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Review

The Impact of Pregnancy and Mode of Delivery on Female Pelvic Floor Function: A Narrative Review

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Abstract

Objective: To summarize and discuss the impact of pregnancy and mode of delivery on pelvic floor function, and to clarify current methods for predicting and preventing pelvic floor dysfunction (PFD). **Mechanism**: The author conducted a literature search in the PubMed, MEDLINE, and Embase databases, focusing on studies from the past 5 years. The search included the keywords: "pelvic floor disorders", "pelvic organ prolapse", "urinary incontinence", "anal incontinence", "pregnancy", and "mode of delivery". To our knowledge, this is the first review to comprehensively analyze the influence of pregnancy and delivery on pelvic floor function, identify associated risk factors, and discuss methods for predicting and preventing PFD based on these risk factors. **Findings in Brief**: Pregnancy and delivery are closely associated with the occurrence of PFD, and different types of PFD are linked to distinct risk factors. Most of these risk factors are difficult to modify, which further emphasizes the significance of preventive measures. Pelvic floor muscle training should be encouraged both during the pregnancy and in the postpartum period. **Conclusions**: Clinicians should perform a comprehensive analysis based on individual risk factors, pregnancy-related symptoms, and physical examination results to identify high-risk individuals and offer personalized recommendations for pregnancy and postpartum rehabilitation suggestions, especially pelvic floor muscle training, in order to lower the incidence of PFD.

Keywords: pelvic floor disorders; pelvic organ prolapse; urinary incontinence; anal incontinence; pregnancy; mode of delivery

1. Introduction

Pregnancy and delivery can cause a series of significant physical changes. Some problems may persist or even tend to deteriorate. Pelvic floor dysfunction (PFD) is one of them. It is a complex disorder resulting from the lack of support of pelvic floor tissues. Specific symptoms encompass pelvic organ prolapse (POP), urinary incontinence (UI), and anal incontinence (AI). Although these diseases are not life-threatening, they can have a significant impact on the quality of life of patients [1,2].

POP is typically manifested as a "bulging" feeling within the vagina, with the tissues within the vagina protruding towards the vaginal opening or outside the vagina. Relevant literature suggests that the incidence of symptomatic POP ranges from 3% to 6%, while from an anatomical perspective, the prolapse phenomenon occurs in as many as 50% of women. The proportion of women requiring surgical treatment per 1000 women per year is 1.5–1.8 cases, and it reaches its peak in the age group of 60–69 years [3]. Furthermore, POP might also be accompanied by other symptoms, such as UI, a feeling of incomplete bladder emptying, defecation difficulties, and the necessity to hold or press the vaginal bulge to facilitate bladder or rectal emptying. These symptoms can lead to a significant decrease in the quality of life and have an influence on daily activities, exercise, and sexual activity.

UI, broadly speaking, refers to the involuntary outflow of urine. Its main types include stress, urge, overflow and mixed. Among them, stress urinary incontinence (SUI) is defined as the involuntary outflow of urine caused by increased abdominal pressure. Nearly 1/3 of women experience such symptoms at different times, and its onset is most closely related to pelvic floor dysfunction [4]. Compared with the non-pregnancy period, the possibility of UI during pregnancy increases significantly. Approximately 3/4 of pregnant women have experienced this condition, and its incidence rate will gradually increase as the gestational weeks progress, and then rapidly decline after delivery [5].

AI refers to the involuntary expulsion of flatus, liquid, and/or solid stool [6]. Its occurrence is closely associated with obstetric anal sphincter injury. The probability of subsequent AI in women who have suffered injury is approximately 3 times that of women who have not [7]. The incidence of AI during pregnancy should not be underestimated. LaCross *et al*. [8] analyzed questionnaires from 228 pregnant women and estimated that the incidence of AI during pregnancy was 40.8% (of which 31.6% was flatus incontinence), which had a significant impact on the quality of life during pregnancy.

