the lowest mean point in the overall POP-Q data was the anterior wall point Aa (mean= -0.67) and the maximum points of descent occurred in the posterior and anterior compartments at the lower vaginal wall; points Aa and Ap. The most frequently occurring point of prolapse among

subjects in the anterior compartment was 0cm at the hymen for point Aa and -2cm for point Ba. In the posterior compartment by comparison, point Ap was most frequently positioned at -3cm and the higher point Bp was also positioned most frequently at -3cms, showing the predominance of anterior compartment prolapse across all subjects. There was an incomplete number of POP-Q recordings for GH (genital hiatus) and PB (perineal body) and TVL (total vaginal length) with a total of nine pairs (table 3.3). These were omitted in error by the measuring consultant.

Table 3-3 POP-Q stage and POP-Q points at baseline

	Mean	*SD*	*Range*
POP-Q	1.83	0.38	1 to 2
Aa	-0.67	1.303	-3 to 1
Ba	-2.17	0.718	-3 to -1
C	-5.67	0.778	-7 to -4
D	-6.50	0.798	-8 to -5
Bp	-2.33	0.985	-3 to 0
Ap	-1.92	1.311	-3 to 1
GH*	3.45	0.934	2 to 5
PB*	2.73	0.905	2 to 4
TVL*	6.64	0.674	6 to 8

See Appendix 1 for key of POPQ points *9 pairs

3.1.2 MRI Measurements at Baseline

Lines and angles of measurements are described in Methodology 2.9.2.

Table 3-4 MRI measurements at baseline

	Mean	*SD*	*Range*
LPA	45.25°	10.41°	30-70°
Bladder neck	12.45 mm	7.90 mm	0-28.6 mm
Cervix	9.65mm	6.63mm	0-21mm
H line	61.6mm	7.86mm	52.6-76.7mm
M line	21.1mm	10.12mm	3.8-40.2mm
ARA	122.8°	13.65°	95-150°

LPA - levator plate angle; H line - hiatus line; M line - muscular relaxation line; ARA- anorectal angle

3.1.3 Symptom Profile

Symptoms that are usually associated with pelvic organ prolapse were the main presenting symptoms. Urinary incontinence was prevalent; ten subjects had urinary incontinence and six had urinary incontinence scores of greater than six out of a total score of 14 on the International Consultation Incontinence Questionnaire – Urinary Index (ICIQ-UI) (Appendix 14a). Two subjects had no urinary incontinence at all.

Pelvic organ prolapse symptoms were measured by the International Consultation Incontinence Questionnaire-Vaginal Symptoms (ICIQ-VS) (Appendix 14b) questionnaire and by the Pelvic Floor Distress Inventory (PFDI-20) (Appendix 14c). The ICIQ–VS was

subdivided into the Vaginal Symptom Score (VSS), Sexual Matters Score (SM) and a QoL score. The PFDI was subdivided into Pelvic Organ Distress Inventory (POPDI) measuring vaginal symptoms, Colorectal-Anal Distress Inventory (CRADI) measuring bowel symptoms and Urinary Distress Inventory (UDI) measuring bladder symptoms. Vaginal symptoms were most common in the cystocele and cystorectocele groups and colorectal symptoms were predominant in the two subjects who had rectocele. Bladder symptoms were slightly more common in the cystocele group than the other two (Fig 3.1).

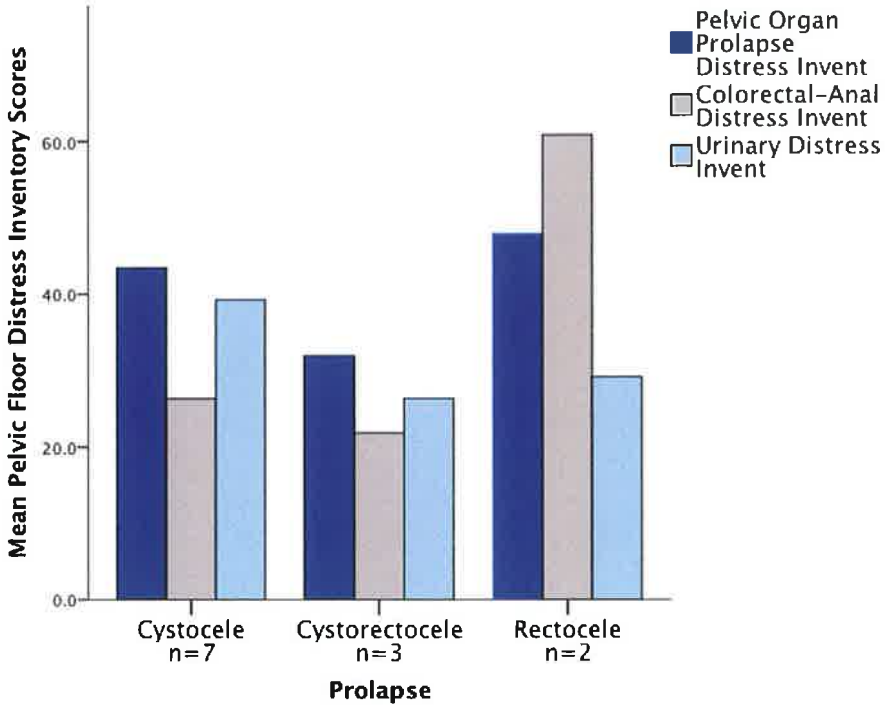


Figure 3-1 Mean Pelvic Floor Distress Inventory scores before treatment

Five of the 12 subjects described the maximum level of interference in their QoL scoring 10 out of 10 in the ICIQ-VS QoL score (mean overall score 7.33 ± 2.83).

The other measure of QoL was in the Pelvic Floor Impact Questionnaire (PFIQ-7) (Appendix 14d), which demonstrated greatest level of interference with ADL across all subjects in vaginal domains. The PFIQ-7 measured the same ADL activities in vaginal (Pelvic Organ Prolapse Impact Questionnaire), bladder (Incontinence Impact Questionnaire) and bowel domains (Colorectal-Anal Impact Questionnaire); bowel symptoms were most bothersome in the rectocele group and bladder symptoms were most bothersome in the cystocele group (Fig 3.2).

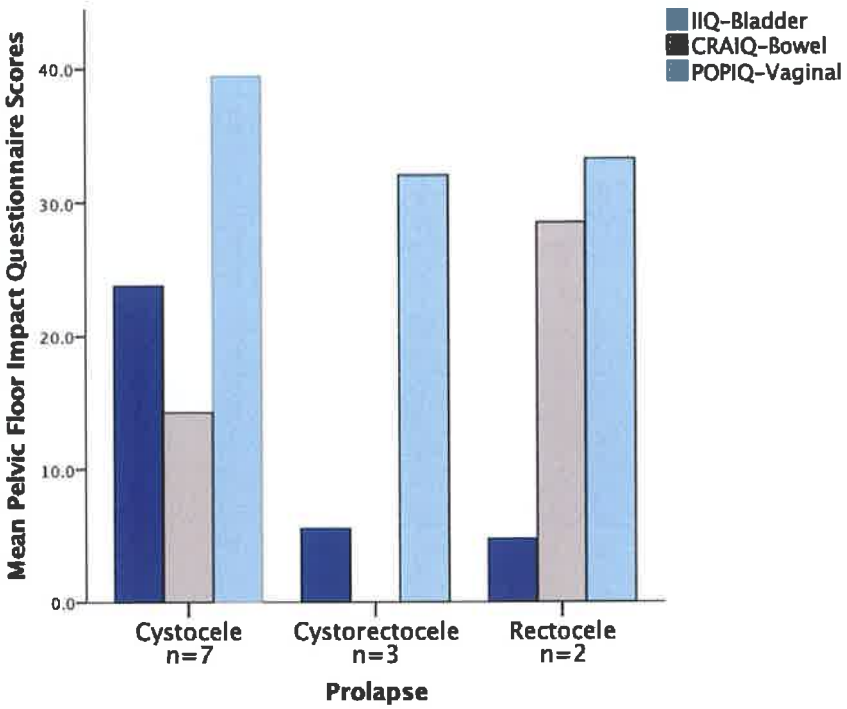


Figure 3-2 Mean Pelvic Floor Impact Questionnaire scores before treatment

3.1.4 Reliability of MRI Measures

Inter-rater reliability was evaluated for MRI measures used in the main study. Two raters were asked to blindly measure 6 measurements (LPA, Bladder neck position, Cervix, ARA, H Line and M line) on 10 MRI scans using the PCL reference line Mean measurements between *Rater 1* and *Rater 2* are outlined in table 3.5.

Table 3-5 Mean MRI measurements of *Rater 1* and *Rater 2 (n=10)*

Variable	*Rater*	*Mean*	*Standard Deviation*	*Standard Error of Mean*	*Variance*
LPA	*1*	45.20	11.31	3.57	127.95
	2	42.70	10.49	3.32	110.23
Bladder	*1*	8.37	8.81	2.78	77.76
neck	*2*	7.99	4.78	1.51	22.86
ARA	*1*	122.30	15.01	4.74	225.34
	2	112.20	5.39	1.70	29.06
Cervix	*1*	9.79	5.95	1.88	35.45
	2	13.29	7.44	2.35	55.49
H Line	*1*	59.69	7.25	2.29	52.62
	2	55.72	8.89	2.81	79.12
M Line	*1*	20.56	10.93	3.45	119.46
	2	17.96	6.28	1.98	39.54

LPA - levator plate angle; ARA- anorectal angle; H line - hiatus line; M line - muscular relaxation line

Reliability was calculated using intra-class correlation coefficients (ICC); two-way mixed model, consistency type and single measure form (ICC 3,1) (table 3.6). Bland and Altman plots of the difference between the two raters' measurements as a function of the average of the two raters' measurements were also performed (table 3.6).

ICC were interpreted according to cut offs as described by Landis and Koch (1977) as follows: 0-0.2 indicates *poor* agreement: 0.3-0.4 indicates *fair* agreement; 0.5-0.6 indicates *moderate* agreement; 0.7-0.8 indicates *strong* agreement; and >0.8 indicates *almost perfect* agreement (Landis and Koch, 1977).

According to this interpretation LPA agreement was strong for the two raters (ICC 0.80) and bladder neck position was moderate-strong (ICC 0.76). Agreement for the H line was moderate (ICC 0.68) and for the M line was fair (ICC 0.49). Agreement for the ARA was poor (ICC 0.15). The cervix position was the least reliable measurement and was poor (ICC 0.08).

Table 3-6 Intraclass Correlation Coefficients and Bland and Altman 95% Limits of Agreement

N=10	*ICCs Rater 1 & Rater 2*			*Bland & Altman 95% LOA*			
	ICC	95% CI		*D*	SD(*D*)	95% LOA	
		Lower	Upper			Lower	Upper
LPA	0.80	0.389	0.947	2.50	6.85	-10.9	15.9
Bladder	0.76	0.304	0.936	2.36	3.65	-4.80	9.52
Cervix	0.08	-0.545	0.654	-3.5	9.12	-21.38	14.38
ARA	0.15	-0.495	0.691	10.1	14.7	-18.7	38.9
H Line	0.68	0.135	0.910	3.97	6.48	-8.73	16.67
M line	0.49	-0.157	0.844	2.6	9	-15.03	20.23

ICC - Intraclass correlation coefficients; CIs – Confidence Intervals; LOA – limits of agreement; D – mean difference ; SD – standard deviation of the difference
LPA - levator plate angle; ARA- anorectal angle; H line - hiatus line; M line - muscular relaxation line

Bland and Altman plots revealed acceptable mean differences (bias) for only LPA, bladder neck and H line and plots for LPA (figure 3.3) and bladder neck (figure 3.4) measurements are illustrated.

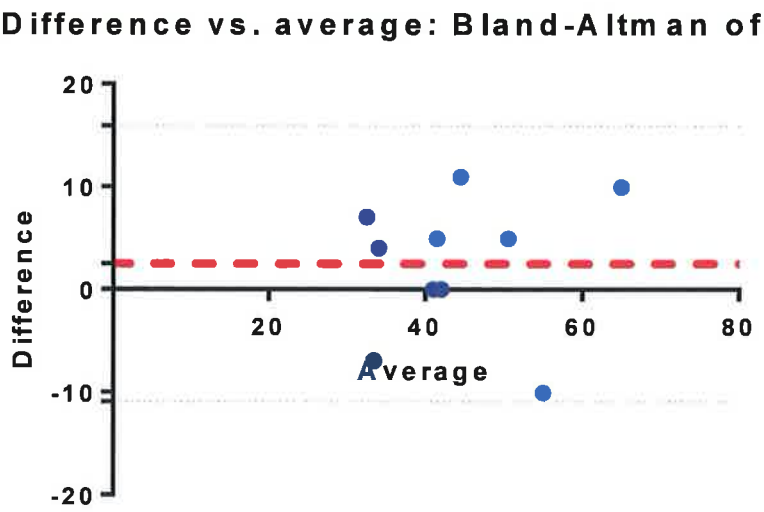


Figure 3-3 Bland and Altman plot for levator plate angle measurements from *Raters 1 and 2*. Broken lines indicate 95% LOA (black) and mean difference (red)

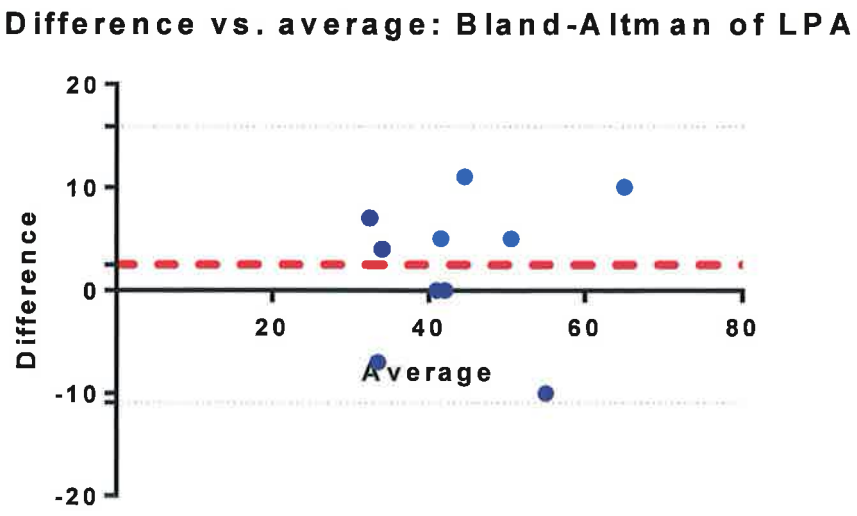


Figure 3-4 Bland and Altman plot for bladder neck measurements from *Raters 1 and 2*. Broken line indicates 95% LOA (black) and mean difference (red)

In order to observe the reliability for the individual subjects within the study, simple plots were also drawn of the measurements from the two raters (Appendix 25). The coloured lines through the average of the two raters measurements are from a non linear regression curve analysis graph but help demonstrate the differences between raters. It was observed from simple plots of the LPA that in 60% of subjects *Rater 1* consistently measured a proportionately wider angle than *Rater 2*. *Rater 1* measured higher bladder neck positions in 60% of subjects relative to *Rater 2*. *Rater 1* also measured the H line consistently higher than *Rater 2*.

3.2 Post Treatment Results

A complete table of post treatment results is presented (table 3-7).

3.2.1 MRI Measures

Shapiro-Wilk normality tests (p value ≥ 0.05) were performed on all MRI measures of LPA, ARA, bladder neck, cervix, H line and M line. All data were found to be normally distributed. Paired t-tests were performed to compare means of pre and post intervention measurements (table3-8).

Table 3-7 Complete post treatment results (n=12)

Variable	*Mean ± SD*		*p value*
	Before	*After*	
MRI Measurements			
LPA	45.25° ± 10.41	45.50° ± 11.76	0.86#
Bladder neck	12.35mm ±7.54	16.2mm ± 8.65	0.12#
Cervix	9.65mm ± 6.62	5.59mm ± 6.70	0.13#
H line	61.64mm ± 7.86	68.41mm ±7.68	**0.01#**
M line	21.1mm ± 10.12	24.23mm ±9.12	0.40#
ARA	122.83° ± 13.65	128.25° ± 7.27	0.26#
POP-Q Scores			
POP-Q Stage	1.83 ± 0.38	1.25 ± 0.45	**0.02**
Aa	-0.67cm ± 1.30	-2.42cm ± 1.16	**0.00#**
Ba	-2.17cm ± 0.71	-2.17cm ± 1.19	0.95
C	-5.67cm ± 0.77	-5.92cm ± 0.28	0.18
D	-6.50cm ± 0.79	-6.33cm ± 0.49	0.41
Bp	-2.33cm ± 0.98	-1.92cm ± 0.66	0.13
Bp (n=11)*	-2.55cm ± 0.68	-1.91cm ± 0.70	**0.00**
Ap	-1.92cm ± 1.31	-2.00cm ± 0.85	0.77#
GH◆	3.45cm ± 0.93	3.20cm ± 1.31	0.67
PB◆	2.73cm ± 0.90	2.70cm ± 0.48	1.00
TVL◆	6.60cm ± 0.67	6.50cm ± 0.70	1.00
ICIQ-Vaginal Symptoms			
ICIQ-VSS	21.33 ± 5.64	11.58 ± 10.04	**0.01**
ICIQ-SM♦	31.50 ± 20.93	20.90 ± 20.69	**0.02**
ICIQ-QoL	7.33 ±2.83	3.58 ± 3.20	**0.00**
ICIQ-Urinary Symptoms			
ICIQ-UI	5.83 ± 4.06	4.58 ± 5.55	0.21
Pelvic Floor Distress Inventory (PFDI)			
POPDI	41.30 ±19.58	25.32 ± 24.84	0.09
CRADI	30.95 ± 19.45	25.21 ± 22.92	0.34
UDI	34.35 ± 22.45	20.80 ± 22.76	0.09
PFDI Total	106.61 ± 35.88	71.35 ± 62.73	0.06
Pelvic Floor Impact Questionnaire (PFIQ)			
POPIQ	36.55 ± 28.61	17.80 ± 20.29	0.05
CRAIQ	13.07 ± 21.47	7.58 ± 14.53	0.60
IIQ	16.04 ± 20.21	12.26 ± 18.20	0.50
PFIQ Total	65.19 ± 63.07	37.65 ± 47.50	0.09

paired t tests, all other tests Wilcoxon signed rank test; ♦ 8 pairs only (3 subjects only became sexually active while taking part in the study, one subject was not sexually active); ◆9 pairs only (3 sets of data could not be analysed as one or other of the pairs was omitted in error by the measuring consultant). * One subject had a cyst on the posterior wall.

LPA – levator plate angle; H line – hiatus line; M line – muscular relaxation line; ARA – anorectal angle: POP-Q Pelvic Organ Prolapse Quantification: see Appendix 1 for all POP-Q abbreviations; ICIQ – International Consultation Incontinence Questionnaire; VSS- Vaginal Symptom Score; SM-Sexual Matters; QoL – Quality of Life; UI – Urinary Incontinence; POPDI- Pelvic Floor Distress Inventory; CRADI – Colorectal-anal Distress Inventory; UDI - Urinary Distress Inventory; POPIQ – Pelvic Organ Prolapse Impact Questionnaire; CRAIQ – Colorectal-anal Distress Inventory; IIQ- Incontinence Impact questionnaire. All increases in values as determined by improvements are coloured blue and all decreases in values as determined by a deterioration are coloured red.

The LPA was marginally wider by mean -0.25 ± 4.99 (SEM 1.44) after treatment and this change was statistically insignificant (p=0.86).

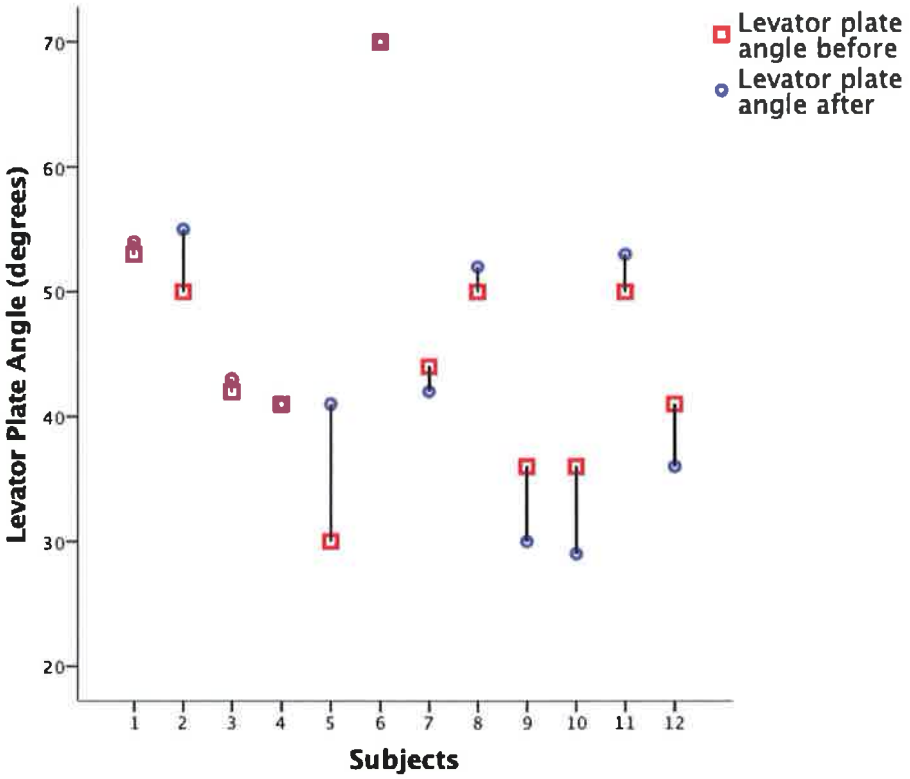


Figure 3-5 Levator plate angle measurement before and after treatment (increasing values in degrees on the Y axis indicate a wider angle after treatment

Table 3-8 MRI measurements before and after treatment (n=12)

MRI Meas-ures	*Mean ± Standard Deviation*			*95% Confidence Interval of the Difference*		*p value*
	Before	*After*	Mean Differences	Lower	Upper	
LPA	45.25°± 10.41	45.50° ± 11.76	-0.25 ± 4.99	-3.42	2.92	0.86
BL	12.35 mm ±7.54	16.2 mm ± 8.65	-3.92 ± 8.22	-9.15	1.30	0.12
ARA	122.83°± 13.65	128.25° ±7.27	-5.41 ± 16.13	15.66	4.83	0.26
CX	9.65mm ± 6.62	5.59mm ±6.70	4.06 ± 8.63	-1.41	9.55	0.13
H line	61.64mm ±7.86	68.41mm ±7.68	-6.98 ± 7.94	-12.03	-1.93	**0.01**
M line	21.1mm ±10.12	24.23mm ±9.12	-3.13 ± 12.55	-11.10	4.84	0.40

LPA - levator plate angle; BL- bladder; ARA- anorectal angle; Cx- cervix; H line - hiatus line; M line - muscular relaxation line Blue indicates improvement in position

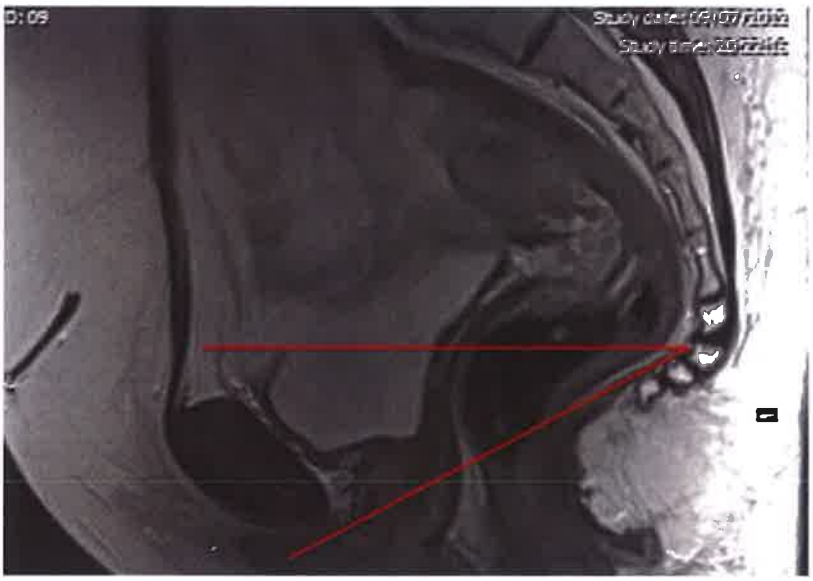


Figure 3-6 Subject 9 LPA before treatment

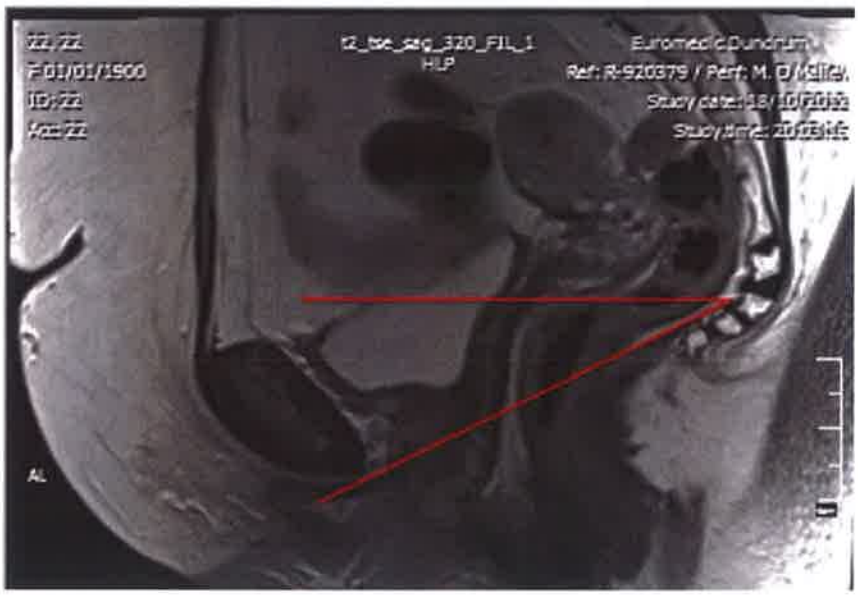


Figure 3-7 Subject 9 LPA after treatment

Figure 3.6 and 3.7 show the LPA by MRI scan before and after treatment. It can be seen in this subject that the LPA is closer to the pubic symphysis after the treatment; this can also be seen in this subject in Fig 3.5.

The mean bladder neck position was raised by 3.92mm ± 8.22 (SEM 2.37) after treatment but this was statistically insignificant (p=0.12).

