Female Pelvic Floor Health

A Developmental Review

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An often neglected but important area of women's health involves the pelvic floor. Pelvic floor health can be reviewed by examining phases of a woman's life. Because pelvic floor health is not readily discussed and few professionals are considered experts in this area, it is often overlooked in women's healthcare. In medicine, care of the pelvic area can become fragmented as it is divided among urologists, gynecologists, and colorectal surgeons.[1,2] The specialty of urogynecology combines 2 of the areas, and some physical therapists and nurses choose to specialize in female pelvic floor health. The issues of pelvic floor health are often addressed only after symptoms have presented. However, healthy practices can enhance pelvic floor well-being and maintain quality of life as a woman ages.[1] This article is a review of clinical, research, and editorial articles on female pelvic floor issues and a discussion of measures that can contribute to optimal pelvic floor health.

The pelvic area is a bowl-shaped grouping of bones, muscles, and ligaments that provides protection for the bladder, urethra, uterus, and rectum. The floor of this bony structure consists of tissues that span the opening. The muscles and ligaments create a support surrounding the vagina, urethra, and rectum, sustaining the pelvic and abdominal viscera. The pelvic floor consists of 3 layers: the endopelvic fascia, the levator ani muscles, and the perineal membrane, as well as a fourth layer of external genital muscles important for sexual function (Figure 1).[2,4] The primary support comes from the levator ani muscle that forms a remarkably effective closure of the pelvic floor.

The pelvic muscles can be visualized as a urogenital diaphragm that is attached to the walls of the pelvic bones, much like the respiratory diaphragm that spans the opening at the bottom of the rib cage. This hammock or trampoline-like floor is structurally weakened by 3 important openings: the urethra, the vagina, and the anus. Each of these 3 openings has some support dependence on the muscles around them. These muscles also provide support for the bladder and the uterus even though they are more securely inside the pelvis. When a woman is standing, the pelvic muscles not only uphold the organs in the pelvis, but gravity forces also require that they support the abdominal organs. Carrying extra weight or physical activity increases the gravitational forces against these muscles.[5] Like other muscles in the body, the muscles in the pelvic floor are subject to fatigue and injury.[6] They can also be actively exercised to increase their tone and size to prevent fatigue and injury.[7-9]

Healthy pelvic muscles have optimum blood supply, strength, and tone; have not been overstretched, torn, or underdeveloped; have not been allowed to decondition and sag with aging; and have not been overused by chronic straining, lifting, or coughing. There are two distinct muscle fiber types based on their contractile characteristics. Type I, or slow-twitch fibers, are characterized by slow speed of contraction (every 100 to 120 msec). They have twice the blood supply per unit as other fiber types and are well suited for prolonged activity. They fatigue more slowly. Type II, or fast-twitch fibers, are characterized by faster contractions (every 40 msec) and are well suited for short bursts of activities required to respond quickly during stressful periods of increased intraabdominal pressure.[10,11] The pelvic floor muscles are approximately 70% slow twitch and 30% fast twitch, with some variation in location and size across the floor.[4]

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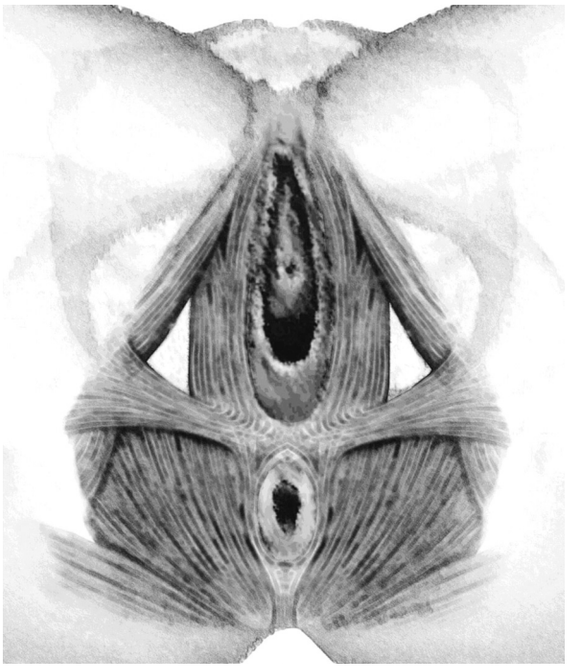

FIGURE 1. The female pelvic floor.

