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EFFECT OF AN EXERCISE PROTOCOL ON PELVIC MUSCLE RESTING PRESSURE IN HEALTHY ADULT WOMEN

By

CORNELIA A. GRIFFIN

A THESIS PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE IN NURSING

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1992

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of the University of Florida in Partial Fulfillment
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EFFECT OF AN EXERCISE PROTOCOL ON PELVIC MUSCLE RESTING PRESSURE IN HEALTHY ADULT WOMEN

By

Cornelia A. Griffin

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Chairperson: Molly C. Dougherty
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A secondary analysis of data was performed examining the effect of a 12-week graded-exercise program on pelvic muscle resting pressure in healthy women (N = 41) aged 35 to 55.

The hypotheses were that resting pressure would remain consistent within each evaluation, and that resting pressure would increase following each three-week exercise interval. Analysis of variance reflected a significant difference in resting pressure within each evaluation ($df = 9$, $F = 5.15$, $p < .0004$). A significant difference was found between baseline and level one of the exercise program ($df = 1$, $F = 7.87$, $p < .0081$). Results suggest exercises performed without a warm-up may result in incomplete relaxation prior to contraction. Significant change between baseline and level one suggests slow relaxation of untrained muscles. Five minutes of submaximal contractions before exercise may be beneficial to the pelvic muscles.

CHAPTER I
INTRODUCTION

Exercises to strengthen the pelvic muscles have long been prescribed to enhance postpartum recovery (Henderson, 1983), improve sexual response (Kline-Graber & Graber, 1978), and relieve stress urinary incontinence (SUI) (Wells, 1990). However, there is no agreement among health care providers concerning the frequency, intensity, or duration of exercise needed to increase pelvic muscle strength (Wells, 1990). Confusion persists because the functions of this muscle group are not as well understood as are other skeletal muscles in the body.

Kegal (1948) was among the first to recommend exercises to strengthen the pelvic muscles. He devised the perineometer, a pneumatic, cylindrical diaphragm attached to a manometer that recorded the amount of pressure exerted on the diaphragm. The diaphragm was placed in the vagina and, when the pelvic muscles were contracted, results were displayed on the manometer, helping the woman to visualize her muscle activity (Kegal, 1948). Kegal also manually palpated increases in muscle size following several weeks of pelvic muscle exercise (Kegal, 1949). Other researchers have followed Kegal, using the perineometer and other devices, to test interventions to improve the integrity of the pelvic floor (Castleden, Duffin, & Mitchell, 1984;

Gordon & Logue, 1985; Stoddart, 1983). A common factor of all these devices was that the shape of the intravaginal device did not conform to the vaginal barrel.

Dougherty, Abrams, and McKey (1986) developed a pressure sensitive, custom-fitted, intravaginal balloon device (IVBD). This device was used in conjunction with a graded exercise program based on principles of exercise physiology. These principles include (a) using the same exercise to test and train the muscle; (b) training regularly; (c) three-week assessment intervals, allowing time for training to take effect; (d) developing endurance through repeated, sustained contractions; and (e) developing strength through rapid, maximal effort when initiating a contraction. Significant improvements after 12 weeks of exercise were found in maximum, minimum, and sustained pressures in 74% of the subjects. Changes in resting pressures were not examined in this study (Dougherty, Bishop, Mooney, Gimotty, & Williams, in press).

Increases in strength, tone, circulation, and muscle size occur in other large skeletal muscles in response to exercise. If the pelvic muscles respond similarly to training, increases in resting pressure can be expected. Examining these pressures will provide information on the effect of exercise on the pelvic muscles at rest, and variation within an assessment. This information may contribute to the design of more effective exercise programs for the pelvic muscles.

Purpose Statement

The purpose of this research was to determine the effect of a 12-week graded exercise program on the pelvic muscle resting pressure in healthy women, aged 35 to 55 years, who completed the program to increase pelvic muscle strength.

Research Hypotheses

1. There will be no significant difference in pelvic muscle resting pressure between ten contractions within five pelvic muscle assessments among healthy women, aged 35 to 55 years.

2. The pelvic muscle resting pressure in healthy women, aged 35 to 55 years, will increase every three weeks corresponding to three-week increases in exercise in the 12 week-long graded exercise program.

Variables

The dependent variable in this research was the resting pressure developed by the pelvic muscles. The independent variable for hypothesis one was the order of sequence of the resting pressure. The independent variable for hypothesis two was the level of exercise intensity in the graded exercise program.

Terminology

1. Abdominal Muscles (AM) of concern in this research are (a) the obliquus externus, (b) the obliquus internus, (c) the transversalis, (d) the rectus, and (e) the pyramidalis (Pick & Howden, 1987).

2. Pelvic Muscles (PM) are comprised of four muscle groups: (a) the superficial and deep transverse perineal

muscles, (b) the bulbocavernosus muscles, (c) the two levator ani muscles, and (d) the sphincter ani muscles (Varney, 1987). Circumvaginal muscle (CVM), pubococcygeus muscle (PC), and pelvic floor muscles (PFM) are terms used interchangeably for pelvic muscles in the literature.

3. The Intravaginal Balloon Device (IVBD) is a pressure sensitive, fluid-filled device made of silicone, and custom-fitted from an alginate impression of the vagina (Abrams, Batich, Dougherty, McKey, Lin, & Parker, 1986). The IVBD is positioned in the vagina at the level of the pelvic muscles and attached to a strain gauge pressure transducer, an amplifier, and a strip chart recorder. The system is calibrated with a mercury manometer, and pressures developed by the pelvic muscles during contraction and relaxation are recorded in millimeters of mercury (mmHg). IVBD reliability demonstrated significant correlation on resting pressure ($N = 16$; $r = .78$) (Dougherty et al., 1986).

4. Kegal Exercises are voluntary pelvic muscle contractions used to tone and strengthen the pelvic muscles. The goal is to isolate and contract these muscles while simultaneously relaxing abdominal, thigh, and buttocks muscles (Kline-Graber & Graber, 1978). CVM, PM, PC, and PFM exercise are other terms used for Kegal exercise.

5. Muscle Tone is defined as the tension that exists in a completely relaxed muscle as a result of the elasticity of the myofibrils and fibrous tissues (Astrand & Rodahl, 1986).

6. The Posterior Balloon Device (PBD) is a .25 x 1 x 2 cm pressure sensitive, fluid-filled device placed in the

posterior fornix of the vagina to monitor abdominal pressure. The accuracy of intravaginal measurements of transmitted abdominal pressure has been demonstrated (Bhatia & Bergman, 1986).

7. Resting Pressure (RP) is the pressure measured (mmHg) over the calibrated zero point, set at atmospheric pressure, on the strip chart recorder when the subject is completely relaxed between voluntary pelvic muscle contractions.

8. The Strain Gauge Pressure Transducer is an instrument that changes energy from one form to another (Polit & Hungler, 1987). In this research, the transducer converted pelvic muscle and AM pressures into electrical signals which were then amplified and recorded on a dual-channel strip chart recorder.

Assumptions

In this research assumptions about the accuracy of the instruments were made. IVBD reliability testing demonstrated a significant correlation on resting pressure (N = 16; r = .78) (Dougherty et al., 1986). It was assumed that the equipment was consistent across evaluations and that any inaccuracy was random. Resting pressure was assumed to reflect muscle hypertrophy.

Limitations

Two investigators conducted the pelvic muscle assessments, so some inconsistency may have occurred with device placement. To minimize this problem, two practice contractions were done prior to each assessment to check correct placement of devices prior to data collection.

Subject movement may have distorted some of the pressure readings.

In this chapter the background and purpose of this research was presented. Chapter 2 is a review of the literature relevant to exercise and the pelvic muscles.

CHAPTER II
LITERATURE REVIEW

Six areas of the literature were considered pertinent to this study (a) pelvic muscle anatomy and physiology, (b) causes of pelvic muscle dysfunction, (c) pelvic muscle assessment methods, (d) exercise and the pelvic muscles, (e) principles of exercise training, and (f) application of a graded exercise program to the pelvic muscles.

Pelvic Muscle Anatomy and Physiology

The pelvic muscles support the bladder, uterus, and rectum, aid in maintaining intraabdominal pressure, and offer some sphincteric control (Whitley, 1985). Beginning with the superficial layer and moving inward, these muscles include (a) the outlet group, (b) the urogenital diaphragm, and (c) the levatores ani.