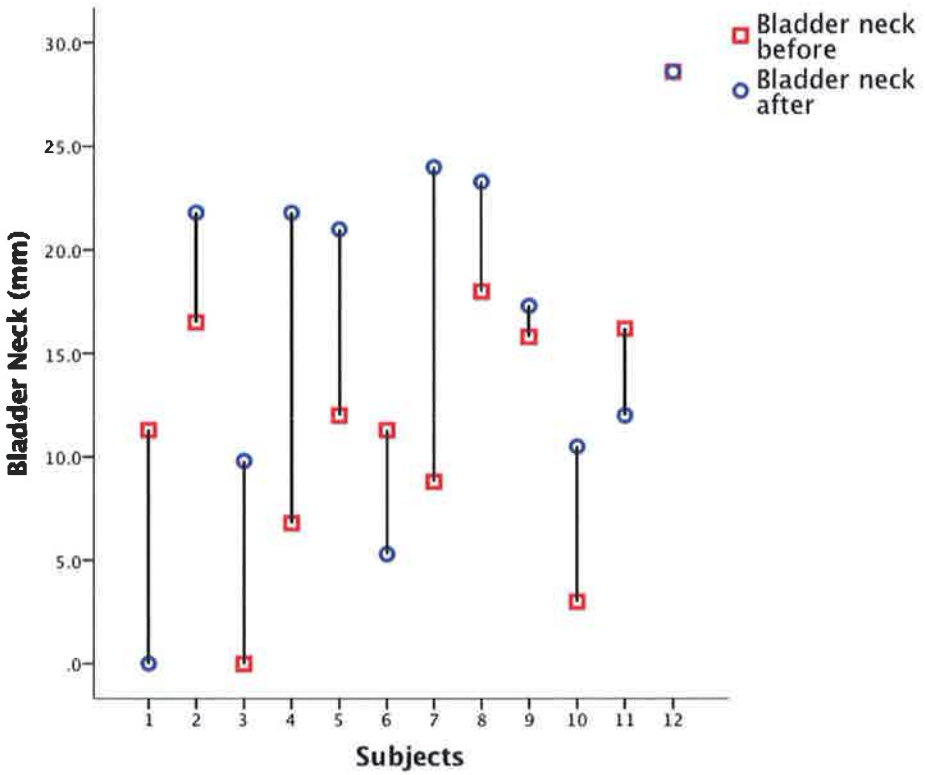


Figure 3-8 Bladder neck position before and after treatment (increasing values on the Y axis indicate improvements in distance from the pubococcygeal line, shown here by blue markers)

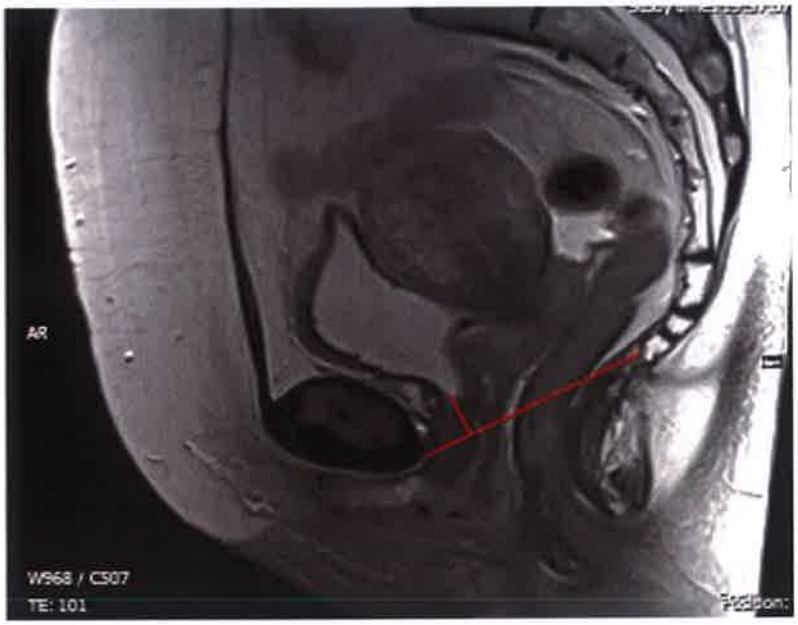


Figure 3-9 Subject 8 Bladder neck before treatment

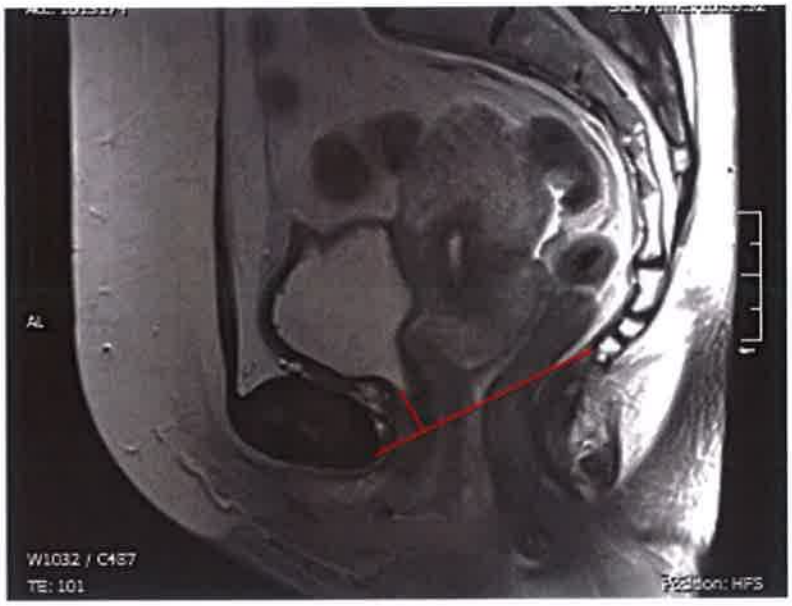


Figure 3-10 Subject 8 Bladder neck after treatment

Fig 3.9 and 3.10 show the bladder neck position by MRI scan in subject 8 before and after treatment. The neck of the bladder can be seen to be higher in Fig 3.10 after treatment by comparison to Fig 3.9 and this can be seen also in Fig 3.8.

The H line widened by mean of 6.98mm ± 7.94 (SEM 2.29) after treatment and this was a statistically significant change (**p=0.01).**

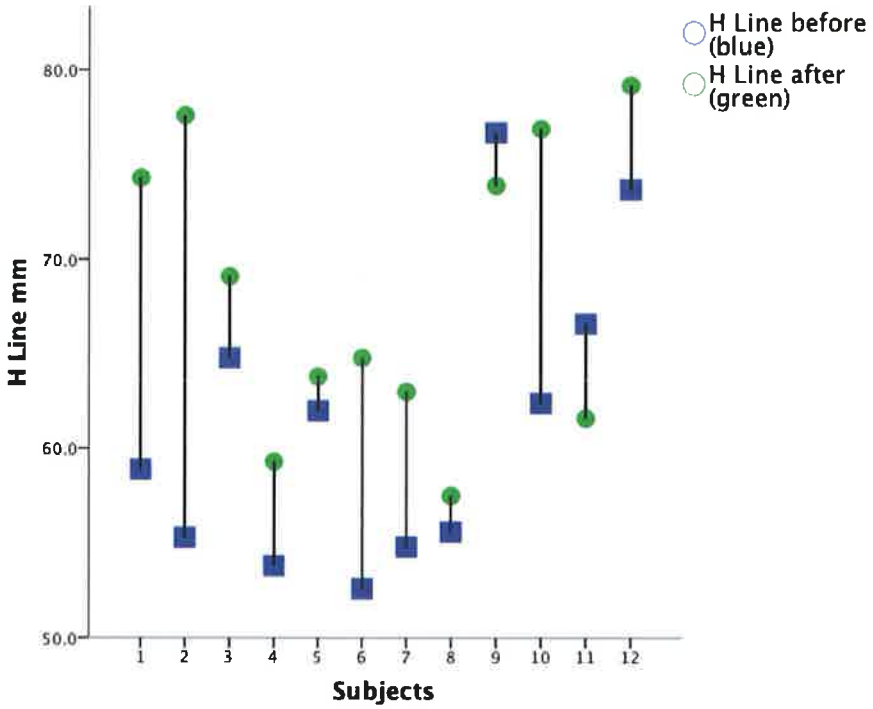


Figure 3-11 H Line before and after treatment (increasing values on the Y axis indicate a wider hiatus after treatment, shown here by the green markers)

The M line dropped by 3.1mm ± 12.55 (SEM 3.62) after treatment but this was not statistically significant (p=0.40). The ARA widened by mean 5.41mm ± 16.13 (SEM 4.65) after treatment but this did not reach statistical significance (p=0.26). The cervix dropped by mean 4.06mm ± 8.63 (SEM 2.49) after treatment and this was not statistically significant (p=0.13).

3.2.2 POP-Q

Data for points Aa and Ap were normally distributed. POP-Q data found not to be normally distributed were POP-Q stages, POP-Q points Ba, Bp, C and D, GH, PB, and TVL. POP-Q points Aa and Ap were analysed using paired t tests and all other POP-Q data was analysed using Wilcoxon signed rank test.

The overall POP-Q stage improved significantly from mean of 1.83 to 1.25 (p=0.02) and of the POP-Q points, point Aa improved significantly from -0.67cm to -2.42cm (p=0.00). The rest of the POP-Q points did not change significantly (table 3.9).

Table 3-9 POP-Q stage and points before and after treatment

	Mean ± SD Before	*Mean ± SD After*	*P value*
POP-Q	1.83 ± 0.38	1.25 ± 0.45	**0.02**
Aa	-0.67 ± 1.30	-2.42 ± 1.16	**0.00***
Ba	-2.17 ±0.71	-2.17 ± 1.19	0.95
C	-5.67 ± 0.77	-5.92 ± 0.28	0.18
D	-6.50 ± 0.79	-6.33 ± 0.49	0.41
Bp	-2.33 ± 0.98	-1.92 ± 0.66	0.13*
Ap	-1.92 ± 1.31	-2.00 ± 0.85	0.77
GH◆	3.45 ± 0.93	3.20 ± 1.31	0.67
PB◆	2.73 ± 0.90	2.70 ± 0.48	1.00
TVL◆	6.64 ± 0.67	6.50 ± 0.70	1.00

**paired t test, all other analysis is Wilcoxon signed rank test* □

◆9 pairs only (3 sets of data could not be analysed as one of the pre and post sets was omitted in error by the measuring consultant, see p. 53) Blue indicates improvement

See abbreviations for POP-Q points in Appendix 1

Of note the leading edge of the prolapse on POP-Q measurement changed over the course of the study from cystocele being the leading edge to rectocele being the leading edge (table 3.10).

Table 3-10 Prolapse leading edge before and after treatment

		Before treatment	*After treatment*
Cystocele	*Stage I*	2	3
	Stage II	5	2
Cystorectocele	*Stage I*	0	0
	Stage II	3	-
Rectocele	*Stage I*	0	6
	Stage II	2	1

POP-Q point Bp was not at first statistically significant, however when further analysed, a statistically significant change was noted. Subject 12 presented with a cyst on the posterior rectal wall; details of this finding are outlined in section "Special Cases". This subject was excluded from this analysis and the data of the other 11 subjects were analysed separately. A statistically significant worsening (p=0.00) was then seen. The upper posterior rectal wall point Bp descended more (-1.91cm ± 0.70) post treatment than pre treatment (-2.55 ± 0.68). This is one of the two points that could reflect the finding of an increased rectocele as the leading edge on the consultant's POP-Q measurements (Table 3-11).

Table 3-11 POP-Q point Bp before and after treatment

	Mean ± SD Before	*Mean ± SD After*	*P value**
Bp (n=12)	-2.33 ± 0.98	-1.92 ± 0.66	0.13
Bp (n=11)	-2.55 ± 0.68	-1.91 ± 0.70	**0.00**

*Wilcoxon signed rank test Red indicates deterioration in position
Bp - most distal portion of remaining upper posterior vaginal wall

It was important to note that the proportionate worsening in POP-Q point Bp was comparatively much smaller than the proportionate improvement in POP-Q Aa. The biggest improvement in Aa can be seen in the cystocele group by comparison to the two other prolapse groups (fig 3.12).

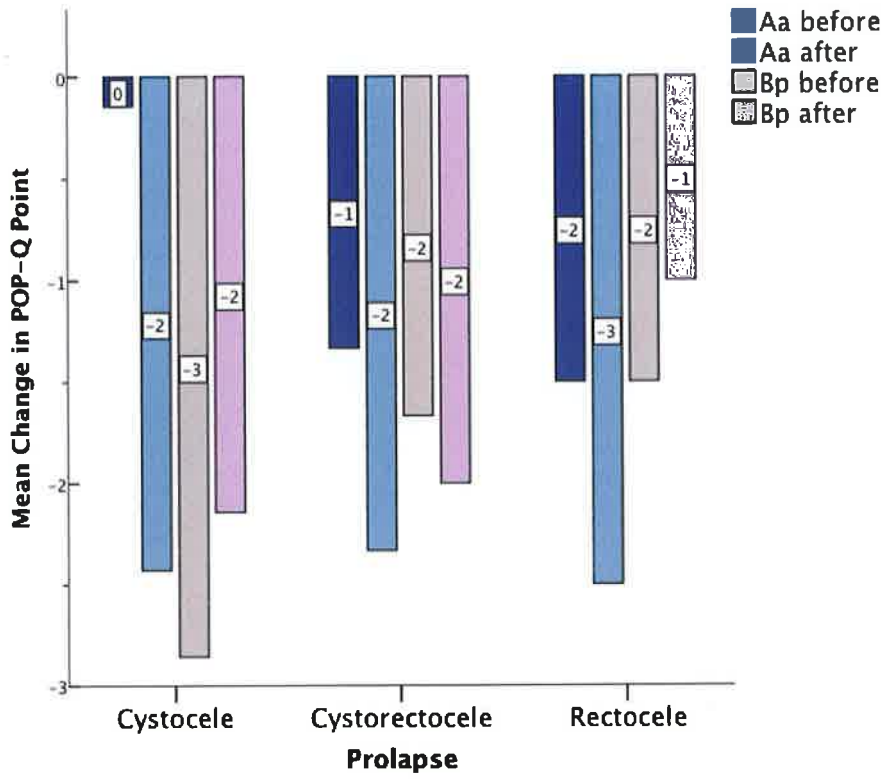


Figure 3-12 Mean change in point Aa by comparison to Bp (the change between the dark to light blue shows the improvement in cms of anterior wall prolapse; the grey to pink shows the comparative worsening of the posterior wall. The graph attempts to show the wider degrees of improvement of the anterior wall)

Thus, in POP-Q analysis there was a swing towards rectocele as a leading edge after treatment. Anterior wall POP-Q point Aa was higher post treatment (mean 1.75 cm) and posterior wall POP-Q point Bp was lower (mean -0.64 cm). The overall changes resulted in a changed leading edge in some instances and an overall improvement in POP-Q stage (fig 3.9 and fig 3.10).

3.2.3 Questionnaires

All questionnaire data were tested for normality using the Shapiro-Wilk test, a value below p=0.05 indicated data were not normally distributed. Questionnaires ICIQ-UI, PFIQ-Bladder (IIQ) and PFIQ total score were not normally distributed. All other questionnaire data were normally distributed, however all questionnaire data were analysed using Wilcoxon signed rank test due to the presence of an outlier.

Table 3-12 ICIQ-Urinary Incontinence before and after treatment

	Mean ± SD Before	*Mean ± SD After*	*P value**
ICIQ-UI	5.83 ± 4.06	4.58 ± 5.55	P=0.21

*Wilcoxon signed rank test Blue indicates improvement

ICIQ-UI International Consultation Incontinence Questionnaire – Urinary Incontinence

There was an improvement in the mean ICIQ-UI score but this did not reach statistical significance (p=0.21) (table 3.12 and fig 3.13).

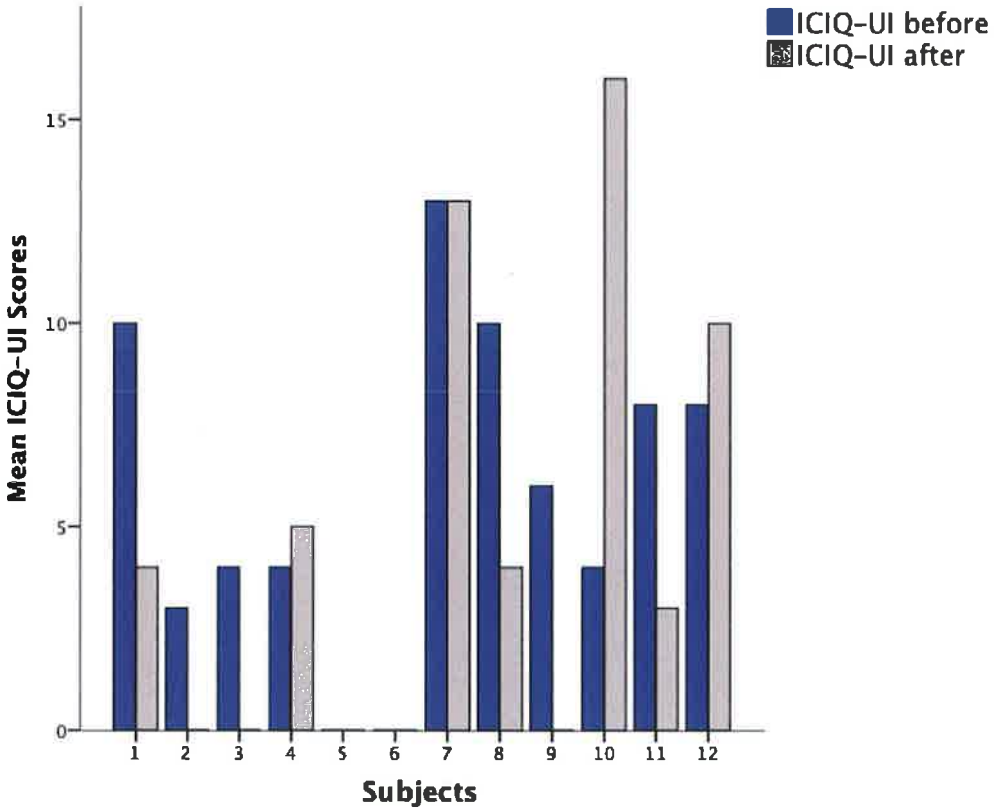


Figure 3-13 International Consultation Incontinence Questionnaire-Urinary Incontinence before and after treatment

The ICIQ-VS was subdivided into the Vaginal Symptom Score, Sexual Matters Score and QoL. The Vaginal Symptom Score was significantly improved with a mean score of 9.75 ±11.25 (p=0.01) (table 3.13 and fig 3.14).

In the Sexual Matters Scores there were eight completed sections pre treatment and 11 completed sections post treatment, this was because three subjects had only wanted to become sexually active during the course of the treatment period. Therefore only eight pairs were used in the analysis. One subject was not currently in a relationship. There was a statistically significant improvement for these eight pairs (p=0.02). One subject (subject 10) was worse following treatment (fig 3.14), possible reasons are outlined in *Discussion*.

Table 3-13 ICIQ –Vaginal Symptoms before and after treatment

	Mean ± SD Before	*Mean ± SD After*	*P value**
Vaginal Symptoms Score	21.33 ± 5.64	11.58 ± 10.04	**0.01**
Sexual Matters	31.50 ± 20.93**	20.90 ± 20.69**	**0.02**
QoL	7.33 ± 2.83	3.58 ± 3.20	**0.00**

*Wilcoxon signed ranks test **n=8 Blue indicates improvement
ICIQ-VS International Consultation Incontinence Questionnaire – Vaginal Symptoms

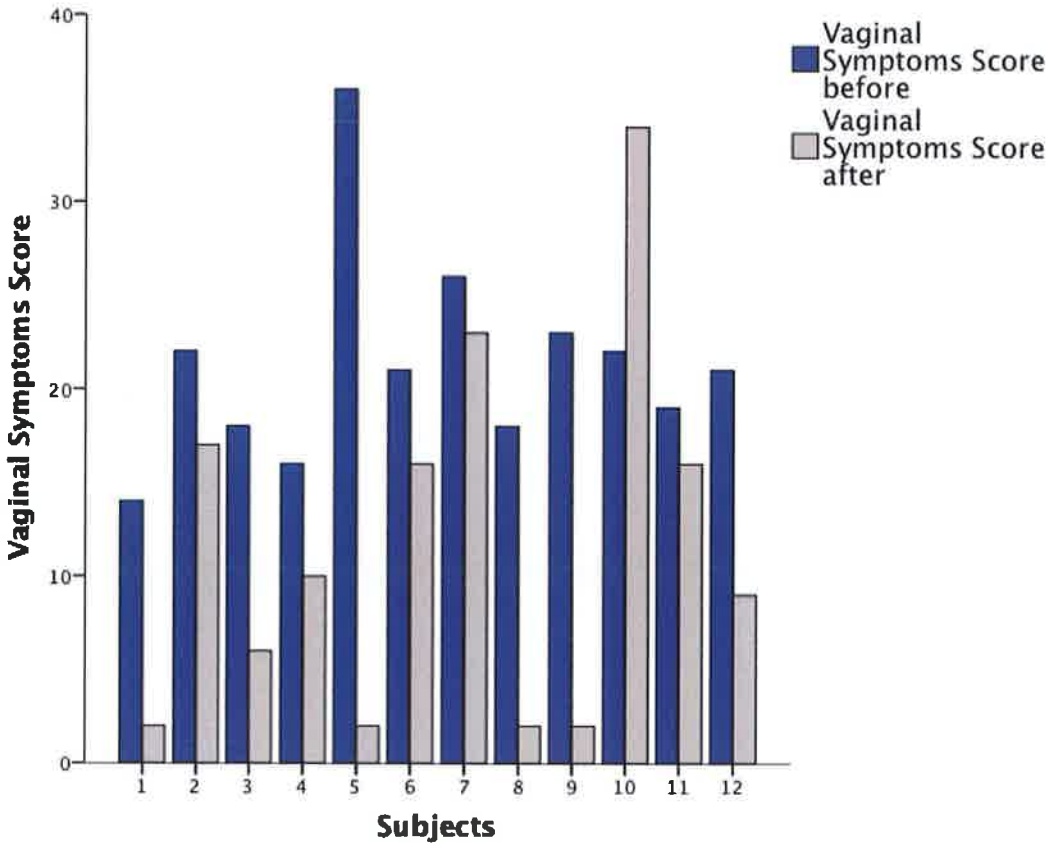


Figure 3-14 International Consultation Incontinence Questionnaire -Vaginal Symptoms scores before and after treatment

QoL changed statistically significantly (p=0.00) with improvements seen in all but two subjects (Fig 3.15).

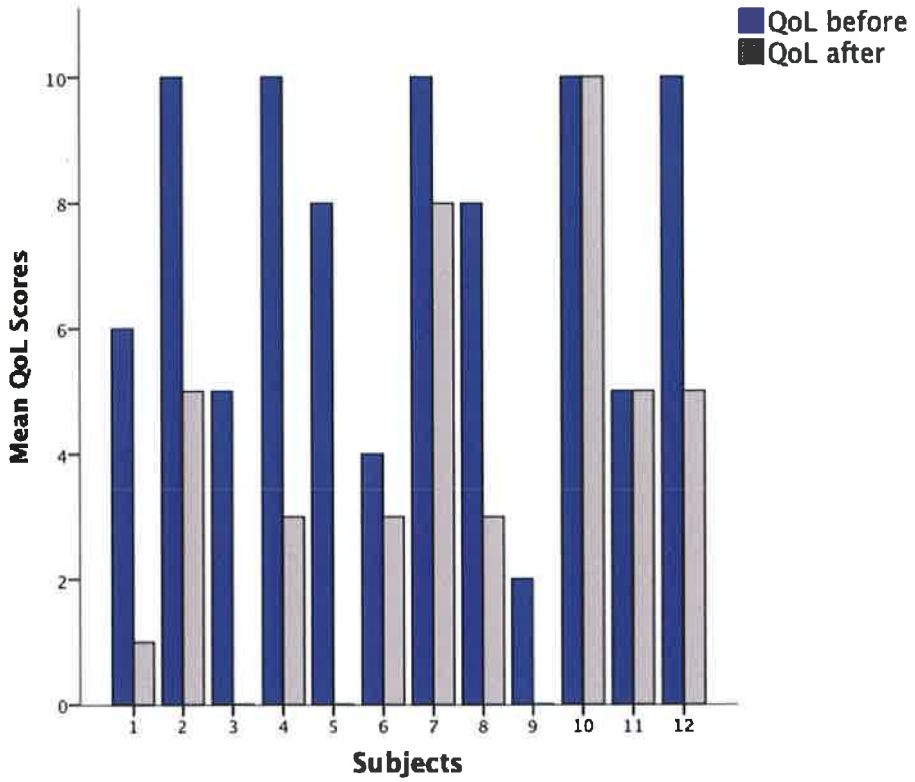


Figure 3-15 International Consultation Incontinence Questionnaire -QoL before and after treatment

The Pelvic Floor Distress Inventory is subdivided into the POPDI, the CRADI and the UDI with a PFDI total score.

Table 3-14 Pelvic Floor Distress Inventory scores before and after treatment

	Mean ± SD Before	*Mean ± SD After*	*P value**
POPDI	41.30 ± 19.58	25.32 ± 24.84	0.09
CRADI	30.95 ± 19.45	25.21 ± 22.92	0.34
UDI	34.35 ± 22.45	20.80 ± 22.76	0.09
PFDI	106.61 ± 35.88	71.35 ± 62.73	0.06

*Wilcoxon signed rank test Blue indicate improvement

POPDI-Pelvic Organ Prolapse Distress Inventory; CRADI-Colorectal-Anal Distress Inventory; UDI-Urinary Distress Inventory; PFDI- Pelvic Floor Distress Inventory

None of the subsections of this symptoms questionnaire showed significant change however the PFDI total almost reached significance (p=0.06) (table 3.14 and figs 3.16, 3.17, 3.18).