In the past, pelvic floor ligaments "were thought to be the most important elements of pelvic support; however, biomechanical analysis suggests that fibrous tissue is poorly suited to support the kind of constant load that gravity and intraabdominal pressure place on the pelvic floor."[12] If the muscles have been damaged, the ligaments and fasciae have to provide support for the pelvic organs.[2] Ligament tissue can stretch to a degree before tearing. A torn ligament often requires surgery to heal and recover its structural purpose. Muscle tissue is more forgiving because it can stretch and contract back to its original shape. If overstretched, muscle fibers can tear. Nerves within the pelvic muscles can only stretch approximately 15% before damage occurs.[13] An athlete or weight lifter may have small muscle tears after a serious workout, which is why it is recommended that training and weightlifting sessions be alternated to allow for tissue recovery.[10] Strengthening the muscles around a ligament can offer protection to the ligament. Athletes strengthen muscles before competition to prevent injury, and rehabilitation specialists use physical therapy to strengthen the muscles around an injured or surgical area.

The muscles and the ligaments that comprise the pelvic floor are subject to the same principles of stretch, overload, resistance, and recovery as other muscles in a woman's body. Overload refers to demanding more of the muscles than normally required. As gains are made, resistance should be increased. Specificity relates to changes in the area that is subjected to overload. Strength and endurance occur at the muscle fiber level from selective recruitment and hypertrophy.[10]

The most important group of muscles in the pelvis is the levator ani. The levator ani muscles close off the pelvic floor so that the organs above rest on their upper surface. They represent a defense to prevent prolapse of the organs.[4] Generally, pelvic muscles in women, specifically the levator ani group, have not been well developed by exercise. Once they have been strained or injured, they are rarely rehabilitated to full recovery. There are several reasons for this. One is the underappreciation and the lack of knowledge of the complex nature of the pelvic floor and its function.[4] Second is the difficulty in learning to isolate this group of muscles.[14] Third is the myth that many women and healthcare practitioners consider pelvic floor weakness a natural result of aging.[2] Fourth, women are not comfortable discussing pelvic floor dysfunction symptoms. Today, more and more women are learning about their personal health and are willing to include good health practices in their lifestyle. This practice of self-responsibility for wellness is for a woman's benefit and should include pelvic floor health. Knowledge about good pelvic health would do well to follow the lead of breast health and become openly discussed as part of women's healthcare. It is important for a woman to understand the function of the pelvic floor, as well as to learn how to prevent problems related to its weakness.

Pelvic health...is often overlooked in women's healthcare.

Phases of Pelvic Floor Health for Women

Initially, during reproduction, the structures of the female and male embryo are the same until about the eighth week. The gonads of the genetically male embryo produce testosterone, and the lack of testosterone causes the female gonads to develop into ovaries. As the gonads develop, the external genitalia begin to form, the male gonads (testes) descend into the scrotum, and the female external genitalia expand through a defect in the pelvic floor structure.[15] Certain fascial and muscular abnormalities can occur that may affect the pelvic floor.[16] Ehlers-Danlos syndrome, an uncommon genetic connective tissue disorder, can result in connective tissue fragility and can contribute to the etiology of urinary incontinence and genital prolapse.[17] An abnormality in collagen synthesis may be able to withstand normal pressures but not additional pressures of obesity, constipation, pregnancy, labor, or cough-inducing conditions, such as asthma or chronic obstructive pulmonary disease.[18]

As toddlers become little girls, various voiding dysfunctions can occur. Pelvic floor overactivity can result in urinary retention, obstipation, and recurrent urinary infections.[19] Constipation can cause detrusor instability, and children

with detrusor instability who use posturing maneuvers to avoid incontinence are at risk for urinary tract infections.[20] Girls achieve toilet training earlier than boys (2.25 years vs 2.56 years), and they also have a greater incidence of daytime enuresis, whereas boys have greater nighttime enuresis.[21] In the child's bladder, uninhibited contractions may still be present and experienced as urgency. Girls sometimes have "giggle incontinence" yet be dry between episodes. This is different from stress incontinence, which occurs when an increased abdominal pressure overcomes a weak bladder outlet mechanism. The passage of time is usually curative as maturation occurs.[21] Toilet avoidance may begin during the toilet training years or with early school years. Children may not want to interrupt play, or they may be fearful of school or public toilet areas. The result may be a "lazy" or oversized bladder with poor emptying process and an increase in urinary tract infections.[21]