The muscles of the outlet group are the bulbocavernosi, the superficial transverse perineal muscles, and the external anal sphincter (Mandelstam, 1978). The bulbocavernosi are located on either side of the vaginal orifice and serve as a weak vaginal sphincter (Varney, 1987). The superficial transverse perineal muscles are the superficial parts of the deep muscles and are absent in some women (Oxorn, 1986). The external anal sphincter is comprised of both superficial (voluntary) and deep (involuntary) fibers which blend to form one flat plate of muscle fibers. Voluntary fibers act during defecation, while involuntary fibers blend with the levatores ani and internal anal sphincter to maintain tone and occlude the anal orifice (Oxorn, 1986). The external anal sphincter originates in the anococcygeal body, a band composed of both muscle and fibrous tissues that extends from the coccyx to the posterior margin of the anus. All muscles of the outlet group insert into the central tendinous point of the perineum (Varney, 1987).

The urogenital diaphragm is attached anteriorly to the ischiopubic ramus and posteriorly to the central tendinous point of the perineum. Within the urogenital diaphragm are contained the deep transverse perineal muscles, the sphincter of the membranous urethra, and openings for the urethra and vagina. Fibers from the deep transverse perineal muscles blend with the sphincter of the membranous urethra and the vagina (Oxorn, 1986). When the deep transverse perineal muscles contract, the urethral lumen is compressed (Delancey, 1988).

The levatores ani include the iliococcygeus, ischiococcygeus, and pubococcygeus. Together these muscles form a sling that extends from the pubic bone to the coccyx, with gaps for the passage of the urethra, vagina, and anus. The iliococcygeus originates from a fascial thickening of the obturator internus muscle and inserts into the coccyx and anococcygeal body. The ischiococcygeus arises from the ischial spine and inserts into the side of the lower sacrum and first two segments of the coccyx. No rectal connection exists with either the iliococcygeus or ischiococcygeus muscles (Mandelstam, 1978).

The pubococcygeus is considered the most important of the levatores ani group. It extends anteriorly from the pubic bone in a nearly straight line and attaches posteriorly to the coccyx. This muscle contracts the middle third of the vagina, and its fibers penetrate the muscles of the vagina, proximal urethra, and rectum. Contraction of the pubococcygeus augments both urethral and anal sphincter control, and helps to maintain continence (Whitley, 1985).

Causes of Pelvic Muscle Dysfunction

Decreased muscle tone causes the pubococcygeus to sag like a hammock between the two points of attachment, and the pelvic organs sag with it. Numerous researchers have tried to discover the causes for loss of pelvic muscle tone. Kegal (1949) attributed pelvic muscle weakness to poor neuromuscular function dating from childhood and/or failure of muscular function to return to normal after childbirth.

Bushnell (1950) related pelvic muscle relaxation to vaginal childbirth. He noted that mothers who performed 150 pelvic muscle contractions daily had improved muscle tone six months postpartum as measured by the Kegal perineometer. These patients also reported less episiotomy pain, and Bushnell attributed diminished pain to decreased perineal edema following pelvic muscle contractions. Other researchers (Levitt, Konovsky, Freese, & Thompson, 1979) used the Kegal perineometer for pelvic muscle evaluation and noted significant negative correlation between the number of vaginal births and pelvic muscle contraction pressure.

Brendsel, Peterson, and Mehl (1980) studied the effect of vaginal childbirth, with and without episiotomy, on the pelvic muscles. Fifty women who had episiotomies were matched with 50 women who did not have episiotomies for age, race, parity, child spacing, previous episiotomies, and socioeconomic status. All subjects had normal pregnancies, vertex presentation at delivery, and infants weighing between five and nine pounds at birth. Kegal perineometer evaluation of the subjects was done one year after delivery. No significant differences were found between perineometer readings in women who had episiotomies and those who did not have episiotomies.

Gordon and Logue (1985) measured pelvic muscle muscle function in 70 primiparous women using a modified Kegal perineometer. Fourteen nulliparous women served as controls. The purpose was to evaluate the relationship between degree of perineal trauma following vaginal delivery and subsequent pelvic muscle function. No significant correlation was found between degree of perineal trauma and pelvic muscle function one year after delivery. Significant positive correlations were found between pelvic muscle strength and an amount of any type of regular exercise.

Samples, Dougherty, Abrams, and Batich (1988) studied pelvic muscle function as it related to the postpartum period, parity, type of delivery, episiotomy, age, breastfeeding, physical activity, body mass, stress urinary incontinence, and orgasm in 98 healthy postpartal and nonpostpartal women. Pelvic muscle pressure measurements were made with the intravaginal balloon device. Significant reduction in pelvic muscle pressures was found among women who had delivered vaginally when compared to nulliparous women or women who had cesarean sections. Weak correlation or no correlation was found among the other variables.

In a smaller study of postpartum women (N = 14), Sampselle, Brink, and Wells (1989) also noted a significant decrease in digital pelvic muscle-strength scores at six weeks postpartum for women who had delivered vaginally, but no change for women who had cesarean births. In addition, these researchers found decreases in postpartum digital muscle-strength scores with increases in the degree of perineal disruption at delivery.

Cosner, Dougherty, and Bishop (1991) studied pelvic muscle pressures in 29 pregnant women. These researchers hypothesized that prenatal pelvic muscle pressures, measured at 18 to 33 weeks gestation, would be significantly higher than pelvic muscle pressures at 6 to 13 weeks postpartum. Twenty-two of the subjects had vaginal deliveries. Prenatal maximum pressure (MP) was significantly higher than postpartum MP, but there was no significant change in sustained pressure (contraction pressure held for 10 seconds) for this group. Subjects who had cesarian sections (n = 5) had no significant change in pelvic muscle pressures between prenatal and postpartum assessments. Follow-up data obtained for 10 of the vaginal delivery subjects at one year postpartum showed significant improvement in pelvic muscle MP over the early postpartum results. The researchers concluded that postpartum restitution of the pelvic muscle occurs after the early postpartum period.

Age was examined as a factor in pelvic muscle strength in 388 women with SUI aged 55 to 90 (Brink, Sampselle, Wells, Diokno, and Gillis, 1989). Both vaginal electromyography (EMG) and digital scores of pelvic muscle strength were found to decrease with increasing age.

The relationship between pelvic muscle dysfunction and life events such as childbirth, episiotomy, age, and activity level have been difficult to measure. One confounding factor is the wide variation among women in amount of muscle mass and proportion of muscle tissue to fascia. While stretched muscles may be strengthened by exercise, overstretched fascia, which ensheaths muscles and forms most of the origins and insertions, can only be repaired surgically (Harrison, 1983). In addition, histological studies have shown lateral thinning of pelvic floor muscle fibers in obese women and the aged (Harrison, 1983) and superior pelvic floor muscle tissue among Chinese women as compared to Occidentals (Zacharin, 1977). Differences in pelvic muscle assessment techniques have added to the confusion.

Pelvic Muscle Assessment Methods

Several techniques of pelvic muscle evaluation have been discussed in the literature. Kegal (1951) introduced one finger into the vagina and palpated while the patient contracted her pelvic muscles. Many women are unable to feel the sensation of contracting the pelvic muscles and will contract abdominal, thigh, or gluteal muscles instead. Kegal termed this "loss of awareness of function" (Kegal, 1949, p. 527) and was careful to point out the need for patient instruction in correct muscle use. He developed the perineometer for biofeedback and as a resistance device for strengthening the pelvic muscles (Kegal, 1948). The perineometer has several drawbacks as an assessment tool. It is sensitive to contraction of muscles other than the pubococcygeus. The cylindrical resistance chamber does not conform to the shape of the vaginal barrel, so size differences among women affect pressure measurement inside the device. Logan (1975) subtracted the initial perineometer reading, when the woman was not contracting her pelvic muscles, from the average contraction measurement and found this technique effectively controlled for vaginal size differences. Other problems with the perineometer include variations in reading with bodily position changes and a tendency for the device to slip during contraction (Levitt et al., 1979).

Attempts were made by later researchers to improve upon the perineometer. Stoddart (1983) created a balloon device that was inserted into the vagina and filled with air until it fit snugly. The subject then contracted her pelvic muscles and the examiner moved the balloon up and down in the vagina to find the level of maximum contraction. The device was used primarily as a biofeedback tool for subjects performing pelvic muscle exercises to decrease SUI. Results given were degree of relief from SUI, and no attempt was made to evaluate changes in pressure readings.