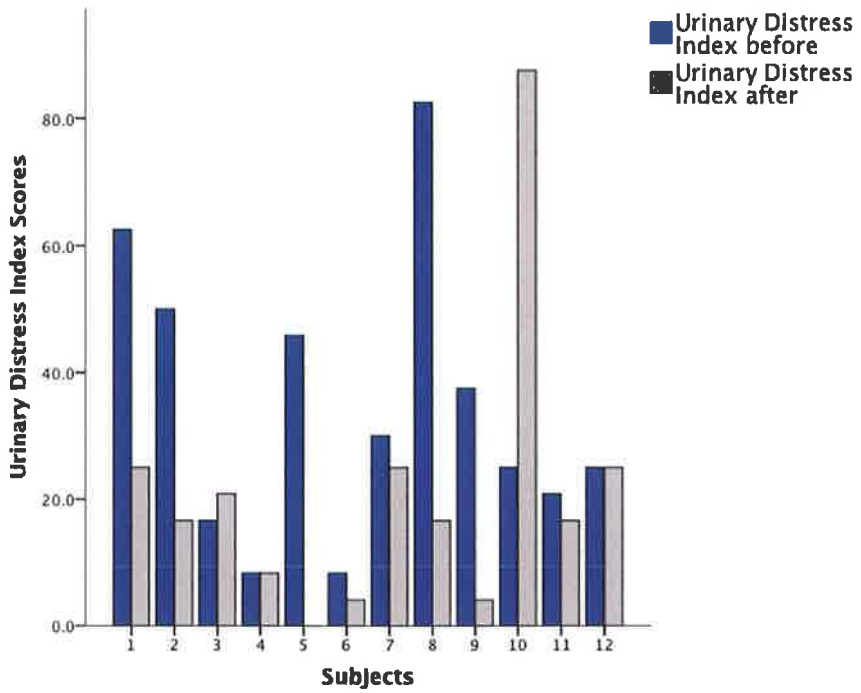


Figure 3-16 Urinary Distress Index before and after treatment

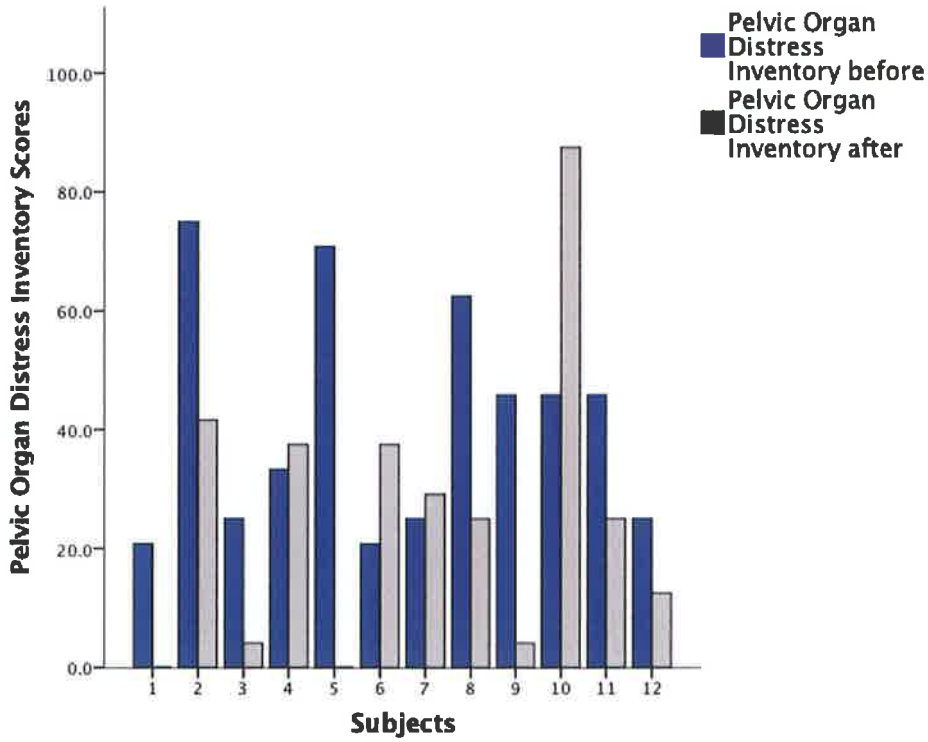


Figure 3-17 Pelvic Organ Prolapse Distress Inventory before and after treatment

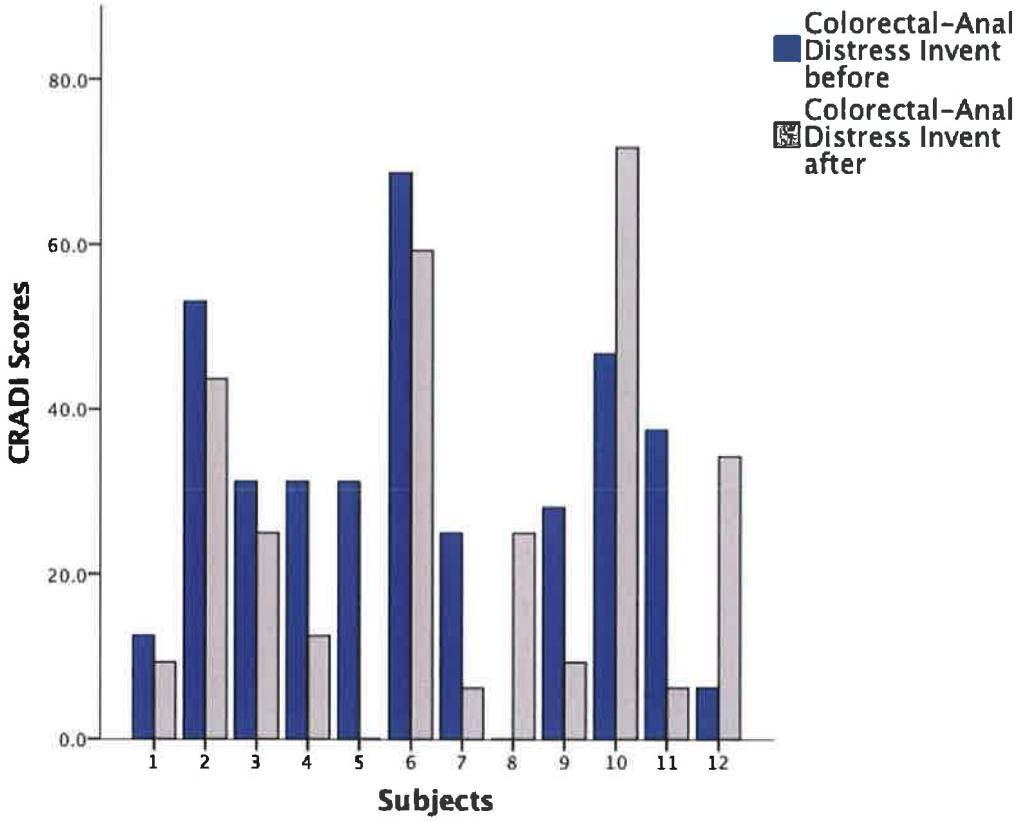


Figure 3-18 Colorectal-Anal Distress Inventory scores before and after treatment

The Pelvic Floor Impact Questionnaire measured the effect of the various symptoms on the quality of life of the subjects and was subdivided into Incontinence Impact Questionnaire (IIQ), Pelvic Organ Prolapse Impact Questionnaire (POPIQ) and Colorectal-Anal Impact Questionnaire (CRAIQ).

Table 3-15 Pelvic Floor Impact Questionnaire before and after treatment

	Mean ± SD Before	*Mean ± SD After*	*P value**
IIQ	16.04 ± 20.21	12.26 ± 18.20	0.50
POPIQ	36.55 ± 28.61	17.80 ± 20.29	0.05
CRAIQ	13.07 ± 21.47	7.58 ± 14.53	0.60
PFIQ	65.19 ± 63.07	37.65 ± 47.50	0.09

*Wilcoxon signed rank test Blue indicates improvement

IIQ-Incontinence Impact Questionnaire; POPIQ- Pelvic Organ Prolapse Impact Questionnaire; CRAIQ-Colorectal-Anal Impact Questionnaire ; PFIQ-Pelvic Floor Impact Questionnaire

None of the individual PFIQ domains; bladder, vagina/pelvis or bowel were significantly changed and thus the total PFIQ was not significantly changed (p=0.09),

however improvements in the vagina/pelvis domain almost reached significance (p=0.05) (table 3.15).

It can be seen that there was a consistent outlier to scores on ICIQ-UI, ICIQ-VS, POPDI and UDI; for this reason the Wilcoxon signed rank test was chosen for analysis over paired t tests. The non parametric test would be less sensitive to this outlier. The consistency & magnitude of this subject's difference to other subjects should be noted and will be discussed in the next chapter.

Subjects were provided with exercise diaries at their first treatment session (Appendix 22). Compliance with the diaries was poor and only three diaries of the 12 subjects were returned completed at the end of the treatment period. Other diaries were partially completed or mislaid although subjects assured that compliance with exercises was higher than compliance with exercise diaries. Thus, exercise diaries were not analysed as part of this study.

3.3 Special Cases

Subject one presented with a fibroid, which was identified by the radiographer at the time of the initial MRI. The procedure in the MRI centre was that this should be reported to the GP so that the GP could then request investigation and reporting of the fibroid necessitating an ultrasound scan. The researcher wrote to the GP advising of the fibroid following the initial scan. The subject remained in the study until its completion as the presence of a fibroid was not an exclusion criterion. The subject was informed of the fibroid and reported no pain or other symptoms. She was satisfied to wait until the study was finished before following up with any further investigation.

Subject 12, who was one year post natal at the time of the study following a traumatic birth, presented on MRI with a cyst on the posterior wall of the vagina at the introitus, measuring 2.5 cms. She had a concurrent rectocele confirmed by POP-Q but the cyst remained following intervention and she was referred back to the consultant gynaecologist following the study. She had been fully evaluated by a gynaecologist before entering the study.

There were no adverse events during the course of the study. All of the subjects reported that they were satisfied with the treatment they received, including the one subject who by questionnaire results had symptomatically deteriorated. This subject reported that she was anxious for surgical intervention but was not unhappy with the physiotherapy that she received. No subjects reported any adverse reactions to the manual therapy techniques that they had received.

3.4 Conclusion

The null hypothesis was upheld; there was no change in the levator plate angle following the manual therapy and exercise intervention.

Secondary outcomes showed significant improvement in POP-Q stage, with lower anterior wall point Aa of the POP-Q showing the greatest improvement; becoming higher by 1.75 cm (p=0.00). Point Bp showed a significant change in the opposite direction, demonstrating greater descent on valsalva after treatment by -0.67 cm (p=0.00). The overall result was an improvement in prolapse stage in a positive direction.

The H line showed a statistically significant difference widening by mean 6.98mm (p=0.01) after the five sessions of pelvic floor manual therapy and exercise. No other MRI lines or angles were significantly changed.

The ICIQ vaginal symptom score, sexual matters score and QoL score were significantly improved (p=0.01, 0.02, 0.00) and the improvements seen in PFDI and PFIQ vaginal domain scores were close to achieving significance (p=0.06, 0.05).

Agreement for both LPA and bladder neck position were moderate-strong for the two raters (ICC 0.80 and ICC 0.76 respectively). Agreement for the H line was moderate (ICC 0.68). Bland and Altman plots revealed acceptable mean differences for only LPA, bladder neck and H line. Agreement was poor for ARA (ICC 0.15) and for cervix (ICC 0.08).

CHAPTER 4 DISCUSSION

The main aim of this research was to investigate the effect of internal manual therapy and PFMT on the levator plate angle (LPA) in women with stage I or II POP where subjects received five treatment sessions over a 10 to 12 week period. This chapter will start with the main study findings including a critical appraisal relating whenever possible to other published literature, followed by a discussion regarding the effect of manual therapy on the study population. This will be followed by the limitations of the study, and finally presentation of ideas for future research.

4.1 Main Study Findings

The main finding following treatment was that the LPA did not change significantly. Overall the POP-Q stage significantly improved where the majority of subjects presented with stage II prolapse pre treatment, which reduced to stage I post treatment ($p=0.02$). This seemed to be related to POP-Q point Aa which changed significantly by descending less on valsalva ($p=0.005$). In line with these changes there were statistically and clinically significant improvements in symptoms and QoL.

An improvement (reduction) in LPA was expected in part because it is observed by the researcher in clinical practice by palpation and in part because it was observed in the single case study. This indicates that there may be variations in anatomical presentation in these subjects as a group or in other external factors that lead to those changes not being reproduced in this study. This discussion will first look at the changes that did take place as the main impact of the study and then explore the mechanism of movement of the levator plate and the possible reasons why it did not change.

4.1.1 POP-Q Changes

POP-Q changed significantly ($p=0.020$) as it has done in other physiotherapy studies focusing on strength training. Hagen et al. (2009b) reported an improvement in POP-Q stage ($p=0.038$) measured at 20 weeks following five individual PFMT sessions over 16 weeks (stage I and II included) and in the follow up RCT to this study reported a lower margin of improvement between control and treatment groups ($p=0.052$) (Hagen et al., 2011b). Braekken et al. (2010) reported an improvement in 19% of the treatment group ($n=59$) compared with 8% of the control group ($n=50$) by one prolapse stage (stages I to III included) and improvements were statistically significant between groups ($p=0.035$). Intervention by Braekken et al. (2010) was more frequent; a total of 18 sessions over 6 months and they reported that women with prolapse beyond the hymen did not show a statistically significant improvement in prolapse stage (this could have been stage II or stage III). Stupp et al. (2011) reported improvements separately for anterior ($p<0.001$) and posterior compartments ($p=0.025$), intervention was over 14 weeks with seven individual sessions. Intervention in this study included

digital facilitation which was not reported in any of the other study protocols and results in this study seem comparatively better. This was defined as a two finger short-duration, high intensity stretch performed in a postero-lateral direction from the central perineal tendon towards the ischial tuberosities and the patient was then asked to contract against the reflex of the stretch. In the current study the timespan of treatment was the shortest and the result in terms of POP-Q change are therefore comparatively good (p=0.020) however this is not directly comparable without a control group as all of the other studies have in their design.

Further to the POP-Q stage changes, in the current study POP-Q point Aa changed significantly (p=0.005). The mean position before was -0.67cm (±1.30) and this changed to the higher mean position of -2.42cm (±1.16). There was an additional finding in POP-Q point Bp showing greater descent on valsalva following treatment, which was also significant (p=0.008). This finding was after removal of an outlier due to the presence of a 2.5 cm cyst on the posterior wall of the vagina, which invalidated POP-Q measurement. The mean position on valsalva was -2.55cm (±0.68) before treatment to -1.91cm (±0.70) after treatment. The amount of descent is not clinically significant although it is statistically significant. Nonetheless, any descent is surprising given the aim of treatment was ultimately to improve pelvic organ positioning by raising it.

Hagen et al. (2009b) also found differences in Aa and Ba measurements with significantly greater improvement in the intervention group in point Aa (p=0.036) and Ba (p=0.007) vs. controls after 20 weeks of PFMT. Frawley et al. (2012) found no overall change in POP-Q stage between groups in the PFMT study that was a 6 and 12 month extension of the PFMT study by Hagen et al. (2011b). However, Frawley et al. (2012) found when broken down into POP-Q points there were significant differences in points Ap and Bp in favour of PFMT group at 6 (p=0.03, 95% CI -0.79 – -0.03) and 12 months (p=0.02, 95% CI -0.86 – -0.08) but not for the other POP-Q points.

Similar to this current study, the intervention by Frawley et al. (2012) was five PFMT sessions with a physiotherapist for 16 weeks; however measurements were taken at 6 months and 12 months. It is worth consideration of the length of time that it may take to recruit the muscles to full activity in posterior compartment, a period of time that was not afforded in the current study. There was an improvement in position of POP-Q points Ap and Bp but this was not enough to change a POP-Q stage. Sixty three per cent of the study participants presented with posterior compartment prolapse and 73% presented with anterior compartment prolapse so this was the dominant prolapse. In the current study similarly the majority of as subjects had leading edge anterior compartment prolapse and changes were mostly to the anterior wall and by contrast the current study was able to demonstrate a change in POP-Q stage. This was despite the fact that there was a small amount of descent in the posterior wall, point Bp.

The prolapse of each subject in the current study had a leading edge as defined by the lowest point of the POP-Q measurement. There were 7 subjects with cystoceles, 3 with cystorectoceles, and 2 with rectoceles. The 2 rectoceles stayed as leading edge

rectoceles after the intervention. The 3 cystorectoceles became leading edge rectoceles, 2 of the grade II cystoceles became grade I rectoceles and 5 cystoceles stayed as leading edge cystoceles. Where there were 10 stage II prolapses initially and 2 stage I, this changed to 3 stage II and 9 stage I (p=0.02). The fact that the leading edges changed the way they did was surprising. One possible explanation for this change was that an alteration in tension through off loading the anterior wall allowed the bladder to 'sit' higher which in turn may have resulted in unmasking a posterior defect which had not previously manifested itself. Overall it is assumed that this is an actual clinical improvement following the intervention of manual therapy and PFMT in part because of the overall reduction in organ descent and also because of improvement in symptoms.

Two subjects were more descended at point Aa, subject 6 and subject 10; nine subjects improved and one stayed the same. The two who were worse at point Aa were also worse across other anterior and posterior wall POP-Q points (Ba, Ap and Bp). It may be that having taken away compensatory mechanisms as outlined by DeLancey et al. (2012) through manual therapy release techniques that subjects are left with no other mechanisms of coping with descent. The result is therefore further descent in organ position where release of the negative muscle tension was removing the only support that they had. Furthermore, there was possibly insufficient time for PFMT to take effect or even with time PFMT might not have been enough for this subgroup. Questionnaires were correspondingly poor for these subjects and this was more so for subject 10.

There was one worsening of POP-Q stage in subject 7 who had a stage I cystocele at the start and a stage II cystocele at the end of the study, having worsened by two cms at POP-Q point Ba. This subject had become pregnant and did not realise that she was pregnant at the time of both MRI and POP-Q examination. At the time of initial examination she would have been approximately three weeks pregnant. It is hard to know categorically what effect that this would have had on her measurement but with hormonal changes it is reasonable to assume that it could have had a deleterious effect. Questionnaires were also correspondingly fair in this subject.

4.1.2 POP Symptom Changes

Urinary incontinence (UI) was prevalent at baseline with symptoms present in 10 out of 12 subjects. The prevalence of incontinence in this group was similar to previous reports in the literature. Ellerkmann et al. (2001) in a study of 237 women who had POP stage 0-IV reported a prevalence of UI in 73% of study participants; 13% had stress urinary incontinence only (SUI), 5% had urge incontinence only, 5% had unconscious leakage and 76% had a combination of both SUI and urge.

In the current study there were improvements in urinary control symptoms in six of 12 subjects, evident by changes in ICIQ-UI scores, but changes did not reach significance (p=0.096). In the UDI, eight out of 12 subjects reported improvements but again scores did not reach significance (p=0.180). The UDI features questions relating to obstructed voiding and lower abdominal discomfort as well as urinary urgency, urinary frequency

and SUI. Where subjects reported worse symptoms it may have been that masking of urinary symptoms was the reason; it is thought that with more advanced prolapse there may be a kink in the urethra as a result of the prolapsed bladder and taking the kink out of the urethra may have put the urethral control system under more pressure. It may therefore have taken more time and muscle strengthening to restore this control or it may not have been possible to correct both prolapse and restore urinary control. It is not possible to conclude within the short timespan of the study.

Ellerkmann et al. (2001) found that half of the patients in their study experienced symptoms of difficulty emptying the bladder and that this symptom, when correlation analysis was performed with Kendall's tau-b, had a weak association with anterior POP (tau-b=0.12). As subjects in that study included stage III and IV prolapse, it would not be expected to find the same symptoms of voiding dysfunction as in the current study with lower stage of POP. However, in the current study with a smaller number of women, it may be that more advanced prolapse obstructs voiding and leads to the manifestation of stress incontinence.

Improvement in urinary incontinence was not always an outcome in other POP physiotherapy studies for comparison. Hagen et al. (2009b) showed no difference between treatment (n=23) and control groups (n= 24) in improvement in ICIQ-UI after five physiotherapy sessions where women were encouraged to perform six sets of PFM exercises daily and questionnaires were at 20 and 26 weeks. This was approximately the same level of intervention as the current study but over a longer period and with more recommended daily exercises (6 times vs 3 times per day). It was noted however, in this study, that the p value was closer to significance at 26 weeks (p=0.070) than at 20 weeks (p=0.494) indicating a greater training effect closer to 6 months even though sessions with the therapist were finished at 16 weeks.

Ghroubi et al. (2008) however showed statistically significant improvement in Measurement of Urinary Handicap scale ($p<0.001$) but not in urodynamics testing following 24 individual physiotherapy sessions. Braekken et al. (2010) demonstrated an improvement in symptoms in PFMT group using ICIQ-UI (p=0.002) before and after 6 months training and 18 individual sessions with a therapist. Their study included POP-Q stages I, II and III.

A period of at least 16 weeks is needed for muscle training effect (Bø, 2004) and this effect will continue for a period of 5 months (Bø, 1995). The most recent Cochrane review on comparison of approaches to pelvic floor muscle training for urinary incontinence in women states that the few available data consistently show that women receiving regular (e.g. weekly) supervision were more like to report improvement than women doing PFMT with little or no supervision (Hay-Smith et al., 2012). The protocol by Braekken et al. (2010) most likely follows these principles.

In the current study the presence of an outlier should be noted (fig 3.13 and 3.16) with regard to urinary symptoms. There were some initial improvements in urinary incontinence and where symptoms were worse the principles of the unkinking of the urethra were probably the case. However the recommendations according to the

principles of training should be followed and certainly these subjects need further PFMT according to these research findings. These recommendations will be discussed further in 4.4.2.

ICIQ-VS improved significantly (p=0.01) before and after treatment with 11 out of 12 subjects showing improvement. The vaginal symptoms questions related to vaginal bulge, laxity, sensation, soreness and dragging and prevalence of these symptoms are in accordance with the current literature that the most common symptoms associated with prolapse are vaginal bulging (Ellerkmann et al., 2001, Tan et al., 2005, Broekhuis et al., 2009a). It is therefore the questionnaire where the greatest changes were expected. The clinical significance of this is that improvements were found in the most important outcome measures. Ultimately regardless of whether a woman has a physical prolapse or not surgical intervention would never be proposed in the absence of symptoms and success would always be measured by symptoms.

Sexual Matters score was measured as part of the ICIQ-VS. Eight of the 12 subjects were sexually active before the study and a further three became sexually active over the course of the study because they had wanted to due to improvements. Of the eight subjects who answered questions before and after, statistically significant (p=0.02) improvements in sexual scores including questions on "interference with sex life", "relationship with partner" and "sex life spoilt" were seen after treatment. Ellerkmann et al. (2001) reported a mild to moderate correlation between the impairment of sexual activity and worsening prolapse in all three compartments (Kendall's tau-b anterior, 0.30; apical, 0.43; posterior, 0.27) and that patients with worse anterior compartment prolapse were also more likely to have been abstinent the longest. Weber et al. (1995) reported that increasing stage of prolapse predicted interference with sexual activity but did not affect description of satisfaction with sexual relationship or frequency of intercourse. Similarly Burrows et al. (2004) found that measures of sexual function were similar in women with and without prolapse. Sexual outcome measures were not used in other physiotherapy studies in POP groups for comparison. Overall although there were just eight subjects these results would seem very favourable.

QoL was measured as part of the ICIQ-VS on a 10 point scale and was significantly improved after treatment (p=0.00). This improvement in QoL did not take place as a result of an improved position in LPA and it is assumed that it did not take place as a result of the training effect of the PFM as according to training principles there was not sufficient time (14 to 20 weeks) for this to have taken place (Bø, 1995; Bø, 2004). It would seem reasonable to assume that it is the combined effect of the exercise and the manual therapy changing organ position, again not being able to separate them without a control group. However another consideration is the effect of the support of an empathetic therapist helping with an otherwise distressing problem. The placebo effect of manual therapy has been researched in relation to pain and it is suggested that the placebo response likely plays a role in all treatment effects associated with manual therapy (Bialosky et al., 2011).

QoL was also evaluated through the PFIQ-7 with questions specifically around vagina/pelvis, bladder and bowel separately. Symptoms did not stop the subjects from doing what they wanted so baseline bladder and bowel scores were low not changing over the course of treatment. Scores may have been higher if higher stages of prolapse were included. The vagina/pelvis baseline scores were higher and improved after treatment, almost reaching statistical significance (p=0.055). The use of a disease specific QoL questionnaire such as the PFIQ-7 may be more likely to show a change than a more generic QoL questionnaire such as the SF-12 as was shown in previous studies that failed to show difference in QoL before and after intervention (Hagen et al., 2009b).

Lack of significant improvement in the POPDI subsection of the PFDI-20 (p=0.091) was evident after treatment, although it would have been expected to change in line with ICIQ –VS as it also measures vaginal symptoms. Eight out of the 12 subjects improved, three worsened slightly and one worsened a lot (fig 3.17). Questions included here and not in the ICIQ-VS were incomplete bladder emptying and digitation necessary to empty bladder. So vaginal symptoms on their own were improved but vaginal symptoms and bladder symptoms together were not as conclusively improved.

Bowel symptoms were evaluated with the CRADI subsection of the PFDI-20 for symptoms and were found to be unchanged (p=0.346) after treatment. There were only two subjects who had rectocele as the leading edge prolapse at the start of the study (both stage II) and these subjects had the highest CRADI scores as would be expected. Nine out of 12 subjects improved on the CRADI questionnaires including the two subjects with rectocele. One subject reported symptoms on the CRADI scale that were not reported at baseline; this subject had moved from a stage II cystocele pre treatment to stage I rectocele post treatment so symptoms were de novo. However both urinary and other vaginal symptoms were improved in all other questionnaires in this same subject. Two subjects reported that symptoms had worsened, one of these was a subject who had a posterior vaginal wall cyst and the other had worsened on all questionnaires. It is important to note that other subjects had improved on the CRADI scale as the Bp posterior vaginal wall point was lower post treatment across all subjects and therefore may have also reflected in worsening in CRADI symptoms, however this was not the case.

Burrows et al. (2004) reported that anorectal dysfunction is probably the least well studied pelvic symptom in women with prolapse. They found that the extent of POP was not predictive of bowel symptoms except for the need for manual assistance during defecation. However Tan et al. (2005) found that the need for manual assistance was similar for stages II, III and IV suggesting that symptomatic rectoceles do not have to be outside the hymen and worsening prolapse does not cause a marked increase in symptomatology. This was consistent with findings by Weber et al. (1998) who found that need for manual evacuation was found in 41% of patients with stage II and only 18% in stage III to IV posterior prolapse.

4.1.3 Changes in MRI Measurements

The mean LPA in this study before treatment was 45.2°(±10.4) and after treatment was 45.50° (±11.76), this was a mean change of - 0.25° (±4.99, p=0.86). In the normal population according to Hsu et al. (2006) the mean LPA is 36.2° (±12.3) at rest. Hsu et al. stated that the mean LPA in their POP group was 45.8° (±12.4), which is similar to the current study. However, in their study they included stage II or more compared to stage I or II in the current study so the mean LPA in the current study was slightly larger given the included stages. Other demographics were similar in terms of parity 2.67 ±1.30 in this study vs. 2.9± 2.0 but BMI was lower in this study 24.9Kg/m^2 ±4.52 vs. 25.8Kg/m^2 ±4.1. It may have been that including a more advanced stage i.e. stage III prolapse as well stages I and II or measurement using dynamic MRI instead of static would both have lead to wider angles of measurement and therefore greater changes. However stage III was not included initially as it was thought that even though the angles may be wider the pelvic floor tissue is more subject to load and therefore perhaps less likely to change and resting LPA was the anatomical position of interest to the researcher as an area in the literature needing to be explored. The mechanism of manual therapy intervention to the levator plate and discussion as to factors that affect the mechanism of levator plate movement will be discussed in the next section, 4.2.

Mean bladder neck position was 12.35mm (±7.54) lifting in position to 16.28mm (±8.65), above the PCL after treatment but was not statistically significant (p=0.127). Subjects were asked to empty their bladders prior to MRI, however it was noted during MRI analysis that bladders were not always completely empty. It was routine radiological protocol to ask subjects to empty their bladders but not to confirm this radiologically before MRI scan. It was not practical and often not possible to stop the MRI scan and ask the subject to empty again and recommence if it was noted that the bladder was not completely empty. It may also have been that emptying was not complete because of the nature of the subject's dysfunction as this is one of the symptoms of prolapse. Braekken et al. (2010) controlled for bladder emptying by scanning the residual volumes to check that they were consistent, this is more easily done with realtime ultrasound than with MRI. It was also noted on some scans that volumes were slightly lower on repeat scans which may naturally have been the case following a few treatment sessions, however this was not the case throughout as some subjects has higher volumes in second scans.

The relevance of bladder neck position at rest in the context of prolapse measurement on strain has been evaluated in two studies where both the LPA and bladder were assessed with MRI. Ansquer et al. (2006) reported a mean bladder neck position at rest in a POP patient group of 13mm (±9) above the PCL. There was a correlation between LPA at rest and anterior bladder wall descent with valsalva measured on MRI (CC 0.051, p=0.001). Ginath et al. (2011) found that there was a strong correlation between both bladder neck position (r=0.62, p=0.007) and LPA (r=0.64, p=0.005) at rest with POP-Q point C. They showed a closer bladder neck position to the PCL at rest of mean 1 mm vs. 20 mm above PCL between prolapse and control groups

respectively. Both studies indicated that observation of bladder neck position at rest is a predictor of prolapse on strain.

Braekken et al. (2010) in a RCT with a PFMT treatment group (n=59) and a control group (n=50) reported baseline values of bladder neck position of 16.7mm (±9.2) in the treatment group and 19.3mm (±7.7) in the control group using RTUS. After 6 months of PFMT 3 times daily with 18 individual sessions, the treatment group improved lifting the bladder neck by 2.3mm in comparison to 0.6mm before (SD not given), a difference of 3.0mm (95% CI, 1.5-4.4; $p<0.001$). This was vertical distance to the pubic symphysis so cannot be directly compared to the current study. In the current study muscle contraction was not measured, therefore it is not known what additional effect the manual therapy would have had to PFMT alone i.e. whether a different resting/starting position for a muscle contraction would have an impact causing more movement at the neck of the bladder or produce a different quality of movement. As there was no control group in the current study there was no possibility of testing this and the muscle training effect cannot be separated from the manual therapy effect.