Between the ages of 9 to 12, the female gonads begin to secrete more sex hormones, estrogen levels rise, and reproductive organs begin to mature. There are many estrogen receptors in the pelvic area. These receptors are in the vulva, the vagina, uterus, urethra, and base of the bladder. The connective tissues, the blood vessels, and, to some degree, even the muscles in the pelvic area, have been identified as having estrogen receptors. These tissues are sensitive to estrogen, and estrogen is a part of their proper functioning during young to middle life.[22] Cyclic changes in estrogen and prostaglandin can affect lower urinary tract function.[6]

Puberty is often the beginning of competitive sports, cheerleading, and increased muscle development for girls. Girls become conscious of their "abs" or abdominal muscles and want to look fit. Cheerleading, ballet, and sports, such as gymnastics, tennis, basketball, and track, add extra strain on the pelvic floor muscles and ligaments from the jarring of jumping, starting, stopping, jogging, and other athletic moves. With well-developed abdominal muscles, intraabdominal pressures that occur during exercise increase the forces on the pelvic floor. Leaking urine can become a barrier to physical activity. Athletic women as young as junior high age are developing urine leakage during their sports activity.[23] Dr Nygaard's study of elite nulliparous college athletes at the University of Iowa found that 32% of the athletes leaked urine during their sports, 13% beginning in junior high.[24] It is not surprising that gymnastic athletes had the highest incidence of urinary leakage at 67%, with basketball close behind at 66%, and tennis at 50%.[24] Factors that may be involved are pelvic floor muscle fatigue, increased intraabdominal pressure with landings and jumps, or changes in collagen concentration.[17] Women with hyper joint mobility may be selectively encouraged to participate in gymnastics or other sports.[2424] If not deliberately exercised and strengthened, the pelvic floor muscles in these young athletes are not strong enough to withstand the gravitational and intraabdominal forces of jumps and landings. When the women pound down on the mat or court from a jump or run, the abdominal muscles contract, pelvic organs are forced downward against the pelvic floor, and the closure mechanism to keep urine from leaking may be temporarily jarred out of position, resulting in urine leaks.[25]

Urinary leakage is a personal and private issue. Athletes talk among themselves about the condition but not to coaches or trainers, according to Dr Nygaard's study.[24] This is consistent with older women who do not bring up the issue with their healthcare practitioner.[26] Women often use an absorbent product and tolerate the symptom of wetness. However, young athletes are not aware of the real damage that could occur to the pelvic muscles or ligaments. Learning about good pelvic health should begin when girls are naturally learning about their bodily changes to womanhood. However, few health educators even consider including pelvic floor health education at this age or even among women of college age. Coaches and trainers for women's athletics at high schools and universities have an opportunity to provide pelvic floor health education. Unfortunately, women often do not develop pelvic health awareness until after there is a major stress or injury to the pelvic area that creates acute symptoms, such as urinary leakage, prolapse, or pain. As with other health issues, healthy behaviors often do not occur before there is an actual symptom or condition that brings attention to the need. By then, opportunity for prevention may be past.

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Another defining phase of pelvic floor health for women occurs when sexual activity begins. At this point, there is some thought to pelvic health in terms of vaginal tone, sensation, and response. Because there are more female sexual function studies, it may be during this phase of a woman's life that attention to pelvic floor health occurs. However, the major pelvic health focus during this time is often on reproduction or preventing reproduction and sexually transmitted diseases. There is no real focus at this time on actual health of the pelvic floor. Women do think of vaginal tone and sexual pleasure, but the concern for prevention of problems or rehabilitation is not present if there has been no prior pelvic floor trauma due to pregnancy and childbirth. A woman may seek information and/or treatment for pelvic health issues only if there is some form of sexual dysfunction, such as pain during intercourse, low sexual desire or arousal, or inability to have an orgasm.

The pelvic floor has been identified as important in treating female sexual dysfunction in areas of arousal and orgasm.[27,28] In the arousal phase, there is an increase in pelvic blood flow. Pelvic muscle exercises and increase in muscle fiber size increase blood flow to the area. The orgasmic phase involves muscle contractions and pelvic muscle activity. Because the pelvic muscles surround the vagina, an increase in size and strength provides more control for the female partner and more sensation for the male partner.

Not every woman engages in sexual activity or becomes pregnant, but this does not negate the need for attention to good pelvic floor health behaviors. In a study of a group of nuns who had not had pelvic floor trauma from pregnancy or childbirth, the prevalence of urinary incontinence was surprisingly similar to parous postmenopausal women.[29] Multiple urinary tract infections, depression, and body mass index (BMI) were significant as well.