Gordon & Logue (1985) attached a condom to a manometer and inflated it until the subject was aware of pressure on the vaginal walls. This pressure reading was considered the resting or zero pressure point. The woman was then asked to contract her pelvic muscles and pressure measurements were recorded. Weaknesses noted in this study were failure to instruct the woman in correct pelvic muscle contraction technique, and accuracy of the zero point depended on subject awareness of vaginal sidewall pressure.

Burgio, Robinson, and Engel (1986) compared the effectiveness of pelvic muscle exercises with and without biofeedback in a group of 24 subjects with SUI. An external anal sphincter balloon was used to measure pelvic muscle pressure in the biofeedback group (n = 13). The results were displayed on a polygraph visible to the biofeedback subjects during each training session. The verbal feedback group (n = 11) trained with an examiner assessing contractions with two gloved fingers in the vagina. Verbal feedback was given to these subjects concerning their ability to contract the pelvic muscles while relaxing the abdominal muscles (AM). Both groups received verbal and written exercise instructions for home use. A 75.9% reduction in incontinence episodes was noted in the biofeedback group as compared to a 51% reduction in the verbal feedback group following four weeks of training.

EMG has been used as a method of pelvic muscle assessment and as biofeedback training to teach pelvic muscle exercises. Perry, Hullett, and Bollinger (1988) treated 31 patients with urinary incontinence (73% female) using a take-home EMG perineometer and computerized biofeedback program. A telephone report line was used to increase compliance. All patients were reported to be cured of incontinence within five visits, but no objective results were given.

A digital pelvic muscle-rating scale was developed by Worth, Dougherty, and McKey (1986) for use in the clinical setting. The scale had four components: pressure, duration, muscle ribbing, and position of the examiner's fingers during contraction. Three degrees of strength were assessed for each of the components with a single gloved finger in the vagina. Both interrater reliability (N = 10, rho = 0.6, p < .04; N = 10, rho = 0.7, p < .05) and test-retest reliability (N = 10, rho = 0.9, p < .003) indicated the instrument was reliable for assessing the pelvic muscles.

A modified version of the digital pelvic muscle-rating scale was used by later researchers to measure pelvic muscle strength in a group of 20 primagravidas prenatally and at six weeks postpartum. Interrater reliabilities ranged from .67 to .77 and validity was demonstrated by fewer incidences of SUI among women with higher digital assessment scores (Sampselle et al., 1989). This instrument was also used to measure pelvic muscle strength in 338 women aged 55 to 90 with SUI. Test-retest reliability for the anteroposterior score was r = .65, p < .01, with interrater reliability r = .91, p < .01 (Brink et al., 1989).

Dougherty et al. (1986) developed an intravaginal balloon device to measure the dynamic characteristics of the pelvic muscles independent of examiner judgment and variability. The balloon was designed from an alginate impression of the vagina. Impressions were made from 20 subjects, and the most representative impression from the group was selected for the balloon model. The balloon was made from silicone, with only the area surrounding the pelvic muscles left hollow to be filled with water for compression. The balloon was filled with water, connected to a strain gauge pressure transducer and a strip chart recorder. The subject assumed the lithotomy position on the examining table. The balloon was placed level with her hips and calibrated to atmospheric pressure (zero). The balloon was then positioned in the vagina and the subject was coached through several contractions. The IVBD was then removed, recalibrated, reinserted, and the procedure was repeated.

Test-retest reliability revealed significant correlations in maximum and resting pressures, indicating performance was reproducible within subjects. Subjects were asked to perform some contractions while using abdominal muscles, and for other contractions they were instructed not to use abdominal muscles. Contraction of the abdominal muscles did not significantly affect IVBD readings.

In a later study, McKey and Dougherty (1986) used the pelvic muscle-rating scale and the IVBD to assess the pelvic muscles and correlated the results. Significant positive correlations were found between the pelvic muscle-rating scale total scores and IVBD maximum contraction results.

These three pelvic muscle assessment methods, pressure, EMG, and digital reflect attempts to provide quantitative measures of pelvic muscle function. It is difficult to compare results of pelvic muscle function across studies because of wide variations in both assessment tools and exercise routines.

Exercise and the Pelvic Muscles

Exercise prescriptions for the pelvic muscles abound in the literature with little consistency among researchers. Kegal (1948) recommended 20 minutes of exercise three times daily. In later writings he noted that exercises must be continued until hypertrophy of the muscles became palpable (Kegal, 1951).

Hendrickson's (1981) subjects performed pelvic muscle contractions, held for two seconds each, and were instructed to progress to 60 repetitions daily. Evaluation was by self-report, and 89% of subjects reported improvement in SUI symptoms after three weeks of exercise.

Stoddart (1983) treated SUI with 40 to 80 pelvic muscle contractions daily, performed in groups of 5 to 10 every two hours. Pre- and post-treatment pad tests were done and indicated a 70% improvement or cure after ten weeks of exercise.

A quasi-experimental design was used by Henderson (1983) to test the effect of a prenatal teaching program for the use of Kegal exercises on postpartum pelvic muscle strength. The experimental group consisted of a convenience sample of patients at 32 to 36 weeks gestation. The subjects were instructed to contract the pelvic muscles for a count of three and then release them. One hundred repetitions daily, or 20 minute sessions three times daily were to be performed. Pelvic muscle contractions were measured at each office visit until delivery using the Kegal perineometer. The control group consisted of 30 women who delivered vaginally and kept their scheduled postpartum appointment. All women received routine postpartum instruction in Kegal exercises by the hospital staff. Perinometer readings were taken on both groups at the routine postpartum office visit. The researcher reported significantly higher mean perineometer scores for the experimental group than the control group.

Several weaknesses were noted in Henderson's study. The experimental subjects stated that they did not comply with the exercise regimen. Subjects were not examined for ability to isolate and contract the pelvic muscles. No prenatal perineometer readings were taken for the control group, therefore there was no initial comparison of pelvic muscle strength between experimental and control subjects. Experimental subjects had several measurements taken with the perineometer, so they were more familiar with the instrument. Finally, control and experimental groups were not matched for variables such as age, parity, forceps delivery, infant weight, or time of postpartum assessment.

The effect of physiotherapy on SUI with and without use of a perineometer was described by Castleden et al. (1984). Nineteen female subjects with SUI performed four or five pelvic muscle contractions hourly, and practiced interrupted micturation on each voiding for a period of two weeks. For two additional weeks, the same exercise program was used, but subjects measured pelvic muscle contractions with the perineometer at least once daily. Fourteen subjects reported improvement in their symptoms, with most of the improvement taking place the first two weeks of the program. Perinometer readings improved also, but the researchers noted no significant advantage in using the perineometer with physiotherapy over using physiotherapy alone.

Tchou, Adams, Varner, and Denton (1988) investigated the effects of pelvic muscle exercise in the treatment of SUI. Fourteen subjects participated in a four-week program. Exercises included stopping and starting urine flow, and various abdominal strengthening exercises combined with pelvic muscle contractions. Pre- and post-training urodynamic evaluations were done and all subjects showed improvement in control of SUI. The researchers concluded that pelvic muscle exercise produced a positive change in subjects with SUI.

Burgio et al. (1986) studied the effectiveness of teaching pelvic muscle exercises using biofeedback, compared to training with vaginal palpation and verbal feedback in 24 women with SUI. Training included four biweekly sessions, one hour in duration. In each session, subjects performed 25 contractions held for 10 seconds each, followed by 10 seconds of relaxation. The biofeedback group watched their progress on a polygraph that recorded bladder, abdominal, and external anal sphincter pressures. For the verbal feedback group, the researcher inserted two gloved fingers into the subject's vagina and instructed her to squeeze the vaginal muscles while relaxing the abdominal muscles. Verbal reinforcement was used to teach contraction of the pelvic muscles with relaxed abdominal muscles. All subjects were given written and verbal instruction for daily home practice of 51 pelvic muscle contractions, divided into three sessions of 17 exercises each. Exercises were to be integrated into other daily activities. Interruption of the urinary stream with each voiding was done also. Follow-up at six months indicated significantly greater improvement in the biofeedback group than the verbal feedback group.