Bladder neck position was higher following treatment in many of the subjects in this study although this was not statistically significant and may have occurred by chance (fig 3.8). There was one exception, subject 1, who had a fibroid, this may have impacted on the lower bladder neck position that was found after treatment as the mechanical weight of the 5 cm fibroid could press on the bladder causing it to appear lower. Although this fibroid was present before treatment, position of the uterus can change and affect the bladder over the period of a few weeks. However this subject was not taken out as an outlier because as previously mentioned it was noted that not all bladders were completely empty so for that reason all subjects were left in for analysis.

As part of the manual therapy treatment, the anterior wall was mobilised indirectly using techniques as described to the LP. Soft tissue attachments to the anterior wall are the anterior attachments of the levator ani muscles, the endopelvic fascia, which is all of the fascia that overlies the LP, the iliococcygeus and the pubovisceralis and finally the fascia that extends forwards from the side walls of the pelvis to the pubic bone lateral to the urethra. By way of these direct and indirect attachments, the anterior wall can change over the course of a treatment session and it can often be noted that where the anterior wall feels initially low it shifts upwards behind the pubic bone where there is a feeling of the tissue being off loaded. Following treatment this was clinically observed with many of the subjects after individual sessions and noted to hold in between sessions. When interpreted in conjunction with symptomatic improvement and improved POP-Q measurements this is an area that should be evaluated further in physiotherapy studies.

The mean measurement of the cervix above the PCL before treatment was 9.65mm (± 6.62) descending to a mean of 5.59mm (±6.70) after treatment ($p=0.131$). The position of the cervix was lower post treatment. However, the uterus is a mobile structure and can change position by small amounts depending on the time of the month during a menstrual cycle. Yang et al. (1991) noted that the cervix at rest in a control group was

mean of 3.89cms ±1.13 and in a prolapse group and was 2.29cms ±0.99 descending to 0.69cm ±0.83 below the PCL on strain. The values appear to be considerably lower in the current study. The reliability of the measure of the cervix in the current study was poor (ICC 0.08) and will be discussed further in section 4.3 (Reliability).

The H line reflects the width of the hiatus to the puborectalis muscle with a mean of 61.64mm (±7.86) before treatment widening to mean 68.41mm (±7.68) after treatment and was statistically significant (0.011). Comiter et al. (1999) found that in a prolapse group the mean H-line on strain was 7.5cm (± 1.5). A widening of the H line was not expected but is also not surprising in a certain subgroup. There is a concept of muscle hypertrophy of puborectalis in response to loading of iliococcygeus (DeLancey et al., 2003, Hsu et al., 2008, Dietz, 2009, DeLancey et al., 2012). In some subjects it is possible that initial release of this hypertrophied muscle led to an initial widening of the hiatus. This is discussed further in section 4.2 (Effect of Manual Therapy on the Levator Plate). It would be a further aim of PFMT that tone would improve over a longer period of time.

The M line represents the muscular relaxation from the PCL and was mean of 21.1mm (±10.12) before treatment, dropping to a mean of 24.23mm (± 9.12) after treatment but not reaching statistical significance (p=0.406). Comiter et al. (1999) found the mean M line was 4.1cm (±1.5) in the prolapse group. This was a considerably smaller value in the current study. The M line was one of the measures that was less reliable (ICC 0.49) in this study. In the current study the M line was measured at rest before and after treatment and in the study above the M line was measured while the patient was straining so that differences were between rest and strain and the values where larger. This is perhaps one of the reasons for the poor reliability of this measure i.e. that the values were small and it was therefore more difficult to achieve reliability with smaller values.

ARA at rest has been reported at between 108° and 127° in a normal population (Colaicomo et al., 2009). In the current study ARA at rest was 122.8° (±13.65, range 95-150°) and increased post treatment to 128.5° (±7.27, range 118-146°) (p=0.269). This change might also be explained by an initial relaxation following release of unwanted muscle tension as a result of the intervention. It would then take a longer period of time, past the 12 week time frame of the study before the full training effect of PFM exercises would be manifested (Bø, 1995). Furthermore, the puborectalis muscle is the muscle that forms the ARA and is a sling muscle, its attachments are different to iliococcygeus and the sling muscle can shorten to an inner range more freely when loaded in a way that the iliococcygeus cannot, thus leading to this shortening mechanism secondary to loading. This will be further discussed in section 4.2 (Effect of Manual Therapy on the Levator Plate). Reliability was similarly difficult in this measure (ICC0.15) and possible reasons will be discussed in 4.3 (Reliability).

Braekken et al. (2010) reported after their 6 month intervention of pelvic floor muscle training that the treatment group demonstrated improved movement of the rectal ampulla by 4.4mm vs controls (mean 10.9mm±12.5) who improved by 1.1mm (diff 5.5mm, 95% CI 1.4-7.3; p=0.022). There was a large difference in study treatment

period and treatment dose between the current study (10-12 weeks) and that by Braekken et al. (2010). It was the researcher's intention to limit the study time frame to under the training period recommended according to the literature for PFMT (Bø, 1995; Bø 2004). The reason for this was to attempt in some way to be able to attribute the changes that took place during the course of the study to the manual therapy as well as the exercise effect i.e. by staying under the exercise time frame. The PFMT effect will be discussed in section 4.4.2.

The use of MRI in this study as an outcome was justified as the LPA was reliably measured (ICC =0.80). Furthermore, the description of measurement of LPA in RTUS research literature is not the same as in MRI research literature so measurement of this line would otherwise not have been possible (Dietz 2011; Morin et al. 2011). Logistically, by arranging evening appointments, the process of attending for MRI was made as easy as possible for participants. In relation to other outcomes, there was no other way to measure a change in the position of the levator plate. Given the improvement in symptoms in the study group, it was important to attempt to establish whether improvement came from a change in position of the levator plate through the use of MRI. It would appear that this change in symptoms was not attributed to the change in LPA, however, there were some limitations in the study due to the small sample size so this cannot be absolutely concluded, see 4.4.1. At a cost of €3,600 for 12 study participants, where it is inconclusive whether the LPA changed as a result of the intervention, it may be more justified to use the other outcomes of this study as well as the less expensive RTUS for an objective measure of organ position and morphological changes following manual therapy intervention (Braekken et al. 2010).

4.2 Impact of Manual Therapy on the Levator Plate

Although POP-Q stage and symptoms improved following the manual therapy intervention on the LPA and the PFMT, there were not the same improvements on the position of the LPA. This section explores the anatomical and therapeutic components to the LPA to evaluate why this happened in a single case study and did not happen in this study group.

Hsu et al. (2006, p.1430) commented on the 9° difference observed between normal subjects and women with POP on valsalva; that "if prolapse was primarily caused by a vertically tipped levator plate angle, we would expect the difference to be more striking". They believed an increased LPA to be an indicator of damage to the levator muscle. They commented that the lack of a more direct relationship may be due to the fact that that the levator plate is part of the iliococcygeal muscle and not the pubovisceral muscle which has different origins and insertions. They suggested that the increased load on the iliococcygeus as a result of pubovisceralis damage may be a mechanism for the downward displacement.

There seems to be a certain amount of agreement in the literature regarding the mechanism of loading to the pelvic floor as a result of fascial and muscular damage. In 2003, a study of 160 women by DeLancey et al. showed levator muscle injury by MRI. They stated that damage to the pelvic floor muscle results in sagging and tipping of the

levator plate and that decreased muscular support presumably increases the load on the fascia and connective tissue of the pelvis. They further suggested that as the load carried by the pelvic floor is shared between the muscles and the connective tissues, a decrease in muscle function would shift additional load to the fibrous elements. They found muscle injury in 32 women and of those the iliococcygeus muscle is injured in only 10% (n=3) with the pubovisceralis muscle being injured in the remaining 90% of cases (n=29).

In a biomechanical study on an anatomical model, Chen et al. (2006) showed once there was loss of apical passive ligamentous support the degree of prolapse was dependant on the pubovisceral impairment and that the larger the impairment, the greater the anterior wall prolapse. DeLancey et al. (2012, p.77) stated that prolapse is associated with a tear of greater than 50% and described the "compensatory hypertrophy hypothesis", that is, where the ventral portion of the levator is damaged the intact dorsal portion hypertrophies in compensation. They stated that this may explain why a loss of <50% of the muscle is not associated with prolapse but a loss of greater than 50 % has a significant association with prolapse. In lesser degrees of injury the remaining muscle can hypertrophy to take over some of the lost function while greater degrees of injury exceed the capability of remaining muscle to increase its activity.

In this same study by DeLancey et al., although all subjects had injury of >50% it was not in the puborectalis muscle, which is the part of the pubovisceralis that has been previously cited as the most vulnerable muscle to injury (Dietz et al., 2010b). The most vulnerable muscles for injury in childbirth were shown to be pubococcygeus, followed by iliococcygeus and lastly, puborectalis. This study showed a more prominent puborectal muscle on MRI consistent with findings by Hsu et al. (2008) who also found thicker levator ani muscle dorsally.

Despite the physical changes to the pelvic floor as a result of muscular and fascial damage, improvements in position have been shown to be possible as a result of surgical prolapse repair. Song et al. (2009) measured differences in LPA of 20 women on valsalva pre op (mean 55.39° ± 8.84) and three months post op (46.92°± 7.08) and found statistically significant improvement in LPA ($p<0.001$) i.e. the levator plate had moved closer to the horizontal axis. They postulated that these differences were due to the mesh used that supported the fascia of both the anterior and posterior wall where there would have otherwise have been a downward sagging of the levator plate with a lengthening of the levator hiatus. Thus the mesh supported the function of levator ani. This theory is similar to that by Hsu et al. (2006) who state that downward sagging is connected to lengthening of the levator hiatus. This was also possibly the mechanism in the researcher's single case study where the downward sagging of the levator plate was connected to a lengthening of the levator hiatus while the uterus was low but when the uterus was lifted by the manual therapy on the levator plate, the hiatus narrowed and the LPA reduced.

So while an improvement of 8° (fig. 1.7) was observed in the single case study it was not reproduced in any of the current study subjects. Ozasa et al. (1992) referred to the

Levator Plate as a line extrapolated from the levator ani, a different definition to a "best fit" line at take-off from coccyx as other studies have defined (Hsu et al., 2006, Song et al., 2009, Ginath et al., 2011). They found that this line extended though the pubis in all of the non prolapse group (n=19) but none of their prolapse group (n=14). This study was observational and there were no measurements associated with these observations. It was an observation by the researcher that in the single case study this line, when drawn extended through the pubis after treatment, but not before treatment (fig. 1.7). This change did not take place before or after treatment with any of the current study patients. The researcher's single case study, similar to the study by Ozasa et al., involved a women with a prolapse of the uterus and loss of apical support but none of the subjects in the current study had prolapse of the uterus so fascial deficits would be different between the single case study and study subjects. Therefore with more intact transverse fascia and levator muscles for leverage in this subgroup it may be possible that a more dramatic effect is visible on MRI than in the subgroup where lateral defects may exist. It may also be that the dramatic effect in the single case study was due to the fact that the uterus was down so low beforehand and this in turn lead to the hiatus being widened by the uterus; there is an association between width of hiatus and angle of LP where the hiatus is wider the LPA can be expected to be further from the horizontal (Hsu et al., 2006).

Dietz (2009, p.54) described palpation associated with bilateral levator avulsion where he noted marked hypertrophy of the pubococcygeus/iliococcygeus, resulting in a levator shelf that is almost as "strong" as the original, just somewhat higher and wider and that "avulsion often seems to have an impact on adjacent or contralateral intact muscle. After unilateral avulsion, the intact contralateral puborectalis may become spastic and very tender, a hitherto unrecognized cause of chronic pelvic pain and dyspareunia". Where this is described as "strong", in physiotherapy terms this might be interpreted as 'loaded' but perhaps meaning the same thing. Similarly in other literature 'load' has referred to what happens when there is fascial or muscular damage and there is secondary loading of adjacent structures due to loss of primary support structures (DeLancey et al., 2003, Hsu et al., 2006, Beco, 2008, DeLancey et al., 2012).

A physiotherapist can manually identify variability in hypertrophied and 'loaded' muscle in pelvic floor muscle rehabilitation although their skills and ability will vary as will reliability of measurement (Slieker-ten Hove et al., 2009a). Clinically however a physiotherapist can palpate a tear in the levator muscle and can identify when there is a hypertrophied muscle. A hypertrophied puborectalis can often be found beside a more 'loaded' iliococcygeus when there has been damage to pelvic floor muscle and fascia. Hsu et al. (2006, p.1430) stated "if there is damage to the pubovisceral muscle it may result in increased loads on the iliococcygeal muscle and raphé, resulting in downward displacement". 'Load' in physiotherapy terms can be palpated as a hard, passive muscular end feel of tension under the palpating finger. This is a clinical observation and specific to the pelvic floor anatomy as there are no other parts of the human anatomy that are subjected to load in this same way. As this is such a new area within physiotherapy it is not expected that there is any previous research literature that would describe the palpation of a 'loaded' muscle in the pelvic floor.

'Load' was clinically identified in each of the study patients and was manually released with internal manual therapy techniques. These techniques are relatively consistent with all POP patients. The "end–feel" is at first hard and by using deep pressure into the muscle (for the most part the iliococcygeus) repeatedly and holding for approximately 6 seconds and sometimes longer and by using the breathing/release technique when appropriate and the contract/relax techniques as well (Appendix 19 & 20), over a 20 minute treatment session the muscle softens, becomes more mobile and therefore more contractile. Direction of release is important with these muscles so prolonged deep pressure into the muscle works best rather than other massage techniques e.g. strumming or stripping where these techniques might also be quite irritating for the vaginal tissue; the techniques as described while uncomfortable on the taut bands or trigger points treated should never be uncomfortable on the vaginal tissue being accessed. The iliococcygeus muscles are attached to the coccyx and to the ischial spine posteriorly so the tendency is for the muscles to be held back, it is for this reason that manual therapy is directed posteriorly in the first instance to release/facilitate posterior attachments and then towards the anterior attachments to the pubic bone so release techniques are based on direction of muscle fibre and sensitivity of vaginal tissue.

One of the findings and indicators of success with POP patients is whether, when the muscles are treated and have become more mobile, they stay mobile or whether they constantly re-inhibit. It can be noted with patients in general who don't improve that the muscles either don't change as easily or if they do change then they can regress more easily. This was also the case with subjects in the study i.e. with those who improved subjectively soft tissue became more mobile and with those who did not improve as well soft tissue remained more inhibited.

One of the measures of this, although it is not reliable, is to estimate how well the patient releases after a pelvic floor contraction. For example if the patient contracted to Modified Oxford Stage (MOS) 4 (Laycock, 2008) then the release could be calculated as a % of that contraction i.e MOS 4 contraction with 70% release means although the muscle is quite strong there is still some tension in the muscle that needs to be released. This method of documentation can be seen in charting (Appendix 13). Once the end feel changes, the cranioventral lift of the pelvic floor increases with an improved excursion in the muscle, as a result of there being more mobility. So that not only is grade of lift evaluated and quality of release but also the excursion of the muscle group.

Overall while subjects improved in POP-Q stage and in some of the questionnaires, it did not relate to a change in LPA. The fact that the LPA did not change could be due to a number of factors: -
(1) Because of the type of prolapse; a uterine prolapse that is actually descended in the levator hiatus and then off loaded is more likely to change the LPA if there is a connection between the LP and levator hiatus (Hsu et al. 2006).

(2) The extent of the muscular and facial deficit may affect the leverage on the levator plate but if this is the only reason then more subjects i.e. the ones with less fascial and muscular deficits should have shown greater improvements.
(3) The levator plate mobilises well as is palpable during a physiotherapy session and as was visible immediately after an MRI scan but once the patient is upright, the pelvic floor re-inhibits again quickly with the recurrent load of the prolapse descending. It does not do this in surgical fixation where the load is surgically held (Song et al. 2009).
(4) The stages of POP included in the study may have played a role in the fact that the LPA did not change. Although this is speculative, subjects' changes occurred between stages I and II, therefore changes might have been smaller than in stages III and IV and therefore it may have been more difficult to detect changes. Loading certainly would have been greater according to more pelvic floor damage with the higher stages III and IV (Dietz 2009).

In the light of the findings of the current study and the previous single case study, it is not possible to conclude the reasons why the same improvement for LPA were not achieved for both studies. However, the most likely reason would seem to be the type of prolapse i.e. that the descent of the uterus widened the hiatus and dropped the LP. Clinically, in the single case study, it could be palpated that manual therapy and facilitation of the LP allowed the uterus to 'sit' back higher on the horizontal shelf support of the upper vagina offloading the LP and reducing the angle dramatically. Furthermore Hsu et al. (2006) found a moderate correlation (r=0.42) between position of the LPA and the hiatus where in the single case study a narrowing of the hiatus may have allowed the LPA to decrease to the horizontal plane. Additionally, there were no subjects in the current study with prolapse of the uterus to demonstrate such a change. There may however be other unknown reasons.

This is the first time that load has been described in a POP study and changes although not as expected in LPA have nonetheless been favourable in POP-Q staging and in symptoms and QoL. This soft tissue off loading appears to be having an effect on patient's symptoms although the mechanism by which this is happening remains unknown.

4.3 Reliability of Measurements

For the purposes of reliability of this study agreement between the two raters was moderate-strong for the LPA (ICC 0.80) and for the bladder neck position (ICC 0.76). Agreement was moderate for the H line (ICC 0.68) and reliability was fair for the M line (ICC 0.49) and poor for the ARA (ICC 0.15) and the cervix (ICC 0.18).

Although Landis and Koch indicated that >0.80 is almost perfect others have suggested that more than 0.75 is good reliability but that clinically a value up to 0.90 should be sought to ensure reasonable clinical validity (Portney and Watkins, 2009). Hsu et al. (2006) evaluated reliability for LPA between two independent examiners using Pearson's correlation and found reliability to be high (r=0.90). However Pearson's coefficient of correlation is limited as an estimate of reliability by comparison to intraclass correlation coefficient (ICC), which reflects both correlation and agreement.

Bland and Altman plots of the difference between the two raters' measurements as a function of the average of the two raters' measurements were also performed. Bland and Altman plots revealed acceptable mean differences for only LPA, bladder neck and H line and not ARA, M line and cervix. Therefore, the fact that there were no changes in ARA, M line and cervix, needs to be interpreted with caution.

The two raters chosen were from different disciplines; urogyaecology and radiology and this may have had an impact on reliability but the urogynaecologist had previous involvement in pelvic floor MRI research and the radiologist specialises in gynaecological intervention radiology so this brings the two disciplines closer together.

A lack of reporting of reliability of measure of landmarks at rest was noted from many of the reviewed studies presumably because for the most part they were dynamic imaging studies so were not measuring fixed points. In the current study there appeared to be greater absolute systematic error in interpretation of position of the soft tissue measurements by comparison with the interpretation of LPA, which had a bony landmark. The least of these was the bladder neck as it had the residual urine as a marker. The H line had the pubic symphysis as a reference point but the soft tissue point at the rectal tissue is more subjective and reliability became progressively poorer for M line, ARA and cervix, in that order without any bony reference points.

Differences were seen where individual scans were anatomically difficult to interpret; the PCL reference line although described in the literature as the most reliable was not always easily measured as the last coccygeal joint was not always visible. There was room for interpretation as to where the take off point from the coccyx was as it was not clear in four out of ten scans. It was noted in the scans that the uterus was not always easy to see being affected by movement from the bowels and cysts sometimes made it difficult to see the point of the cervix to be measured. The H line, M line and ARA would be more defined for measurement if the rectum had been opacified and has been recommended in some studies (Colaicomo et al., 2009). However other studies have measured H and M line without opacification (Lakeman et al., 2012). The M line was less reliable (ICC 0.49) than the H line (ICC 0.68) probably because it is taken off two reference points that are made by the rater whereas one of the points on the H line has a bony take off point (the pubic symphysis). The ARA seems to be a very subjective measure and opacification would have to be recommended in the rectum for a clearer view of the anorectal junction in order to improve reliability. Stool in the rectum for one scan where there was not stool in the rectum for another may have affected definition of the anorectal junction, making it more visible in some scans than in others. Scans were not as clearly defined where subjects were overweight; the average BMI was 24.9kg/m^2 a weight that is defined as a risk factor for POP (Glazener et al., 2013).

Further reasons for varied reliability of measurement in the study are the fact that all MRI scans were at rest. Studies to date on MRI scans have focused on measurements between rest and strain on dynamic MRI (Yang et al., 1991, Comiter et al., 1999, Hsu et al., 2006). The prolapse stages measured in this study were stage I or II prolapse only

and not the more advanced stages including stage III and IV where increased stages are more likely to demonstrate reliability (Portney and Watkins, 2009).

Overall, reliability was moderate-strong for the LPA and the bladder neck. Reliability was moderate for the H line and was not acceptable for M line, cervix and ARA. Clinical use therefore cannot be recommended for these measures at this time. Furthermore only changes in LPA, bladder neck and H line in this study can be interpreted with a degree of certainty; other changes must be interpreted with caution.

As this was not a RCT, results would have been affected by bias, where subjects would have known that they were in the treatment group and therefore the likelihood was that they were to improve. Furthermore, all treatment was administered by the researcher increasing bias. Elimination of bias was dealt with as much as possible by administering of repeat questionnaires at the time of the consultant follow up appointment and not by the researcher. Subjects attended the consultant for re-measurement of POP-Q without him having any access to the initial measurements. The consultant measuring the MRI scans received before and after scans together and would not have been aware whether the subject had received treatment or not. Furthermore, the subjects were asked by the researcher not to feel that they should answer the questionnaires in any particular way and that their honest answers were preferred to anything they thought the researcher would like to hear. These measures were taken to eliminate bias as much as possible however, it is acknowledged that bias is a limitation of this study.

4.4 Limitations

4.4.1 Study Design

Sample size was calculated based on the estimated number of degrees of change of LPA with the intervention and the number of subjects needed to place upper confidence intervals on various levels of success (Personal communication R. Conroy 2011). Calculations based on mean differences of the LPA resulted in large sample sizes that were prohibitively expensive for the use of MRI and were not justified in these early stages of investigation of a novel intervention, where changes in LPA as an outcome were not yet proven. Furthermore, on this basis these larger sample sizes would have been unethical and this study was undertaken as pilot work.

There is a possibility of Type II error, where this study has shown that the LPA did not change. The LPA may have changed in a larger study where there were more uterine prolapses included in the study population as well as cystoceles and rectoceles. This is based on the assumption that the single case study was a subject with a uterine prolapse and that there has been shown to be an association between caudal descent of the levator plate and widening of the hiatus (r=0.42), which both reduced in this subject post treatment (Hsu et. al 2006).

This study was a same subject pre and post-test study of a novel intervention. Given the cost involved in MRI scans, a control group was not included in this study. A control group would have provided the opportunity to compare the existing study group with a PFMT group as a control and this would have demonstrated the true effect of the manual therapy on the levator plate. A third (control) group that might have only received lifestyle advice would have provided even more information to further separate the manual therapy from both PFMT and lifestyle changes/no intervention.

If there had been a control group then the study could have been extended to the more usual 20 weeks of other POP studies and therefore compared to other studies, it is a limitation that it cannot be compared to these studies. However, given the lack of a control group, it was considered the best study design, with the short time frame available and limited resources to stay under the recommended PFM training time to 12 weeks and therefore to be able in some way to attribute some of the changes in the study to the manual therapy.

It is a limitation that these subjects could not be followed up at intervals after treatment was completed, to monitor the lasting effect of the symptomatic improvement e.g. after 6 months. Current physiotherapy studies are extending out to 24 month periods (Hagen et al. 2011; Frawley et al. 2012).

As this was not a RCT, results would have been affected by bias, where subjects would have known that they were in the treatment group and therefore the likelihood was that they were to improve. Furthermore, all treatment was administered by the researcher increasing bias. Elimination of bias was dealt with as much as possible by administering of repeat questionnaires at the time of the consultant follow up appointment and not by the researcher. Subjects attended the consultant for re-measurement of POP-Q without him having any access to the initial measurements. The consultant measuring the MRI scans received before and after scans together and would not have been aware whether the subject had received treatment or not. Furthermore, the subjects were asked by the researcher not to feel that they should answer the questionnaires in any particular way and that their honest answers were preferred to anything they thought the researcher would like to hear. These measures were taken to eliminate bias as much as possible however, it is acknowledged that bias is a limitation of this study.

A recommendation in the Cochrane review on conservative management of POP was that there should be standardisation of use of validated outcomes measures, both anatomical and symptom based, to ensure that data from future prolapse studies are relevant and have the potential for appropriate pooling (Hagen and Stark, 2011). Since the inception of the current study there have been more POP physiotherapy studies published (Hagen et al., 2011a, Hagen et al., 2011b, Frawley et al., 2012), therefore it is considered a limitation that the symptom scores in this study cannot be directly compared with the POP-SS in the larger ongoing studies.

A limitation and difficulty in the study was trying to identify changes in MRI anatomy between two prolapse stages, I and II, and at rest. If it had been possible with financial resources and MRI equipment as well as allowing for the increased amount of time that it would have taken to measure, ideally MRI images would have been taken at rest on strain and on muscle contraction in order to compare to other physiotherapy studies in the literature.

4.4.2 Training Effect

Training effect in SUI can take place from as soon as 14 weeks (Balmforth et al., 2004) or 16 weeks in pelvic floor muscle (Bø, 1995). In a review on the physiology of pelvic floor muscle exercise training, Bø (2004) stated that there is evidence that physical activity and strength training can increase connective tissue mass and that intensity of training and load bearing are major factors for effective training. For effective muscle strengthening in skeletal muscles in adults, exercise physiologists recommend three sets of 8–12 slow velocity close to maximum contractions 2–4 days a week where maximal effect may not be achieved for 5 months (Pollock et al., 1998, Bø, 2004).

Bø (2004) stated that the theoretical rationale for PFMT is that strength training may build up the structural support of the pelvis by elevating the levator plate to a permanent higher location inside the pelvis and by enhancing hypertrophy and stiffness of the pelvic floor muscles and connective tissue. This would facilitate a more effective automatic motor unit firing (neural adaptation), preventing descent during an increase in abdominal pressure.

The Cochrane review comparing PFMT to no treatment in SUI, stated that women in a programme of PFMT were more likely to report cure or improve and have better QoL and have fewer leak episodes per day and less leak episodes on pads than controls, also that treatment effect was better in women with SUI, particularly when supervised for at least 3 months (Dumoulin and Hay-Smith, 2010). This was supported by a further Cochrane review comparing different approaches to PFMT in SUI, stating that PFMT with weekly supervision seems to be more effective than unsupervised PFMT (Hay-Smith et al., 2012). The NICE guidelines state that there is good evidence that PFMT continued for 3 months is safe and effective treatment for stress and mixed incontinence (NICE, 2006).

In the current study the limited treatment time of 12 weeks did not allow the optimal training time from 14 to 20 weeks to take place for the pelvic floor muscles. This was shorter than all other physiotherapy studies and so training effect cannot be compared. Training time in the study by Stupp et al. (2011) was 14 weeks and by Hagen et al. (2009b, 2011b) and Frawley (2012) was 16 weeks but the questionnaires for comparison of symptoms and POP-Q measurements in these studies were at 6 months and 12 months and training time for Braekken et al. (2010) was 6 months. It is therefore considered a limitation that the current study could not compare to any of these studies in terms of training time.