Pregnancy and childbirth markedly bring into focus what pelvic floor health can mean in a woman's life. The state of pregnancy adds a 5 (plus)-pound baby, sometimes even more than one, to the pelvic area, increasing the support demands on the pelvic floor. The enlarging pregnant uterus now competes with the other pelvic organs for space within the "bowl" of the pelvic bones. A pregnant woman may feel the need to go to the bathroom frequently because the bladder has less space to expand and store urine. Leaking urine during pregnancy can occur as the bladder is pushed forward, losing some of the angle at the bladder neck that is needed for closure and continence. The increased weight of the fetus adds pressure to the pelvic floor muscles and ligaments. The "hammock-like" floor is in a constant state of increased weight bearing during pregnancy. Women who have not been pregnant are less likely to have pelvic organ prolapse.[30]

Pregnancy is only the initial part of this phase. Additional trauma to the pelvic floor can occur during childbirth. The baby must pass through the pelvic floor if the delivery is vaginal. In this case, the opening in the vagina and its surrounding muscles must stretch enough to accommodate the baby's head and shoulders. The blood vessels, nerves, muscles, and ligaments of the pelvic floor have to stretch. Sometimes the stretching causes a tearing of tissues.[31] An episiotomy may be done to facilitate delivery, but even this represents trauma to the tissues. The use of forceps can increase the odds of having a later diagnosis of stress urinary incontinence.[32] Trauma to the pelvic floor area can be sufficiently significant to become the beginning of pelvic floor weakness and symptoms that can last a lifetime.[33] Urinary and fecal incontinence, as well as pelvic organ prolapse, can begin at this time.[34] A controversial topic today is the option for women to choose Cesarean section for childbirth to reduce risk of pelvic floor injury.[35,36] However, Taskin showed that antepartem pelvic floor muscle exercises combined with episiotomy were as effective as Cesarean delivery in avoiding pelvic organ prolapse 2 months postpartum.[37] Third-world countries have a major problem with postpartum pelvic floor weakness because of the prolonged stages of delivery, increasing the stress and stretch of the pelvic floor tissues.[38]

If a woman has not thought of pelvic health before, pregnancy and childbirth bring her attention to potential problems. After vaginal childbirth, a woman should be serious about rehabilitation of the pelvic muscles to prevent long-term problems.[39] In sports medicine, rehabilitation is routine after an injury to restore optimal postinjury function. Full recovery of the pelvic floor helps the area withstand either a subsequent pregnancy or delivery and/or continue to function at an optimal level to support the organs in the pelvis.[40]

Cheerleading, ballet, and sports add extra strain on the pelvic floor muscles and ligaments from the jarring of jumping, starting, stopping, jogging, and other athletic moves.

Pelvic floor trauma has the potential to increase with each subsequent delivery.[41] If rehabilitation has not occurred after the first delivery, it becomes even more important to consider by the second delivery.[35] With pregnancy and delivery of the second child, many women begin to realize that there can be consequences to pelvic floor weakness, such as incontinence, loss of vaginal tone and sensation, and possibly prolapse of the uterus and/or bladder. Yet, young mothers are not ready to give up exercising, playing with their children, or to begin wearing diapers or pads order to accommodate urinary leakage.

Perimenopause and menopause affect pelvic floor health. This is a time when estrogen levels decrease and the tissues that have been relying on estrogen for health become thinner, drier, and more fragile, even to the point of discomfort.[15,41] Women who never leaked urine before may develop urinary leakage. Although the bladder neck and the proximal urethra form the continence mechanism, the folds in the submucosal tissues of the urethra can offer an additional seal affect. If the urethral tissues are thinner and drier from estrogen deficiency, they cannot make as tight a closure to prevent leakage. Sexual intercourse may also become uncomfortable because of thinner and drier vaginal tissues. Artificial lubrication used during sexual activity or every 2 to 3 days can increase comfort.[42] Women may find that it takes longer to become aroused and to reach an orgasm. Symptoms of bladder or uterine prolapse may occur, and corrective sur-

gery may be recommended. Women of perimenopausal or menopausal age may also notice that they have to go to the bathroom more frequently and with greater urgency. They need to know where the next bathroom is located, leave meetings, and cut back on travel or social events for fear of embarrassing leaks, which can be disruptive and stressful. Medications such as tolterodine and oxybutynin and/or transcutaneous electrical nerve stimulation have been prescribed for these symptoms.[43,44] This is an important time to keep the pelvic muscles exercised, increasing the blood supply to the muscles and providing strength and tone of the fibers for support. Women in their 50s and beyond are physically and sexually active. Pelvic floor weakness with incontinence or pelvic organ prolapse can interfere with social, recreational, and career activities.

