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Mechanical Biofeedback for Treatment of Female Urinary Incontinence

Rhonda J. Salentiny
University of North Dakota

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MECHANICAL BIOFEEDBACK FOR TREATMENT
OF FEMALE URINARY INCONTINENCE

by



Rhonda J. Salentiny
Bachelor of Science in Physical Therapy
University of North Dakota, 1996

An Independent Study

Submitted to the Graduate Faculty of the

Department of Physical Therapy

School of Medicine

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in partial fulfillment of the requirements

for the degree of

Master of Physical Therapy

Grand Forks, North Dakota

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1997

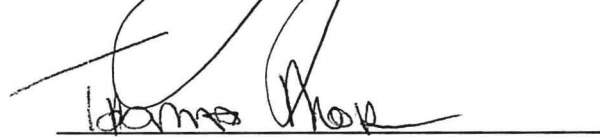
This Independent Study, submitted by Rhonda J. Salentiny in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.



(Faculty Preceptor)



(Graduate School Advisor)



(Chairperson, Physical Therapy)

PERMISSION

Title Treatment of Female Urinary Incontinence with
Mechanical Biofeedback

Department Physical Therapy

Degree Master of Physical Therapy

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ABSTRACT

Urinary incontinence (UI), the involuntary loss of urine so severe as to have social and/or hygienic consequences, is becoming a medical diagnosis for which patients are referred to physical therapy. It is estimated that between 10 and 12 million American adults suffer from UI. Conservative treatment including physical therapy is sought for UI because of its superior cure rate compared to surgical intervention.

The purpose of this study is to educate its readers on the types, anatomy, physiology, and conservative treatments of UI. Most importantly, however, is the understanding of how pelvic floor exercises (PFE) with use of mechanical biofeedback decrease UI, enhance patient motivation and provide objective data. Biofeedback provides patient motivation through visual and auditory means. It also helps the essential isolation of the pelvic floor muscles and cues unwanted substitution of muscles.

Awareness of the benefits of conservative treatment will result in an increased number of patients referred to physical therapy. This paper will be a guide for the practicing clinician in the management and treatment of female urinary incontinence.

CHAPTER 1

INTRODUCTION

*"Conservative management of urinary incontinence is the wave of the future"*¹ Conservative management of urinary incontinence (UI) has been slow to catch on in the United States as it has not been stressed in academic teaching centers.² Because patients are beginning to become more willing to participate in their health care, more physicians, especially gynecologists, are including the conservative management of UI in their options offered to the patient. The use of pelvic floor physical therapy as an initial alternative to surgery is well documented.²⁻⁹ It is also becoming increasingly popular because the use of pelvic floor physical therapy is less costly both financially and physiologically, and second party payers are beginning to reimburse for conservative management of urinary incontinence.¹⁰

Urinary incontinence is defined as the involuntary loss of urine, so severe as to have social and/or hygienic consequences.¹¹ It is estimated that between 10 and 20 million American adults suffer from urinary incontinence, exact figures are difficult to obtain because of the tremendous stigma and feelings of isolation that lead to underreporting by many patients.^{10,12,13} Most industrialized nations report prevalence rates from 8 to 51 percent in the general population with prevalence rates twice as high for women as for men. Yarnell et al² found that

45% of a community dwelling sample population reported urinary incontinence; 50% had stress incontinence, 20% had urge incontinence and 30% reported mixed symptoms.

Of community dwelling women with incontinence, it is estimated that at most one-half have consulted a physician. Norton et al¹¹ found that 60% of women in his study had waited to seek treatment for more than one year from the time their symptoms became severe. These women had been through numerous referrals. Half of these women said they waited to seek treatment because they were too embarrassed to discuss the problem with their physician, and 17% said they thought the condition was normal for their age.

It is generally accepted by women that incontinence is inevitable due to aging, childbirth, gender and menopause.^{2,14} Shepard⁹ found in her experiences that women in all parts of the world are affected by UI differently. She reports that women in southern Africa, Malaysia and Borneo (part of China) are rarely found to suffer from stress incontinence with 90 percent demonstrating adequate pelvic floor muscle strength. She attributes this to differences in lifestyle, voiding patterns and early education of pelvic floor exercises in later childhood. Women in the "Western" cultures tend to be overweight, smokers with a chronic cough, habitual coffee or tea drinkers (or other caffeinated beverages with such as soda pop), and do not squat while voiding but rather sit to void in a relaxed, uncontrolled manner. The latter is important because it takes a conscious effort for the individual to direct the urine stream into a hole in a controlled manner. Western women are also not taught pelvic floor awareness or exercises at a

young age due to Western societal idiosyncrasies such as the idea of “such talk is dirty or too embarrassing.” Certain types of urinary incontinence can then be construed as a self induced problem that can be corrected by changing societal views and educating our population.

Urinary incontinence also has a major financial impact on society in general with over eight billion dollars per year spent managing incontinence in the United States alone.^{14,15} Therefore, it is very beneficial for an individual socially, psychologically and financially to seek treatment for urinary incontinence.

It is the intent of this paper to provide a guideline for the use of biofeedback in an urinary incontinence treatment program. First, the anatomy and physiology of urinary incontinence will be addressed explaining the types of urinary incontinence, the basic organs and muscles involved, their functions, as well as the phases of urination along with their link to the central nervous system. Secondly, conservative treatment of urinary incontinence will be discussed: treatments a physical therapist may provide, drug management and a discussion of mechanical devices. Finally, there will be a synopsis of how mechanical biofeedback may enhance an urinary incontinence treatment program concentrating on advantages, disadvantages, cost, patient education and outcome studies on the effectiveness of biofeedback on urinary incontinence.

CHAPTER 2

ANATOMY AND PHYSIOLOGY OF URINARY INCONTINENCE

The awareness in our society of urinary incontinence has led people with urinary incontinence to be more frequently referred to physical therapists.²⁻⁹ Physicians, especially family practice physicians, are increasingly utilizing conservative treatment as an initial alternative to surgery. Physical therapy techniques have been documented as having a high success rate and, accordingly, it is indicated that the treatment of urinary incontinence by physical therapists will only continue to grow. Therefore, knowledge of the anatomy and physiology of structures associated with the pelvic region are important in order to understand urinary incontinence.

There are four basic types of incontinence: stress incontinence, urge incontinence, overflow incontinence and total incontinence.^{1,12,14} Stress incontinence is leakage of urine caused by a sudden increase in abdominal pressure and may occur with coughing, sneezing or laughing. It is associated with the relaxation of the pelvic floor muscles. This is illustrated in Figure 1. Urge incontinence is leakage of urine that develops suddenly after a person experiences the sensation of bladder fullness causing a severe urge to urinate. Urge incontinence is contributed to incompetent muscles of the internal sphincter or external sphincter of the urethra or of the detrusor muscle of the bladder wall

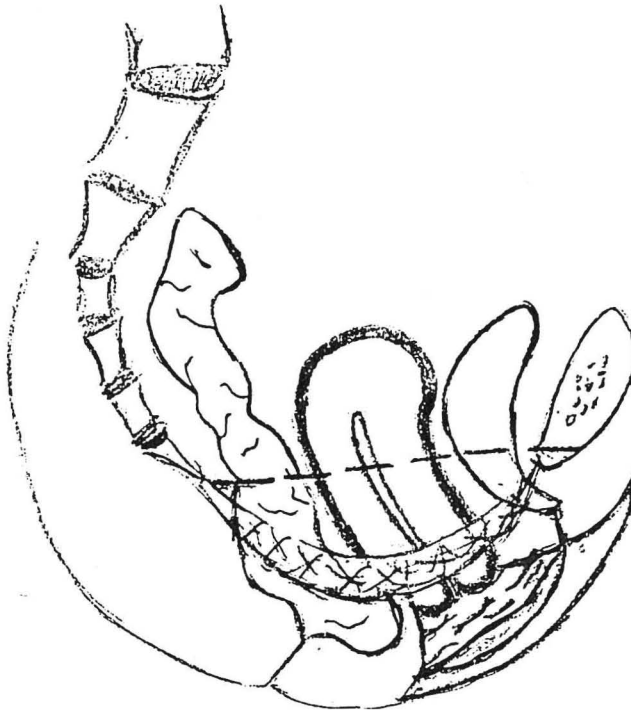
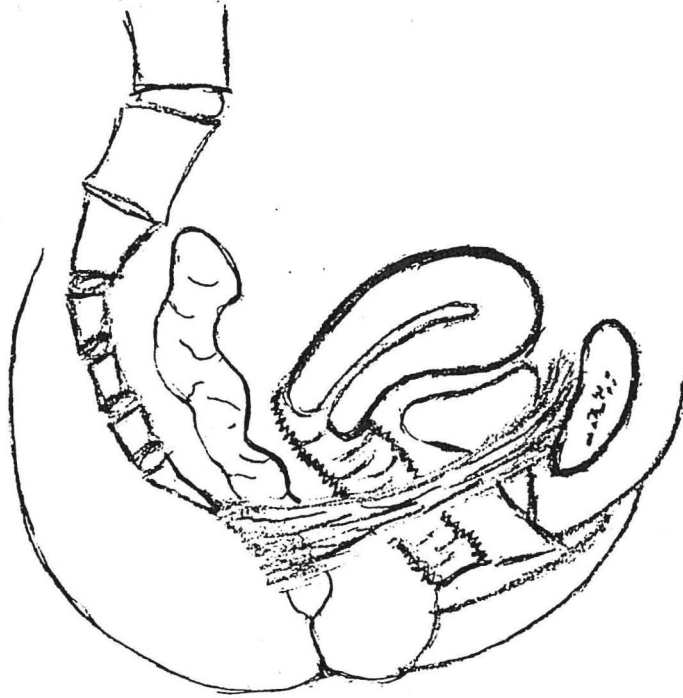


Fig. 1.--Top, The pelvic floor muscles are supporting the urinary bladder and other abdominal contents properly. Bottom, The pelvic floor muscles are relaxed and allowing the abdominal organs to prolapse as seen in stress UI.

(Figure 2). Overflow incontinence, fairly uncommon in women, is the dribbling of small amounts of urine, particularly with movement. Finally, total incontinence, a continuous drainage of urine, is relatively rare and can be secondary to a vesicovaginal fistula, an ectopic ureter draining directly in the vagina, or a completely incompetent sphincter. Incontinence may be one of the above or mixed incontinence, a combination of two or more types of urinary incontinence. Physical therapy is most helpful in treating stress incontinence and mixed incontinence made up of stress and urge incontinence. The literature also suggests that individuals with urge incontinence may benefit from physical therapy methods.

The basic organs and muscles associated with urinary incontinence includes the bladder, urethra, their sphincters and the pelvic floor muscles.^{2,16} Figures 3 - 5 provide an anatomical review. This is just a "shell" of the structures involved, the urogenital system is quite complex and beyond the scope of this paper. A full appreciation of the urogenital system requires an understanding of the anatomy of the perineal region. Functionally, the region is divided into the pelvic diaphragm (pelvic floor muscles) and the urogenital diaphragm. Tables 1 and 2 provide the reader with a review of the origin, insertion and action of the primary musculature involved with treatment of urinary incontinence.