In the current study the treatment dose was five sessions. Within the time periods of

the studies above the treatment doses varied greatly. Ghroubi et al. (2008) delivered 24 sessions, it is not known over what period of time. Braekken et al. (2010) delivered 12 sessions, Stupp et al. (2011) delivered 7 sessions and Hagen et al. (2009b, 2011b) and Frawley et al. (2012) delivered five sessions. In the current study the amount of intervention that was administered over the time frame is considered minimal in the context of the other studies and the improvements that were achieved were comparable given the short training period.

4.5 Recommendations for Future Research

There is enough evidence to recommend a RCT of internal manual therapy to pelvic floor combined with PFMT and using a control group of PFMT alone. A trial should follow current physiotherapy research with 5-7 intervention sessions over an initial 14-16 weeks. Subjective outcome measures should include ICIQ-UI, ICIQ-VS and POP-SS and objective outcome measures should include POP-Q as well as MOS measured across both groups with at least 6 months follow up. The intervention group would receive the same manual therapy as described in this study and the same exercise dose and the control group would receive instruction in contracting and relaxing the pelvic floor only and the same exercise dose but none of the instruction in sniff, flop and drop, which would be considered to be part of the manual therapy programme.

Some recommendations for weekly supervision for PFMT have been made with regard to SUI (Hay-Smith et al., 2012), however the evidence presented in this study for POP is less conclusive with regard to the necessity for very frequent treatment sessions. Furthermore, increased frequency of treatment is also less affordable. Therefore in the first instance this frequency is thought to be sufficient for a RCT however, follow up must extend into the six month period to test for full muscle training effect and within the studies presented there are sufficient positive results to warrant follow up over this period and where possible longer.

As MRI is expensive, its use in a RCT needs to be justified. Reliability was found to be moderate-strong for LPA and bladder neck, however as change in LPA did not correlate with any improvements in this study it would be difficult to justify the use of MRI in an extended RCT involving manual therapy. However, if MRI was available for the study design as described above, dynamic MRI would be preferable to static MRI to measure the pelvic floor position at rest and at contraction. Measurement at 6 months would afford the opportunity to measure muscle bulk at a time when the muscle has trained sufficiently. In the clinical situation however, RTUS may be more accessible and less expensive.

Although clear criteria for defining MRI structures were agreed between examiners, it is possible that with further training, or using observers with similar experience of observing MRI scans or from the same disciplines, this may have reduced the effect of operator variance when defining the structures. Therefore future studies undertaking measurement of these same structures at rest should take these factors into consideration.

CONCLUSION

In this novel intervention study evaluating the effect of five treatment sessions of manual therapy and PFMT to the levator plate in a group of women with POP, there were many changes with improvements in POP symptoms and QoL.

The null hypothesis of the study was that there would be no change in the LPA with manual therapy intervention and the hypothesis was upheld.

There were improvements in symptom score questionnaire (ICIQ-VS, p=0.01) and in QoL (p=0.00). POP-Q stage improved from baseline (p=0.02) and where the predominant leading edge was cystocele before treatment (n=7), the predominant leading edge was rectocele after treatment (n=7). There were also three cystorectoceles before treatment and none treatment after as all has changed to leading edge either cystocele or rectocele. POP-Q point Aa improved in position becoming higher by 1.75cms (p=0.00) on valsalva. An unexpected change was descent of POP-Q point Bp on valsalva (p=0.00) becoming lower by 0.64cms on valsalva. This point became lower by a smaller degree than the degree that POP-Q point Aa raised and the overall result was an improved POP-Q stage.

Two raters demonstrated moderate-strong reliability for the LPA (ICC 0.80) and for the bladder neck (ICC 0.76) and moderate reliability for the H line (ICC 0.68). Reliability for M line was fair and for the ARA and cervix was poor. Bland and Altman plots revealed acceptable mean differences only for the LPA, bladder neck and H line. While reliability for LPA and bladder was considered strong for purposes of this study, clinical use of these measures cannot be recommended at this time.

Further statistical changes happened as a result of the manual therapy and PFMT that were unexpected; there was a widening of the H line (p=0.01) on MRI. This may have been as a result of the release of unwanted muscle tension in the 'loaded' puborectalis and iliococcygeus muscles, a tension that will build up secondary to pelvic floor muscle and fascial damage. The period of this study was 10-12 weeks and the period of time for a training effect to take place in muscle is longer, from 14-16 weeks onwards, so the training effect would not have taken place at the time of the MRI scan, a further reason for the muscle outline to have shown the release of tension only and not yet to have shown muscle bulk.

Where muscular and fascial defects exist it seems that the attachments to the levator plate are not sufficient to lever a change to its resting position through this targeted intervention. Manual therapy to the levator plate and other levator muscles may have an indirect effect via muscle and fascia off loading the anterior wall and this should be considered as a possible reason for the symptomatic and QoL improvement that was achieved in the short time period of this study. Given that this improvement can be achieved without the training effect of muscle, then it might be reasonable to conclude that the addition of manual therapy to a PFMT programme will have an

added effect whereby the patients will see an improvement more quickly. It remains to be seen in a RCT whether this improvement then has a more lasting effect.

A combined intervention study involving manual therapy and PFMT has not previously been undertaken and these results are encouraging. Symptom and QoL improvement in POP are recognised as the most important measures in clinical evaluation, therefore as a result of improvements shown in this study there is enough evidence to recommend proceeding to investigate this novel intervention in a randomised controlled trial.

REFERENCES

ABDOOL, Z., SHEK, K. L. & DIETZ, H. P. 2009. The effect of levator avulsion on hiatal dimension and function. *American Journal of Obstetrics & Gynecology,* 201, 89 e1-5.

ABRAMS, P., AVERY, K., GARDENER, N. & DONOVAN, J. 2006. On behalf of the ICIQ Advisory Board: The International Consultation on Incontinence modular questionnaire. *Journal of Urology,* 175. 1063-3

ALI-ROSS, N. S., SMITH, A. R. & HOSKER, G. 2009. The effect of physical activity on pelvic organ prolapse. *British Journal of Obstetrics & Gynaecology,* 116, 824-8.

ANDERSON, R. U., WISE, D., SAWYER, T. & CHAN, C. 2005. Integration of myofascial trigger point release and paradoxical relaxation training treatment of chronic pelvic pain in men. *Journal of Urology,* 174, 155-60.

ANSQUER, Y., FERNANDEZ, P., CHAPRON, C., FREY, C., BENNIS, M., ROY, C., SALOMON, L., MANDELBROT, L. & CARBONNE, B. 2006. Static and dynamic MRI features of the levator ani and correlation with severity of genital prolapse. *Acta Obstetrica Gynecologica Scandinavica,* 85, 1468-75.

ASHTON-MILLER, J. A. & DELANCEY, J. O. 2009. On the biomechanics of vaginal birth and common sequelae. *Annual Review of Biomedical Engineering,* 11, 163-76.

AUWAD, W., FREEMAN, R. M. & SWIFT, S. 2004. Is the pelvic organ prolapse quantification system (POPQ) being used? A survey of members of the International Continence Society (ICS) and the American Urogynecologic Society (AUGS). *International Urogynecology Journal,* 15, 324-7.

AVERY, K., DONOVAN, J. & ABRAMS, P. 2001. Validation of a new questionnaire for incontinence: The International Consultation on Incontinence Questionnaire (ICIQ). *Neurourology & Urodynamics,* 20, 510-512.

AVERY, K., DONOVAN, J., PETERS, T., SHAW, C., GOTOH, M. & ABRAMS, P. 2004. ICIQ: a brief and robust measure for evaluating the symptoms and impact of urinary incontinence. *Neurourology & Urodynamics,* 23, 322-30.

BALMFORTH, J., BIDMEAD, J. & CARDOZO, L. 2004. Raising the tone: a prospective observational study evaluating the effect of PFMT on bladder neck mobility and associated improvement in stress urinary incontinence. *Neurourology & Urodynamics,* 23, 553-554.

BARBER, M. D. 2007. Questionnaires for women with pelvic floor disorders. *International Urogynecology Journal,* 18, 461-5.

BARBER, M. D., CHEN, Z., LUKACZ, E. S., MARKLAND, A., WAI, C., BRUBAKER, L., NYGAARD, L., WEIDNER, A., JANZ, N. K. & SPINO, C. 2011. Further validation of the short form versions of the pelvic floor distress inventory (PFDI) and pelvic floor impact questionnaire (PFIQ). *Neurourology & Urodynamics,* 30, 541-546.

BARBER, M. D., LAMBERS, A. R., VISCO, A. G. & BUMP, R. C. 2000. Effect of patient position on clincal evaluation of pelvic organ prolapse. *Obstetrics & Gynecology,* 96, 18-22.

BARBER, M. D., WALTERS, M. D. & BUMP, R. C. 2005. Short forms of two condition-specific quality-of-life questionnaires for women with pelvic floor disorders (PFDI-20 and PFIQ-7). *American Journal of Obstetrics & Gynecology,* 193, 103-13.

BECO, J. 2008. Interest of retro-anal levator plate myorrhaphy in selected cases of descending perineum syndrome with positive anti-sagging test. *Biomed Central Surgery,* 8, 13.

BIALOSKY, J. E., BISHOP, M. D., GEORGE, S. Z. & ROBINSON, M. E. 2011. Palcebo response to manual therapy. *Journal of Manual Manipulative Therapy,* 19.

BLAND, J. M. & ALTMAN, D. G. 1990. A note on the use of Intraclass correlation coefficient in the evaluation of agreement between two methods of measurement. *Computers in Biology & Medicine,* 20, 337-40.

BØ, K. 1995. Pelvic floor muscle exercise for the treatment of stress urinary incontinence: an exercise physiology perspective. *International Urogynecology Journal,* 6, 282-291.

BØ, K. 2004. Pelvic floor muscle training is effective in treatment of female stress urinary incontinence, but how does it work? *International Urogynecology Journal,* 15, 76-84.

BØ, K., MAJIDA, M. & ENGH, M. E. 2012. Does a ring pessary in situ influence the pelvic floor muscle function of women with pelvic organ prolapse when tested in supine? *International Urogynecology Journal.* 23, 5, 573-7

BOYLES, S. H., WEBER, A. M. & MEYN, L. 2003. Procedures for urinary incontinence in the United States, 1979-1997. *American Journal of Obstetrics & Gynecology,* 189, 70-5.

BRAEKKEN, I. H., MAJIDA, M., ELLSTRÖM ENGH, M., HOLME, I. M. & BØ, K. 2009a. Pelvic floor function is independently associated with pelvic organ prolapse. *Brittish Journal of Obstetrics & Gynaecology,* 116, 1706-14.

BRAEKKEN, I. H., MAJIDA, M., ENGH, M. E. & BO, K. 2009b. Test–retest reliability of pelvic floor muscle contraction measured by 4D ultrasound. *Neurourology & Urodynamics,* 28, 68-73.

BRAEKKEN, I. H., MAJIDA, M., ENGH, M. E. & BO, K. 2010. Can pelvic floor muscle training reverse pelvic organ prolapse and reduce prolapse symptoms? An assessor-blinded, randomized, controlled trial. *Amercian Journal of Obstetrics & Gynecology,* 203, e1-7.

BROEKHUIS, S. R., FUTTERER, J. J., BARENTSZ, J. O., VIERHOUT, M. E. & KLUIVERS, K. B. 2009b. A systematic review of clinical studies on dynamic magnetic resonance imaging of pelvic organ prolapse: the use of reference lines and anatomical landmarks. *International Urogynecology Journal,* 20, 721-9.

BROEKHUIS, S. R., FUTTERER, J. J., HENDRIKS, J. C., BARENTSZ, J. O., VIERHOUT, M. E. & KLUIVERS, K. B. 2009a. Symptoms of pelvic floor dysfunction are poorly correlated with findings on clinical examination and dynamic MR imaging of the pelvic floor. *International Urogynecology Journal,* 20, 1169-74.

BROWN, J. S., WAETJEN, L. E., SUBAK, L. L. & AL., E. 2002. Pelvic organ prolpase surgery in the United States. *American Journal of Obstetrics & Gynecology.,* 186, 712-16.

BUMP, R. C., MATTIASSON, A., BO, K., BRUBAKER, L. P., DELANCEY, J. O., KLARSKOV, P., SHULL, B. L. & SMITH, A. R. 1996. The standardization of terminology of female pelvic organ prolapse and pelvic floor dysfunction. *American Journal of Obstetrics & Gynecology,* 175, 10-7.

BURROWS, L. J., MEYN, L. A., WALTERS, M. D. & WEBER, A. M. 2004. Pelvic symptoms in women with pelvic organ prolapse. *Obstetrics & Gynecology,* 104, 982-8.

CARDOZO, L. 1995. *Dewhurse's textbook of obstetrics and gynaecology for postgraduates,* Oxford, Blackwell Science *ED Whitfield C.D., Prolapse, p. 642-52*

CARTER, S. & TUBARO, A. 2001. Standardisation of Bladder Ultrasonography. *On behalf of International Continence Society sub committee for standardisation of imaging*

CHAITOW, L. 1994. Integrated neuromuscular inhibition technique. *British Journal of Osteopathy,* 13, 17-20.

CHAITOW, L. & DELANY, J. 2002. Ch 9. Summary of modalities. p 201-208. *Clinical Application of Neuromuscular Techniques* Edinburgh: Churchill Livingstone.

CHEN, L., ASHTON-MILLER, J. A., HSU, Y. & DELANCEY, J. O. L. 2006. Interaction between apical supports and levator ani in anterior vaginal support: theoretical analysis. *Obstetrics & Gynecology,* 108 324-332.

CLARK, A. L., GREGORY, T., SMITH, V. J. & EDWARDS, R. 2003. Epidemiologic evaluation of reopereation for surgically treated pelvic organ prolapse and urinary incontinence. *American Journal of Obstetrics & Gynecology,* 189, 1261-67.

COLAICOMO, M., MASSELLI, G., POLETTINI, E., LANCIOTTI, S., CASCIANI, E., BERTINI, L. & GUALDI, G. 2009. Dynamic MR imaging of the pelvic floor: a pictorial review. *Radiographics,* 29.

COMITER, C. V., VASAVADA, S. P., BARBARIC, Z. L., GOUSE, A. E. & RAZ, S. 1999. Grading prolapse and pelvic floor relaxation using dynamic magnetic resonance imaging. *Urology,* 54, 454-457.

CUNDIFF, G. W., A.C., W., VISCO, A. G., BUMP, R. C. & W.A., A. 2000. A survey of pessary use by members of the American Urogynecologic Society. *Obstetrics & Gynecology,* 95, 931-35.

DALLENBACH, P., KAELIN-GAMBIRASIO, I., DUBUISSON, J. B. & BOULVAIN, M. 2007. Risk factors for pelvic organ prolapse repair after hysterectomy. *Obstetrics & Gynecology,* 110, 625-32.

DELANCEY, J. O. & HURD, W. 1998. Size of the urogenital hiatus in the levator ani muscles in normal women and women with pelvic organ prolapse. *Obstetrics & Gynecology,* 91, 364-8.

DELANCEY, J. O., KANE LOW, L., MILLER, J. M., PATEL, D. A. & TUMBARELLO, J. A. 2008. Graphic integration of causal factors of pelvic floor disorders: an integrated life span model. *American Journal of Obstetrics & Gynecology,* 199, 610 e1-5.

DELANCEY, J. O., KEARNEY, R., CHOU, Q., SPEIGHTS, S. & BINNO, S. 2003. The appearance of levator ani muscle abnormalities in magnetic resonance images after vaginal delivery. *Obstetrics & Gynecology,* 101, 46-53.

DELANCEY, J. O., SORENSEN, H. C., LEWICKY-GAUPP, C. & SMITH, T. M. 2012. Comparison of the puborectal muscle on MRI in women with POP and levator ani defects with those with normal support and no defect. *International Urogynecology Journal,* 23, 73-7.

DELANCEY, J. O. L. & ASHTON-MILLER, J. A. 2007. Ch 5, MRI of intact and injured female pelvic floor muscles, p.94. *In:* BO, K., BERGHMANS, B., MORKVED, S. & VAN KAMPEN, M. (eds.) *Evidence based physical therapy for the pelvic floor* Butterworth Heinemann Elsevier.

DELANCEY, J. O. L., MORGAN, D. M., FENNER, D. E., KEARNEY, R., GUIRE, K., MILLER, J. M., HUSSAIN, H., UMEK, W., HSU, Y. & ASHTON-MILLER, J. A. 2007. Comparison of levator ani muscle defects and function in women with and without pelvic organ prolapse. *Obstetrics & Gynaecology* 109, 295-302.

DIETZ, H. P. 2009. Pelvic Floor Assessment *Fetal and Maternal Medicine Review* 20, 49-66.

DIETZ, H. P. 2011. Pelvic floor ultrasound in incontinence: what's in it for the surgeon? *International Urogynecology Journal,* 22, 1085-97.

DIETZ, H. P., CHANTARASORN, V. & SHEK, K. L. 2010a. Levator avulsion is a risk factor for cystocele recurrence. *Ultrasound Obstetrics & Gynecology,* 36, 76-80.

DIETZ, H. P., CHANTARASORN, V. & SHEK, K. L. 2010b. Levator avulsion is a risk factor for cystocele recurrence. *Ultrasound Obstetrics & Gynecoogyl,* 36, 76-80.

DIETZ, H. P., STEENSMA, A. B. & VANCAILLIE, T. G. 2003. Levator function in nulliparous women. *International Urogynecology Journal,* 14, 24-6; discussion 26.

DUMOULIN, C., GLAZENER, C. & JENKINSON, D. 2011. Determining the optimal pelvic floor muscle training regimen for women with stress urinary incontinence. *Neurourology & Urodynamics,* 30, 746-53.

DUMOULIN, C. & HAY-SMITH, J. 2010. Pelvic floor muscle training versus no treatment, or inactive control treatments , for urinary incontinence in women (Review). *Cochrane Database of Systematic Reviews Issue 1 CD005654.*

DUMOULIN, C., PENG, Q., STODKILDE-JORGENSEN, H., SHISHIDO, K. & CONSTANTINOU, C. 2007. Changes in levator ani anatomical configuration following physiotherapy in women with stress urinary incontinence. *Journal of Urology,* 178, 970-7; quiz 1129.

EL SAYED,R. F., EL MASHED, S., FARAG, A., MORSY, M. M. & ABDEL AZIM, M. S. 2008. Pelvic floor dysfunction: assessment with combined analysis of static and dynamic MR imaging findings. *Radiology,* 248, 518-30.

ELLERKMANN, R. M., CUNDIFF, G. W., MELICK, C. F., NIHIRA, M. A., LEFFLER, K. & BENT, A. E. 2001. Correlation of symptoms with location and severity of pelvic organ prolapse. *Americal Journal of Obstetrics & Gynecoogy,* 185, 1332-7; discussion 1337-8.

FIELDING, J. R. 2002. Practical MR imaging of female pelvic floor weakness. *Radiographics,* 22, 295-304.

FIELDING, J. R. 2003. MR imaging of pelvic floor relaxation. *Radiological Clinics of North America,* 41, 747-756.

FITZGERALD, M. P., ANDERSON, R. U., POTTS, J. & AL., E. 2009. Randomised multicenter feasibility trial of myofascial physical therapy for the treatment of urological chronic pelvic pain syndromes. *Journal of Urology,* 182, 570-80.

FITZGERALD, M. P., PAYNE, C. K., LUKACZ, E. S., YANG, C. C., PETERS, K. M., CHAI, T. C., NICKEL, J. C., HANNO, P., KREDER, K. J., BURKS, D. A., MAYER, R. & KOTARINOS, R. 2012. Randomised multicenter clinical trial of myofascial physical therapy in women with interstitial cystitis/painful bladder syndrome and pelvic floor tenderness. *Journal of Urology,* 187, 2113-8.

FRAWLEY, H., HAGEN, S., NEUMANN, P., HERBISON, P., HAY-SMITH, J. & GALEA, M. 2012. Changes in prolapse following pelvic floor muscle training. *Neurourology & Urodynamics,* 31**,** 163.

FRAWLEY, H., HAGEN, S., SHERBURN, M., NEUMANN, P., HERBISON, P., HAY-SMITH, J. & GALEA, M. 2011. What is the relationship between pelvic floor muscle strength, prolapse stage and prolapse symptom severity? *Proceedings of 41st Annual Meeting of ICS, Neurourology and Urodynamics,* 30**,** 862-863.

GATTERMAN, M. I. & HANSEN, D. T. 1994. Development of Chiropractic nomenclature through consensus. *Journal of Manipulative Physiologigal Therapy,* 17**,** 302-309.

GEARHART, S. L., PANNU, H. K., CUNDIFF, G. W., BULLER, J. L., BLUEMKE, D. A. & KAUFMAN, H. S. 2004. Perineal descent and levator ani hernia: a dynamic magnetic resonance imaging study. *Diseases of Colon & Rectum,* 47**,** 1298-304.

GHROUBI, S., KHARRAT, O., CHAARI, M., BEN AYED, B., GUERMAZI, M. & ELLEUCH, M. H. 2008. Effect of conservative treatment in the management of low-degree urogenital prolapse. *Annales de Réadaptation et de Médicine Physique,* 51**,** 96-102.

GINATH, S., GARELY, A., LUCHS, J. S., SHAHRYARINEJAD, A., OLIVERA, C., ZHOU, S., ASCHER-WALSH, C., CONDREA, A., BRODMAN, M. & VARDY, M. 2011. MRI pelvic landmark angles in the assessment of apical pelvic organ prolapse. *Archives of Gynecology & Obstetrics,* 284**,** 365-70.

GLAZENER, C., ELDERS, A., MACARTHUR, C., LANCASHIRE, R., HERBISON, P., HAGEN, S., DEAN, N., BAIN, C., TOOZS-HOBSON, P., RICHARDSON, K., MCDONALD, A., MCPHERSON, G. & WILSON, D. 2013. Childbirth and prolapse: long-term associations with the symptoms and objective measurement of pelvic organ prolapse. *Brittish Journal of Obstetrics & Gynaecology,* 120**,** 161-168.

GOODRICH, M. A., WEBB, M. J., KING, B., BAMPTON, A. E., CAMPEAU, N. G. & RIEDERER, S. J. 1993. Magnetic resonance imaging of pelvic floor relaxation: dynamic analysis and evaluation of patients before and after surgical repair. *Obstetrics & Gynecology,* 82, 883-91.

GRANT, S. R., SALVATI, E. P. & RUBIN, R. J. 1975. Levator Syndrome: An analysis of 316 cases *Diseases of Colon & Rectum,* 18, 161-3.

GYHAGEN, M., BULLARBO, M., NIELSEN, T. & MILSOM, I. 2013. Prevalence and risk factors for pelvic organ prolapse 20 years after childbirth: a national cohort study in singleton primiparae after vaginal or caesarean delivery. *Brittish Journal of Obstetrics & Gynaecology,* 120**,** 152-60.

HAGEN, S., GLAZENER, C., SINCLAIR, L., STARK, D. & BUGGE, C. 2009a. Psychometric properties of the pelvic organ prolapse symptom score. *Brittish Journal of Obstetrics & Gynaecology,* 116**,** 25-31.

HAGEN, S., SINCLAIR, L., GLAZENER, C., STARK, D., PRINGLE, S. & LOGAN, J. 2011a. PEssary Plus PhysiotherapY for Pelvic Organ Prolapse - The PEPPY Study. *Neurourology & Urodynamics,* 30.

HAGEN, S. & STARK, D. 2011. Conservative prevention and management of pelvic organ prolapse in women (Review). *Cochrane Database of Systematic Reviews, Issue 12, CD 003882.*

HAGEN, S., STARK, D., GLAZENER, C., SINCLAIR, L. & RAMSAY, I. 2009b. A randomized controlled trial of pelvic floor muscle training for stages I and II pelvic organ prolapse. *International Urogynecology Journal,* 20, 45-51.

HAGEN, S., STARK, D., GLAZENER, C., SINCLAIR, L., WILSON, D., NORRIE, J., DICKSON, S., MCPHERSON, G., LOGAN, J., FRAWLEY, H., MOORE, K. & WALKER, A. 2011b. A multicentre randomised lifestyle controlled trial of a pelvic floor muscle training PFMT for women with pelvic organ prolapse. *Neurourology & Urodynamics,* 30, 983-984.

HALL, A. F., THEOFRASTOUS, J. P., CUNDIFF, G. W., HARRIS, R. L., HAMILTON, L. F., SWIFT, S. E. & BUMP, R. C. 1996. Interobserver and intraobserver reliability of the proposed International Continence Society, Society of Gynecologic Surgeons, and American Urogynecologic Society pelvic organ prolapse classification system. *American Journal of Obstetrics & Gynecology,* 175, 1467-70; discussion 1470-1.

HANDA, V. L. & JONES, M. 2002. Do pessaries prevent the progression of pelvic organ prolapse. *International Urogynecology Journal,* 13, 349-352.

HANDA, V. L., LOCKHART, M. E., KENTON, K. S., BRADLEY, C. S., FIELDING, J. R., CUNDIFF, G. W., SALOMON, C. G., HAKIM, C., YE, W. & RICHTER, H. E. 2009. Magnetic resonance assessment of pelvic anatomy and pelvic floor disorders after childbirth. *International Urogynecology Journal,* 20, 133-9.

HAY-SMITH, J., HERDERSCHEE, R., DUMOULIN, C. & HERBISON, G. P. 2011. Comparison of approaches to pelvic floor muscle training for urinary incontinence in women (Review). *Cochrane Collaboration Syst Review (12) CD009508*

HAY-SMITH, J., HERDERSCHEE, R., DUMOULIN, C. & HERBISON, P. 2012. Comparisons of approaches to pelvic floor muscle training for urinary incontinence in women: an abridged Cochrane systematic review. *European Journal of Physical Rehabilitaion Medicine,* 48, 689-705.

HEALY, J., HALLIGAN, S., REZNEK, R. & AL., E. 1997. Dynamic MR imaging compared with evacuation proctography when evaluating anorectal configuration and pelvic floor movement. *American Journal Roentgenology,* 169, 775-779.

HENDRIX, S. L., CLARK, A., NYGAARD, I., ARAGAKI, A., BARNABEI, V. & MCTIERNAN, A. 2002. Pelvic organ prolapse in the Women's Health Initiative: gravity and gravidity. *American Journal Obstetrics & Gynecology,* 186, 1160-6.

HERSCHORN, S. 2004. Female pelvic floor anatomy: the pelvic floor, supporting structures, and pelvic organs. *Reviews Urology,* 6 Suppl 5, S2-S10.

HJARTARDOTTIR, S., NILSSON, J., PETERSON, C. & LINGMAN, G. 1997. The female pelvic floor: A dome - not a basin. *Acta Obstetrica et Gynecologica Scandinavica,* 76, 567-71.

HOYTE, L., SCHIERLITZ, L., ZOU, K., FLESH, G. & FIELDING, J. R. 2001. Two- and 3-dimensional MRI comparison of levator ani structure, volume, and integrity in women with stress incontinence and prolapse. *American Journal of Obstetrics Gynecology,* 185, 11-9.

HSU, Y., CHEN, L., TUMBARELLO, J., ASHTON-MILLER, J. A. & DELANCEY, J. O. 2010. In vivo assessment of anterior compartment compliance and its relation to prolapse. *International Urogynecology Journal,* 21, 1111-5.

HSU, Y., LEWICKY-GAUPP, C. & DELANCEY, J. O. 2008. Posterior compartment anatomy as seen in magnetic resonance imaging and 3-dimensional reconstruction from asymptomatic nulliparas. *American Journal of Obstetrics & Gynecology,* 198, 651 e1-7.