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With aging, a stretching or sagging of the pelvic floor may result in hernia-like positions of the bladder, the uterus, or the rectum.[45] The medical terms for these are *cystocele* (*cysto* meaning bladder, *cele* meaning bulging into, thus bladder bulging in to the vagina), *prolapse* (falling of the uterus out of position), and *rectocele* (*recto* meaning rectum, thus rectum bulging in to the vagina). This situation can result in urinary leakage, fecal incontinence,[46] discomfort similar to pressure or feeling like sitting on something, the sensation that "the bottom is falling out," and/or painful intercourse. Even walking can become difficult and more strenuous activity may be prohibited. Urination and bowel movement can be affected by the structural changes of the bladder and rectal position. Some women use a pessary (medical device inserted in the vagina) for support in lieu of surgery. Others opt for surgical repair.

Other Risk Factors for Pelvic Floor Weakness

Including some of the events already mentioned, there are other risk factors that can contribute to pelvic floor weakness.[47,48] They are as follows:

- Obesity—being overweight puts extra strain on the pelvic support muscles
- Chronic constipation—frequent straining and bearing down to have a bowel movement stretches the pelvic muscles
- Hysterectomy—the removal of the uterus removes one of the support structures for the other pelvic organs
- Situational—prolonged standing, lifting, or carrying weight for a job or exercise; smoking; and chronic coughing add extra stress to the pelvic floor muscles and ligaments

Possible Results of Pelvic Floor Weakness

Because of the function of the pelvic floor, the results of not having a strong and healthy pelvic floor can affect urinary and sexual activities.[49] Some symptoms are identified as follows:

- Urinary incontinence when laughing, coughing, lifting, jumping, pushing, carrying, running, or exercising (called stress incontinence)
- Frequency and urgency of urination (loss of bladder control, also called urge incontinence)
- Getting up more than once at night for the bathroom
- Inability to hold urine when in a hurry or stepping out in the cold
- Pelvic organ prolapse (of uterus, bladder, or rectum)
- Loss of vaginal tone
- Reduced feeling or sensation during sex
- Leakage of urine during sex

How to Improve Pelvic Health

Because pelvic floor weakness is the underlying cause of many of the problems discussed in this article, the path to improvement is through pelvic floor fitness. Proper function of the levator ani muscles is required to prevent pelvic floor prolapse.[50] The principles of muscle fitness apply to pelvic floor muscles. Many women do not actively exercise the pelvic floor muscles as they go through life stages. The only form of exercise these muscles get consistently is the constant state of tone required to support pelvic and abdominal organs when a woman is standing.[4] Prolonged standing or carrying extra weight can lead to muscle fatigue, making symptoms worse at the end of the day or during a general state of body fatigue. The best method of muscle exercise is active muscle contraction with some degree of resistance.[10] Active exercises performed correctly can increase the muscle strength and the size of the muscle fibers in the group, enabling them to withstand more stress and reduce the likelihood of weakness or injury.

Pelvic muscle exercises were named for Dr Arnold Kegel in the late 1940s and are often referred to by his name. However, pelvic muscle reeducation is a more correct term. The exercises themselves are not difficult to perform. Learning to isolate the correct group of muscles is most difficult because of the lack of proprioception or awareness of where they are located.[14] For example, when a woman bends her arm, she can be aware of the muscle that she has moved. Most women cannot easily determine if their pelvic muscle has properly contracted. The

study by Bump showed that at least 50% of women do not correctly contract their pelvic floor muscles with just verbal or written instructions.[14] That is why some type of feedback is so essential to learning these exercises. With any type of exercise session, exercises performed incorrectly or inefficiently can be a wasted effort. It is also why many women have said, "Oh, I tried Kegels and they didn't help me." They were not doing the exercises correctly or consistently enough to see changes in muscle strength.

Full recovery of the pelvic floor helps the area either withstand a subsequent pregnancy or delivery or continue to function at an optimal level to support the organs in the pelvis.

With poor attempts at pelvic muscle exercises, symptoms can even get worse. In doing proper exercises, the first few weeks are required just to learn to do the exercise properly. Biofeedback is an essential part of this process, both for learning and for continued motivation if a home unit is available. An increase in muscle fiber size and volume may require 4 to 6 months of exercise to become noticeable. Therefore, a woman cannot just start "Kegels" and hope to be better in 2 or 3 weeks. Development of muscle strength does not progress that quickly. Because muscle exercise and development is a behavior, learning to change behavior and incorporate it in to one's life is important to affect quality of life.