The bladder and urethra act together in the process of storing and emptying urine.^{12,16} In the storage phase of urination, the bladder expands to accommodate a building supply of urine and is dependent upon a stable detrusor muscle in the bladder wall. The storage phase also requires a competent

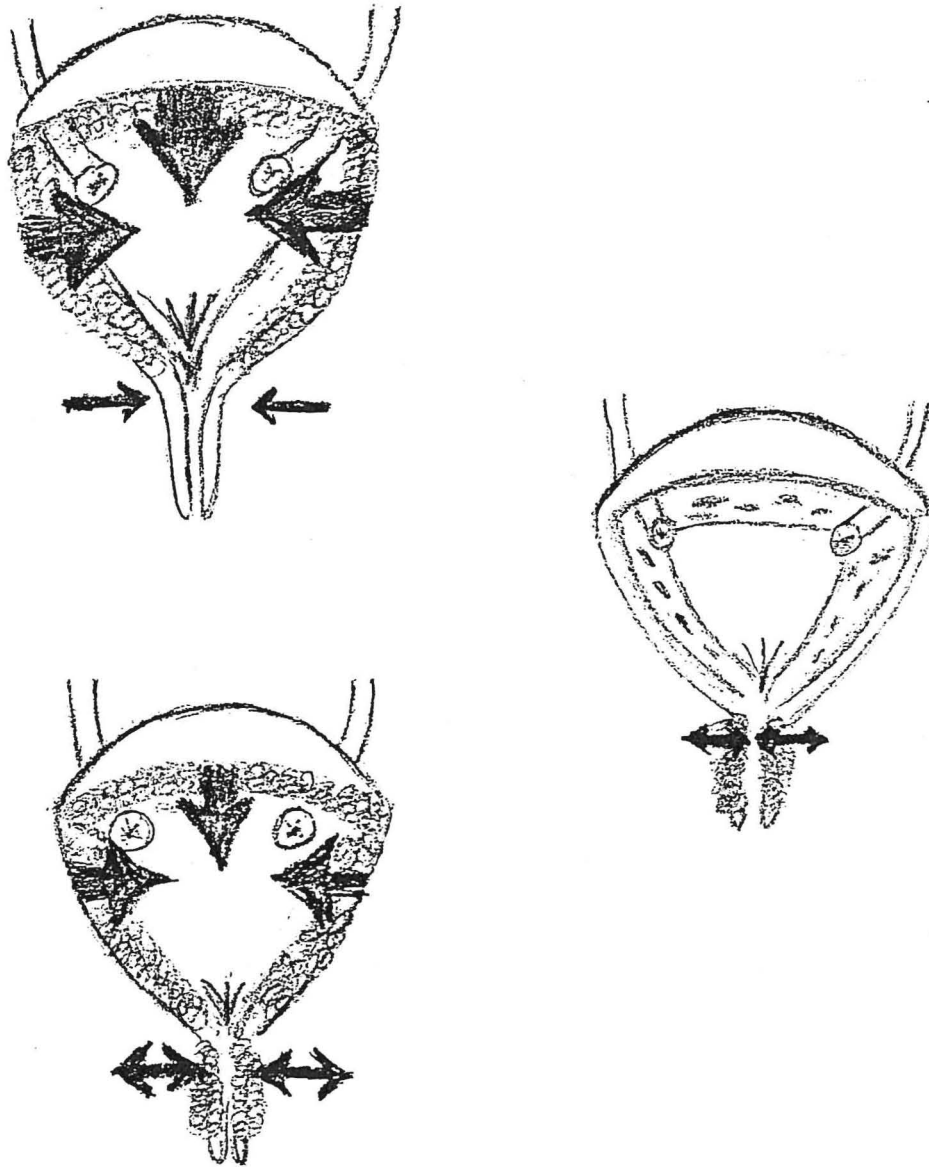


Fig. 2.--Urge incontinence is contributed to incompetent internal or external sphincter mechanisms as shown above: Top, High bladder pressure exceeds normal sphincter tone (hyperactive bladder). Middle, sphincter mechanisms unstable with normal bladder pressure. Bottom, combination of increased bladder pressure and unstable sphincter.

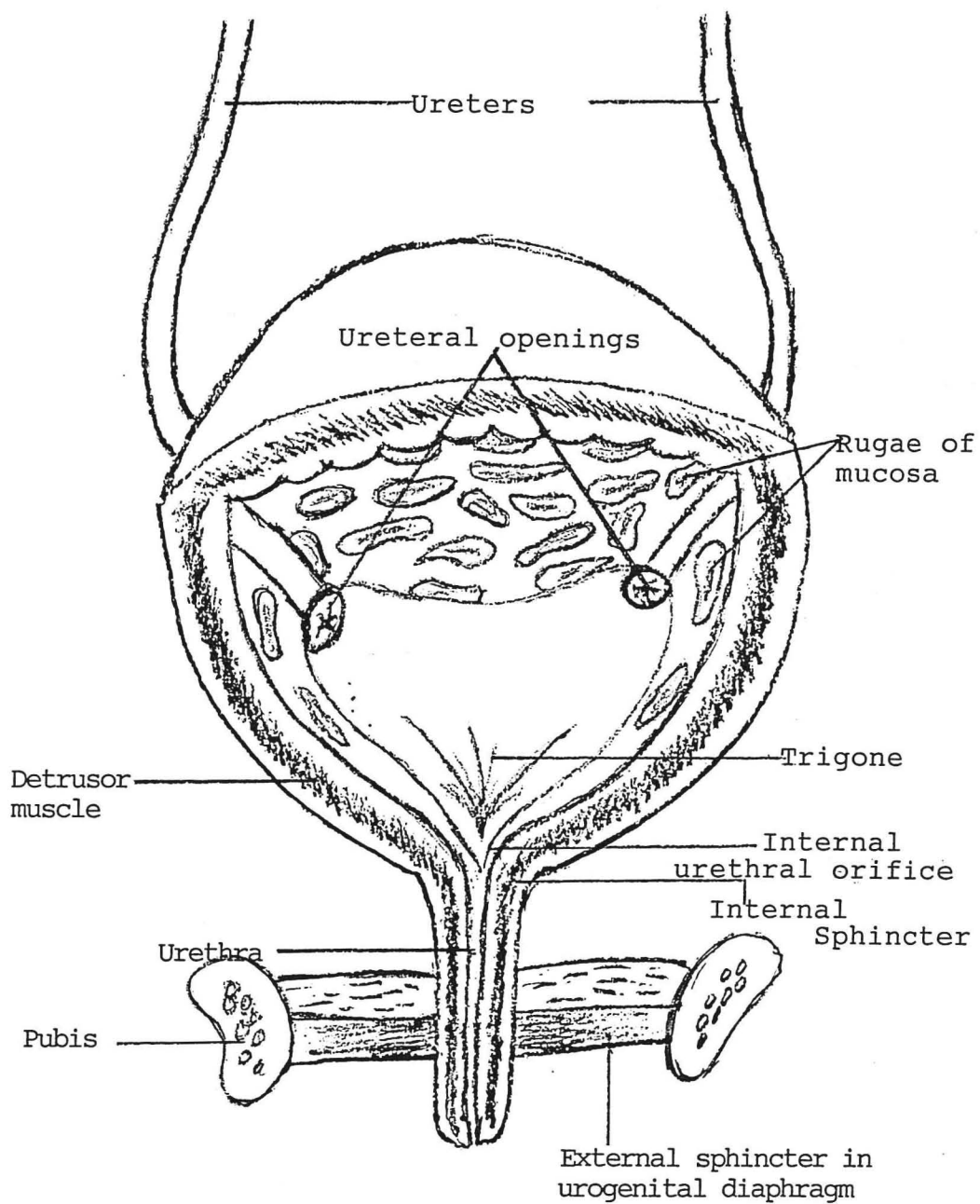


Fig. 3.--Urinary bladder transected in frontal plane.

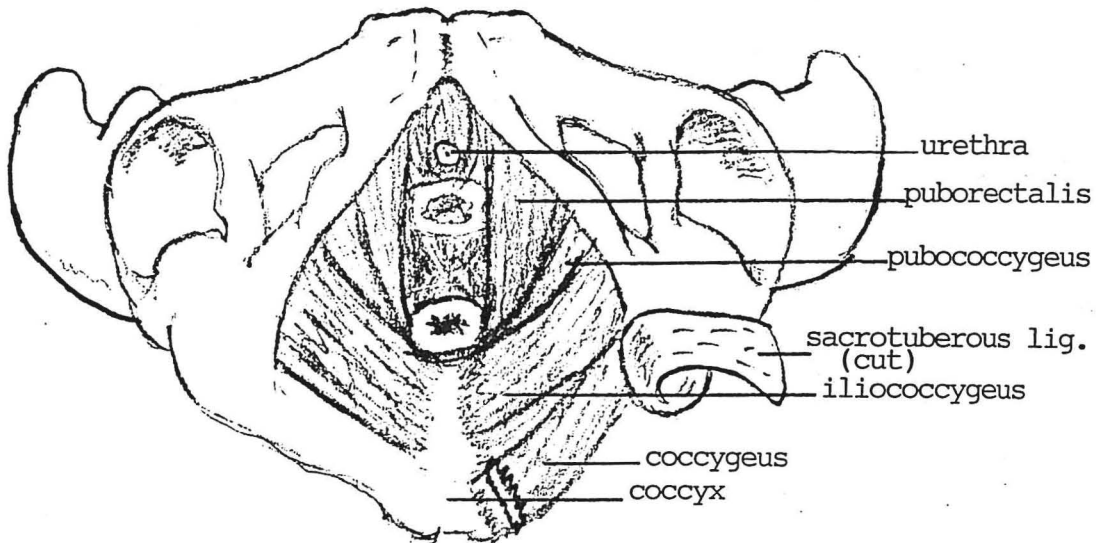
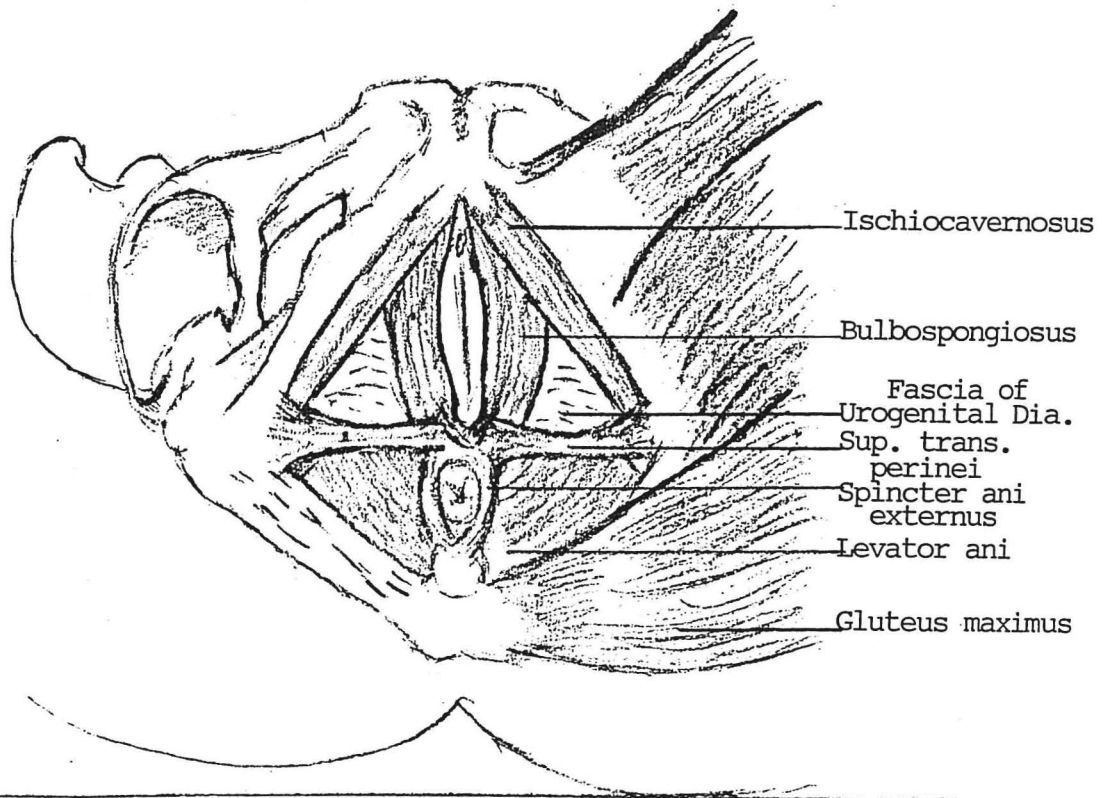