In a larger study Burns, Pranikoff, Nochajski, Desotelle, and Harwood (1990) used a randomized design to compare subjects who performed pelvic floor exercise with and without biofeedback to a control group. Urodynamic and electromyographic assessment was performed on all subjects before starting treatment and again following the eight weeks of therapy. One hundred thirty-five subjects were randomized into three groups: (a) a Kegal exercise group (n = 38), (b) a biofeedback with Kegal exercise group (n = 40), and (c) a control group (n = 40).

The Kegal exercise group performed a combination of quick tighten and relax pelvic muscle contractions, and slow pelvic muscle contractions held for a count of three. Exercises were done four times daily. Kegal exercise subjects kept a daily urine loss record and returned weekly to evaluate their progress. The biofeedback group performed Kegal exercises with coaching in 20 minute sessions once a week. A vaginal probe was used and EMG recordings of contraction efforts were displayed for the subject. The findings showed similar reductions in urine loss for both experimental groups. The control group showed increased urine loss. The biofeedback group, however, significantly increased their EMG scores over the Kegal exercise group and the control group. The researchers concluded that both biofeedback and exercise have a role in the treatment of SUI, and further analysis of biofeedback is needed.

Dougherty, Bishop, Abrams, Batich, & Gimotty (1989a) studied the effects of an exercise program on pelvic muscle strength in postpartum women. An IVBD and a posterior balloon device (PBD) were used, and permanent strip chart recordings of baseline pelvic muscle contraction pressures were made. Forty-five healthy postpartum subjects were randomly assigned to three equal groups. One group exercised with an IVBD in place to assess the effect of a resistance device, and one group exercised without the IVBD. The control group used the IVBD for 30 minutes daily, but performed no exercises. Principles of strength and endurance training were applied to the exercise prescription.

For three days a week, subjects in the experimental groups were instructed to contract the pelvic muscles as hard as possible and hold for six seconds, with abdominal and gluteal muscles relaxed. Fifteen exercises were completed the first week, with two contractions added each week until the sixth and final week. On three alternate days each week, the subjects contracted the pelvic muscles 30 times and held each contraction for 6 seconds. One second was added to the contraction time each week until the sixth week. No statistically significant differences were found among the three groups on follow up IVBD pressure measurements, although higher pressures were noted in the two groups that exercised.

Also, Dougherty, Bishop, Mooney, and Gimotty (1989b) used the same design, but examined 48 nonparturient women of reproductive age and in normal health. Significant improvement (p = .016) for peak maximum pressure attained during a contraction was noted for the women who exercised with no resistance device in place when compared to the other two groups.

Choice of posture for performing pelvic muscle exercises varies with researchers. Supine position is chosen by some for both clinical training and home exercise programs (Dougherty et al. 1989a, 1989b; Ferguson, McKey, Bishop, Kloen, Verheul, & Dougherty, 1990). Harrison (1983) used the supine position for clinical training, but encouraged sitting or standing with legs slightly apart for home exercise. The rationale for this position is that the weight of the pelvic organs acts as resistance to the pelvic muscles. Other researchers (Benvenuti, Caputo, Bandinelli, Mayer, Biagini, & Somavilla, 1987; Burgio et al, 1986; Stoddart, 1983; Tchou et al., 1988) preferred to have subjects combine pelvic muscle exercises with daily routine, regardless of posture.

Bishop (1990) studied the effect of posture on intravaginal and intraabdominal pressures in healthy women. A convenience sample of 32 women were randomly assigned to one of four posture pairing groups: (a) supine and sidelying, (b) sidelying and supine, (c) sitting and standing, or (d) standing and sitting. An IVBD and PBD developed for earlier pelvic muscle research (Dougherty et al., 1989b) were used to obtain pressure measurements. A baffle device to secure the IVBD and PBD during position changes was added. This device consisted of a sanitary belt attached to a perineal pad with openings cut into the pad for IVBD and PBD tubing.

A biofeedback training session was conducted in the supine position to familiarize subjects with the devices and to ensure proper device placement and equipment function. Subjects then performed 5 pelvic muscle contractions, held for 12 seconds each, in each of the 4 positions. Five minute rest periods were provided between each position change. When the examination was completed, each subject was asked to rate her pelvic muscle contraction performance, from best to worst, for each of the four postures.

Results showed the maximum pressure of the pelvic muscles was significantly different in the supine and sitting postures when contrasted with the sidelying and standing postures. The maximum pressure for the abdominal muscles was greater in the sitting and standing positions. Resting pressure and minimum pressures were also significantly dependent on posture. Subjects were unable to identify their best contraction efforts, supporting previous research showing that women have difficulty recognizing the sensation of the contracted pelvic muscles.

These results indicate that research in pelvic muscle exercise has been limited by quality of design. Important questions concerning proper exercise technique, and level and intensity of exercise needed to achieve positive results remain to be answered.

Principles of Exercise Training

Certain training principles for large skeletal muscles can be applied to exercise programs for the pelvic muscles. The best way to train a muscle for a particular activity is to perform the activity with greater frequency, intensity, and duration than usual. Strength gains of 20% to 40% may occur within the first two weeks of training with no measurable increase in muscle size (Astrand & Rodahl, 1986). These early strength increases are believed to result from improved levels of motor activity and, if training at the same level of effort is continued, subsequent additional strength gains are made through muscle hypertrophy (deLateur, 1983). This muscle hypertrophy is a result of increases in the myofibrillar proteins, actin and myosin, contained within the muscle fibers. Fast twitch, Type II, fibers seem to have a higher potential for muscle hypertrophy and are recruited during rapid contractions of low force. Slow twitch, Type I, fibers are fatigue resistant and better adapted to prolonged activity. These fibers have more mitochondria, more myoglobin, and more dense capillary networks than the Type II fibers (Astrand & Rodahl, 1986).

The ratio of fast twitch to slow twitch fibers varies among muscles and among individuals. The levator ani muscles are composed of 95% type I endurance fibers (Gosling, Dixon, Critchley, & Thompson, 1981). They maintain constant tone, relaxing only during urination or defecation. The remaining 5% are type II fibers. These fast twitch fibers are probably used to increase the force and speed of contraction of the levatores ani during events that increase intra-abdominal pressure, like a cough or sneeze (DeLancey, 1990).

Muscle disuse can result in a reduction of muscle mass of up to 40% after several months. This reflects a reduction in cross sectional area of both Type I and Type II fibers. Atrophy also occurs with age, but it is uncertain whether this is due to degeneration of muscle fibers or death of motor neurons (Astrand & Rodahl, 1986). There is a need to document degree of muscle hypertrophy in the pelvic muscles to assess how effectively current exercise prescriptions promote muscle conditioning.

Application of a Graded Exercise Program to the Pelvic Muscles

Dougherty et al. (in press) studied healthy parous women, aged 35 and over, to determine the intensity and duration of pelvic muscle exercise needed to significantly increase intravaginal pressure in this population (N = 85). Subjects were volunteers recruited from the local community. Those subjects who could not attain a 5mmHg maximum intravaginal pressure during voluntary contraction of the pelvic muscles, or those who could not maintain abdominal pressures of 5mmHg or less during pelvic muscle contractions were excluded from the study.

The IVBD and PBD, developed for earlier pelvic muscle research, were used. A series of IVBDs were made using healthy, nonpregnant women with intact pelvic organs, no history of surgical repair to pelvic structures, and no use of exogenous hormones. Alginate impressions of the vagina were made, and set in silicone rubber split molds. After choosing 11 models, representing the range of vaginal sizes and shapes, resin models were made. The resin models were repeatedly dipped in silastic dispersion (medical grade) (Dow Corning, Midland, MI). The IVBD was separated from the mold when the silicone was set. The portion of the IVBD that lies in the posterior vagina was filled with silicone, leaving only the area surrounded by the pelvic muscles free for compression. The open end of the IVBD was attached to silicone tubing (Cole-Parmer, Chicago, IL) with silicone sealant.

This set of 11 IVBDs was used to collect the data. Each subject had an alginate impression of the vagina made and the IVBD that best matched the impression was used for data collection. The posterior balloon device, a flat, hollow .25 x 1 x 2 cm silicone balloon device with silicone tubing (Cole-Parmer, Chicago, IL) attached, was used to record abdominal pressures.

The IVBD, PBD, and attached silicone tubing were filled with water and each device was connected to a pressure transducer. The pressure transducers were attached to amplifiers, and each amplifier was connected to a channel of the strip chart recorder. Permanent records of the intravaginal and abdominal pressures were made during both contraction and relaxation phases of each pelvic muscle exercise evaluation.