Strengthening Pelvic Muscles

Pelvic floor muscles are comprised of short and long muscle fibers. The short fibers make up about 30% of the muscles, and their purpose is to respond with a quick short contraction. This group is important to respond with a contraction just before a cough or sneeze to help prevent urinary leakage. The other 70% of the muscles consist of long fibers. These are for endurance and long contractions and are important to maintain the constant support of the pelvic floor for the pelvic and abdominal organs. They provide strength against excessive stress from lifting, standing all day, or being overweight. Their fitness can minimize pelvic floor injury during pregnancy and childbirth. Exercising these muscles increases the blood flow to the area, improving vaginal and urethral tissue health. Both of these muscle groups require exercise for optimal strength and function of the pelvic floor. A correct pelvic muscle contraction can help provide improved bladder closure to prevent leakage. The stronger the muscle and the larger the muscle fibers, the better the effort to provide a tight closure. A correct pelvic muscle contraction can also inhibit a bladder contraction, offering more control over the bladder. For example, the bladder may relay an urgent need to go to the bathroom at a time when a bathroom is not convenient. Contracting pelvic floor muscles properly sends a message through the sacral nerve to the bladder to delay the urge and stop the bladder contraction, allowing time to reach a bathroom without hurry or leakage.[6,46]

Benefits of Exercise

Effective and consistent pelvic muscle exercises can provide many benefits across the lifespan of women. Beginning in young healthy women, strengthening the pelvic floor muscles provides support for the bladder and urethra against the forces of increased intraabdominal pressures from activity or exertion; provides increased sensation and control during sexual activity, and prepares the pelvic floor for pregnancy and childbirth. Stronger pelvic muscles can recover from initial pregnancy faster and become rehabilitated for resumed sexual activity and later pregnancies and deliveries. As women age, the muscle strength provides protection against pelvic floor weakness and prolapse.

Protecting the Pelvic Floor

After pelvic surgery, such as a hysterectomy or bladder suspension or after pregnancy and delivery, it is prudent to protect the pelvic floor while the area heals. Avoiding prolonged standing, lifting, pushing, and straining helps to minimize forces on the pelvic floor. The use of stool softeners and a diet high in fiber and fluids can prevent constipation and the need to strain or bear down with bowel movement. Adding bran and prunes or dates to jam (with increased fluid intake) on a cracker or toast can help with constipation, as can commercial fiber pills or powder. Because the area is painful in the early postoperative period, women may postpone having a bowel movement, leading to constipation and straining later. Active rehabilitation of the pelvic floor with pelvic muscle exercises can begin after approval from a healthcare practitioner.

Summary

Awareness of the structure and function of the pelvic floor area can help professionals educate women about healthy practices through life stages. Women can learn risk factors that affect the pelvic floor and make personal decisions to reduce their risk of pelvic floor weakness or injury. Women and healthcare providers can play an active role in prevention and treatment of pelvic floor health problems. Additional research is needed to further understand the functions of the pelvic floor, how it affects women's quality of life, and how pelvic floor health can be improved.

Key Points

✔ Similar to breast health, pelvic floor health should be an openly discussed part of women's health education.

✔ The pelvic floor is a hammock or trampoline-like structure, weakened by 3 important openings: the urethra, the vagina, and the anus.

✔ Pelvic floor health can be reviewed by examining phases of a woman's life and lifestyle choices. The pelvic floor can be compromised by obesity, pregnancy, and childbirth; injured during rigorous sports and physical activity; undergo thinning and drying during perimenopause and menopause; and damaged while undergoing pelvic surgery, such as a hysterectomy.

✔ Kegel muscle exercises and development is a behavior, and learning to change behavior and incorporate it into one's life is important to affect quality of life.