Fig. 4.--Superficial muscles of the pelvic floor. The primary muscles of interest in UI are the pubococcygeus portion of the levator ani and the urogenital diaphragm (not shown here).

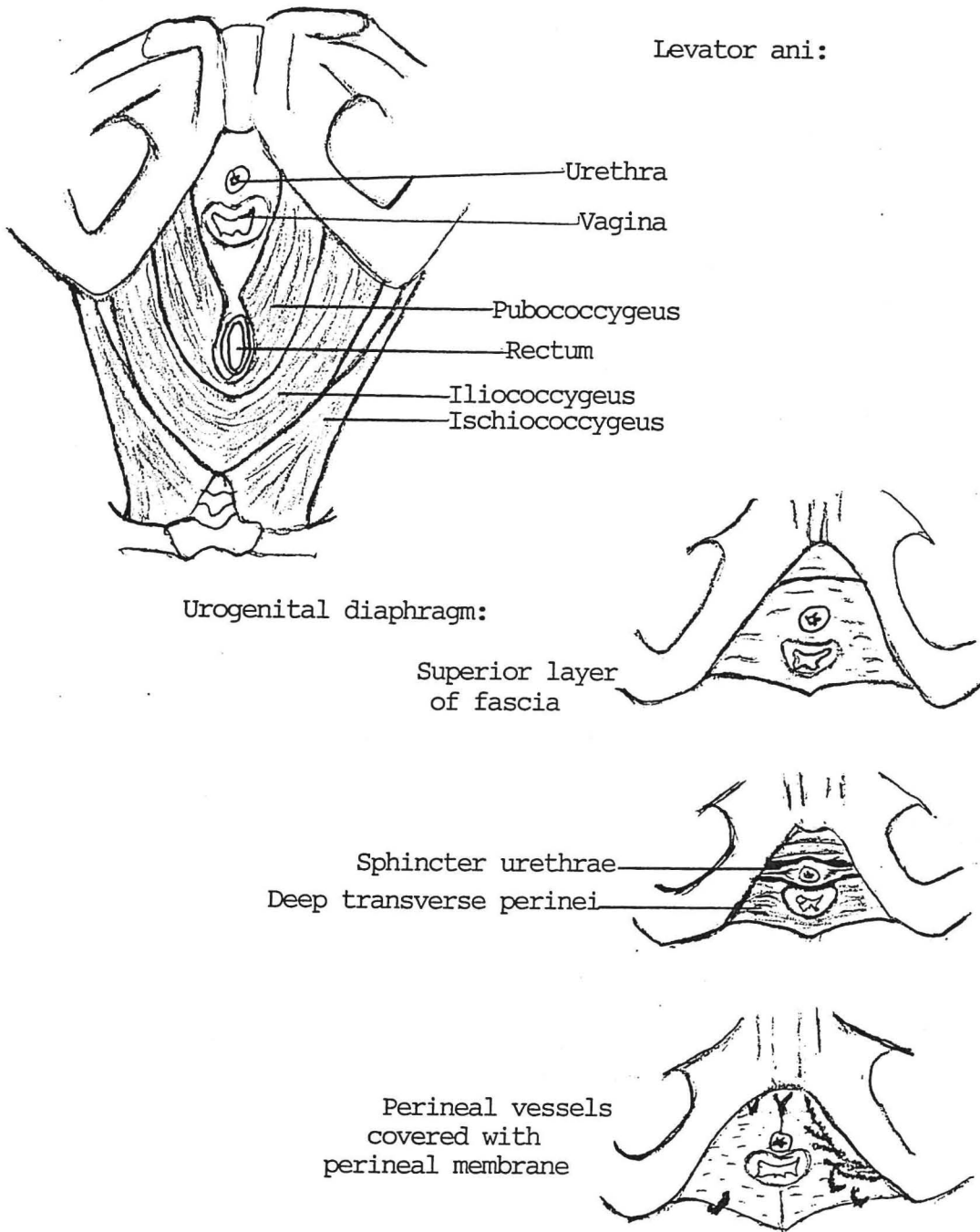


Fig. 5.--The pelvic floor muscles (or perineum) are divided into layers as shown above. The pubococcygeus of the levator ani as well as the sphincter urethrae and deep transverse perinei muscles of the urogenital diaphragm are easily identified here, the primary muscles of urinary incontinence.

Table 1. Pelvic Floor Muscles (Pelvic Diaphragm)

MUSCLE	ORIGIN	INSERTION	ACTION
Levator ani:			
Pubococcygeous	Dorsal surface of pubic bone & fascia or obturator	Anococcygeal body & Perineal body	Supports the pelvic viscera
Pubovaginalis	Medial & anterior portion of pubic group	Perineal body	Sphincter of vagina & urethra
Puborectalis	Posterior portion of pubic group	Anococcygeal body	Loops around rectum, elevates and helps constrict anal canal
Iliococcygeous	Dorsal surface of pubic bone	Anococcygeal body & coccyx	Assists in support of pelvic viscera
Ischio-coccygeous	Spine of ischium	Caudal portion of sacrum/coccyx	Flexes coccyx, assists in support of pelvic viscera, & stabilizes the sacroiliac joint
Obturator Internus	Inner pelvic brim-obturator membrane, margin of obturator foramen	Medial surface of greater trochanter proximal to the trochanteric fossa	Lateral or external rotator of the hip
Piriformis	Pelvic surface of sacrum, margin of greater sciatic foramen & pelvic surface of sacrotuberous ligament	Superior border of greater trochanter	External rotator of hip, stabilizes the hip joint

Table 2.-Urogenital Diaphragm

MUSCLE	ORIGIN	INSERTION	ACTION
Superficial layer:			
Ischiocavernosus	Ischial tuberosity	Aponeurosis of crus clitoris	Erection of clitoris
Bulbocavernosus	Perineal body	Fascia covering corpus cavernosus	Vaginal sphincter & assists in erection of clitoris
Superficial Transverse Perineals	Ischial ramus	Perineal body	Fixes perineal body
Deep layer:			
Consists of Perineal membrane and striated urogenital sphincter muscles			
Sphincter Urethrae	Pubic arch	Trigonal ring	Constrict urethral lumen
Urethrovaginal Sphincter	Vaginal wall	Ventral surface of urethra	Compresses ventral wall, assists incontinence mechanism
Compressor Urethrae	Inschiopubic ramus	Ventral surface of urethra	Compresses ventral wall, assists incontinence mechanism

urethral sphincter mechanism consisting of the internal sphincter and the external sphincter, which is responsible for maintaining increased urethral pressure and maintaining closure at the base of the bladder neck to keep urine contained within the bladder.

In both phases of urination, spinal reflex contraction impulses continuously generated between the spinal column and the bladder ask the detrusor muscle to contract.^{12,16} However, there are also continuous inhibitory signals from the brain (pons) allowing the bladder to relax by preventing these spinal reflex contraction signals from causing bladder contractions. Urination or voiding is under voluntary control through joint effort of the brain by the cortical areas (frontal cortex), subcortical areas (thalamus, hypothalamus, basal ganglia, and limbic system), and the brain stem (mesencephalic-pontine-medullary reticular formation). The sacral micturition center of the spinal cord (S2-S4) acts as a relay station for these spinal reflex contraction impulses and inhibitory signals to and from the brain and the bladder. Figure 6 shows a comparison of signals causing relaxation and contraction of the urinary bladder, along with the nerve pathways between the bladder, spine and micturition control center.