HSU, Y., SUMMERS, A., HUSSAIN, H. K., GUIRE, K. E. & DELANCEY, J. O. 2006. Levator plate angle in women with pelvic organ prolapse compared to women with normal support using dynamic MR imaging. *American Journal of Obstetrics & Gynecology,* 194, 1427-33.

JELOVSEK, J. E., MAHER, C. & BARBER, M. D. 2007. Pelvic organ prolapse. *Lancet,* 369, 1027-38.

JHA, S. & MORAN, P. 2011. The UK national prolapse survey: 5 years on. *International Urogynecology Journal,* 22, 517-28.

JONES, K., YANG, L., LOWDER, J. L., MEYN, L., ZYCZYNSKI, H. M., MOALLI, P. A. & LEE, T. 2008. Effect of pessary use on genital hiatus measurements in women with pelvic organ prolapse. *Obstetrics & Gynecology,* 112, 630-6.

KEARNEY, R., MILLER, J. M. & DELANCEY, J. O. 2006. Interrater reliability and physical examination of the pubovisceral portion of the levator ani muscle, validity comparisons using MR imaging. *Neurourology & Urodynamics,* 25, 50-4.

KEARNEY, R., SAWHNEY, R. & DELANCEY, J. O. 2004. Levator ani muscle anatomy evaluated by origin-insertion pairs. *Obstetrics & Gynecology,* 104, 168-73.

LAKEMAN, M. M., ZIJTA, F. M., PERINGA, J., NEDERVEEN, A. J., STOKER, J. & ROOVERS, J. P. 2012. Dynamic magnetic resonance imaging to quantify pelvic organ prolapse: reliability of assessment and correlation with clinical findings and pelvic floor symptoms. *International Urogynecology Journal,* 23, 1547-54.

LANDIS, J. R. & KOCH, G. G. 1977. The measurement of observer agreement for categorical data. *Biometrics,* 33, 159-74.

LAW, Y. M. & FIELDING, J. R. 2008. MRI of pelvic floor dysfunction: review. *American Journal Roentgenology,* 191, S45-53.

LAWSON, J. O. 1974. Pelvic anatomy. I. Pelvic floor muscles. *Annals of Royal College of Surgeons in England,* 54, 244-52.

LAYCOCK, J. 2008. Patient Assessment. *In:* LAYCOCK, J. & HASLAM, J. (eds.) *Therapeutic Management of Incontinence and Pelvic Pain.* Springer. Chapter 7 patient Assessment, p.62

LOCKHART, M. E., FIELDING, J. R., RICHTER, H. E., BRUBAKER, L., SALOMON, C. G., YE, W., HAKIM, C. M., WAI, C. Y., STOLPEN, A. H. & WEBER, A. M. 2008. Reproducibility of dynamic MR imaging pelvic measurements: a multi-institutional study. *Radiology,* 249, 534-40.

MADILL, S., TANG, A., PONTBRIAND-DROLET, S. & DUMOULIN, C. 2011. Comparison of two methods for measuring the pubococcygeal line from sagittal-plane magnetic resonance imaging. *Neurourology & Urodynamics,* 30, 1613-9.

MAHER, C., FEINER, B., BAESSLER, K. & GLAZENER, C. 2010. Surgical management of pelvic organ prolapse in women. *Cochrane Database of Systematic Review 14 (4) CD004014*

MAJIDA, M., BRAEKKEN, I. H., BO, K., SALTYTE BENTH, J. & ENGH, M. E. 2010. Validation of three-dimensional perineal ultrasound and magnetic resonance imaging measurements of the pubovisceral muscle at rest. *Ultrasound Obstetrics & Gynecology,* 35, 715-722.

MALBOHAN, I. M., MOJISOVA, L. & TICHY, M. 1989. The role of coccygeal spasm in low back pain *Journal of Manual Medicine,* 4, 140-41.

MANT, J., PAINTER, R. & VESSEY, M. 1997. Epidemiology of genital prolapse: observations from the Oxford family planning association study. *Brittish Journal of Obstetrics & Gynaecology,* 104, 579-85.

MILLER, J. M., ASHTON-MILLER, J. A. & DELANCEY, J. 1998. A pelvic muscle pre contraction can reduce cough related urine loss in selected women with mild SUI. *Journal of American Geriatric Society,* 46, 870-874.

MOALLI, P. A., JONES IVY, S., MEYN, L. A. & ZYCZYNSKI, H. M. 2003. Risk factors associated with pelvic floor disorders in women undergoing surgical repair. *Obstetrics & Gynecology,* 101, 869-74.

MORIN, M., BERGERON, S., KHALIFE, S., BINIK, Y. & OUELLET, S. 2011. Comparing pelvic floor muscle biometry in women with and without dyspareunia using 4D real time transperineal ultrasound. *Proceedlings of ICS International meeting, Glasgow* 165, 1033-1034.

NICE 2006. The management of urinary incontinence in women. *National Institute for Health and Clinical Excellence,* London.

NYGAARD, I., BRADLEY, C. & BRANDT, D. 2004. Pelvic organ prolapse in older women: prevalence and risk factors. *Obstetrics & Gynecology,* 104, 489-97.

OLSEN, A. L., SMITH, V. J., BERGSTROM, J. O., COLLING, J. C. & CLARK, A. L. 1997. Epidemiology of surgically managed pelvic organ prolapse and urinary incontinence. *Obstetrics & Gynecology,* 89, 501-6.

OZASA, H., MORI, T. & TOGASHI, K. 1992. Study of uterine prolapse by magnetic resonance imaging: Topographical changes involving the levator ani muscle and the vagina. *Gynecologic & Obstetric Investigation,* 34, 43-48.

PIYA-ANANT, M., THERASAKVICHYA, S., LEELAPHATANADIT, C. & TECHATRISAK, K. 2003. Integrated health research program for the Thai elderly: prevalence of genital prolapse and effectiveness of pelvic floor exercise to prevent worsening of genital prolapse in elderly women. *Journal of Medical Association of Thailand,* 86, 509-15.

POLLOCK, M. L., GAESER, G. A., BUTCHER, J. D., DESPRES, J. P., DISHMAN, R. K., FRANKLIN, B. A. & A., E. 1998. the recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness and flexibility in healthy adults. *Medicine Science Sports & Exercise,* 30, 975-991.

PORTNEY, L. G. & WATKINS, M. P. 2009. Ch 26, Statistical Measures of Reliability, p. 597. *Foundations of Clinical Research.* London: Pearson Educaion Ltd.

POTT-GRINSTEIN, E. & NEWCOMER, J. R. 2001. Gynecologists' patterns of prescribing pessaries. *Journal of Reproductive Medicine,* 46, 205-8.

PRICE, N., JACKSON, S. R., AVERY, K., BROOKES, S. T. & ABRAMS, P. 2006. Development and psychometric evaluation of the ICIQ Vaginal Symptoms Questionnaire: the ICIQ-VS. *Brittish Journal of Obstetrics & Gynaecology,* 113, 700-12.

RAMANAH, R., BERGER, M. B., PARRATTE, B. M. & DELANCEY, J. O. 2012. Anatomy and histology of apical support: a literature review concerning cardinal and uterosacral ligaments. *International Urogynecology Journal,* 23, 1483-94.

RANKIN, G. & STOKES, M. 1998. Reliability of assessment tools in rehabilitation: an illustration of appropriate statistical analysis. *Clinics in Rehabilitation,* 12, 187-99.

SAMUELSSON, E. C., ARNE, V. F. T., TIBBLIN, G. & SVARDSUDD, K. F. 1999. Signs of genital prolapse in a Swedish population of women 20-59 years of age and possible related factors. *American Journal of Obstetrics & Gynecology*, 299-305.

SHALOM, D. F., LIN, S. N., ST. LOUIS, S. & WINKLER, H. A. 2012. Effect of age, body mass index, and parity on Pelvic Organ Prolapse Quantification system measurements in women with symptomatic pelvic organ prolapse. *Journal of Obstetrics & Gynaecology Research,* 38, 415-9.

SINGH, K., REID, W. & BERGER, L. 2001. Assessment and grading of pelvic organ prolapse by use of dynamic magnetic resonance imaging. *American Journal of Obstetrics & Gynecology,* 185, 71-77.

SLIEKER-TEN HOVE, M. C., POOL-GOUDZWAARD, A. L., EIJKEMANS, M. J., STEEGERS-THEUNISSEN, R. P., BURGER, C. W. & VIERHOUT, M. E. 2009a. Face validity and reliability of the first digital assessment scheme of pelvic floor muscle function conform the new standardized terminology of the International Continence Society. *Neurourology & Urodynamics,* 28, 295-300.

SLIEKER-TEN HOVE, M. C., POOL-GOUDZWAARD, A. L., EIJKEMANS, M. J., STEEGERS-THEUNISSEN, R. P., BURGER, C. W. & VIERHOUT, M. E. 2009b. The prevalence of pelvic organ prolapse symptoms and signs and their relation with bladder and bowel disorders in a general female population *International Urogynecology Journal,* 20, 1037-45.

SONG, Y., YE, P., HONG, X., KE, G., SUN, Q., CHEN, Z. & MA, M. 2009. Changes in levator ani muscle after vaginal hysterectomy and prolapse repair using the Total Prolift procedure. *International Journal of Gynecology & Obstetrics,* 106, 53-6.

STROHBEHN, K., ELLIS, J. H., STROHBEHN, J. A. & DELANCEY, J. O. 1996. Magnetic resonance imaging of the levator ani with anatomic correlation. *Obstetrics & Gynecology,* 87, 277-85.

STUPP, L., RESENDE, A. P., OLIVEIRA, E., CASTRO, R. A., GIRAO, M. J. & SARTORI, M. G. 2011. Pelvic floor muscle training for treatment of pelvic organ prolapse: an assessor-blinded randomized controlled trial. *International Urogynecology Journal,* 22, 1233-9.

SWIFT, S., WOODMAN, P., O'BOYLE, A., KAHN, M., VALLEY, M., BLAND, D., WANG, W. & SCHAFFER, J. 2005. Pelvic Organ Support Study (POSST): the distribution, clinical definition, and epidemiologic condition of pelvic organ support defects. *American Journal of Obstetrics & Gynecology,* 192, 795-806.

SWIFT, S. E. 2000. The distribution of pelvic organ support in a population of female subjects seen for routine gynecologic healthcare. *American Journal of Obstetrics & Gynecology*, 277-85.

SWIFT, S. E., TATE, S. B. & NICHOLAS, J. 2003. Correlation of symptoms with degree of pelvic organ support in a general population of women: what is pelvic organ prolapse? *American Journal of Obstetrics & Gynecology,* 189, 372-77.

TAN, J. S., LUKACZ, E. S., MENEFEE, S. A., POWELL, C. R. & NAGER, C. W. 2005. Predictive value of prolapse symptoms: a large database study. *International Urogynecology Journal,* 16, 203-9; discussion 209.

THIELE, G. H. 1963. Coccydynia: cause and treatment. *Diseases of Colon & Rectum,* 6, 422-436.

TRAVELL, J. & SIMONS, D. 1999. *In:* TRAVELL, J. & SIMONS, D. (eds.) *Myofascial Pain and Dysfunction: The trigger point manual; Volume1, The upper half of the body.* Philadelphia: Lippincott Williams & Wilkins. Chapter 3, Apropos of All Muscles, p119.

TRAVELL, J. & SIMONS, D. 1993. Pelvic floor muscles. *In:* TRAVELL, J. & SIMONS, D. (eds.) *Myofascial Pain and Dysfunction: The trigger point manual; The lower extremities.* Philadelphia: Lippincott Williams & Wilkins.

WEBER, A. M. & RICHTER, H. E. 2005. Pelvic Organ Prolapse. *Obstetrics & Gynecology.,* 106.

WEBER, A. M., WALTERS, M. D., BALLARD, L. A., BOOHER, D. L. & PIEDMONTE, M. R. 1998. Posterior vaginal prolapse and bowel function. *American Journal of Obstetrics & Gynecology,* 179, 1446-9; discussion 1449-50.

WEBER, A. M., WALTERS, M. D., SCHOVER, L. R. & MITCHINSON, A. 1995. Sexual function in women with uterovaginal prolapse and urinary incontinence. *Obstetrics & Gynecology,* 85, 483-7.

WEISS, J. M. 2001. Pelvic floor myofascial trigger points; manual therapy for interstitial cystitis and the urgency frequency syndrome. *Journal of Urology,* 166, 2226-31.

WHELAN, M. 2006. Changing the Pelvic Floor. *Journal of the Association of Chartered Physiotherapists in Women's Health*, Issue 98, 20-27.

WHELAN, M. 2008. Chapter 11b, Advanced manual therapy for the pelvic floor *In:* LAYCOCK, J. & HASLAM, J. (eds.) *Therapeutic management of incontinence and pelvic pain.* Springer-Verlag London.

WHELAN, M. 2012. Practical anatomy, examination, palpation and manual therapy release techniques for the pelvic floor. *In:* CHAITOW, L. & LOVEGROVE JONES, R. (eds.) *Chronic Pelvic Pain and Dysfunction; Practical Physical Medicine.* UK: Elsevier Churchill Livingstone. Chapter 13.

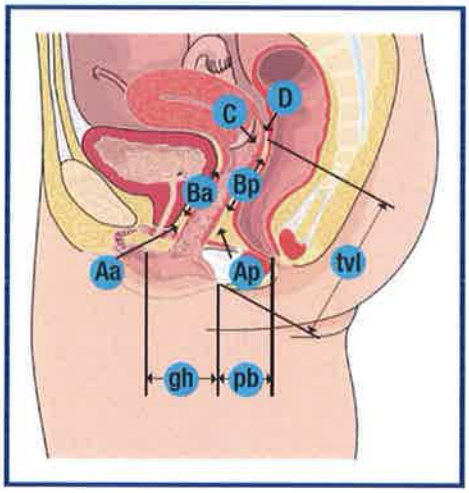
YANG, A., MOSTWIN, J. L., ROSENHEIM, N. B. & ZERHOUNI, E. A. 1991. Pelvic floor descent in women: dynamic evaluationwith fast MR imaging and cinematic display. *Radiology,* 179, 25-33.

ZACHARIN, R. F. 1980. Pulsion enterocele: review of functional anatomy of the pelvic floor. *Obstetrics & Gynecology,* 55, 135-40.

Appendix 1 POP-Q Points

POP-Q Exam – Reference Guide

POPstix.co.nz



The pelvic organ prolapse quantification (POP-Q) exam is used to quantify, describe, and stage pelvic support.

- There are 6 points measured at the vagina with respect to the hymen.
- Points above the hymen are negative numbers; points below the hymen are positive numbers.
- All measurements except tvl are measured at maximum valsalva.

Point	Description	Range of Values
Aa	Anterior vaginal wall 3 cm proximal to the hymen	-3 cm to +3 cm
Ba	Most distal position of the remaining upper anterior vaginal wall	-3 cm to +tvl
C	Most distal edge of cervix or vaginal cuff scar	
D	Posterior fornix (N/A if post-hysterectomy)	
Ap	Posterior vaginal wall 3 cm proximal to the hymen	-3 cm to +3 cm
Bp	Most distal position of the remaining upper posterior vaginal wall	-3 cm to + tvl

Genital hiatus (gh) – Measured from middle of external urethral meatus to posterior midline hymen
Perineal body (pb) – Measured from posterior margin of gh to middle of anal opening
Total vaginal length (tvl) – Depth of vagina when point D or C is reduced to normal position

POP-Q Staging Criteria	
Stage 0	Aa, Ap, Ba, Bp = -3 cm and C or D ≤ – (tvl – 2) cm
Stage I	Stage 0 criteria not met and leading edge < -1 cm
Stage II	Leading edge ≥ -1 cm but ≤ +1 cm
Stage III	Leading edge > +1 cm but < + (tvl – 2) cm
Stage IV	Leading edge ≥ + (tvl – 2) cm

REFERENCE: Bump RC, Mattiasson A, Bo K, et al. The standardization of terminology of female pelvic organ prolapse and pelvic floor dysfunction. *Am J Obstet Gynecol.* 1996;175:13.

Appendix 2 RCSI Research Ethics Committee (REC 684)

Royal College of Surgeons in Ireland
The Research Ethics Committee
121 St. Stephens Green, Dublin 2, Ireland.
Tel: +353 1 4022373 Fax: +353 1 4022449 Email: recadmin@rcsi.ie

Dr. David Smith, Acting Chair
Ms. Stephanie O'Connor, Convenor

Royal College of Surgeons in Ireland
Coláiste Ríoga na Máinleá in Éirinn

RCSI

23rd December, 2011

Ms Maeve Whelan,
20 Lower Churchtown Rd,
Dublin 14

Ethics Reference No:	REC684
Project Title:	A study of the effect of manual therapy on the levator plate
Researchers Name:	Ms Maeve Whelan
Other Individuals Involved:	Louise Keating, School of Physiotherapy, RCSI.

Dear Ms Maeve Whelan,
Thank you for your Research Ethics Committee (REC) application. We are pleased to advise that ethical approval has been granted by the committee for this study.

This letter provides approval for data collection for the time requested in your application and for an additional 6 months. This is to allow for any unexpected delays in proceeding with data collection. Therefore this research ethics approval will expire on **3rd October, 2013.**

Where data collection is necessary beyond this point, approval for an extension must be sought from the Research Ethics Committee.

This ethical approval is given on the understanding that:

- All personnel listed in the approved application have read, understand and are thoroughly familiar with all aspects of the study.
- Any significant change which occurs in connection with this study and/or which may alter its ethical consideration, must be reported immediately to the REC, and an ethical amendment submitted where appropriate.
- Please submit a final report upon completion of your project.

We wish you all the best with your research.

Yours sincerely,

PP Ms. Stephanie O'Connor (Convenor)
Dr David Smith (Acting Chair)

Appendix 3 Gatekeeper - letter of support

Mr Kelvin Boos BSc, MRCP(I), MD, FRCOG
Obstetrician & Gynaecologist

Mount Carmel Clinic
Braemor Park
Churchtown
Dublin 14
Tel: (01) 4063449

Hermitage Medical Clinic
Old Lucan Road
Dublin 20
Tel: (01) 645 9656
086 366 4290

16 August 2011

Research Ethics committee
RCSI
121 St. Stephen's Green
Dublin 2

Re: A study to evaluate the effect of manual therapy and exercise on the pelvic floor in women with pelvic organ prolapse

To whom it may concern

I have been contacted by Maeve Whelan with regard to this study and the recruitment of patients with anterior compartment prolapse. I confirm that I will act as gatekeeper and will be in a position to recruit patients for participation in the study.

Kind regards
Yours sincerely

Kelvin Boos
Consultant Obstetrician & Gynaecologist
MCRN 13163

Appendix 4 Hermitage Medical Clinic – letter of support

Hermitage Medical Clinic
A Community Hospital for our Patients' Needs

Old Lucan Road
Dublin 20
Tel: +353 1 645 9000
Fax: +353 1 645 9235
Email: info@hermitageclinic.ie
Web: www.hermitageclinic.ie

18th November, 2011

Ms. Maeve Whelan
Milltown Physiotherapy
9 Lower Churchtown Road
Dublin 14

Dear Maeve

Physiotherapy MSc Research through RCSI
A Study to evaluate the effect of manual therapy and exercise on the levator plate in women with pelvic organ prolapse

I refer to your letter of the 25th October and to our email correspondence in relation thereto.

I am happy to inform you that, following a recent meeting of the Medical Advisory Committee, your above proposed study research programme has been approved. We understand that Kelvin Boos is fully supportive of your study research programme and will be acting as gatekeeper for same.

May I take this opportunity to wish you every success with your initiative.

Yours sincerely

Eamonn Fitzgerald
Chief Executive.

c.c. Mr. Kelvin Boos, Suite 32

Appendix 5 UPMC Hermitage Medical Clinic – letter of support

UPMC Beacon Hospital
Beacon Hospital, Beacon Court, Sandyford • Dublin 18

TEL +353 1 293 6600 FAX + 353 1 293 6601 www.beaconhospital.ie

Ms. Maeve Whelan
Specialist Chartered Physiotherapist
Milltown Physiotherapy
98 Lower Churchtown Rd,
Dublin 14

5th March 2012

Study Title: A study to evaluate the effect of manual therapy and exercise on the levator plate in women with pelvic organ prolapse.

Dear Ms. Whelan,

Thank you for your letter and supporting documentation dated 29th January 2012. The UPMC Beacon Hospital Healthcare, Research & Ethics Advisory Committee have been made aware of your study and of Mr. Boos involvement.

We wish you all the best in your research and would appreciate a copy of your findings on completion.

Yours sincerely,

Mr. Maher Shuhaibar
Chairperson,
UPMC Beacon Hospital Healthcare,
Research & Ethics Advisory Committee

Appendix 6 Medical Director Euromedic – letter of support

EUROMEDIC
Dundrum

Research Ethics Committee
Royal College of Surgeons Ireland
Dublin 2

17 September 2011

RE: A study to evaluate the effect of manual therapy and exercise on the levator plate in women with pelvic organ prolapse

Researcher : Maeve Whelan SMISCP
Milltown Physiotherapy
98 Lower Churchtown Road
Dublin 14
maevewhelan@rcsi.ie
01 2960603

Study Supervisor: Louise Keating
School of Physiotherapy, RCSI
121 St. Stephen's Green
Dublin 2
lkeating@rcsi.ie
01 4022259

To Whom It May Concern,

Maeve Whelan, MSc Physiotherapy Research student has approached us requesting permission to carry out the above named study at Euromedic, Dundrum.

I can confirm that

- We have given permission for this study to be carried out at our institution
- That we do not have a Research Ethics Committee
- It will be possible to carry out sagittal pelvic scans for study participants
- Consultants referral letter will not be necessary
- There are no safety concerns with scanning patients twice in a 16 week period

Yours sincerely,

Dr. S Hamilton MA MD FRCR FRCPC FFRRCSI FFSEMRCSI LMCC DMRD DipMedEd
Consultant Radiologist
Medical Director, Euromedic

Rockfield Medical Campus, Balally, Dundrum, Dublin 16
T +353 1 213 5959 F +353 1 213 0950
dundrum@euromedic.ie www.euromedic.ie

Directors: Colm Davitt, Stephen Funge
Euromedic (HO) Ireland Limited trading as Euromedic Ireland
Registered number: 416896 Part of Euromedic International

Appendix 7 RCSI Research Ethics Committee (684b)

Royal College of Surgeons in Ireland
The Research Ethics Committee
121 St. Stephens Green, Dublin 2, Ireland.
Tel: +353 1 4022373 Fax: +353 1 4022449 Email: recadmin@rcsi.ie

Dr. David Smith, Acting Chair
Ms. Stephanie O'Connor, Convenor

Royal College of Surgeons in Ireland
Coláiste Ríoga na Máinleá in Éirinn

RCSI

19th April, 2012

Ms Maeve Whelan,
20 Lower Churchtown Rd,
Dublin 14

Ethics Reference No:	REC684b
Project Title:	A study of the effect of manual therapy on the levator plate
Researchers Name:	Ms Maeve Whelan
Other Individuals Involved:	Louise Keating, School of Physiotherapy, RCSI.

Dear Ms Maeve Whelan,
Thank you for your amendment to Research Ethics Committee (REC) application REC684. We are pleased to advise that ethical approval has been granted by the committee for this amendment.

Content of Amendment:
1. Participant upper age limit raised to 70 years.

This letter provides approval for data collection for the time requested in your original application and for an additional 6 months to allow for any unexpected delays in proceeding with data collection. Therefore this research ethics approval will expire on **3rd October, 2013.** Where data collection is necessary beyond this point, approval for an extension must be sought from the Research Ethics Committee.

This ethical approval is given on the understanding that:

- All personnel listed in the approved application have read, understand and are thoroughly familiar with all aspects of the study.
- Any significant change which occurs in connection with this study and/or which may alter its ethical consideration, must be reported immediately to the REC, and an ethical amendment submitted where appropriate.
- Please submit a final report upon completion of your project.

We wish you all the best with your research.

Yours sincerely,

PP Ms. Stephanie O'Connor (Convenor)
Dr David Smith (Acting Chair)

Appendix 8 RCSI Research Ethics Committee (684bb)

Royal College of Surgeons in Ireland
The Research Ethics Committee
121 St. Stephens Green, Dublin 2, Ireland.
Tel: +353 1 4022373 Fax: +353 1 4022449 Email: recadmin@rcsi.ie

Dr. David Smith, Acting Chair
Ms. Stephanie O'Connor, Convenor

Royal College of Surgeons in Ireland
Coláiste Ríoga na Máinleá in Éirinn

RCSI

22nd August, 2012

Ms Maeve Whelan,
20 Lower Churchtown Rd,
Dublin 14

Ethics Reference No:	REC684bb
Project Title:	A study of the effect of manual therapy on the levator plate
Researchers Name:	Ms Maeve Whelan
Other individuals involved:	Louise Keating, School of Physiotherapy, RCSI.

Dear Ms Maeve Whelan,
Thank you for your amendment to Research Ethics Committee (REC) application REC684b. We are pleased to advise that ethical approval has been granted by the committee for this amendment.

Content of Amendment:
1. Change of inclusion Criteria to: anterior compartment, uterine prolapse or posterior wall prolapse stages I or II.

This letter provides approval for data collection for the time requested in your original application and for an additional 6 months to allow for any unexpected delays in proceeding with data collection. Therefore this research ethics approval will expire on **3rd October, 2013.** Where data collection is necessary beyond this point, approval for an extension must be sought from the Research Ethics Committee.

This ethical approval is given on the understanding that:

- All personnel listed in the approved application have read, understand and are thoroughly familiar with all aspects of the study.
- Any significant change which occurs in connection with this study and/or which may alter its ethical consideration, must be reported immediately to the REC, and an ethical amendment submitted where appropriate.
- Please submit a final report upon completion of your project.

We wish you all the best with your research.

Yours sincerely,

PP Ms. Stephanie O'Connor (Convenor)
Dr David Smith (Acting Chair)

Appendix 9 POP-Q Consultant Measurement Form

A study to evaluate the effect of manual therapy on the levator plate in women with pelvic organ prolapse

Patient ID number				
DOB				
Date & time of day				
Bladder & bowel (Patient should be offered opportunity to void before exam)	Bladder empty Yes / No		Bowel empty Yes / No	
Menstrual cycle	Post menopausal	Peri menopausal	First half cycle	Second half cycle
Consent to be contacted by researcher	Yes / No			

Any other comments about examination:

	External									H	Internal									
cm	+10	+9	+8	+7	+6	+5	+4	+3	+2	+1	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10
Aa																					
Ba																					
C																					
D																					
Bp																					
Ap																					
	STAGE IV							S III		STAGE II			S I	STAGE 0 or I (depending on TVL)							

	cms
GH	
PB	
TVL	

Maximum protrusion seen: Yes No

Prolapse stage: 0 I II III IV
(Refers to leading edge)

Prolapse type: Cystocele Urethrocele Vault Uterine Rectocele
(Tick as many as appropriate)

Signed by Consultant:

Researcher: Maeve Whelan , Milltown Physiotherapy, 98 Lower Churchtown Rd. , D.14.
Contact: Phone 01 2960603 ; Fax 01 2960647
Email: maevewhelan@rcsi.ie

Appendix 10 Patient Information Sheet

Researcher:
Maeve Whelan
RCSI
maevewhelan@rcsi.ie
01-2960603

RCSI Supervisor:
Louise Keating
School of Physiotherapy
lkeating@rcsi.ie
01-4022259

Patient Information
Research Title: A study to evaluate the effect of manual therapy and exercise on the levator plate in women with pelvic organ prolapse

What is the aim of the study?
This is a research project to evaluate the effect of exercise and manual therapy (soft tissue mobilisation) on pelvic floor support structures in women with pelvic organ prolapse. Usually strengthening of the pelvic floor is recommended. In this study women will additionally receive internal muscle release techniques to mobilise any unwanted tension in the muscles that may be there as a result of the prolapse. The idea is that the pelvic floor would then become more supportive to the organs.