References

1. Wall L, DeLancey JOL. The politics of prolapse: a revisionist approach to disorders of the pelvic floor in women. *Perspect Biol Med*. 1991;34:486-496.
2. Wall L, Norton PA, DeLancey JOL. *Practical Urogynecology*. Baltimore: Williams & Wilkins; 1993:1-30.
3. Bo K, Talseth T, Vinsnes A. Randomized controlled trial on the effect of pelvic floor muscle training on quality of life and sexual problems in genuine stress incontinent women. *Acta Obstet Gynecol Scand*. 2000;79:598-603.
4. DeLancey J. Functional anatomy of the pelvic floor and urinary continence mechanisms. In: Schussler B, Laycock J, Norton P, Stanton S, eds. *Pelvic Floor Re-education: Principles and Practice*. New York: Springer-Verlag, 1994:9-24.
5. Davis GD, Goodman M. Stress urinary incontinence in nulliparous female soldiers in airborne infantry training. *J Pelvic Surg*. 1996;2:68-71.
6. Bump RC, Norton PA. Epidemiology and natural history of pelvic floor dysfunction. *Obstet Gynecol Clinics North Amer*. 1998;4:723-746.
7. Morkved S, Bo K. Effect of postpartum pelvic floor muscle training in prevention treatment of urinary incontinence: a one-year follow up. *Br J Obstet Gynaecol*. 2000;107:1022-1028.
8. Bo K. Functional aspects of the striated muscles within and around the female urethra. *Scand J Urol Nephrol*. 1995;29(Suppl):27-35.
9. Norton P. Treatment of stress urinary incontinence. In: Schussler B, Laycock J, Norton P, Stanton S, eds. *Pelvic Floor Re-education: Principles and Practice*. New York: Springer-Verlag; 1994:123-126.
10. DeNubile NA. Strength training. *Clin Sports Med*. 1991;10:33-63.
11. Dixon J, Gosling J. Histomorphology of pelvic floor muscle. In: Schussler B, Laycock J, Norton P, Stanton S, eds. *Pelvic Floor Re-education: Principles and Practice*. New York: Springer-Verlag; 1994:28-33.
12. Wall LL. The muscles of the pelvic floor. *Clin Obstet Gynecol*. 1993;36:910-925.
13. Jozwik M, Jozwik M. The physiological basis of pelvic floor exercises in the treatment of stress urinary incontinence. *Br J Obstet Gynaecol*. 1998;105:1046-1051.
14. Bump RC, Hurt WG, Fantl JA, Wyman JF. Assessment of Kegel pelvic muscle exercise performance after brief verbal instruction. *Am J Obstet Gynecol*. 1991;165:322-329.
15. Robinson KM, McCance KL, Gray P. Structure and function of the reproductive systems in McCance KL and Huether SE, eds. *Pathophysiology: The Biologic Basis for Disease in Adults and Children*. 2nd ed. St. Louis: Mosby-Year Book, Inc.; 1994:711-744.
16. DeLancey JOL. Fascial and muscular abnormalities in women with urethral hypermobility and anterior vaginal wall prolapse. *Am J Obstet Gynecol*. 2002;187:93-98.
17. McIntosh LJ, Stanitski DF, Mallett VT, Frahm JD, Richardson DA, Evans MI. Ehlers-Danlos Syndrome: relationship between joint hypermobility, urinary incontinence, and pelvic floor prolapse. *Gynecol Obstet Invest*. 1996;41:135-139.
18. Rinne KM, Kirkinen PP. What predisposes young women to genital prolapse? *Eur J Obstet Gynecol Reprod Biol*. 1999;84:23-25.
19. De Paepe H, Renson C, Van Laecke E, Raes A, Bande WJ, Hoebeke P. Pelvic-floor therapy and toilet training in young children with dysfunctional voiding and obstipation. *Br J Urol Int*. 2000;85:889-893.
20. Hellerstein S, Linebarger JS. Voiding dysfunction in pediatric patients. *Clin Pediatr*. 2003;42:43-49.
21. Abidari JM, Shortliffe LMD. Urinary incontinence in girls. *Urol Clin North Am*. 2002;29:661-675.
22. Carson CC, Chaikin D, Haney AF, Staskin DR. Confronting the urogenital consequences of estrogen deficiency. *Contem Urol*. 2000;(Suppl):3-12.
23. Bo K, Borgen JS. Prevalence of stress and urge urinary incontinence in elite athletes and controls. *J Amer Coll Sports Med*. 2001;33:1797-1799.
24. Nygaard IE, Thompson FL, Svengalis BS, Albright JP. Urinary incontinence in elite nulliparous athletes. *Obstet Gynecol*. 1994;84:183-187.
25. Bo K, Stien R, Kulseng-Hanssen S, Kristofferson M. Clinical and urodynamic assessment of nulliparous young women with and without stress incontinence symptoms; a case-control study. *Obstet Gynecol*. 1994;84:1028-1032.
26. van der Vaart CH, de Leeuw JRE, Roovers JP, Heintz AP. The effect of urinary incontinence and overactive bladder symptoms on quality of life in young women. *Br J Urol Int*. 2002;90:544-549.
27. Berman J, Berman L. *For Women Only*. New York: Henry Holt and Company, LLC.; 2001:87, 200, 203, 208, 213.
28. Heiman JR, Lopiccolo J. *Becoming Orgasmic*. New York: Prentice Hall Press. 1988:51, 137, 139.
29. Buchsbaum GM, Chin M, Glantz C, Guzick D. Prevalence of urinary incontinence and associated risk factors in a cohort of nuns. *Obstet Gynecol*. 2002;100:226-229.
30. Harris RL, Cundiff GW, Coates KW, Bump RC. Urinary incontinence and pelvic organ prolapse in nulliparous women. *Obstet Gynecol*. 1998;92:951-954.
31. Morkved S, Bo K, Schei B, Salvesen KA. Pelvic floor muscle training during pregnancy to prevent urinary incontinence: a single-blind randomized controlled trial. *Obstet Gynecol*. 2003;101:313-319.
32. Van Kessel K, Reed S, Newton K, Meier A, Lente G. The second stage of labor and stress urinary incontinence. *Am J Obstet Gynecol*. 2001;184:155-157.
33. Farrell SA, Allen VM, Baskett TF. Parturition and urinary incontinence in primiparas. *Obstet Gynecol*. 2001;97:350-356.