Bladder filling of the storage phase causes smooth muscle and connective tissue in the bladder wall to stretch and accommodate the increase in the volume of urine. Because of the elasticity of the bladder wall, there is little or no increase in the pressure within the bladder.¹² When the bladder accumulates about 150 to 250 ml of urine, the pressure within the bladder begins to increase slightly and triggers the urge to urinate. This urge to urinate happens when

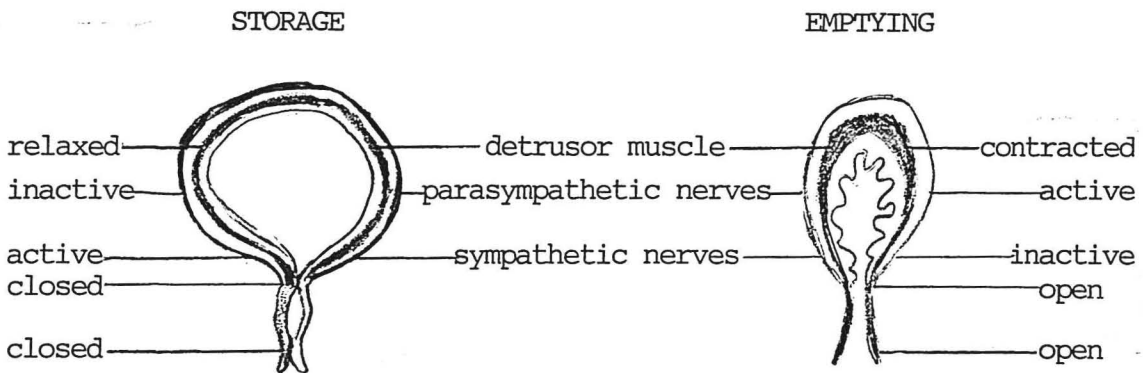
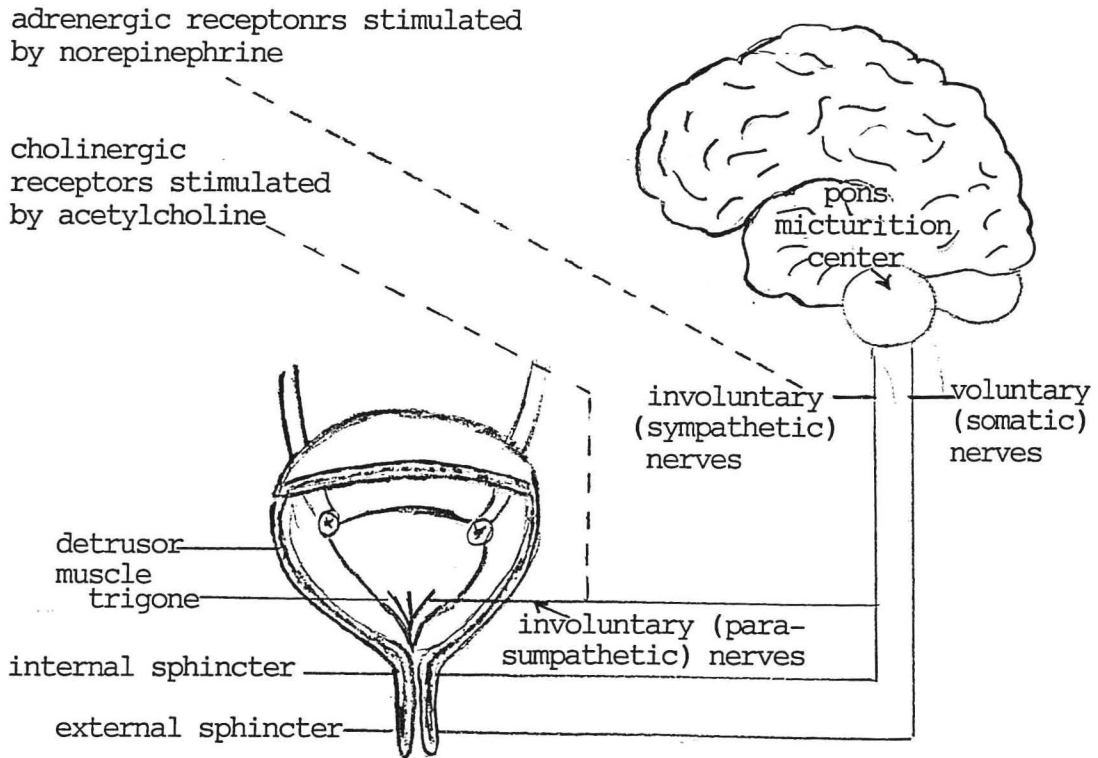
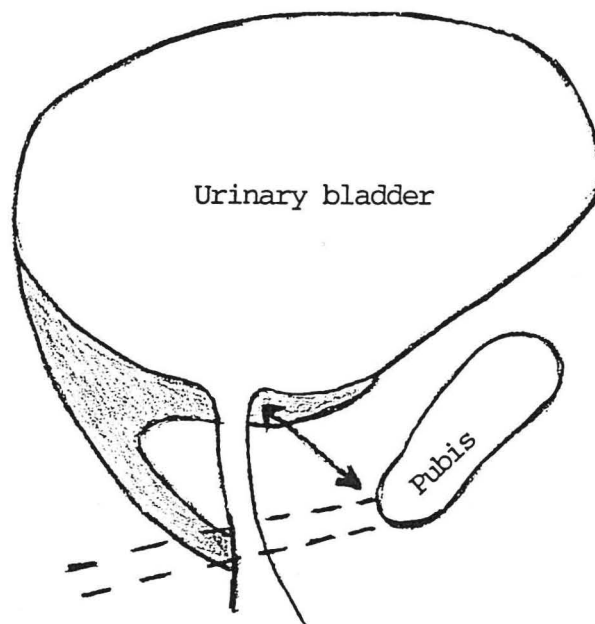


Fig. 6.--Nerve pathways between the bladder, spine and micturition control center: Top, Nerves that control bladder function. Bottom, Coordination of activity of the detrusor muscle and sphincter mechanism in urination.

mechanoreceptors in the bladder wall are stimulated at functional bladder capacity or the point at which one would feel the need to seek out a bathroom. The reflex stimulation of alpha-adrenergic receptors of the bladder increase resistance within the smooth muscle of the bladder neck and proximal urethra to accommodate the increase in the bladder pressure so no urine can leak out into the urethra. As long as the urethral pressure is greater than the bladder pressure, continence is maintained.

Emptying of the bladder happens when the internal and external sphincters of the urethra relax and an increase in bladder pressure is provided by a constant contraction of the bladder with the spinal reflex contraction impulses no longer inhibited.^{12,16} This is possible through voluntary control of the central and autonomic nervous systems as described earlier. In other words, the person who needs to void consciously relaxes their pelvic floor muscles and tells their bladder to release its contents. The bladder empties when the bladder neck lowers and funnels to allow the flow of urine (Figure 7). At the end of voiding, the striated muscles of the urethra and pelvic floor contract to lift the bladder which again increases urethral pressure and inhibits detrusor muscle contractions in the bladder wall.

In review, normal lower urinary tract support and normal sphincteric function are essential for continence. Problems with the sphincteric function can be attributed to either the internal sphincter or to the external sphincter. The internal sphincter lies in the region where the bladder and urethra meet extending for approximately 20 percent of the urethra. Problems with support of



Unshaded area: bladder in normal position
Shaded area: bladder descended to allow flow of urine

Fig. 7.--The bladder empties when the bladder neck lowers and funnels to allow the flow of urine.

the proximal urethra and bladder neck are the most common causes of stress incontinence.

The pelvic floor has three functions: supportive, sphincteric and sexual.¹⁰ The supportive and sphincteric functions are what we want to focus on for a deeper understanding of urinary incontinence.

The pelvic floor muscles along with the pelvis bones, smooth muscle, and connective tissue support the pelvic organs against gravity and increases in abdominal pressure (such as laughing, sneezing, coughing, sit to stand, etc.).^{4,10} The pelvic floor also provides support and tone for the vaginal wall. The urethra and anterior vaginal wall are held in close proximity by connective tissue (fascia). Therefore, urethral support is influenced by all of these structures.

Muscles of the pelvic floor have several sphincteric functions^{1,16}. During contraction, the pelvic floor muscles contribute to the maintenance of continence by increasing pressure within the urethra and stabilizing supporting fascia. The muscles also relax for defecation and contract to help control flatus. They help in fecal continence by keeping the anorectal angle closed. Consequently, when pelvic floor muscles are fecal incontinence may accompany urinary incontinence.

The pelvic floor muscles of primary interest are the pubococcygeus portion of the levator ani muscles and the urogenital diaphragm (deep transverse perineal and sphincter urethrae muscles).^{2,4,10} Figures 4 and 5 demonstrate the position of the pelvic floor muscles in relation to the urethra. The pubococcygeus muscle is a supportive muscle to keep the bladder neck in its proper intraabdominal position. The deep transverse perineal and sphincter

urethrae muscles contract compressing the anterior wall of the urethra which decreases the urethral lumen and increases urethral pressure. Therefore, a woman can voluntarily contract her pelvic floor muscles to stop urine flow.

The urogenital diaphragm has the ability to produce relatively strong, rapid forces on the urethra demonstrating a functional response that is typical of type II striated muscle fiber.^{2,4} The type II (fast) striated muscle fibers produce a strong, rapid contraction and can be trained and strengthened for a quick response with brief, rapid contract/relax exercises of one to two second duration. In comparison, type I (slow) fibers generate a less intense, sustained contraction which is typical of the Levator ani muscle group. Type I muscle fibers are located in antigravity muscles and are trained for endurance by performing prolonged muscle contraction holds of 10 to 15 seconds. Both muscle types can be assessed for strength and quality by digital examination of the pelvic floor muscles and treated according to deficits with a resistive exercise program just like any other muscular disuse syndrome.

Although the urogenital system is quite complex, basic knowledge of the types of urinary incontinence and the anatomy and physiology of urinary continence is essential to understanding and treating urinary incontinence with conservative methods of physical therapy.

CHAPTER 3

CONSERVATIVE TREATMENT OF URINARY INCONTINENCE

It is generally accepted that surgery is the most appropriate treatment for severe female urinary incompetence.¹¹ However, conservative treatment is a viable option and possibly the treatment of choice in the management of mild to moderate incontinence and should be tried initially as at least eight out of ten patients benefit.¹⁷ The current most popular nonoperative treatment is physical therapy, however; there are other forms of conservative management used for urinary incompetence (urethral and detrusor) including drug therapy and mechanical devices.^{11,17,18}

Conservative management should be considered a choice for patients who are motivated to put in the time and effort necessary as it could eliminate the need for surgery. It is also indicated for those women for whom surgery is not acceptable--for example, those who do not want or who are not medically fit for surgery. Women who plan future pregnancies may want to consider conservative management since later vaginal deliveries may adversely affect the prior surgical procedure.

Correction of obesity and treatment of any associated medical condition, particularly chronic bronchitis, have been suggested as general conservative measures for urinary incompetence because these could cause increases in

intraabdominal pressure that in turn increase the downward forces on the pelvic floor muscles and bladder encouraging incontinence.

The scope of physical therapy intervention for urinary incontinence may include: patient education, bladder drills, pelvic floor exercises, faradism and inferential therapy (electrical stimulation), and vaginal cones.

Bladder drills are done by voiding according to a routine.^{1,19} This is usually the first step of a urinary incontinence program along with pelvic floor muscle isolation techniques. The individual initially goes to the bathroom to void every hour on a schedule. Once this amount of time is adapted to and the individual is able to maintain dryness, the time interval is increased in 15 minute increments. An optimal time frame to maintain continence is two and one-half to three hours. A diary is kept by the individual while progressing during bladder drills. This diary helps pinpoint times of the day incontinence is more likely to occur and what types of “things” trigger incontinence (e.g. exercise, waiting too long between voiding, foods and liquids ingested, etc.). It also works as a way to keep track of the bladder drills and time intervals. The diary is kept with the patient at all times. Figure 8 shows an example of a voiding diary.

Pelvic floor exercises (PFEs), first described by Kegel⁴ in 1948 is still the primary exercise protocol prescribed in physical therapy for urinary incontinence. Because PFEs are often performed incorrectly, women must receive explicit instruction on how to do them. Mallard¹⁹ and Bo et al²⁰ found that 50 to 60 percent of the women in their PFE programs were doing the exercises incorrectly. There is a wide variation in the type, frequency, and duration of

exercises recommended for strengthening the pelvic floor, which reflects the lack of published data in this area. See Appendix A for an example of a pelvic floor exercise protocol.