Materials used for the pelvic muscle assessment system were as follows (a) a mercury manometer (W. A. Baum Company, Inc., Copiaque, NY); (b) two pressure transducers and two amplifiers (Bell & Howell, Instrument Division, Chicago, IL); (c) dual-channel strip chart recorder (Cole-Parmer, Chicago, IL); (d) syringes (20 cc, 6 cc, 3 cc, and 1 cc); (e) water; (f) silicone rubber tubing to 100 cm in length (Cole-Parmer, Chicago, IL); (g) three-way stopcocks; (h) IVBD; (i) PBD; (j) audio tape recording of instructions and audio tape recorder; (k) water soluble lubricant; (l) disinfectant solution (5:1 mixture of water and bleach approved by the Center for Disease Control, United States Government); and (m) alginate (Healthco International, Inc., Boston,MA), alginate mixing bowl, alginate graduated cylinder, and alginate spatula.

Calibration of the system required a (a) mercury manometer, (b) dual chart strip-channel recorder with two attached transducers and amplifiers, (c) three-way stopcock, and (d) felt tip pen. The pressure transducer and strip-chart recorder were turned on 30 minutes prior to calibration. The gain, chart speed, and atmospheric pressure point on the strip-chart recorder were preset. A stopcock was placed on one transducer port and the mercury manometer attached to the other. The stopcock was closed to atmospheric pressure and, with the manometer at zero, the calibration knob on the strip-chart recorder was adjusted until the baseline on the strip chart was at zero. Then, manometer pressure was increased to the desired maximum pressure for each strip-chart recorder channel (usually 30 mmHg for channel one and 100 mmHg for channel two). Approximately 85 divisions on the strip-chart paper corresponded to 100 mmHg, and approximately 75 divisions corresponded to 30 mmHg. After rechecking the zero point and maximum pressure points against the mercury manometer. the manometer was detached from the transducer.

Subjects, after giving informed consent, assumed a modified (head elevated 20 degrees) lithotomy position on the examining table. An alginate impression of the vagina was made. The impression was used to match an IVBD from the series to the subject. During the bimanual exam, each subject was coached through four to five pelvic muscle contractions to assess her ability to contract the pelvic muscles while relaxing the abdominals.

Water soluble lubricant was applied to the balloon devices. The PBD was placed in the posterior vaginal fornix; the IVBD was positioned in the distal third of the vagina. One or two test contractions were performed to assess the system and familiarize the subject with the procedure.

Audio tape instructions were used during each exercise session and evaluation. A baseline assessment of the pelvic muscles during contraction and relaxation was recorded. If problems arose during an assessment, the audio tape was stopped, adjustments made, and notations indicating the problem recorded on the strip-chart paper with a felt tip pen.

The exercise program began with 15 repetitions of 12 second contractions, to be performed three times per week (every other day) for three weeks. Ten repetitions were added every three weeks, for a total of 45 repetitions in the fourth, and final, interval.

Research staff telephoned subjects weekly to monitor progress and each subject mailed in a weekly written exercise report. On the average, subjects documented completing 33.5 of the 36 prescribed pelvic muscle exercise sessions.

Maximum pressure (MP10), minimum pressure (MinP10), and sustained pressure (SP10) were analyzed. Maximum pressure was defined as the average of the differences between the resting pressures and the maximum pressures attained during each of the ten contractions. To obtain MinP10 and SP10 the 10 seconds representing the maximum effort during each 12 second contraction was bracketed. The minimum values within each 10 second bracket for every contraction were obtained, and the values averaged to represent MinP10. SP10 was obtained by averaging the pressure within the 10 second bracket for each contraction, then averaging the values obtained for each of the 10 contractions.

Increases were found in each of the variables after 12 weeks of pelvic muscle exercise. Statistically significant differences were found among the exercise intervals for MP10 (df = 4,81; f = 18.4; p = .0001), MinP10 (df = 4,79; f = 16.5; p = .0001), and SP10 (df = 4,64; f = 12.2; p = .0001). For exercise intervals 1, 2, and 3, significant increases in intravaginal pressure occurred for MP10, MinP10, an SP10, but for exercise interval 4 only MinP10 showed significant increases. The greatest improvements in MP10 and MinP10 were found following exercise interval 1, although a clinically significant change (5 mmHg increase) was not found. At exercise levels 2 and 3, consistent, small increases were found in each of the study variables. Only MinP10 showed significant improvement at exercise level 4. The researchers concluded that 35 repetitions may represent optimal exercise intensity, or that subjects became demotivated with 45 repetitions and decreased their efforts.

The data from this research were further analyzed to examine factors that affected exercise response in subjects who did not improve (NI) and subjects who were much improved (MI) at completion of the program (Bishop, Dougherty, Mooney, Gimotty, & Williams, in press). It was hypothesized that younger age, lower parity, higher baseline intravaginal pressures, and documented adherence to the exercise program would result in significant increases in maximum pressures. The NI group (N = 22) were those who improved less than 2 mmHG, and the MI group (N = 21) improved 15 mmHg or more. Significant differences between the groups for age were found ($t = -2.29$, df 41, one-tail probability = .0136). There was no relationship found between parity and improvement ($X^2 = .73$, df 2, p = n. s.). The baseline intravaginal pressures of the two groups showed no significant differences ($t = -.38$, df 41, $p = .35$). Both groups adhered to the exercise program. Application of principles of exercise physiology was cited as a contributing factor to improvement found in the MI group. Effort expended, attitudes, motivation, and individual response to training were proposed as factors affecting the NI group results.

Summary

Several factors have foiled attempts to fully appreciate the pelvic muscles. Anatomical studies, performed on cadavers or anesthetized subjects, afford a distorted view of the relationship of the muscles to each other and to the pelvic organs. Variations noted in muscle tissue quality may be related to individual activity levels, genetics, or both. Life events, such as weight gain, childbirth, and aging appear to have an impact on the pelvic muscles. Pelvic muscle assessment methods, instruments used, and exercise prescriptions are so diverse that it is difficult to define relationships between exercise and pelvic muscle function. One consistent finding is that exercise increases pelvic muscle strength for most women. Measurements of improvement, however, vary from expressed relief from SUI to statistically validated increases in pressure or EMG. To date, no studies have been found in the literature that measure increases in pelvic muscle size following exercise. In this research, changes in pressure corresponding with hypothesized changes in the underlying muscle following a graded exercise program were measured. Pelvic muscle resting pressures between contractions were also examined for consistency within each assessment. Documentation of changes in resting pressure following pelvic muscle exercise may further our knowledge of the performance of the pelvic muscles during voluntary contraction. This information may lead to improved pelvic muscle exercise prescription and instruction.

CHAPTER III
METHODOLOGY

In this chapter the research design, setting, sample, instruments, and procedures for the data collection are addressed.

Design

This research was a secondary analysis of data from a study by Dougherty et al. (in press) on the effect of graded exercise on pressures developed by the pelvic muscles during contraction. The original research was a repeated measures design; subjects served as their own controls. This research examined the relationship between resting pressures and the level of exercise intensity in the graded exercise program.

Setting

Data for this research were collected at a research site in North Central Florida.

Subjects

The subjects of the original research were 85 parous women, age 35 years and over, in normal health, who were recruited from the local community. Excluded were those women who could not attain a 5 mmHg maximum intravaginal pressure during voluntary contraction of the pelvic muscles, or who could not maintain abdominal pressures at 5 mmHg or less during pelvic muscle contractions. Each subject had a baseline pressure measurement and subsequent pressure measurements every 3 weeks for 12 weeks following a graded exercise program. A strip chart recorder was used to display the pressure measurements and to provide a permanent record for each evaluation. In some strip-chart recordings, resting pressures were distorted due to subject and/or device movement or irregular performance of equipment. These problems were noted on the strip-chart recordings. To avoid skewed results, only technically sound strip-chart recordings were analyzed in this research. The data set was further limited to subjects age 55 and under, because in subjects 56 years of age and over (n = 33) improvement as a result of pelvic muscle exercise was less than in the younger subjects. The combination of the two above criteria limited this study to 41 subjects. This research was approved as exempt status from the University of Florida Health Science Center Institutional Review Board.

Instruments

A data form (see appendix) was used to record calculated mean resting pressures from the strip chart recordings.