34. Rortveit G, Dalveit AK, Hannestad YS, Hunskaar S. Urinary incontinence after vaginal delivery or cesarean section. *N Engl J Med*. 2003;348:946-950.
35. Viktrup L, Lose G. The risk of stress incontinence five years after first delivery. *Am J Obstet Gynecol*. 2001;185:82-87.
36. Thorp JM, Norton PA, Wall LL, Kuller JA, Eucker B, Wells E. Urinary incontinence in pregnancy and the puerperium: a prospective study. *Am J Obstet Gynecol*. 1999;181:266-273.
37. Taskin O, Wheeler JM, Yalcinoglu AI. The effects of episiotomy and Kegel exercises on postpartum pelvic relaxation: A prospective controlled study. *J Gynecol Surg*. 1996;12:123-127.
38. Wall LL. Birth trauma and the pelvic floor: Lessons from the developing world. *J Women Health*. 1999;8:149-155.
39. Sampselle CM, Miller JM, Mims BL, DeLancey JOL, Ashton-Miller JA, Antonakos CL. Effect of pelvic muscle exercise on transient incontinence during pregnancy and after birth. *Obstet Gynecol*. 1998;91:406-412.
40. Groutz A, Gordon D, Keidar R, et al. Stress urinary incontinence: prevalence among nulliparous compared with primaparous and grand multiparous premenopausal women. *Neurourol Urodynam*. 1999;18:419-425.
41. Forsbert JG. A morphologist's approach to the vagina. *Acta Obstet Gynecol*. 1996;75(Suppl 163):3-10.
42. Sherburn M, Guthrie JR, Dudley EC, O'Conell HE, Dennerstein L. Is incontinence associated with menopause? *Obstet Gynecol*. 2001;98:628-633.
43. Soombro NA, Khadra WR, Neal DE. A crossover randomized trial of transcutaneous electrical nerve stimulation and Oxybutynin in patients with detrusor instability. *J Urol*. 2001;166:146-149.
44. Lavelle JP, Yokoyama T, Chancellor MB. How best to treat detrusor instability in patients with stress incontinence? *Contemp Urol*. 2000;May:28-47.
45. Brown JS, Grady D, Ouslander JG, Herzog AR, Varner RE, Posner SF. Prevalence of urinary incontinence and associated risk factors in postmenopausal women. *Obstet Gynecol*. 1999;94:66-70.
46. Leroi A-M, Weber J, Menard J-F, Touchais J-Y, Denis P. Prevalence of anal incontinence in 409 patients investigated for stress urinary incontinence. *Neurourol Urodynam*. 1999;18:579-590.
47. Moller LA, Lose G, Jorgenson T. Risk factors for lower urinary tract symptoms in women 40-60 years of age. *Obstet Gynecol*. 2000;96:446-451.
48. Zorn B, Steers WD. Incontinence: urinary risk factors in women. *Contemp Urol*. 2000;Jan:44-63.
49. Luber KM, Boero S, Choe JY. The demographics of pelvic floor disorders: current observations and future projections. *Am J Obstet Gynecol*. 2001;184:1496-1503.
50. Heit M, Benson JT, Russell B, Brubaker L. Levator ani muscle in women with genitourinary prolapse: Indirect assessment by muscle histopathology. *Neurourol Urodynam*. 1996;15:17-19.
51. DeLancey JOL. Pelvic floor dysfunction: causes and prevention. *Contemp Ob/Gyn*. 1993;38:68-79.