For PFEs to be effective, the patient should be given a simple description of the pelvic floor and its function. Instruction aided by anatomic models and diagrams is helpful. Digital examination of the pelvic floor muscle contraction is an important part of the physical therapy assessment, with a suggested grading scale of 0-4 (none=0; poor=1; fair=2; good=3; normal=4).²¹ This is one type of muscle grading scale though nontraditional used in this literature. Vaginal digital self-assessment provides a simple method of determining if the individual is correctly contracting the pelvic floor muscles and assessing progress. It is believed to be a critical part of any PFE program. The patient is instructed to insert the index and middle fingers of her dominant hand into her vagina. The fingers are then held apart within the vagina and the patient is asked to squeeze the fingers together by contracting the pelvic floor. Women should be informed at the start of the exercise program that it may take 6 - 10 weeks to build up the strength of the pelvic floor muscles before they will see improvement.¹¹ Several studies indicate a 67 to 84 percent success rate of complete to moderate continence.^{8,22}

Studies show that biofeedback used in conjunction with PFEs provides improved patient motivation and a success rate that is long term.^{23,24,25} This topic will be addressed in detail in a future chapter.

An alternative to pelvic floor exercises has been stimulation by faradism and interferential therapy to striated muscle of the pelvic floor, but the value of these methods have not been ascertained.^{11,17} Faradism uses a low-frequency current to stimulate the levator ani. It is used to help make the patient aware of the muscles contracting in the pelvic floor (muscle reeducation) and to improve muscle tone. Faradism is a procedure used in physical therapy involving two electrodes: an indifferent electrode is placed over the sacrum and an active electrode is placed externally, such as to the perineum, or internally (vaginal or anal insertion). A battery operated stimulator connected by cable to an anal or vaginal plug electrode is used for home use. The stimulation strength is selected by the patient to just below the level of discomfort. Daily stimulation sessions up to 20 minutes are suggested.¹¹ There are conflicting results of faradic treatment. Many studies of the use of faradism with stress urinary incontinence have been uncontrolled and subjective making an accurate assessment difficult.²⁶ The difficulty in producing a low-frequency current that is effective enough to provide muscle stimulation without causing pain because of resistance of the skin and superficial tissue is a downside to Faradism.

Interferential therapy has a low-frequency current that works inside the body without the problem of skin resistance. Four medium sized suction electrodes are placed on the patient: two electrodes on the abdomen and two electrodes on the adductors of the thigh. Each set of electrodes (one electrode on the thigh and one on the abdomen constitutes a set) transmits a different medium-frequency current of around 4,000 cyc/sec (or 20 - 25 mA current which

gives 15 pulses at pressure peak 0.25 - 0.30 Pa/cm²) for up to 15 minutes. These currents cross causing the two currents to meet and mix together. The combined current will increase and decrease its intensity rhythmically providing the interference frequency. This interference frequency is the difference between the two original frequencies. The reported results of interferential therapy are no better than Faradism. Wilson et al²⁶ found little subjective or objective difference between women doing supervised PFE and those doing PFE combined with interferential therapy. Similar findings were found in other studies done by Henalla et al⁸ and Laycock²¹.

Plevnik²⁷ introduced vaginal cones in 1985. He demonstrated that pelvic floor muscles could be contracted and strengthened by women in order to hold the different weighted cones in the vagina. This concept comes from ancient China whose women used "stone eggs" to strengthen the pelvic floor to increase sexual satisfaction. There are five to nine cones of identical shape and volume of increasing weight in each set. They weigh from 20 to 100 grams and have a nylon thread for easy removal. A cone is placed with the tapered end resting on the pelvic floor and the base extending up into the vagina. The patient will experience a feeling of the cone wanting to slip out as the cone exerts a downward pressure; the downward pressure provides sensory biofeedback. This biofeedback makes the pelvic floor contract around the cone "holding it up" (Figure 9). Resting pelvic floor tone is represented by passive weight, which is the heaviest weight retained in the vagina without voluntary control. Active weight is the heaviest weight retained with voluntary pelvic floor contractions.

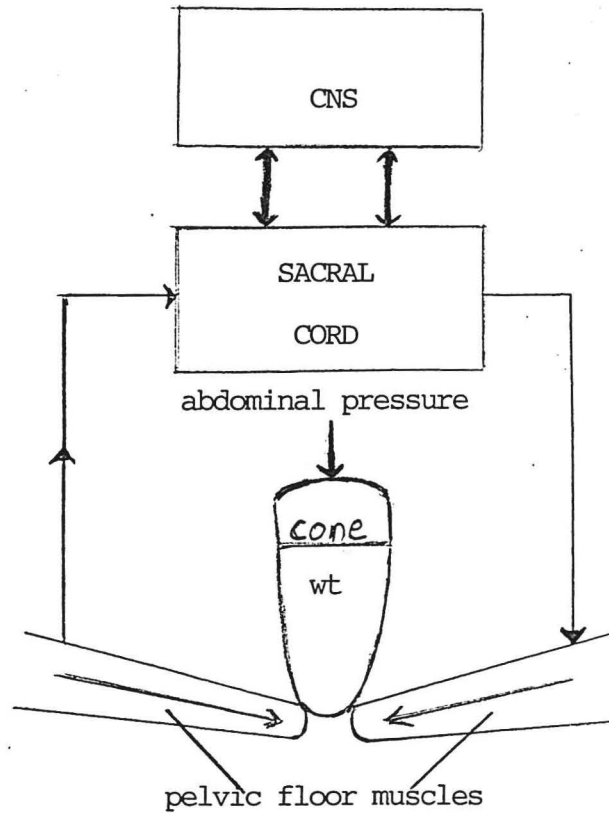


Fig. 9.--The pelvic floor muscles must contract to keep the vaginal cone from slipping out. Abdominal pressure may add to the downward pressure causing the pelvic floor to work even harder at retaining the cone. Vaginal cones also create a sensory biofeedback helping the individual become aware of contracting the proper muscles.

The patient starts with the passive weight and holds the cone intravaginally 15 minutes twice per day. When the patient is able to hold the cone for two successful attempts, she then moves on to the next heaviest cone. Women were evaluated for improvement after one month of exercises, seventy percent of these women felt they were improved or cured.²⁸ Similarly in another study 68 percent reported improvement and 47 percent felt they were cured.²⁹

It has been estimated that it takes one-third the time to teach vaginal cone use as compared to PFEs.¹¹ In addition, cone therapy when compared to perineometry (an internal sensor that measures electrical activity of muscles and used for biofeedback) has advantages in that perineometry does not distinguish pelvic floor from abdominal wall contractions. The patient must use pelvic floor muscles to retain the cones. Increased intraabdominal pressure can actually add to the exercise effect by adding to the downward gravity force of the cone making the pelvic floor muscles work harder.

Teamwork of a motivated patient and enthusiastic physical therapist is imperative for success with physical therapy as most treatment procedures will require 6 to 12 weeks before improvement is evident. It has not been agreed upon as to what types of patients benefit from physical therapy. Wilson et al²⁶ found that successful treatment was more likely to occur in younger women, in those with lesser degrees of urethral sphincter incompetence and in those who had not had previous pelvic floor surgery. The literature does not support an accurate means to predict which patient population will benefit from the effects of physical therapy treatments. Because physical therapy does not have adverse

side effects associated to its practices and does not affect whether the patient can pursue surgery in the future, it is a viable option for patients who are motivated to put in the time and effort as it may alleviate the need for surgery.

Drug therapy has also been used to reduce the effects of urinary incontinence.^{11,17} Although no drug alone has been shown to effectively cure urinary incontinence, used in combination or with other conservative measures urinary incontinence may be reduced. Anticholinergics such as oxbutynin chloride (Ditropan) and imipramine hydrochloride (e.g. Tofranil) promote bladder relaxation and are used for detrusor instability. It is suggested that in women with detrusor instability a higher response rate may come from a combination of an anticholinergic drug with bladder drills and functional electrical stimulation.¹¹ The side effects of dry mouth and constipation may limit the usefulness of anticholinergic drugs. Antihypertensive alpha blocking agents (eg. prazosin) may cause incontinence by relaxing urethral tone. Alpha agonists such as phenylpropanolamine hydrochloride (Propagest and various nonprescription diet aids) increase urethral closure pressure but are not effective in treating stress incontinence when used alone (Table 3).

Mechanical devices are for patients with incontinence who have not responded to other therapy or who are not medically fit for surgery.¹¹ These devices are thought to work by compressing the urethra (decreasing its lumen thereby raising urethral pressure) and elevating the urethrovesical junction (bladder neck).

Table 3. Drug management of UI promoting continence.

DRUG	ACTION	SIDE EFFECTS
Alpha-adrenergics: Ephedrine Chlorpheniramine phenylpropanoloamine isopropamide Ornade	Increases bladder outlet resistance	Epigastric distress Arrhythmias Palpitations Insomnia
Anticholinergics: Propantheline Pro-Banthine Banthine Oxybutynin Ditropan Flavoxate HCl Urispas	Decrease bladder activity	Dry mouth Blurred vision Restlessness Constipation
Cholinergics: Bethanecol Urecholine	Bladder emptying by increasing intrabladder pressure	Sweating Abdominal cramps Headache

An ordinary tampon can be helpful for stress incontinence if leakage occurs only intermittently, as when exercising. However, vaginal soreness and dryness can be caused by continuous use because of the absorbent material of the tampon. A reusable tampon made of foam rubber with an attached string for easy removal is also available.

Another mechanical device is the Edwards pubovaginal spring. This device has three parts: a triangularly shaped pressure pad which fits anterior to the symphysis pubis, a corrugated plastic pressure pad which is placed intravaginally and exerts pressure on the anterior wall of the vagina and posterior urethra, and a spring arm that connects the two pads (Figure 10). Patients who have been treated with this device have shown a 70 percent improvement in their genuine stress incontinence.¹¹ These patients were followed anywhere from 5 months to 4 years. A disadvantage of the Edwards pubovaginal spring is the possibility of vaginal ulcerations, especially if decreased vaginal sensation exists. Also, obese patients or those who have vaginal narrowing may have difficulty placing the device in the proper position.