Materials

Materials to obtain resting pressures were (a) cassette player and audiocassette tape recording used to guide data collection, (b) stopwatch, (c) numerical list of research subjects and their ages, (d) strip chart recordings from the original research, (e) six-inch ruler, and (f) pen.

Procedures

Dougherty provided an audiocassette tape recording of instructions used to guide each data collection session, all strip chart recordings from the original research, and a numerical list of subjects and their ages. Gross examination of the strip-chart recordings suggested that resting intervals prior to some contractions varied. The audiocassette tape was played, and the relaxation phase preceding each contraction was timed with a stopwatch and values recorded. The resting phase was 19 seconds prior to contraction 7, and 12 seconds prior to contraction 10. All other resting phases were 15 or 16 seconds long.

Subjects 55 years old and younger were chosen from the numerical listing and their strip chart recordings, if technically sound, were selected for analysis. Recordings of 5 subjects randomly selected from this group (N = 41) had all resting pressures (10 per trial) in all trials (5 per subject) measured. These values were used to calculate within-subject variance and to test hypothesis one. Insignificant variation in the ten resting pressure values within a trial means any one value may be used to represent the subject's performance. The balance of the recordings (5 per subject, n = 36) had alternate resting pressures (5 per recording) measured. Often, the resting pressure before the first contraction in a trial was reflected on the strip-chart tracing for less than 5 seconds. To ensure precise values, the alternate resting pressures chosen were those pressures prior to contractions 2, 4, 6, 8, and 10. These values were used to examine between-subject variance and to test hypothesis two. Between-subject variance increases over the baseline if the level of exercise intensity results in a change in the subject's resting pressure.

Resting pressure is not graphically represented as a straight line. A six-inch ruler was used as a straight edge to draw lines on the strip chart recordings defining the area of each resting pressure. First, a horizontal line was drawn along the zero pressure point, or baseline. Resting pressure was measured by starting at the beginning of each contraction and measuring the distance on the strip chart paper to the left of the contraction equivalent to the number of seconds in the resting phase for that contraction. Two seconds were eliminated at the beginning of each resting pressure because this represents the approximate length of time it takes from the command "relax now" until the subject is fully relaxed.

Vertical lines were drawn from the baseline to the resting pressure line to define the beginning and end of each resting pressure. Then, values were measured at the midpoint of the area defined as resting pressure and at points halfway from the midpoint to the left and right. For each of these values a vertical line was drawn from the baseline to the resting pressure line. The distance along each of these lines was measured from the baseline up to the resting pressure line and recorded. The three values were averaged and this quantity converted to millimeters of mercury and defined as the resting pressure. In most cases, if the black pen was used, 85 divisions on the strip chart paper correspond to 100 mmHg. If the red pen was used, 75 divisions correspond to 30 mmHg. Deviations from these values are noted on the strip chart recordings, and calculations were adjusted accordingly.

After the resting pressures were calculated for each strip-chart recording, mean values were noted on the data form (appendix). When all values were obtained they were entered into Statistical Analysis System (SAS), a computerized statistical analysis program, and checked for errors against the data form. Results of the data analysis and discussion follow in the next chapter.

CHAPTER IV
RESULTS AND DISCUSSION

The purpose of this research was to determine the effect of a 12 week graded exercise program on the pelvic muscle resting pressure in healthy women aged 35 to 55 years. Repeated measures analysis of variance (ANOVA) was chosen to analyze the data.

To obtain accurate results from ANOVA, three assumptions must be satisfied. The first assumption is that the dependent variable is normally distributed. The second assumption, homogeneity of variance, means that the variance of the groups should not differ significantly from one another (Munro, Visintainer, & Page, 1986).

The third assumption is the assumption of compound symmetry and it contains two parts. The first part states that correlations across measurements (i.e., correlations between the first measurement taken and all subsequent measurements) are about the same. The second part states that variances across measurements are approximately equal. This assumption is considered critical because when subjects are measured repeatedly variations may occur due to repeated exposure to the instrument, fatigue, motivation, or other factors not related to the independent variable. The SAS program tests the symmetry of orthogonal components (sphericity test) rather than compound symmetry. The sphericity test is a sufficient and necessary condition, but it is less restrictive than compound symmetry (Munro et al., 1986).

If the assumption of compound symmetry is not met, a type I error is more likely to occur. In this case, the Greenhouse-Geisser procedure may be used. This approach employs a more stringent, corrected F value. The disadvantage to this test is that it tends to overcorrect and increase the likelihood of a type II error. ANOVA is considered fairly robust, meaning that even if the assumptions are not rigidly adhered to, the results may still be close to the truth (Munro et al., 1986).

For hypothesis one, the mean and standard deviation (SD) of the resting pressure between the 10 contractions within the 5 pelvic muscle assessments are shown in table 4.1.

Table 4.1
Mean Resting Pressures (mmHg) Between Ten Contractions Within Five Pelvic Muscle Assessments (n = 5)

Contraction	1	2	3	4	5	6	7	8	9	10
Mean	11.89	12.89	13.78	14.06	14.31	14.34	14.94	14.03	13.82	14.13
SD	4.02	3.59	4.18	4.56	4.15	3.96	5.19	4.39	4.01	4.40
RPS*	15	15	15	16	16	16	19	15	16	12

*Resting Phase in Seconds

The repeated measures ANOVA showed a significant change in the resting pressure within subjects (df 9, $F = 2.92$, $p < .04$). The test for sphericity was significant ($p = .015$), indicating the criterion of symmetry was not met. The Greenhouse-Geisser correction also showed a significant change in resting pressure within subjects (df 9, F = 5.15, $p < .0004$). The within-subject variabilities for the 10 resting pressures are displayed in figure 4.1.

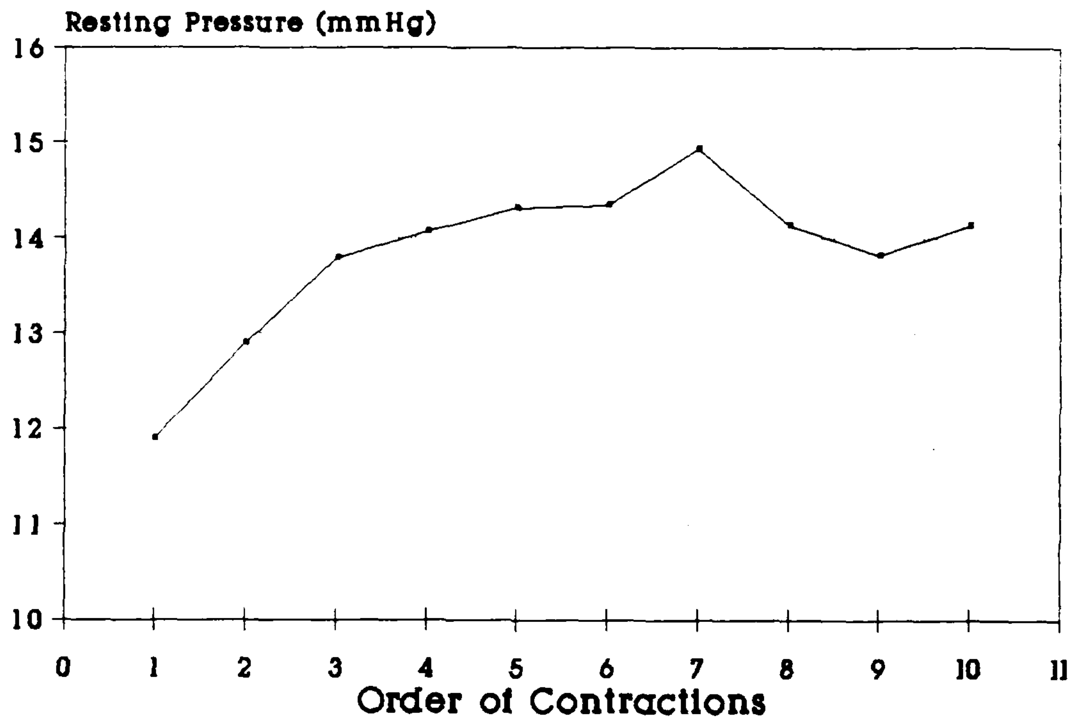

Figure 4.1 Mean Intervaginal Resting Pressures Between Contractions Across All Levels Of Exercise Intensity (n = 5)

ANOVA of contrast variables showed no significant differences between adjacent resting pressures. However, significant differences were found between the resting pressure preceding contraction 1 and all other resting pressures, with the noted exception of the resting pressure preceding contraction 2. Correlations across measurements were high, and no interaction was found.