How many groups are there is this study?
There is just one group in the study and all participants will receive the same treatment.

What is the procedure?
In order to measure the effect of the manual techniques used, MRI scans will be performed once before treatment begins and again after 12 weeks. Treatment sessions are 1 hour for the first session and 5 more half hour sessions with the researcher at two week intervals. There will be 3 symptom questionnaires asking about bladder and vaginal symptoms and 1 quality of life questionnaire to be completed, to determine the effect of the symptoms on quality of life. These should be filled out by you before and after the 12 weeks and returned to the researcher.

How would I become involved?
Participation in this study is voluntary. If following your visit with your consultant he/she thinks that you fulfil the criteria of having the right type of prolapse to be included in the study then he/she will ask you if it is ok for you to be contacted by the researcher. Once you have agreed to this you will be contacted by phone and all questions relevant to the research will be discussed on the phone. If you agree to be in the study you will be offered an appointment at Milltown Physiotherapy where you will have an opportunity to discuss all aspects of the study prior to signing a consent form.

How many treatment sessions will this involve?
Your first appointment will be a one hour session at Milltown Physiotherapy with the researcher. Your next appointment will be your MRI scan in Euromedic in Dundrum. The scan duration will be 5 minutes. There will be 5 more follow up treatment sessions of 30 minutes each at Milltown Physiotherapy at 98 Lower Churchtown Road, Dublin 14 over 10-12 weeks. Finally there will be a last MRI scan and a review appointment with your Consultant Urogynaecologist to evaluate the position of the pelvic floor following the physiotherapy.

What does the physiotherapy session involve?
Usually physiotherapy for the pelvic floor involves an internal examination of the pelvic floor to evaluate pelvic organ position and pelvic floor muscle function plus teaching of a correct pelvic floor contraction. In this study participants will additionally receive internal pelvic floor manual therapy where muscles will be palpated (pressed) internally in order to identify any unwanted tension that may be preventing them from working correctly. Once identified, these tension or trigger points will be released through passive stretching and breathing techniques.

Will this be painful?
Pelvic floor examination should not usually be painful. The techniques performed can be uncomfortable at the time as areas of tension are identified but are always performed to the tolerance of the patient and learning the breathing techniques to assist with the release will reduce any discomfort. The discomfort always stops when the pressure is stopped and there should be no discomfort at all after the session. The session would be terminated immediately if treatment was too uncomfortable.

Are there any risks?
There may be bleeding (spotting) with manual therapy but this would be rare and would only occur if there was some underlying tissue weakness. Treatment would be discontinued immediately and the bleeding/spotting should stop. If it recurred later or if you were concerned you should contact the researcher at the contact number provided or you could contact your GP.

What happens if I am menstruating?
If you are menstruating at the time of the scheduled MRI then we would need to cancel and reschedule for after menstruation.

What happens if I can't tolerate the techniques?
The session will be terminated immediately without affecting your subsequent clinical care.

What are the benefits of the study?
It is hoped that by taking part in this study you will benefit with improvement in your symptoms. All treatments will be free of charge because you are taking part in the study. It is also hoped that the publication of this study will benefit other women with pelvic organ prolapse by demonstrating the effect of interventions that may be beneficial to them.

What happens if I decide not to take part in the study?
If you decide not to take part in the study, you can follow another path of physiotherapy treatment as referred by your consultant.

Can I decide to withdraw from the study?
You can withdraw at any stage without giving a reason, without any personal consequence and without this affecting any subsequent treatment.

What would happen if I became pregnant?
If you became pregnant you would inform the researcher immediately and you would no longer take part in the study. You will be asked by Euromedic in Dundrum prior to both scans if there is any chance you could be pregnant. An MRI scan would not be carried out in pregnancy.

What happens after the study?
This will be discussed with you and recommendations will be made to you and your consultant before the end of the study period, regarding the need for further treatment.

Will my details be confidential?
Any records of this study will be strictly confidential. The data collected will be used as part of the research study which will be published with patient anonymity. The data will be stored in the Royal College of Surgeons Ireland in a locked cabinet for a period of 5 years and then destroyed according to the Data Protection Act 2003. The supervisor as well as the researcher will ensure this data protection.

Who should I contact about this study?
If you have any concerns relating to any procedure throughout the study or if you have any further questions that you would prefer not to raise with the researcher you can contact the study supervisor in confidence at the phone number or email address provided.

Does this study have Ethics approval?
Approval has been granted by RCSI Research Ethics Committee.

Appendix 11 Patient Consent Form

RCSI Headed Paper

A study to evaluate the effect of manual therapy and exercise on the levator plate in women with pelvic organ prolapse

Please complete the following by circling the correct response:

Have you read or has someone read to you the study information sheet?	**Yes/No**
Have you had an opportunity to ask questions and discuss the study?	**Yes/No**
Do you understand the information provided?	**Yes/No**
Have you received satisfactory answers to all your questions?	**Yes/No**
Have you received enough information about the study?	**Yes/No**

To whom have you spoken?_____

Do you understand that you are free to withdraw from the study:

At any time?	**Yes/No**
Without having to give a reason for withdrawing?	**Yes/No**
And without affecting your future medical care?	**Yes/No**

Do you agree to partake in this study? **Yes/No**

Signed _____ **Date** _____

Name in block letters_____

Signed (Researcher)_____ **Date**_____

Researcher:
Maeve Whelan
RCSI
maevewhelan@rcsi.ie
01-2960603

RCSI Supervisor:
Louise Keating
School of Physiotherapy
lkeating@rcsi.ie
01-4022259

Appendix 12 POP-Q Consultant Measurement Guide

GYNAECOLOGISTS' GUIDE TO COMPLETING POP-Q

EXAMINATION CONDITIONS:

1. Record the name of examiner and time of examination.
2. Bladder should be emptied by spontaneous void prior to examination.
3. Woman positioned supine on examination couch with head rest raised to 45^0.
4. Record content of rectum.
5. Ensure maximum protrusion of prolapse is seen (all measurements except total vaginal length are taken while patient is bearing down).
6. Use vaginal speculum to retract vaginal walls.

POP-Q MEASUREMENTS:

The 9 measurements described below make up the POP-Q. All measurements are in centimetres. Record all measurements to the nearest 0.5cm using the disposable rulers provided.

The first 3 measurements are recorded in the boxes above the grid. All values are positive.

gh (genital hiatus)	is measured from the middle of the external urethral meatus to the posterior midline hymen.
pb (perineal body)	is measured from the posterior margin of the genital hiatus to the midanal opening.
tvl (total vaginal length)	is the greatest depth when point C or D is reduced to its normal position.

The remaining 6 measurements are vaginal points which can be negative (internal) or positive (external). Record each point on the grid by marking a cross in the centre of the corresponding box (e.g. for -1cm) or on the line between boxes (e.g. for -1.5cm).

Points on the anterior vaginal wall:

Aa	is located in the midline of the anterior vaginal wall 3cm proximal to the external urethral meatus (range -3 to +3cm).
Ba	is a point that represents the most distal (most dependent) position of any part of the upper anterior vaginal wall from the vaginal cuff/anterior fornix to point Aa.

Points on the superior vagina:

C	is a point that represents either the most distal (most dependent) edge of the cervix or the leading edge of the vaginal cuff (hysterectomy scar).
D	is a point that represents the location of the posterior fornix (or pouch of Douglas) in a woman who still has a cervix. Point D is omitted in the absence of the cervix.

Points on the posterior vaginal wall:

Ap	is located in the midline of the posterior vaginal wall 3cm proximal to the hymen (range -3 to +3cm).
Bp	is a point that represents the most distal (most dependent) position of any part of the upper posterior vaginal wall from the vaginal cuff/ posterior vaginal fornix to point Ap.

STAGING THE PROLAPSE:

Stages are assigned according to the most severe portion of the prolapse when the full extent of the protrusion has been demonstrated.

Stage 0	No prolapse is demonstrated. Points Aa, Ap, Ba and Bp are all at -3cm and point C or D is between –tvl and –(tvl-2) cms.
Stage I	The criteria for stage 0 are not met, but the most distal portion of the prolapse is >1cm above the level of the hymen.
Stage II	The most distal portion of the prolapse is ≤1cm proximal (above) to or distal (below) to the plane of the hymen (≥ -1cm but ≤+1cm)
Stage III	The most distal portion of the prolapse is >1cm below the plane of the hymen but protrudes no further than 2cm less than the tvl in cm.
Stage IV	Essentially, complete eversion of the total length of the lower genital tract is demonstrated. The distal portion of the prolapse protrudes to at least tvl-2cm. In most instances, the leading edge of stage IV prolapse will be the cervix or vaginal cuff scar.

Appendix 13 Physiotherapy Assessment Form

Milltown Physiotherapy
Pelvic Floor Assessment

Name		D.O.B.	
Address		G.P.	
		Consultant	
		E-Mail	
Tel		Occupation	
Mobile		Referred by	

Current Hx	
Past Hx	
Previous physiotherapy	
Exercise	
ADL	
Obstetric Hx	
Gynecologic Hx	
Menopause	
Med Hx	
Surgical Hx	

BLADDER			
SUI		Initiation & Flow	
Urgency, UI		Complete emptying	
Frequency		Nocturia	

BOWEL			
Frequency		Difficulty cleaning	
Urgency		Incomplete evacuation	
F.I.		Constipation	
Laxatives			
Fluid intake			

Pelvic pain	
Dyspareunia	
LBP	
Investigations	
Medications	

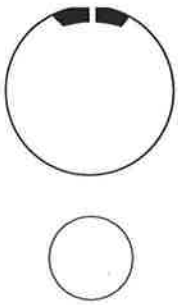
EXAMINATION

Informed consent ☐

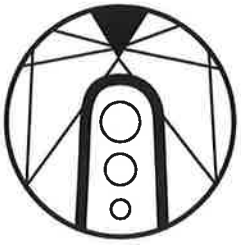
PROLAPSE	ANT WALL	UTERUS/ APEX	POST WALL
Diagnosis: Initial stage			
Current prolapse at rest			
Current prolapse on strain			

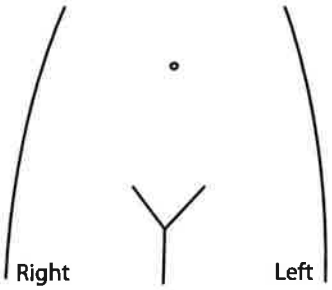
TONE	NORMO R	NORMO L	HYPO R	HYPO L	HYPER R	HYPER L	TAUT R	TAUT L	GAPS R	GAPS L
Superficial										
Deep										
EAS										
Puborectalis										

VERTICAL



HORIZONTAL

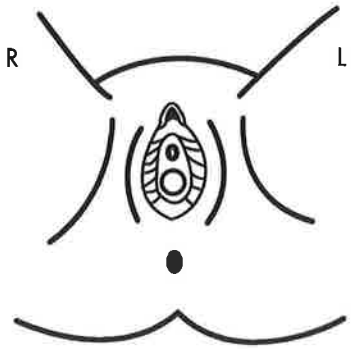




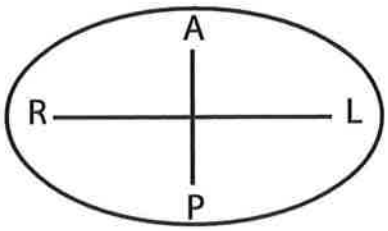
PELVIC FLOOR		GRADE (R)	% RELEASE	GRADE (L)	% RELEASE
Initial	Superficial				
	Deep				
Instruction	Superficial				
	Deep				
Breathing					
TrA co-ord					
EAS					
Puborectalis					
♂					
COUGH					
Without PFM*					
With PFM*					

*On palpation stability of urethrovesical junction is maintained: not at all, partially, completely

PERINEAL RESTRICTIONS



VAGINA / TVL / SCAR



Appendix 14a International Consultation Incontinence Questionnaire – Urinary incontinence (ICIQ – UI)

Initial number

ICIQ-UI Short Form

CONFIDENTIAL

DAY MONTH YEAR

Today's date

Many people leak urine some of the time. We are trying to find out how many people leak urine, and how much this bothers them. We would be grateful if you could answer the following questions, thinking about how you have been, on average, over the PAST FOUR WEEKS.

1 Please write in your date of birth: DAY MONTH YEAR

2 Are you *(tick one)*: Female ☐ Male ☐

3 How often do you leak urine? *(Tick one box)*

never ☐	0
about once a week or less often ☐	1
two or three times a week ☐	2
about once a day ☐	3
several times a day ☐	4
all the time ☐	5

4 We would like to know how much urine <u>you think</u> leaks.
How much urine do you <u>usually</u> leak (whether you wear protection or not)?
(Tick one box)

none ☐	0
a small amount ☐	2
a moderate amount ☐	4
a large amount ☐	6

5 Overall, how much does leaking urine interfere with your everyday life?
Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**
not at all — a great deal

ICIQ score: sum scores 3+4+5 ☐☐

6 When does urine leak? *(Please tick all that apply to you)*

never – urine does not leak	☐
leaks before you can get to the toilet	☐
leaks when you cough or sneeze	☐
leaks when you are asleep	☐
leaks when you are physically active/exercising	☐
leaks when you have finished urinating and are dressed	☐
leaks for no obvious reason	☐
leaks all the time	☐

Thank you very much for answering these questions.

Appendix 14b International Consultation Incontinence Questionnaire – Vaginal Symptoms

☐☐ ☐☐ ☐☐ ☐☐☐ ICIQ-VS 10/05

Initial number **CONFIDENTIAL**

VAGINAL SYMPTOMS QUESTIONNAIRE

Many people experience vaginal symptoms some of the time. We are trying to find out how many people experience vaginal symptoms, and how much they bother them. We would be grateful if you could answer the following questions, thinking about how you have been, on average, over the PAST FOUR WEEKS.

Please write in today's date: ☐☐ DAY ☐☐ MONTH ☐☐ YEAR

Please write in your date of birth: ☐☐ DAY ☐☐ MONTH ☐☐ YEAR

Vaginal symptoms

1a. Are you aware of dragging pain in your lower abdomen?

never ☐ 0
occasionally ☐ 1
sometimes ☐ 2
most of the time ☐ 3
all of the time ☐ 4

1b. How much does this bother you?
Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**
not at all — a great deal

2a. Are you aware of soreness in your vagina?

never ☐ 0
occasionally ☐ 1
sometimes ☐ 2
most of the time ☐ 3
all of the time ☐ 4

2b. How much does this bother you?
Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**
not at all — a great deal

3a. **Do you feel that you have reduced sensation or feeling in or around your vagina?**

not at all ☐ 0
a little ☐ 1
somewhat ☐ 2
a lot ☐ 3

3b. **How much does this bother you?**
Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**
not at all — a great deal

Prolapse is a common condition affecting the normal support of the pelvic organs, which results in descent or 'dropping down' of the vaginal walls and/or the pelvic organs themselves. This can include the bladder, the bowel and the womb. Symptoms are usually worse on standing up and straining (e.g. lifting, coughing or exercising) and usually better when lying down and relaxing.

Prolapse may cause a variety of problems. We are trying to find out how many people experience prolapse, and how much this bothers them. We would be grateful if you could answer the following questions, thinking about how you have been, on average, over the PAST FOUR WEEKS.

4a. **Do you feel that your vagina is too loose or lax?**

not at all ☐ 0
a little ☐ 1
somewhat ☐ 2
a lot ☐ 3

4b. **How much does this bother you?**
Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**
not at all — a great deal

5a. **Are you aware of a lump or bulge coming down in your vagina?**

never ☐ 0
occasionally ☐ 1
sometimes ☐ 2
most of the time ☐ 3
all of the time ☐ 4

5b. **How much does this bother you?**
Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**
not at all — a great deal

6a. **Do you feel a lump or bulge come out of your vagina, so that you can feel it on the outside or see it on the outside?**

never ☐ 0
occasionally ☐ 1
sometimes ☐ 2
most of the time ☐ 3
all of the time ☐ 4

6b. **How much does this bother you?**
Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**
not at all — a great deal

7a. **Do you feel that your vagina is too dry?**

never ☐ 0
occasionally ☐ 1
sometimes ☐ 2
most of the time ☐ 3
all of the time ☐ 4

7b. **How much does this bother you?**
Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**
not at all — a great deal

8a. **Do you have to insert a finger into your vagina to help empty your bowels?**

never ☐ 0
occasionally ☐ 1
sometimes ☐ 2
most of the time ☐ 3
all of the time ☐ 4

8b. **How much does this bother you?**
Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**
not at all — a great deal

9a. **Do you feel that your vagina is too tight?**

never ☐
occasionally ☐
sometimes ☐
most of the time ☐
all of the time ☐

9b. **How much does this bother you?**
Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**
not at all — a great deal

Sexual matters

We would be grateful if you could answer the following questions, thinking about how you have been, on average, over the PAST FOUR WEEKS.

10. Do you have a sex life at present?

yes ☐ 1
no, because of my vaginal symptoms ☐ 0
no, because of other reasons ☐ 2

If NO, please go to question 14

11a. Do worries about your vagina interfere with your sex life?

not at all ☐ 0
a little ☐ 1
somewhat ☐ 2
a lot ☐ 3

11b. How much does this bother you?

Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**
not at all — a great deal

12a. Do you feel that your relationship with your partner is affected by vaginal symptoms?

not at all ☐ 0
a little ☐ 1
somewhat ☐ 2
a lot ☐ 3

12b. How much does this bother you?

Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**
not at all — a great deal

13. How much do you feel that your sex life has been spoilt by vaginal symptoms?

Please ring a number between 0 (not at all) and 10 (a great deal)

0 1 2 3 4 5 6 7 8 9 **10**
not at all — a great deal

Quality of life

We would be grateful if you could answer the following questions, thinking about how you have been, on average, over the PAST FOUR WEEKS.

14. Overall, how much do vaginal symptoms interfere with your everyday life?

Please ring a number between 0 (not at all) and 10 (a great deal)

0	1	2	3	4	5	6	7	8	9	**10**
not at all										a great deal

Thank you very much for answering these questions.

VAGINAL SYMPTOMS QUESTIONNAIRE

SCORING

(This section is for administrative use only)

Patient number

Vaginal symptoms score

Vaginal symptom score = 2×(dragging pain) + 2×(soreness in vagina) + (reduced sensation) + 2×(vagina too loose) + 2×(lump felt inside) + 2×(lump seen outside) + 2×(vagina too dry) + (faecal evacuation)

symptom*	score	weighted score
Q1. 'dragging pain'		x 2 =
Q2. 'soreness in vagina'		x 2 =
Q3. 'reduced sensation'		x 1 =
Q4. 'vagina too loose'		x 2 =
Q5. 'lump felt inside'		x 2 =
Q6. 'lump seen outside'		x 2 =
Q7. 'vagina too dry'		x 2 =
Q8. 'faecal evacuation'		x 1 =
Total vaginal symptoms score		

*(Note: Q9, 'vagina too tight', is primarily for detecting a potential post-treatment complication and is therefore not included in the scoring)

Sexual matters score

Sexual matters score = (sex-life spoilt) + 8×(worries about vagina interfere with sex-life) + 8×(relationship affected)

sexual matter	score	weighted score
Q11. 'worries about vagina interfere with sex-life'		x 8 =
Q12. 'relationship affected'		x 8 =
Q13. 'sex life spoilt'		x 1 =
Total sexual matters score		

Quality of life score

quality of life	score
Q14. 'quality of life affected'	

Appendix 14c Pelvic Floor Distress Inventory

Center for Female Continence PFDI-20

PT INITIALS_____**DOB**_____**DATE**_____
I.D. Number_____ **Research Site**_____

Pre ☐, 3 mo☐, 6mo☐, 12 mo☐, 24 mo☐, 36 mo☐, 60 mo☐

POPDI-6

1. Usually experience *pressure* in the lower abdomen?

☐ No ☐ Yes If yes, how much does it bother you?
Not at all Somewhat Moderately Quite a bit
☐ ☐ ☐ ☐ Score

2. Usually experience *heaviness or dullness* in the pelvic area?

☐ No ☐ Yes If yes, how much does it bother you?
Not at all Somewhat Moderately Quite a bit
☐ ☐ ☐ ☐ Score

2. Usually have a bulge or something falling out that you can see or feel in your vaginal area?

☐ No ☐ Yes If yes, how much does it bother you?
Not at all Somewhat Moderately Quite a bit
☐ ☐ ☐ ☐ Score

3. Ever have to push on the vagina or around the rectum to have or complete a bowel movement?

☐ No ☐ Yes If yes, how much does it bother you?
Not at all Somewhat Moderately Quite a bit
☐ ☐ ☐ ☐ Score

4. Usually experience a feeling of incomplete bladder emptying?

☐ No ☐ Yes If yes, how much does it bother you?
Not at all Somewhat Moderately Quite a bit
☐ ☐ ☐ ☐ Score

6. Ever have to push up on a bulge in the vaginal area with your fingers to start or complete urination?

☐ No ☐ Yes If yes, how much does it bother you?
Not at all Somewhat Moderately Quite a bit
☐ ☐ ☐ ☐ Score

POPDI-6 Total **x 25 =**

PFDI-20

P.I._____ **DOB**_____ **D ate**_____

CRADI-8

7. Feel you need to strain too hard to have a bowel movement?
☐ No ☐ Yes If yes, how much does it bother you?
Not at all Somewhat Moderately Quite a bit
☐ ☐ ☐ ☐ Score

8. Feel you have not completely emptied your bowels at the end of a bowel movement?
☐ No ☐ Yes If yes, how much does it bother you?
Not at all Somewhat Moderately Quite a bit
☐ ☐ ☐ ☐ Score

9. Usually lose stool beyond your control if your stool is well formed?
☐ No ☐ Yes If yes, how much does it bother you?
Not at all Somewhat Moderately Quite a bit
☐ ☐ ☐ ☐ Score

10. Usually lose stool beyond your control if your stool is loose?
☐ No ☐ Yes If yes, how much does it bother you?
Not at all Somewhat Moderately Quite a bit
☐ ☐ ☐ ☐ Score

11. Usually lose gas from the rectum beyond your control?
☐ No ☐ Yes If yes, how much does it bother you?
Not at all Somewhat Moderately Quite a bit
☐ ☐ ☐ ☐ Score

12. Usually have pain when you pass your stool?
☐ No ☐ Yes If yes, how much does it bother you?
Not at all Somewhat Moderately Quite a bit
☐ ☐ ☐ ☐ Score

13. Experience a strong sense of urgency and have to rush to the bathroom to have a bowel movement?
☐ No ☐ Yes If yes, how much does it bother you?
Not at all Somewhat Moderately Quite a bit
☐ ☐ ☐ ☐ Score

14. Does par of your bowel ever bulge outside the rectum during or after a bowel movement?☐ No ☐ Yes If yes, how much does it bother you?
Not at all Somewhat Moderately Quite a bit Score
☐ ☐ ☐ ☐

CRADI-8 Total x 25=

UDI-6

15. Usually experience frequent urination?

☐ No ☐ Yes If yes, how much does it bother you?

Not at all	Somewhat	Moderately	Quite a bit	
☐	☐	☐	☐	Score

16. Usually experience urine leakage associated with a feeling of urgency, i.e. i.e. a strong sensation of needing to go to the bathroom?

☐ No ☐ Yes If yes, how much does it bother you?

Not at all	Somewhat	Moderately	Quite a bit	
☐	☐	☐	☐	Score

17. Usually experience urine leakage with coughing, laughing, or sneezing?

☐ No ☐ Yes If yes, how much does it bother you?

Not at all	Somewhat	Moderately	Quite a bit	
☐	☐	☐	☐	Score

18. Usually experience small amounts of urine leakage (small drops of urine)?

☐ No ☐ Yes If yes, how much does it bother you?

Not at all	Somewhat	Moderately	Quite a bit	
☐	☐	☐	☐	Score

19. Usually experience difficulty emptying your bladder?

☐ No ☐ Yes If yes, how much does it bother you?

Not at all	Somewhat	Moderately	Quite a bit	
☐	☐	☐	☐	Score

20. Usually experience *pain or discomfort* in the lower abdomen or genital region?

☐ No ☐ Yes If yes, how much does it bother you?

Not at all	Somewhat	Moderately	Quite a bit	
☐	☐	☐	☐	Score

UDI-6 Total **x 25 =**

Scale scores: Obtain the mean value of all of the answered items within the corresponding scale (possible value 0 – 4) and then multiply by 25 to obtain the scale score (range 0 – 100). Missing items are dealt with by using the mean from answered items only.

PFDI-20 Summary Score: Add the scores from the 3 scales together to obtain the summary score (range 0 – 100).

POPDI-6 _____
CRADI-8 _____
UDI-6 _____

PFDI-20 SCORE _____

Appendix 14d Pelvic Floor Impact Questionnaire

Pelvic Floor Impact Questionnaire - Short Form 7

Some women find that bladder, bowel or vaginal symptoms affect their activities, relationships, and feelings. For each question, place an X in the response that best describes how much your activities, relationships or feelings have been affected by your bladder, bowel or vaginal symptoms or conditions over the last 3 months. Please be sure to mark an answer in all 3 columns for each question. Thank you for your cooperation.

How do symptoms or conditions related to the following ~~~~~➢ usually affect your ➘	**Bladder or urine**	**Bowel or rectum**	**Vagina or pelvis**
1. ability to do household chores (cooking, housecleaning, laundry)?	☐Not at all ☐Somewhat ☐Moderately ☐Quite a bit	☐Not at all ☐Somewhat ☐Moderately ☐Quite a bit	☐Not at all ☐Somewhat ☐Moderately ☐Quite a bit
2. ability to do physical activities such as walking, swimming, or other exercise?	☐Not at all ☐Somewhat ☐Moderately ☐Quite a bit	☐Not at all ☐Somewhat ☐Moderately ☐Quite a bit	☐Not at all ☐Somewhat ☐Moderately ☐Quite a bit
3. entertainment activities such as going to a movie or concert?	☐Not at all ☐Somewhat ☐Moderately ☐Quite a bit	☐Not at all ☐Somewhat ☐Moderately ☐Quite a bit	☐Not at all ☐Somewhat ☐Moderately ☐Quite a bit
4. ability to travel by car or buss for a distance greater than 30 minutes away from home?	☐Not at all ☐Somewhat ☐Moderately ☐Quite a bit	☐Not at all ☐Somewhat ☐Moderately ☐Quite a bit	☐Not at all ☐Somewhat ☐Moderately ☐Quite a bit
5. participating in social activities outside your home?	☐Not at all ☐Somewhat ☐Moderately ☐Quite a bit	☐Not at all ☐Somewhat ☐Moderately ☐Quite a bit	☐Not at all ☐Somewhat ☐Moderately ☐Quite a bit
6. emotional health (nervousness, depression, etc.)?	☐Not at all ☐Somewhat ☐Moderately ☐Quite a bit	☐Not at all ☐Somewhat ☐Moderately ☐Quite a bit	☐Not at all ☐Somewhat ☐Moderately ☐Quite a bit
7. feeling frustrated?	☐Not at all ☐Somewhat ☐Moderately ☐Quite a bit	☐Not at all ☐Somewhat ☐Moderately ☐Quite a bit	☐Not at all ☐Somewhat ☐Moderately ☐Quite a bit

Appendix 15 Request letter for MRI

Researcher : Maeve Whelan SMISCP
Milltown Physiotherapy
98 Lower Churchtown Road
Dublin 14
maevewhelan@rcsi.ie
01 2960603

Study Supervisor: Louise Keating
S chool of Physiotherapy, RCSI
121 St. Stephen's Green
D ublin 2
l keating@rcsi.ie
01 4022259

Euromedic
Dundrum
Dublin 14

INSERT DATE

RE: A study to evaluate the effect of manual therapy and exercise on the levator plate in women with pelvic organ prolapse

Patient Name:
DOB:
Tel:

To Whom It May Concern,

Please arrange an axial and sagittal pelvic scan for PATIENT NAME with reference to the above named study. I confirm that through the coordination of John Kelleher I have correspondance from Dr. Sam Hamilton stating that a doctor's referral for the patient will not be necessary. Kolbe Mooney is aware of the study and has a specific protocol for procedure and has undertaken to be the radiographer of all scans in association with this study. Payment in full will be made by myself in respect of this scan.