Banner's device is made of soft latex with an inflatable balloon on its upper surface (Figure 10). It also works by elevating the urethrovesical junction and the proximal urethra via the inflated balloon. Reversing the pump will deflate the balloon and allow the patient to void without removal. Cardozo, et al³⁰ found that about one-half the patients had improved, this was measured by an increase in urethral pressure profiles and bladder neck elevation. However, the patients

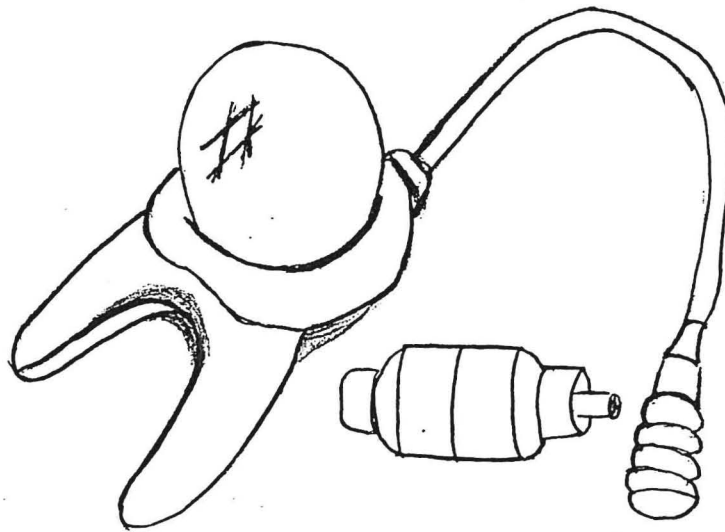
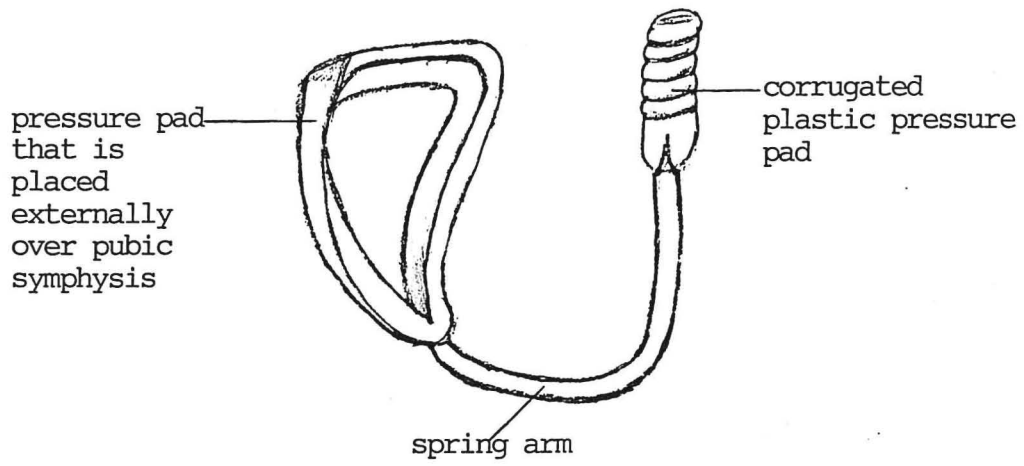


Fig. 10.--Top, Edwards Pubovaginal spring (labeled). Bottom, Banner's Device. Mechanical devices not drawn to scale.

reported problems with the size of the device finding it either too small or too large.

The general disadvantages of all of these mechanical devices include discomfort, displacement and the possible need for removal before urination. Also, they must be used cautiously where vaginal sensation is impaired. However, they are worth trying for carefully selected patients with urinary incontinence.

Each of the types of conservative treatment has been considered briefly along with their respective benefits and disadvantages. However, the cost of each conservative method of treating urinary incontinence should be considered. Table 4 lists the approximate cost of several approaches to the treatment of urinary incontinence. With today's increasing cost of health care and formation of health care packages (managed care, health maintenance organizations, etc.) and the trend of focused care, the cost of treatment will be a major determinant in the treatment prescribed. Third party payers must also be convinced of the benefits and affordability of the prescribed treatment of urinary incontinence for reimbursement. Conservative approaches to the treatment of urinary incontinence are affordable in comparison to surgical intervention and their long terms results are superior.¹⁰

Knowledge of all options available to persons with urinary incontinence is necessary for a physical therapist in today's practice. A physical therapist should be able to describe these options to patients and be able to refer them to the proper resources. As more individuals are referred to physical therapy for

Table 4.-Costs of Treatment and Management of UI

INTERVENTION	COST
Kegel Exercises	0
Vaginal Cones	\$100
Medication*	\$325-500
Pelvic Floor Stimulation	\$695
Adult Diapers	\$1,200
Collagen Injections	\$4,463
Surgical Procedures	\$3,900-8,000

*Estimated wholesale cost of a common medication for UI - Oxbutynin Chloride (Ditropan)

**These figures are based upon per incident or year as appropriate. These figures also do not include initial assessment or follow up fees.

***The dollar amounts are from the Agency for Health Care Policy and Research, 1992; Impi, Inc., 1995.

conservative treatment of urinary incontinence, awareness of the most beneficial and acceptable treatment for a patient is important. Pelvic floor exercises with biofeedback has become the “popular” procedure amongst family practice physicians and physical therapists so further investigation of this conservative treatment is warranted.

CHAPTER 4

Biofeedback in an Urinary Incontinence Program

Urinary incontinence as a natural part of aging is a persistent myth according to Dr. Jacques Corcos, Chief of Urology at Sir Mortimer Davis Jewish General Hospital in Montreal, Canada.²³ Although Dr. Corcos does not feel urinary incontinence (UI) is altogether an older person's problem, it is cited as a major reason for nursing home admissions^{31,32} Many women believe that losing urine when intraabdominal pressure is suddenly increased, such as in sneezing, laughing or lifting, is the normal result of childbearing or aging and this accounts for an underestimated reporting of the incidence of urinary incontinence. Instead, perineal pads or diapers are worn and many women do not seek medical or surgical options since UI is not perceived as a problem that has a solution. However, a 50 to 60 percent cure rate for a period of six months to one year after surgical intervention is reported by the American College of Obstetrics and Gynecology.³³ Kegel claims a much higher success rate of 86 percent with his pelvic floor exercises.³⁴ Jones³⁵ study supports Kegel's findings.

Pelvic floor muscle exercises (PFE), such as Kegel exercises, are used as both uptraining and downtraining techniques to improve function.^{3,36} Please refer back to Chapter 3 for a more in depth discussion of pelvic floor exercises. Appendix A contains sample instructions for patient education of pelvic floor

exercises, a typical protocol of pelvic floor exercises and a detailed explanation of this protocol. These exercises should be prescribed by assessment of the strength of the pelvic floor muscles. A referral to physical therapy for neuromuscular re-education through biofeedback and therapeutic exercise would be beneficial for a patient with fair (3) or less strength as this muscle grade requires rehabilitation efforts. A patient should be encouraged to maintain strength through an appropriate exercise program with an assessment of a good (4-5) grade even though asymptomatic. Of course, if the patient is symptomatic, rehabilitation efforts should be pursued after medical screening. Relaxation strategies and specificity (type of contraction and muscle isolation) of the targeted muscles is indicated for hypertonus. A description of the grades ascertained in manual muscle testing of the perineal muscles is provided in Table 5. The pubococcygeal muscle, the main support of the pelvic floor, surrounds all the outlets of the perineal area including the urethra, vagina, and rectum and is easily assessed for strength intravaginally. In all studies related to the pelvic floor muscles and their relationship to incontinence, it has been assumed that testing of these muscles high in the vagina for contractile ability is an accurate assessment of their strength.

The first line of management of UI is conservative treatment of bladder drills with bladder retraining, biofeedback, electrical stimulation and exercise. Training sessions may include general contract/relax techniques for relaxation and breathing, education for isolation of the pelvic floor muscles, assistance in the coordination of breathing with exercise and conscious relaxation of the pelvic

Table 5.--Scale for Grades for Digital Assessment of Muscle Strength

Score	Description
0	No contraction
1/5	Trace contraction: <2 seconds
2/5	Weak contraction: with or without posterior elevation of fingers, held for at least 3 seconds
3/5	Moderate contraction: with or without posterior elevation of fingers, held for at least 4-6 seconds, repeated 3 times
4/5	Strong contraction: with posterior elevation of fingers, held for at least 7-9 seconds, repeated 4-5 times
5/5	Unmistakably strong contraction: with posterior elevation of fingers, held for at least 10 seconds, repeated 4-5 times

floor muscles. The main focus of physical therapy in UI is utilizing re-education skills and exercises to strengthen the pelvic floor muscles in order to maintain continence by providing support to the lower urinary tract structures.¹⁰ The focus of our discussion will be how biofeedback enhances the effects of a PFE program.

Biofeedback for lower urinary tract is defined as "a technique by which information about which a normally unconscious physiological process is presented to the patient and the therapist as visual, auditory or tactile signal."³⁷ The signal is a measurement of the electrical impulses generated by the pelvic floor muscles during a contraction. This measurement is then displayed and/or recorded in a quantitative way such as different pitches of sounds, rows of lights, or simple line or bar graphs shown on a computer monitor. The individual is then taught how to alter these visual or auditory signals which results in achieving control of the amount and length of the contractions of the pelvic floor musculature.

The basic concept of biofeedback provides that responses may produce changes in a physiological process that are learnable but only the patient can produce this change.³⁸ For example, the therapist may elicit a response with a stimulus to the perineal muscles. However, the muscles will continue their normal routine once the stimulus is gone unless the patient consciously changes this routine. Biofeedback conceives that the longer the interval between the response and the performance, the worse the performance. Since non-verbal feedback stimuli is much faster and more accurate than therapist comment,

mechanical biofeedback is more effective. The concept of biofeedback further provides that the more feedback given to the individual, the better she will be at performing PFE.¹³ Mechanical biofeedback also requires the patient to be able to call up internal differential correlates between pelvic floor contractions and substitutions. If this cannot be done, learning to control audio or visual signals is useless. In other words, if the patient is unable to differentiate pelvic floor muscles from other muscle contractions, or the urinary bladder and urethral sphincters do not have a competent nerve supply, biofeedback will not be beneficial.

Biofeedback with PFE have specific objectives for treating the pelvic floor muscles with surface electromyography (SEMG).²⁵ As stated earlier, PFE are used with uptraining and downtraining. Uptraining is defined as "increasing the activity of a weak muscle as seen supportive and disuse dysfunctions."³⁸ Downtraining is defined as "decreasing the activity of an overly tense muscle", known as hypertonus dysfunctions.³⁸ SEMG with pelvic floor exercises provides the patient with a more efficient means of achieving these goals and allows instantaneous encouragement or rewards for her effort. It also provides coordination training to encourage wanted synergists and discourage unwanted muscle substitution patterns or pathologic synergies seen in incoordination dysfunctions.