Hypothesis two states that the pelvic muscle resting pressures will increase with each increase in exercise intensity in the graded exercise program. The mean and SD of the resting pressures for the baseline and each level of exercise intensity are shown in table 4.2.

Table 4.2 Mean Resting Pressures (mmHg) for Baseline and Four Levels of Exercise Intensity (n = 36)

Repetitions	Exercise Level	Mean	SD
	Baseline	10.53	4.08
15	1	12.29	4.61
25	2	11.65	4.38
35	3	12.90	4.87
45	4	13.03	5.52

Repeated measures ANOVA showed a significant change in resting pressures between subjects (df 4, $F = 3.54$, $p < .0168$). The criterion of symmetry was met (sphericity test $p = .738$). ANOVA of contrast variables showed a significant difference in the resting pressures between the baseline and levels 1, 3, and 4 of the graded exercise program. No significant difference was found between the baseline and level 2. No significant differences were found between levels 1 and 2, levels 2 and 3, or levels 3 and 4 in the graded exercise program. Chapter V summarizes the research, and presents conclusions and recommendations for further investigation.

CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

This chapter contains a summary of the research findings and conclusions, implications for future research, and implications for clinical practice.

Summary and Conclusions

This research was a secondary analysis of data to examine the relationship between pelvic muscle resting pressures and the level of exercise intensity in a graded exercise program. The original study was conducted to determine the intensity and duration of pelvic muscle exercise needed to significantly increase intravaginal pressure in healthy, aging women. Pressure measurements were obtained during contraction and relaxation and permanent records of subject performance were preserved. In this research, the hypotheses were that (a) there would be no significant difference in pelvic muscle resting pressure between ten contractions within five pelvic muscle assessments among healthy women ($n = 5$), aged 35 to 55 years, and (b) the pelvic muscle resting pressure in healthy women ($n = 36$), aged 35 to 55 years, would increase every three weeks corresponding to three-week increases in exercise in the 12 week-long graded exercise program.

Results of ANOVA showed a significant change in the resting pressure within subjects. The absence of significant differences in resting pressures between adjacent contractions justifies the analysis of contractions 2, 4, 6, 8, and 10 for hypothesis two.

While adjacent resting pressures were not significantly different, significant changes occured between the RP preceding contraction 1 and all other resting pressures, with the exception of the RP preceding contraction 2. There was a gradual increase in the mean RP prior to each contraction until contraction number eight. At this point, there was an abrupt decrease in resting pressure. This decrease occurs after the contraction preceded by the longest period of rest (19 seconds) in the series. It is also noteworthy that the RP prior to contraction eight begins 3.27 minutes from the beginning of the assessment.

DeVries (1986) notes that the relaxation phase takes two to three times longer than the contraction phase in a cool muscle. Generally, a 5 minute warm-up of light to moderate exercise is recomended prior to ordinary exercise (Astrand & Rodahl, 1986). Because the graded exercise program does not provide a warm-up phase, gradual increases in the resting pressure suggest that subjects may be performing contractions while the pelvic muscles are still in a partially contracted state from the previous stimulation. The longer resting phase prior to contraction number seven may have afforded the pelvic muscles adequate recovery time and account for the decrease in RP prior to contraction eight. Also, at this point, the subject is 3.27 minutes into the program and her muscles may be starting to warm-up. The markedly shortened resting phase prior to contraction ten probably accounts for the rise in pressure at this point. These findings indicate that an analysis of the contractions and rest phases within the assessment is advisable before final outcome measures and data handling procedures are set.

For hypothesis two, significant increases in RP were found between the baseline and levels 1, 3, and 4 of the graded exercise program. Small, but not statistically significant, increases were found between levels 2 and 3, and between levels 3 and 4. A decrease in resting pressure was noted between levels 1 and 2 of the graded exercise program.

DeVries (1986) notes that in young subjects (under age 60) neural factors account for most of the strength gain in the first 3 to 4 weeks of exercise, after which hypertrophy accounts for nearly all the strength gain. In view of this, it is doubtful that the change in RP at exercise level one (3 weeks of training) reflects hypertrophy. However, EMG studies have shown that the ability to relax voluntarily improves with training (deVries, 1986). Perhaps the decrease in RP at exercise level 2 indicates improved relaxation. Subsequent increases in RP at levels 3 and 4 may be a more accurate index of muscle hypertrophy.

Implications for Future Research

The benefits of warm-up prior to exercise have been recognized by exercise physiologists for some time. Higher muscle temperature speeds metabolic processes within the cells, facilitates the exchange of oxygen and carbon dioxide, and permits faster transmission of neural messages

(Astrand & Rodahl, 1986). This research suggests that initiating pelvic muscle exercise without a warm-up may have resulted in summation, or contraction of the muscles prior to complete relaxation. Perhaps 5 minutes of submaximal contractions prior to exercise would be beneficial for the pelvic muscles. Greater consistency in the length of the resting phase during pelvic muscle exercise would facilitate evaluation.

Significant changes in RP from baseline measurements in response to exercise have implications for researchers using pressure as a method of measurement. When measuring a voluntary contraction, it may be advisable to begin at the resting pressure point rather than the baseline, or zero pressure point. This will avoid artifically elevated measurements from increased resting pressures as the pelvic muscles respond to increased exercise intensity.

The IVBD, while an improvement over earlier intravaginal pressure devices, is still prone to slipping which affects pressure readings (M. C. Dougherty, personal communication, January 27, 1992). Researchers using EMG have reported recording differences in resting muscle activity of less than 1 microvolt. EMG output can also be separated into the effects of strength through improvement of neural factors and true muscle hypertrophy (deVries, 1986). The sensitivity of this method of measurement may yield more information about the response of the pelvic muscles to exercise.

Implications for Clinical Practice

Researchers have demonstrated the effectiveness of pelvic muscle exercise in relieving SUI, but health professionals seldom incorporate teaching these exercises into the routine gynecological exam. While SUI is prevalent, patients are often too embarrassed to discuss the problem, or believe the condition is a normal part of aging (Norton, 1990). Health care providers may contribute to improving women's health by taking a more active role in eliciting this information, assessing the pelvic muscles, and teaching pelvic muscle exercises. Use of a biofeedback device may help patients to appreciate their efforts and encourage commitment to the exercise program.

REFERENCES

Abrams, R. M., Batich, C. D., Dougherty, M. C., McKey, P. L., Lin, Y. C., & Parker, J. (1986). Custom-made vaginal balloons for strengthening circumvaginal musculature. Biomaterials, Medical Devices and Artificial Organs, 14, 239-248.

Astrand, P. O. & Rodahl, K. (1986). Textbook of work physiology: Physiological bases of exercise. New York: McGraw-Hill.

Benvenuti, F., Caputo, G. M., Bandinelli, S., Mayer, F., Biagini, C., & Sommavilla, A. (1987). Reeducative treatment of female genuine stress incontinence. American Journal of Physical Medicine, 66(4), 155-168.

Bhatia, N. N. & Bergman, A. (1986). Urodynamic appraisal of vaginal versus rectal pressure recordings as an indication of intra-abdominal pressure changes. Urology, 27(5), 482-485.

Bishop, K. R. P. (1990). Dynamic characteristics of the circumvaginal muscles: The effect of posture. Unpublished master's thesis, University of Florida, Gainesville.

Bishop, K., Dougherty, M., Mooney, R., Gimotty, P., & Williams, B. (in press). Age, parity and adherence: Factors affecting pelvic muscle performance. Journal of Obstetric, Gynecologic, and Neonatal Nursing.

Brendsel, C., Peterson, G., & Mehl, L. E. (1980). Routine episiotomy and pelvic symptomatology. Women and Health, 5(4), 49-60.

Brink, C. A., Sampselle, C. M., Wells, T. J., Diokno, A. C., & Gillis, G. L. (1989). A digital test for pelvic muscle strength in older women with urinary incontinence. Nursing Research, 38(4), 196-199.

Burgio, K. L., Robinson, J. C., & Engel, B. T. (1986). The role of biofeedback in Kegal exercise training for stress urinary incontinence. American Journal of Obstetrics and Gynecology, 154(1), 58-64.