Many thanks,

_____
Maeve Whelan
Specialist Chartered Physiotherapist

Appendix 16 MRI Safety Questionnaire

MRI Safety Questionnaire

Patient's Name Mobile Number *or* Phone Number	Date of Birth: ☐☐☐☐☐☐ **Patient's Weight** *(required for scan acquisition please specify kilos or stones)*:

NB: Please inform a radiographer if you answer 'yes' to any of the following questions.

	YES	NO
Have you ever had surgery on your heart? **Type:**	☐	☐
Do you have a **CARDIAC PACEMAKER** or artificial heart valve?	☐	☐
Have you had surgery on your brain or head? **Type:**	☐	☐
Have you had aneurysm clips inserted to stop a bleed in the brain or elsewhere?	☐	☐
Have you had an eye or ear (cochlear) implant?	☐	☐
Have you ever had metal fragments in your eyes?	☐	☐
Have you any replacement joints or metal implants/plates/clips?	☐	☐
Do you have any dentures/dental plate?	☐	☐
Do you have any shrapnel (metal fragments) from an injury?	☐	☐
Do you have a hearing aid in at the moment?	☐	☐
Do you suffer from epilepsy or have you recently had a fit?	☐	☐
Do you have a spinal or pain stimulator?	☐	☐
Do you have tattoos or body piercings or a medicated skin patch?	☐	☐
Do you have an artificial limb/caliper/brace?	☐	☐
NECK/BACK/SPINE MRI PATIENTS: Have you ever had surgery on your spine?	☐	☐
If yes: **Type:** **When?**		
Do you give your consent should an injection of MRI contrast be required? This may be required to enhance the clarity of your images. Please ask the Radiographer to explain this further to you should an injection be required	☐	☐
Do you have asthma?	☐	☐
Do you suffer from renal disease?	☐	☐
Do you have diabetes?	☐	☐
Do you have any allergies?	☐	☐
If yes, name:		
FEMALE PATIENTS: Could you be pregnant?	☐	☐

I am aware that Euromedic Ireland may request previous images and reports.

Patient's Signature: _____

Date: _____

Radiographer's Signature: _____ **Comments:** _____

While waiting for your scan please remove all loose metal objects from your person including the following: All jewelry, watch, earrings, hairclips, wallets/coins/bank cards, keys, hearing aid, mobile phones and please switch off your mobile phone.

----------OFFICE USE ONLY----------

eGFR_____ml/min/1.73m2 Creatininelevel_____µmol/l Taken by:_____

Appendix 17 MRI Data Sheet

	T2 sag filtered/Trufi	LPA	ARA	BL	CX	H Line	M Line
Ref 01	5003IMA12-14						
Ref 02	5006IMA12						
Ref 03	5007IMA10-13						
Ref 04	5006IMA13-16						
Ref 05	5005IMA12						
	(T2Trufi IMA11)						
Ref06	5006IMA12-14						
Ref 07	5003IMA12						
Ref08	5006IMA12						
Ref09	5005IMA13-14						
	(Trufi 2IMA11)						
Ref10	5008IMA 12-14						

Appendix 18 Physiotherapy Treatment Record Sheet

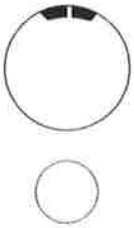
NAME & DATE:

Prolapse	Ant wall	Uterus	Post wall
Prolapse at rest			
Prolapse on strain			

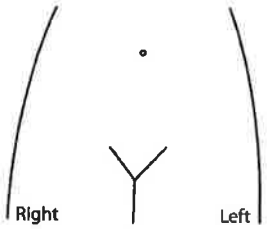
Tone	Nomo R L	Hypo R L	Hyper R L	Taut R L	Gaps R L
Superficial					
Deep					

		Right		Le ft	
Pelvic Floor Muscles		Grade	% Release	Grade	% Release
Instruction	Superficial				
	Deep				

Vertical



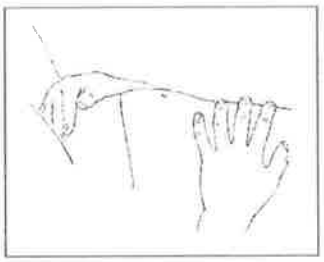
Horizontal



Treatment :

Appendix 19 Sniff Flop & Drop Patient Hand Out

Sniff, Flop and Drop



Correct

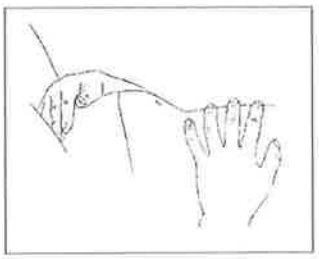
SNIFF in through the nose

FLOP, swell or fill out your soft stomach

DROP, release or open at the back passage – backwards

Do all three at exactly the same time
Try to feel that the sniff-in connects with the pelvic floor and helps to let go.
The less effort the better the connection will be
Stay on the in-breath for 3 seconds keeping the stomach soft
Exhale with a soft 'hah' as if cleaning your spectacles

Keep doing this for 5-10 minutes (as long as you can stay focused), lying on your back with your knees bent , or with two pillows under your knees or lying on your side.



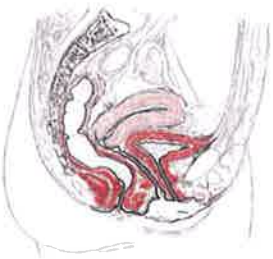
Incorrect

DON'T brace, hold or force your upper abdomen
DON'T push down with the ribs
DON'T try too hard
DON'T lift your chest

Appendix 20 Contract / Relax Patient Hand out

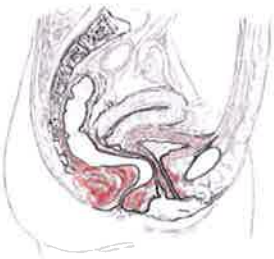
Contract / Relax

Relaxed



Before you start contracting the pelvic floor you must make sure it is first completely relaxed. Look at the diagram here and see th e difference between relaxed and contracted below

Contraction



Breathe out before you start to make sure that your lungs are empty

Squeeze the pelvic floor in isolation, think of the back passage coming in from the back up towards the front

Make sure you don't lift your chest

Hold the back passage for 5 seconds

Drop it backwards completely

Finish then with sniff flop and drop to let go completely

Repeat this 10 times after you have finished your sniff, flop and drop exercise

PLUS do **TWO** more sets of .....reps of .....secs per day

Appendix 21 Exercise Progression

Exercise Progression
Try to do your exercises 3 times per day:

- Once per day do your breathing exercise and 10 reps of your contract/relax exercise
- Two more times per day do 10 reps of your contract/relax exercise.
- The breathing exercise must be done in the lying down position and one set of 10 reps done in this position also at the start of any program.
- The other two sets of 10 reps can be done in any position, lying, sitting or standing if able.

You should only progress your pelvic floor exercises once you are able to both contract and then completely release your pelvic floor. The focus remains on the release rather than further strengthening until this has been practiced. This may take a few weeks

Stage 1:
Exhale before you start
Contract in isolation , hold x 5 secs, release in isolation, sniff flop and drop to complete

Stage 2:
Exhale before you start
Contract in isolation, hold while you breathe in and out once
Keep contracting into the end of range while you finish your out-breath
Drop in isolation
Sniff flop and drop to complete

Stage 3:
Exhale before you start
Contract in isolation,
Keep holding hold while you breathe in and out for 10 seconds
Keep contracting into the end of range while you finish your last out-breath
Drop in isolation
Sniff flop and drop to complete

Do 10 reps at a time
Three times per day
To progress this practice your exercises in sitting or standing instead of lying down

Strengthening:
Exhale before you start
Contract in isolation right into the end of range
Reinforce 5 times
Don't breathe as this is done very quickly
Drop in isolation
Sniff flop and drop to complete
Repeat 5 times

Progress lying to siting to standing

Endurance:
The number of seconds that you hold for as well as the number of repetitions and the number of sets can be increased. The stage you are at depends on your most recent assessment. And your physiotherapist will advise you
Further progression may include practicing challenging activities with bladder empty and then with the bladder a little fuller. You can practice coughing with your spine in the correct, neutral position.

Appendix 22 Home Exercise Diary

A study to evaluate the effect of manual therapy and exercise on the levator plate in women with pelvic organ prolapse

Exercise Diary

Do your exercises 3 times per day. Once per day do your breathing exercise (Sniff, Flop & Drop) and 10 reps of your Contract / Relax exercise and 2 more times per day do 10 reps of your Contract / Relax exercise. The breathing exercise must be done in the lying down position and one set of 10 reps done in this position also. The other two sets of 10 reps can be done in any position, lying, sitting or standing.

Date	Contract /Relax (Completed sets)	Sniff, Flop & Drop (Completed sessions)	Comment

Appendix 23 Lifestyle Advice Sheet

A study to evaluate the effect of manual therapy and exercise on the levator plate in women with pelvic organ prolapse

Lifestyle Advice Sheet

Prolapse can be related to daily activities. Increases in intra-abdominal pressure can contribute to or even worsen symptoms of pelvic organ prolapse. If you follow some of the small changes below it may have a positive effect on your symptoms.

Weight

If you feel you are overweight it may help to lose a few pounds. Your body works harder to carry excessive weight and this can result in more pressure on the pelvic floor. Increased weight may also reduce the contractility of the muscles when performing strengthening exercises.

Constipation

Regular straining of the bowels may make prolapse symptoms worse. It is important to have a balanced diet and to drink 1.5 – 2 litres of fluid every day. This should not include fizzy drinks. If you think you are constipated despite a good diet then you may need some laxatives. Please ask for advice on laxatives if you feel you need them. Remember your 'defecation dynamic' technique.

Heavy Lifting

Heavy lifting should be avoided. Try to modify your life style to ensure that you are not regularly lifting heavy loads such as toddlers, shopping, performing household chores and gardening. In the diagram overleaf you can see how the woman maintains a long sternal bone to coccyx when bending forwards. This can be practiced and then carried into activity where this long front is maintained while bending at the knees whenever lifting.

Coughing

Whenever you are coughing you should try to maintain this length between the pubic and sternal bone. This is also maintaining a pelvic neutral position. This will prevent the intra-abdominal pressure from loading the pelvic floor as much. When either lifting or coughing draw in your pelvic floor muscles just before you cough to provide extra support to the neck of the bladder and to the other pelvic organs, this is described as 'the knack'.

Flex at the hips to maintain long torso and bend knees when lifting.

Maintain pelvic neutral when coughing.

Posture

It is important NOT to hold on to your tummy all the time thinking that you are helping the pelvic floor. A braced tummy is more likely to negatively load the pelvic floor than to help support it. A tense tummy often leads to a negatively tensed pelvic floor rather than a flexible, supportive pelvic floor. Maintaining length through your body with a very gentle drawing in action of the lower tummy (only 25% of the action of the corset muscle) is best. The pelvic floor will be doing enough if you do this.

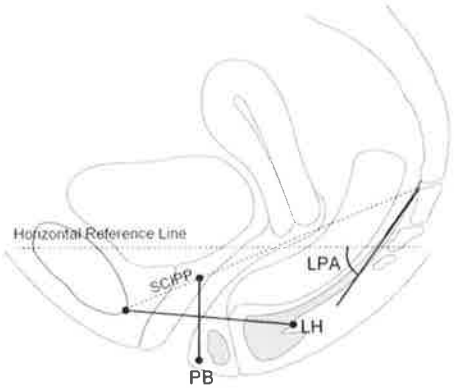
Exercise

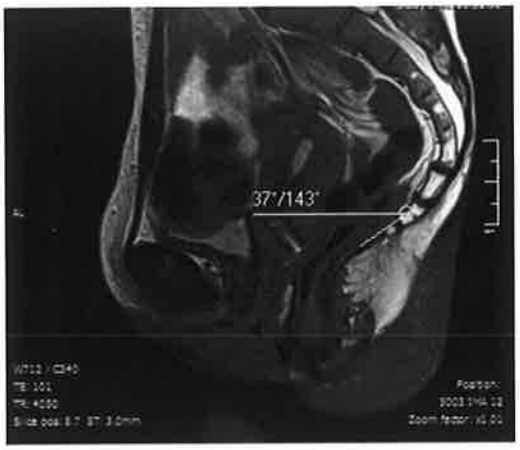
Regular exercise is good for you and you should **not** avoid it just because of your prolapse. Try to get out for 3 walks per week. Maintain a tall posture lifting gently with your sternal bone, keeping your arms slightly flexed close to your body in running style and rotating your upper body on your lower body. This will help maintain length through your body and stops you from loading your pelvic floor when you are walking.

Appendix 24 Pdf of MRI Measurements

Levator Plate Angle (LPA)

A best-fit line is placed through the levator plate at the initial take off portion of the iliococcygeus from the coccyx. The angle between this and a horizontal reference line is measured as the levator plate angle

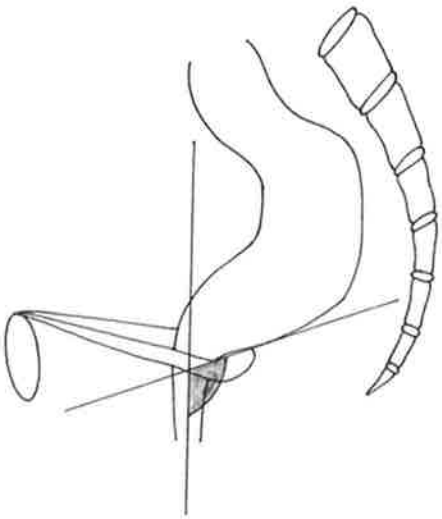


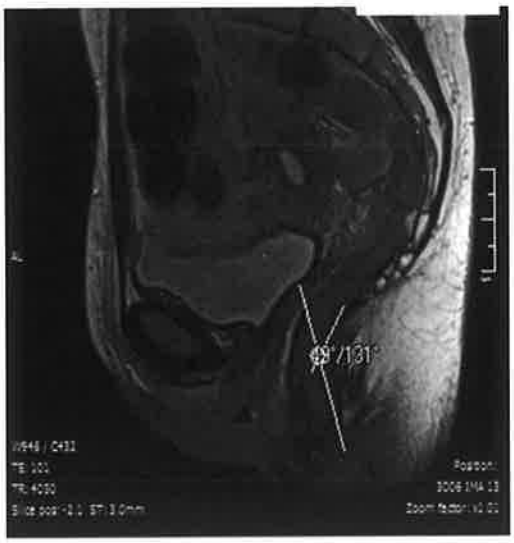


Hsu et al. (2006)

Anorectal angle (ARA)

The anorectal junction is the apex of the anorectal angle. The anorectal angle is defined as the point of taper of the posterior border of the distal part of the rectum as it meets the central axis of the anal canal. It corresponds to the posterior impression of the transition between puborectal muscle and levator plate, and represents the point of reference for posterior compartment descent. The anorectal angle normally measures between 108° and 127° at rest. (Colaiacomo et al. 2009)

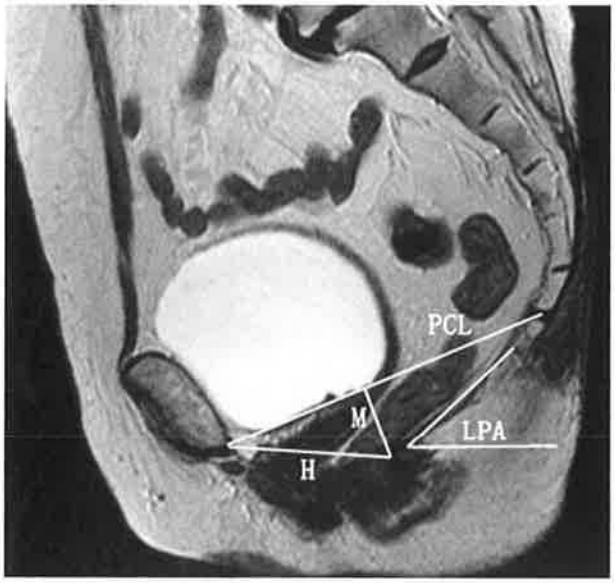




Colaiacomo et al. (2009)

Pubococcygeal Line (PCL)

The PCL is drawn from the inferior border of the pubic symphysis to the last coccygeal joint (Colaiacomo et al. 2009; Comiter et al. 1999; Ansquer et al. 2006; Song et al. 2009; Ginath et al. 2011)

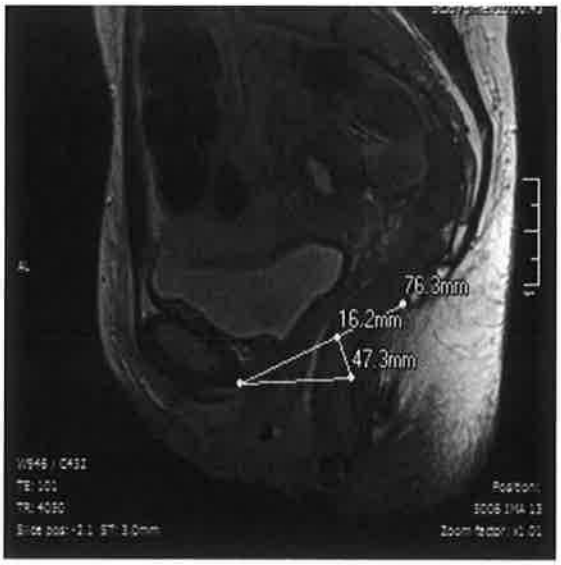


Song et al. (2009)

H & M lines

The H line corresponds to the antero-posterior width of the levator hiatus and is drawn from the inferior border of the pubic symphysis to the posterior wall of the rectum at the level of the anorectal junction.

The M line is a vertical line drawn perpendicularly from the PCL to the most posterior aspect of the H line and represents the vertical descent of the levator hiatus. Normally, the H and M lines should not exceed 5 cm and 2 cm in length, respectively (Comiter 1999, Fielding 2003, Colaiacomo 2009

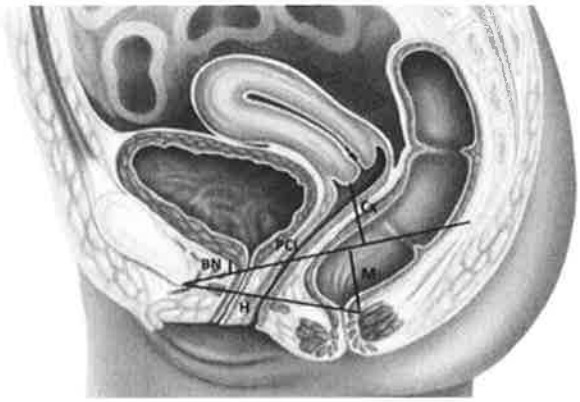


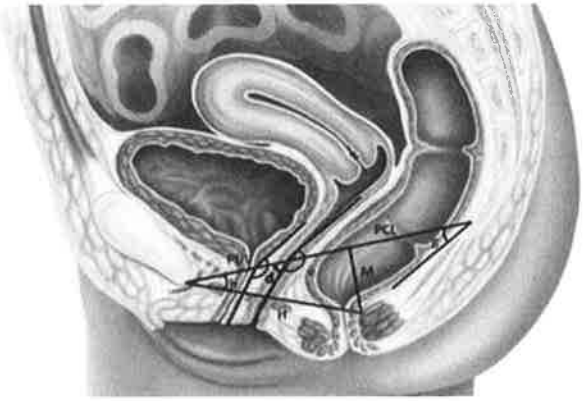
Bladder neck

A perpendicular line from the most inferior border of the bladder to the PCL
Ansquer et al. (2006); Song et al. (2009); Ginath et al. (2011)

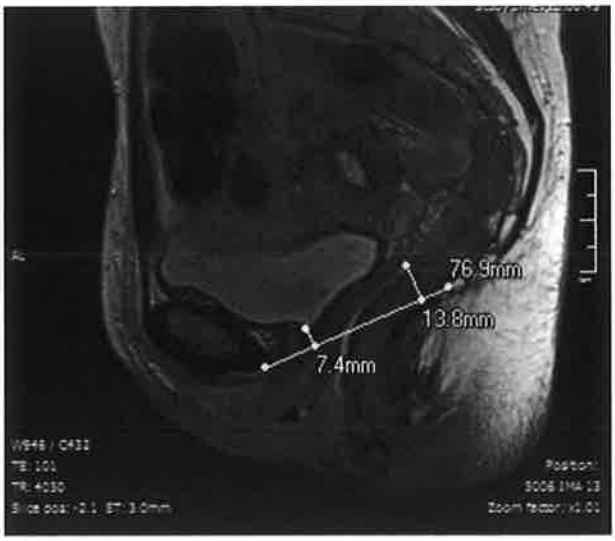
Cervix

A perpendicular line between the most inferior border of the uterine cervix to the PCL
Ansquer et al. (2006); Song et al. (2009); Ginath et al. (2011)



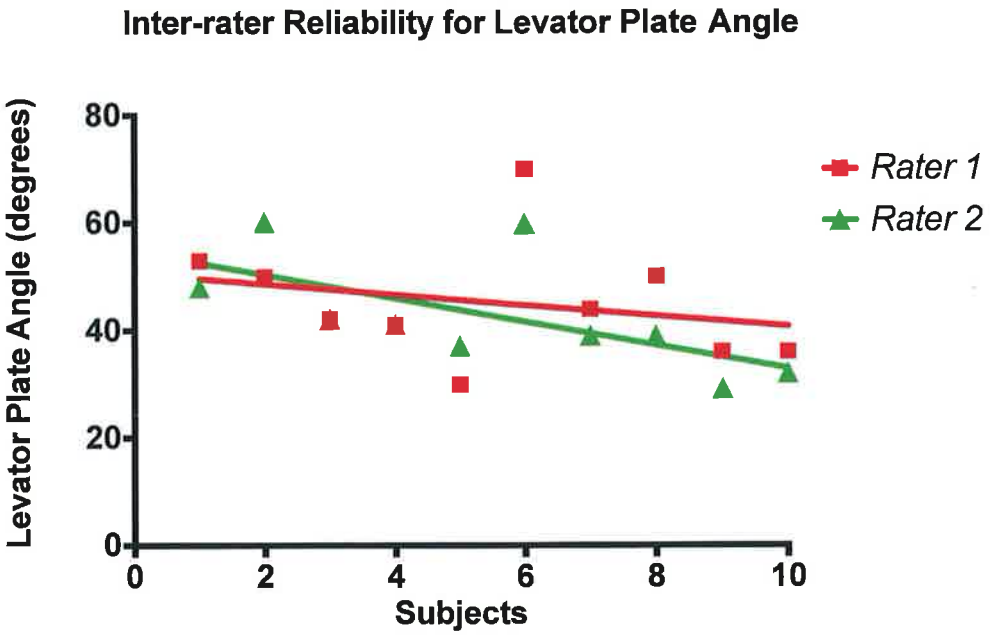


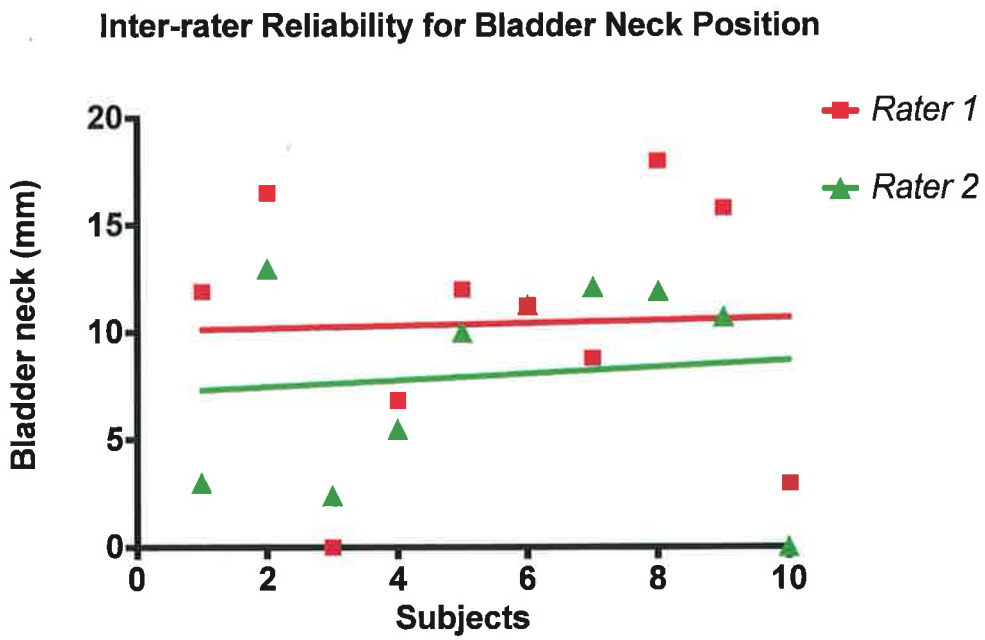
Ginath et al. (2011)

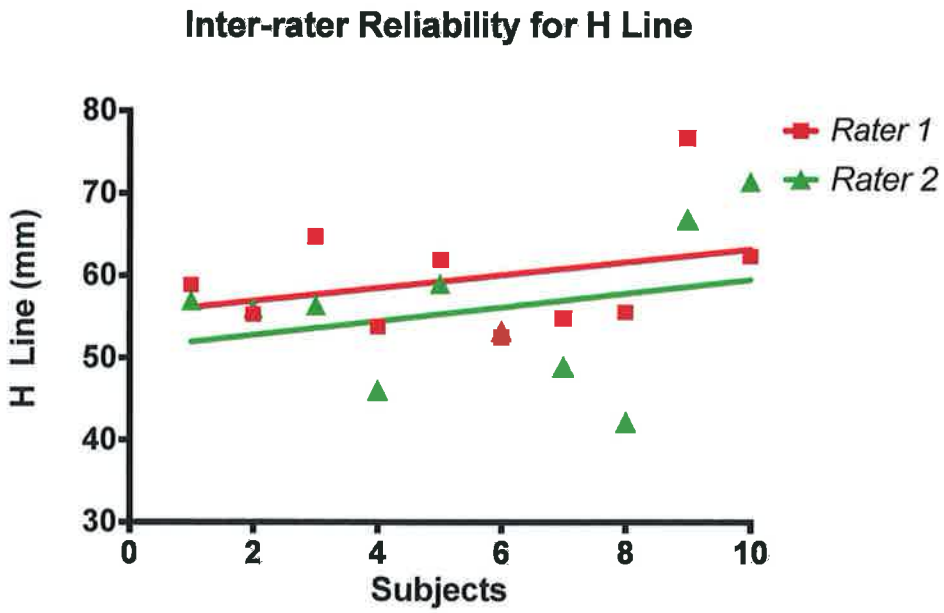


Where the tip of the cervix was not visible on the same image as the PCL the images were scrolled the cervix was marked and then referred back to the PCL

Appendix 25 Inter-rater reliability plots of MRI measurements for Rater 1 & Rater 2






Inter-rater Reliability for H Line
H Line (mm)
80
70
60
50
40
30
0
2
4
6
8
10
Subjects
Rater 1
Rater 2