Locating the appropriate muscles and identifying muscle contractions of the pelvic floor can be challenging for physical therapists treating UI.¹⁰ In muscle isolation, biofeedback is instrumental as it uses internal or surface sensors to

take information from the contracting muscles and turning it into a form the patient can understand. Figure 11 illustrates positional external placement of mechanical biofeedback electrodes. The placement of an internal sensor is depicted in Figure 12. With the use of biofeedback, therapists can ascertain whether the dysfunction is being caused by muscle weakness, poor coordination or a chronic spastic condition in the muscle. The physical therapist can begin treatment once the type of the dysfunction is ascertained.¹⁰

Treatment of pelvic floor dysfunctions with PFE in conjunction with mechanical biofeedback can greatly benefit the patient.¹⁰ A woman can be shown exactly which muscles are contracting with this device, thus helping her to isolate the appropriate muscles. Digital palpation by the individual of the right and left sides of the pelvic floor muscles separately is also needed to help the woman identify the proper muscles for exercise.¹³ With patience and adequate instruction, many women will be able to exercise the pelvic floor selectively one side separately or both sides simultaneously. Oftentimes a clinician will see in treating pelvic floor dysfunctions that patients tend to use abdominals, hip or leg muscles to substitute for a weak pelvic floor. A patient can see this with biofeedback and correct the unwanted substitution. Although it is important for women to use their abdominal muscles along with the pelvic floor muscles, isolation of the pelvic floor muscles must first be attained. Once the patient can successfully isolate and contract the necessary muscles, exercises should be implemented to strengthen the pelvic floor. This can be done through vaginal cones and PFE.

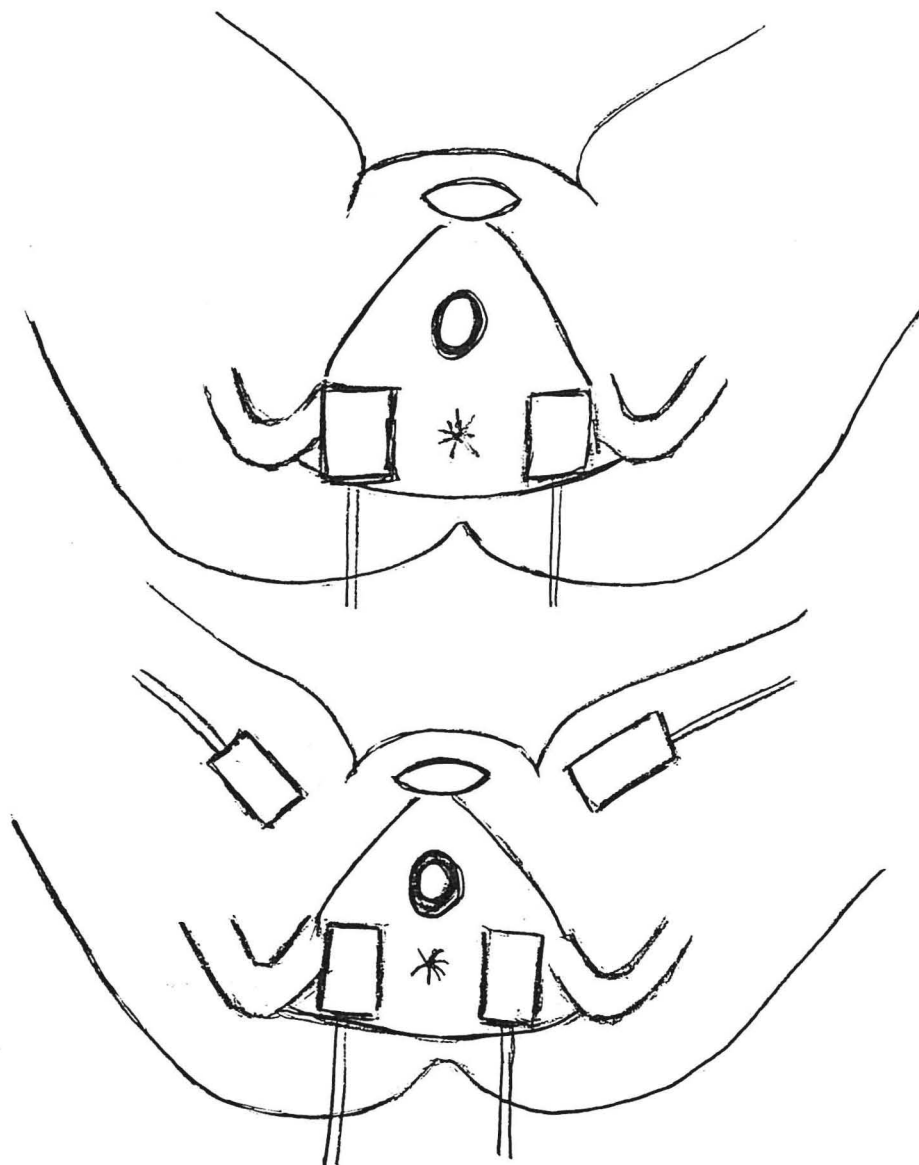


Fig. 11.--External placement of mechanical biofeedback electrodes. Top, Placement of electrodes with use of one channel. Bottom, Placement of electrodes when two channels are used. A dual channel unit provides feedback to the patient on unwanted contractions of muscle substitutions. The most common regions of muscle substitutions are the abdominals, hip adductors and gluteals.

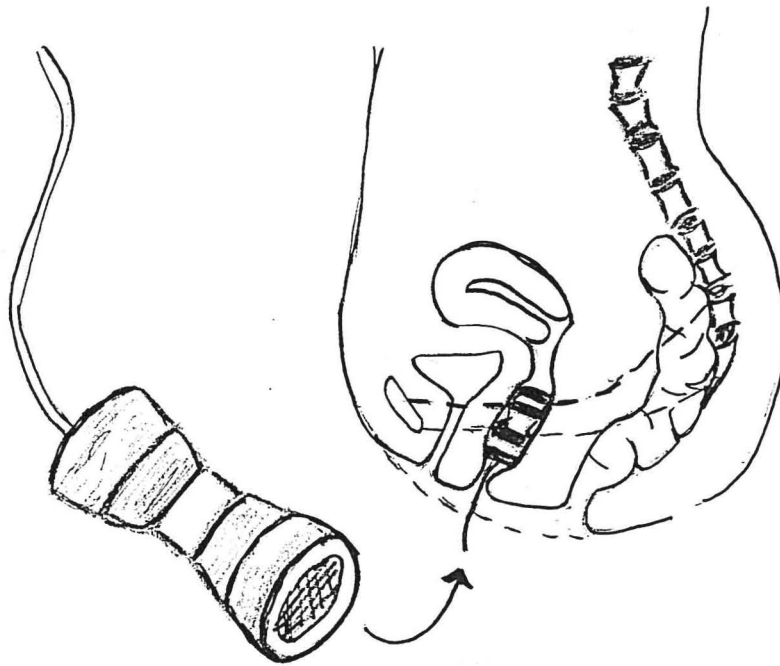


Fig. 12.--Placement of an internal mechanical biofeedback sensor unit (electrode). Carbon rings around the sensor unit pick up electrical activity of the pelvic floor muscles and relay these signals back to the biofeedback unit.

Other muscle groups also need to be strengthened to help prevent incontinence.^{32,35,38} After isolation and strengthening of the pelvic floor muscles, all four hip motions are targeted for strength and flexibility. Then attention is focused to the abdominal wall muscles, especially the lower abdominals, with strengthening and aerobic exercises to increase endurance. Walking is the preferred aerobic exercise since it is weight bearing and exercises the whole pelvic girdle.

The most important aspect of any physical therapy program is patient education.³⁸ The woman must be instructed in normal bladder function, function of pelvic floor muscles, effect of Valsalva and bearing down on pelvic floor musculature, bladder records and bladder training, and incorporating exercises into functional activities. Lack of patient motivation has been indicated as the number one reason for the failure of PFE. Since a high prevalence of women have stress or mixed UI, accurate and precise instruction in pelvic floor exercises is essential. PFE have the stigma of being unsuccessful. This is because many women have been misinformed on how to perform PFE. They have been told further that the "best" treatment is surgery, making instruction of the proper technique of PFE to increase its success rate very important.

Taylor and Henderson²⁴ found in their study, examining the effects of biofeedback on pubococcygeal muscle strength and simple urinary stress incontinence in postmenopausal women, that the use of biofeedback in addition to pelvic floor exercises (Kegel) obtained a 100 percent continence rate and, without biofeedback, their study demonstrated a 67 percent continence rate.

The researchers felt that their findings were subjective but also felt that the biofeedback device is useful in early identification of the correct muscle and a motivating factor in increasing the strength of the contractions. Another source reports that eight out of ten incontinent women can once again maintain continence or, at least, decrease their incontinence significantly. Since the average woman in the United States does not know she has a pubococcygeal muscle, identifying and contracting this muscle can be very challenging. According to the study, the subjects, being seen in a clinical setting, commented that when concentrating on the "lights", they were able to contract their pelvic floor muscles much harder. Thus, it was concluded that mechanical biofeedback may be a valuable tool in time conservation in a clinical situation. The author also pointed out that "diminishing frequency of embarrassing incidents is both a type of biofeedback and motivating factor among already incontinent women."

Once the muscles have been strengthened, the individual must be able to use it in her daily life.¹⁰ The pelvic floor muscles should be contracted when the woman sneezes, coughs or moves from sit to stand. Physical therapists are valuable in treating pelvic floor dysfunctions because they have the ability to incorporate exercises into a person's everyday life. It is how the patient uses her pelvic floor muscles in the daily life that is going to effect whether she has leakage episodes, not the exercises, per se, which function just to strengthen and increase endurance of the pelvic floor and, in return, gives the patient the ability to use these muscles appropriately. "The therapist's natural ability to

incorporate exercise into function makes them an invaluable resource to patients suffering from pelvic floor dysfunctions.”¹⁰

There are, however, limitations of biofeedback assisted PFE. These include the possibility of cross talk affecting microvolt readings decreasing the accuracy of muscle isolation, equipment limitations for comparison work, and the interference of Valsalva techniques which may cause an unsolicited EMG signal. There are also contraindications for internal sensors such as vaginal or urinary tract infections, pregnancies and possibly menstruation. With the price of physical therapy intervention so minimal and its high patient satisfaction rates as compared to other treatment options, the possibility of these limitations creating longer treatment time is insignificant.

Rapidly rising costs of medical services dictate that the treatment of urinary incontinence be cost effective. The price of physical therapy instructed PFE with mechanical biofeedback is negligible when considering the financial impact surgical intervention has (hundreds of dollars versus thousands of dollars). Table 6 reflects a statement of charges that are typical of a urinary incontinence treatment program in 1996. It must be pointed out that there will be a variation of charges from location to location. These charges include an initial evaluation, patient education, mechanical biofeedback setup and instruction, home exercise program and several follow-up treatment sessions. Costs of the various treatment options for UI were briefly outlined in Table 4 of Chapter 3.

In summary, the benefits of mechanical biofeedback assisted pelvic floor muscle exercises include assisting in pelvic floor muscle identification and

Table 6.- Payment scale of PFE with mechanical biofeedback UI program.