Burns, P. A., Pranikoff, K., Nochajski, T., Desotelle, P., & Harwood, M. K. (1990). Treatment of stress incontinence with pelvic floor exercises and biofeedback. Journal of the American Geriatric Society, 38, 341-344.

Bushnell, L. F. (1950). Physiologic prevention of postpartal relaxation of the genital muscles. Western Journal of Surgery, Obstetrics and Gynecology, 11(6), 479-490.

Castleden, C. M., Duffin, H. M., & Mitchell, E. P. (1984). The effect of physiotherapy on stress incontinence. Age and Aging, 13, 235-237.

Cosner, K. R., Dougherty, M. C., & Bishop, K. R. (1991). Dynamic characteristics of the circumvaginal muscles during pregnancy and the postpartum. Journal of Nurse-Midwifery, 36(4), 221-225.

DeLancey, J. O. L. (1988). Structural aspects of the extrinsic continence mechanism. Obstetrics and Gynecology, 72(3), 296-301.

DeLancey, J. O. L. (1990). Anatomy and physiology of urinary continence. Clinical Obstetrics and Gynecology, 33(2), 298-307.

deLateur, B. J. (1984). Exercise for strength and endurance. In J. V. Basmajian (Ed.). Therapeutic exercise (pp. 88-109). Baltimore, MD: Williams & Wilkins.

deVries, H. A. (1986). Physiology of exercise for physical education and athletics (3rd ed.). Dubuque, IA: Wm. C. Brown.

Dougherty, M. C., Abrams, R. M., & McKey, P. L. (1986). An instrument to assess the dynamic characteristics of the circumvaginal musculature. Nursing Research, 35, 202-206.

Dougherty, M. C., Bishop, K. R., Abrams, R. M., Batich, C. D., & Gimotty, P. A. (1989a). The effect of exercise on the circumvaginal muscles in postpartum women. Journal of Nurse-Midwifery, 34(1), 8-14.

Dougherty, M., Bishop, K., Mooney, R., & Gimotty, P. (1989b). The effect of circumvaginal muscle (CVM) exercise. Nursing Research, 38(6), 331-335.

Dougherty, M. C., Bishop, K. R., Mooney, R., Gimotty, P. A., & Williams, B. (in press). Graded exercise: Effect on pressures developed by the pelvic muscles. In S. G. Funk, E. M. Tornquist, M. T. Champagne, & R. E. Wiese (Eds.), Key aspects of elder care: Managing falls, incontinence, and cognitive impairment. New York: Springer.

Ferguson, K. L., McKey, P. L., Bishop, K. R., Kloen, P., Verheul, J. B., & Dougherty, M. C. (1990). Stress urinary incontinence: Effect of pelvic muscle exercise. Obstetrics and Gynecology, 75(4), 671-675.

Gordon, H., & Logue, M. (1985). Perineal muscle function after childbirth. Lancet, 2, 123-125.

Gosling, J. A., Dixon, J. S., Critchley, H. O. D., & Thompson, S. (1981). A comparative study of the human external sphincter and periurethral levator ani muscles. British Journal of Urology, 53, 35-41.

Harrison, S. M. (1983). Stress incontinence and the physiotherapist. Physiotherapy, 69(5), 144-147.

Henderson, J. S. (1983). Effects of a prenatal teaching program on postpartum regeneration of the pubococcygeal muscle. Journal of Obstetric, Gynecologic, and Neonatal Nursing, 12, 403-408.

Hendrickson, L. S. (1981). The frequency of stress incontinence in women before and after the implementing of an exercise program. Issues in Health Care of Women, 3(2), 81-92.

Kegal, A. H. (1948). Progressive resistance exercise in the functional restoration of the perineal muscles. American Journal of Obstetrics and Gynecology, 56, 238-248.

Kegal, A. H. (1949). The physiologic treatment of poor tone and function of the genital muscles and of urinary stress incontinence. Western Journal of Surgery, Obstetrics, and Gynecology, 57, 527-535.

Kegal, A. H. (1951). Physiologic therapy for urinary stress incontinence. Journal of the American Medical Association, 146, 915-917.

Kline-Graber, F., & Graber, B. (1978). Diagnosis and treatment procedures of pubococcygeal deficiencies in women. In J. LoPiccolo & LoPiccolo (Eds.), Handbook of sex therapy (pp. 227-239). New York:Holt.

Levitt, E. E., Konovsky, M., Freese, M. P., & Thompson, J. F. (1979). Intravaginal pressure assessed by the Kegal perineometer. Archives of Sexual Behavior, 8, 425-430.

Logan, T. G. (1975). The vaginal clasp. A method of comparing contractions across subjects. The Journal of Sex Research, 11, 353-358.

Mandelstam, D. (1978). The pelvic floor. Physiotherapy, 64, 236-239.

McKey, P. L., & Dougherty, M. C. (1986). The circumvaginal musculature: Correlation between pressure and phvsical assessment. Nursing Research, 35, 307-309.

Munro, B. H., Visintainer, M. A., & Page, E. B. (1986). Statistical methods for health care research. Philadelphia: Lippincott.

Norton, P. A. (1990). Prevalence and social impact of urinary incontinence in women. Clinical Obstetrics and Gynecology, 33(2), 295-297.

Oxorn, H. (1986). Human labor and birth (5th ed.). Norwalk, CT: Appleton-Century-Crofts.

Perry, J. D., Hullett, L. T., & Bollinger, J. R. (1988). EMG biofeedback treatment of incontinence. Biofeedback and Self-Regulation, 13(1), 86.

Pick, T. P., & Howden, R. (1987). Gray's anatomy. New York: Bounty Books.

Polit, D. F., & Hungler, B. P. (1987). Nursing research principles and methods (3rd ed.). Philadelphia: J. B. Lippincott.

Samples, J. T., Dougherty, M. C., Abrams, R. M., & Batich, C. D. (1988). The dynamic characteristics of the circumvaginal muscles. Journal of Obstetric, Gynecologic, and Neonatal Nursing, 17(3), 194-201.

Sampselle, C. M., Brink, C. A., & Wells, T. J. (1989). Digital measurement of pelvic muscle strength in childbearing women. Nursing Research, 38(3), 134-138.

Stoddart, G. D. (1983). Research project into the effect of pelvic floor exercises on genuine stress incontinence. Physiotherapy, 69, 148-149.

Tchou, D., Adams, C., Varner, R. E., & Denton, B. (1988). Pelvic floor musculature exercises in treatment of anatomical urinary stress incontinence. Physical Therapy, 68(5), 652-655.

Varney, H. (1987). Nurse-Midwifery (2nd ed.). Boston: Blackwell Scientific Publications.

Wells, T. J. (1990). Pelvic (floor) muscle exercise. Journal of the American Geriatric Society, 38, 333-337.

Whitley, N. (1985). A manual of clinical obstetrics. Philadelphia: J. B. Lippincott.

Worth, A. M., Dougherty, M. C., & McKey, P. L. (1986). Development and testing of the circumvaginal muscles (CVM) rating scale. Nursing Research, 35, 166-168.

Zacharin, R. F. (1977). A Chinese anatomy: The pelvic supporting tissues of the Chinese and occidental female compared and contrasted. The Australian and New Zealand Journal of Obstetrics and Gynaecology, 17(1), 1-11.

APPENDIX
DATA FORM

Trial # ______ C = Contraction

Subject number	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10

BIOGRAPHICAL SKETCH

Cornelia A. Griffin received her Bachelor of Science degree in nursing in May of 1979 from East Carolina University. Following graduation, she was employed as a newborn nursery staff nurse at Cape Fear Valley Hospital, Fayetteville, NC, until January 1980 when she was commissioned as a U. S. Air Force officer. Her military nursing experience began as a lieutenant at the neonatal intensive care unit at Keesler Air Force Base Medical Center, MS, 1980 to 1983, and as a captain she was assigned staff duties in labor and delivery, postpartum, and the newborn nursery at Misawa Air Base in Japan, 1983 to 1986. In November 1987, she completed the Air Force OB/GYN Nurse Practitioner course and was certified in February 1988 while stationed at Mountain Home Air Force Base, ID, as OB/GYN Nurse Practitioner. There she was promoted to major and in July 1990 she was selected for Air Force sponsored graduate education at the University of Florida. Major Griffin is a member of NAACOG, an organization for obstetric, gynecologic, and neonatal nurses; the Uniformed Nurse Practitioners Association; and, Sigma Theta Tau, a national honor society of nursing.