*Goal: 6 visits; \$375.00			
VISITS	TIME BETWEEN TREATMENTS	TREATMENT TIME	AMOUNT
Initial visit	One week	60 min eval & add'l 15 min	\$ 80.00
2nd visit	Two weeks	45 min.	75.00
3rd visit	One month	30 min.	55.00
4th visit	Six weeks	30 min.	55.00
5th visit	Two months	30 min.	55.00
6th visit	Discharge	30 min.	55.00
TOTAL			\$ 375.00

*Payment scale courtesy of Arlene Johnson, Physical Therapist, Grand Forks, ND.

awareness and teaching specificity of exercise (type of contraction and muscle isolation). It also helps re-educate the muscles to discriminate between contraction and relaxation, recognize accessory muscle patterns and identify muscle substitutions. Data from the mechanical biofeedback assists the therapist in prescribing the appropriate exercise regime. In addition, patient motivation is improved through the instantaneous information on performance. When cost effectiveness is factored in, mechanical biofeedback with PFE may be considered the treatment of choice for certain types of UI or, at least, a predecessor of surgical intervention.

CONCLUSION

The awareness of urinary incontinence in our society is growing in the general population, not only as a problem in the elderly, but also as a problem for women in all age groups. Although urinary incontinence has been attributed to childbirth, aging and menopause, it is also reported among women who cannot be classified in one of these groups.

Even though public awareness of the prevalence of urinary incontinence has grown, and this has been brought to the attention of the medical professionals, very little has been done in way of addressing this problem. The first step may be to address urinary incontinence in the curriculum of medically related programs. Screening and patient education at the time of physical examinations may be appropriate. Flyers and brochures distributed to medical facilities would provide women with a resource to seek help. Publishing articles in popular magazines that target the general population may provide women information helping them to realize urinary incontinence as a problem and not a normal part of aging, childbearing and menopause, and may direct women to appropriately trained professionals. Implementing a pelvic floor exercise program and educating students on urinary incontinence and its risk factors in

health education classes of primary schools may decrease the incidence of preventable urinary incontinence in the generations to come.

Along with awareness of urinary incontinence, the number of persons seeking treatment for this problem will increase. Therefore, physical therapists will see an increasing number of patients referred to them and will need to be able to know how to treat these patients or be able to direct them to appropriate resources.

Many treatment options are available to persons with urinary incontinence. However, research supports and patient satisfaction concurs that pelvic floor exercises with mechanical biofeedback has the greatest success rate of all conservative treatments available. Mechanical biofeedback is an asset to an urinary incontinence program in that it provides the incentive a person may need to continue a program in which results are delayed for six to eight weeks. Mechanical biofeedback also provides the patient with instantaneous feedback and rewards small gains by providing objective data of these accomplishments that could not be assessed by the therapist.

Research seems not to have addressed some beneficial aspects of mechanical biofeedback. Mechanical biofeedback has the ability to produce documentation in the form of graphs or numerical printouts that could be used for comparison of treatments allowing determination of the progress of the patient in an understandable form. These hard copies are used, and could be more so, to provide physicians with objective information on the progress of their patients,

provide insurance companies with documentation required for reimbursement and provide valuable information in the realm of future research.

Urinary incontinence may be an inadvertently self-induced problem but physical therapy intervention of patient education, PFE and mechanical biofeedback may cure or significantly reduce the effects of UI. However, other individuals may not be as fortunate and require further medical intervention.

APPENDIX
PELVIC FLOOR EXERCISE PROGRAM

PELVIC FLOOR EXERCISES

The pelvic floor consists of a sheet of muscles which covers the bottom of the pelvic cavity and assists in supporting the abdominal and pelvic organs. It includes several pairs of muscles which join in the midline. The pelvic floor encircles the bowel and bladder openings, and in the female, the vagina.

HOW TO RECOGNIZE THE PELVIC FLOOR MUSCLES

Sit on the toilet. Empty a small amount of urine, then try to stop the flow for 1 to 2 seconds. Relax completely allowing the bladder to empty. The pelvic floor muscles are responsible for this control. Most people take a few trials to be successful. Keep trying.

Insert one or two fingers into the vagina and squeeze or place a fingertip on or into the rectal outlet and contract the muscles as though you are holding back a bowel movement. You should be able to feel the pelvic floor move with these muscle contractions.

BENEFITS OF THE EXERCISES

Pelvic floor or Kegel exercises were originally developed by Dr. Arnold Kegel to help women with problems controlling urination. Positive effects of regular pelvic floor exercise include the following:

1. Helps improve or maintain control of bowel and bladder.
2. Heightened sexual response.
3. Maintenance of strength, tone, and elasticity, which helps support the abdominal and pelvic contents against gravity.

Like other muscles of the body, if the pelvic floor muscles get weak or tense, they are no longer efficient at their job.

STARTING THE EXERCISES

1. Remember to relax the body before and after the exercises.
2. Tighten only the muscles of the pelvic floor. No muscle movement will be seen if done properly.
3. Breathe during the exercises. Holding your breath makes it more difficult for the muscles to work.

When you start, you will probably notice that the muscles do not want to stay contracted or tightened for very long. If you feel it letting go, just tighten again, several times if necessary. In a week or two, you will probably notice improvement with control.

Start by doing the exercises in a lying or sitting position. For example, do these while watching television, driving a car, sitting at a desk, or lying in bed. Once you feel you can perform the exercises well, try them when standing, while waiting in lines, doing chores, or even as you brush your teeth.

Those beginning the program should concentrate on improving awareness, strength and the ability to relax the pelvic floor.

For those who need to concentrate on relaxation, be sure to let the pelvic floor relax totally, letting go quickly after each contraction.

THE EXERCISES

Begin with one set of 10 repetitions of these exercises 3-4 times per day. Gradually increase the number of repetitions you do with each set up to 15. We recommend that you do 50 to 100 repetitions per day.

1. **FLICKS:** Tighten the pelvic floor muscles for one or two counts, then relax.
2. **HOLD KEGELS:** Tighten the pelvic floor muscles as you do with the flick exercise, but now hold it for a slow count of five. Then relax. As the hold of five becomes easy, work towards the goal of holding for 10 seconds. **HOLD KEGELS ARE THE MOST IMPORTANT EXERCISE FOR IMPROVING AND MAINTAINING STRENGTH.**

If you have any questions or difficulties with the exercises, talk to your health care provider.

(You must read through instructions or start at level one to understand the terminology!)

GRADUATED STRENGTH TRAINING: A PELVIC MUSCLE EXERCISE PROGRAM

LEVEL 1: Beginning Muscle Identification

Goal: Short, fast contractions (flicks). Use only the pelvic muscles. Avoid bearing down or straining. Avoid contracting abdominal, thigh or buttock muscles.

Prescription: 10 short contracts/set; 5 sets/day
Allow 30 seconds rest between each set

Minimum Time: 5 minutes daily/5 days per week

LEVEL 2: Advanced Muscle Identification

Goal: Identify higher muscle levels. Contraction, performed as three progressively higher, shorter flicks. Count 1,2,3 as each level is quickly contracted.

Prescription: 10 graded contractions/set; 5 sets/day
Allow 30 seconds rest between each set

Minimum Time: 5 minutes daily/5 days per week

LEVEL 3: Beginning Strength Training

Goal: With each contraction, move smoothly through all levels of muscle. Direct the force inward and upward. Hold each contraction 3 seconds at the top (work up to holding for 6 seconds). While holding, contract the muscle as hard as you can.

Prescription: 10 contractions/set; 3 sets/day
Allow 10 seconds rest between contractions
Allow 30 seconds rest between sets

Minimum Time: 10 minutes daily/5 days per week

LEVEL 4: Advanced Strength Training (Do not begin until you can solidly hold each Level 3 contraction for 6 seconds).

Goal: With each contraction hold at the top for 5 seconds, then relax to midlevel and hold at midlevel for 5 seconds as well. Concentrate on high intensity, powerful contractions.

Prescription: 5 contractions/set; 3 sets/day
Allow 10 seconds rest between contractions
Allow 30 seconds rest between sets

Minimum Time: 10 minutes daily/5 days per week

LEVEL 5: Maintenance

Goal: Continue active pelvic muscle exercise in ongoing self care. Concentrate on becoming aware of contracting the pelvic muscles preparatory to sneezing, coughing, lifting, etc. until this becomes **second nature**. Maintain optimum strength through practicing highly skilled, hard contractions.

Prescription: 5 contractions/set; 1-2 sets/week or more as able to fit into your routine.
Allow 10 seconds rest between contractions

Minimum Time: 5-10 minutes/week

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The Graduated Strength Training Protocol of Pelvic Muscle Exercises (PME)

The Graduated Strength Training Protocol (GST) is proposed as a standardized protocol of PME training based on muscle physiology and application of exercise training principles: (1) specificity of training, (2) plasticity of muscle response, (3) isolation of correct muscle groups, (4) individualization of the training regimen, and (5) maintenance of the training effect. The GST protocol involves five advancing levels of exercise (Appendix A-3).

The GST is a standardized but flexible protocol that allows for placement of women along graduated levels of training according to individual need in both skill acquisition and accompanying strength training. There is an emphasis on high-intensity contractions that is coupled with realistic expectations in the number of repetitions. The reduced time and energy required by the maintenance level introduces the greater likelihood that PME will be incorporated into a woman's life-time health habits.

The first two levels of the GST, level 1 and level 2, concentrate on attaining correct isolation of all layers of the target muscles. These first two levels are designed for women who tend to strain or valsava, who begin with severe PFM weakness, or who have some trouble with identifying and contracting the higher layers of the PFM. With rare exception, these women can adequately contract at least the lower levels of the PFM using a quick flick contraction but become extremely frustrated when asked to hold a contraction for even a couple seconds. The PFM are unable to respond to the duration demand, and compensatory contractions of accessory muscles or straining dominate. Quick short flicks of contractions seem to prevent the tendency towards these technique errors. Layering three progressively higher flicks on top of each other, as in level 2, serves to

increase not only the intensity of the PFM contractions but the layers of muscles activated, while still focusing on avoiding straining or resorting to excessive use of accessory muscles.

Once level 2 is mastered, the woman can move on to techniques at levels 3, then 4. In both of these levels, smooth continuous high hard contractions aim to develop the kind of high-intensity work necessary for expanding type II muscle fiber size and number. Level 3 allows the woman to concentrate on learning to work at near maximum voluntary contraction with each effort, thus emphasizing strength building. Level 4 adds a practice mechanism for maximum voluntary contractions performed at the level of the urogenital diaphragm and at the level of the pubococcygeus muscle. This technique adds the duration component of PME that is dependent on type I fiber activity. An emphasis on sustaining effort across 6 seconds has been shown to improve strength¹ and may contribute to the muscles' ability to contract over a longer period of time, for example during a bout of successive coughing or sneezing. At level 4 the muscles are sufficiently prepared to incorporate a duration component into the strength-building efforts.

Once the response goal has been achieved, adequate strength development or satisfaction with continence status, a maintenance protocol can be prescribed as in level 5. The maintenance protocol is based on a reduced level of exercise theoretically sufficient to maintain a given state of skeletal muscle strength.² It is intended as a sensible exercise activity that can be easily adopted as a long-term self care practice to maintain pelvic muscle tone over the entire lifetime.

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