2. The Influence of Pregnancy on Pelvic Floor Function

2.1 During Pregnancy, the Pressure within the Abdominal and Pelvic Cavities Gradually Increases

The pelvic floor is at the bottom of the abdominal cavity, offering a supporting structure for the organs within the abdominal and pelvic cavities. For women, its integrity depends on the synergy of muscles (such as the levator ani muscle, urethral sphincter, and anal sphincter), nerves (such as the sacral plexus and pudendal nerve), and connective tissues (such as the pelvic fascia, perineal body, uterosacral ligament, and cardinal ligament). Among them, the principal ligaments being the uterosacral complex anchors the uterus and vaginal fornix to the sacrum of the pelvis. During pregnancy, the increase in weight and the expansion of the uterus lead to an elevated pressure within the abdominal and pelvic cavities, thereby increasing the burden on the pelvic floor muscles and relevant ligaments, weakening the pelvic floor function, and eventually causing pelvic floor dysfunction.

Çetindağ *et al*. [9] concluded, after examining 33 primiparas, that all pelvic organ prolapse points (POP-Q) of the vaginal wall during pregnancy decrease to varying degrees, and this decrease was correlated with the aggravation of pelvic organ prolapse symptoms evaluated by the Pelvic Floor Distress Inventory Short Form 20 (PFDI-20). Shek *et al*. [10] had a similar conclusion. They conducted a comparative study of 688 women in the 3rd trimester of pregnancy and 74 nulliparous women. Their results showed that the levator hiatus in women during the 3rd trimester of pregnancy increased by 27% at rest and by 41% during the Valsalva maneuver. The descent of the anorectal junction and the increase of the levator hiatus at rest have been clearly identified as risk factors for prolapse symptoms during pregnancy [11].

2.2 During Pregnancy, Significant Alterations Occur in Hormone Levels

The content of muscles and collagen has crucial significance for maintaining the dynamic supportive ability of pelvic floor tissues. Kamisan Atan *et al*. [12] carried out a study involving 129 nulliparous women and 113 women who underwent cesarean section delivery. They found that compared with nulliparous women, women who delivered by cesarean section had a greater degree of pelvic organ descent during the Valsalva maneuver, indicating that the pelvic floor tissues of women who have experienced pregnancy have stronger elasticity and higher compliance. This change may be related to the cellular-level changes in the pelvic floor muscles and fascial tissues caused by the alteration of hormone levels during pregnancy [13]. Researchers have also noticed a significant correlation between menopause and POP. Currently, estrogen and progesterone receptors have been detected in the vagina, urethra, bladder, and pelvic floor muscle tissues [14]. This phenomenon further proves that hormone levels play a key role in maintaining pelvic floor function.

Estrogen has a profound impact on the synthesis and metabolism of pelvic connective tissues. Currently, the research focus is on the prevention of POP [14]. However, there are relatively few related studies on progesterone, and the results are controversial. A study in 2001 [15] showed that patients with SUI symptoms during pregnancy had a low concentration of progesterone. Nevertheless, a study in 2022 [5] revealed that those with a higher progesterone concentration in the early pregnancy stages had a higher risk of UI throughout the pregnancy.

Relaxin has also been the subject of research focus in recent years. Relaxin pertains to a type of peptide hormone within the insulin-like growth factor family. It increases significantly in the early stage of pregnancy, reaches its peak at the 12th week, and then begins to decline to approximately 50% of the peak from the 17th week, remaining at this stable level [5]. Relaxin remodels the connective tissue and enhances its elasticity. This physiological effect on the cervix, vagina and uterus is beneficial for the preparation of the birth canal and creates conditions for the delivery of the fetus [16]. Currently, it is generally believed in both clinical practice and academic circle that a high level of relaxin can induce pelvic floor dysfunction, especially the occurrence of UI. However, recent studies have obtained conclusions that are different from the traditional viewpoints. A prospective study in 2022 [5] showed that the concentration of relaxin in patients with SUI was lower in the early and late stages of pregnancy. In another study [17], it was also reported that women with POP had a lower level of relaxin. To explain this phenomenon, Parker *et al*. [18] proposed a theory. They postulated that relaxin functions as both an endocrine factor and a paracrine factor. Therefore, the measured serum level may not be able to reflect the true activity level. We believe that it is still necessary to conduct strict and well-controlled studies to clearly determine the role of hormones in the pathogenesis of PFD.

3. The Influence of Mode of Delivery on Pelvic Floor Function

The supportive function of pelvic organs will change during pregnancy, vaginal delivery and following cesarean section. Analyzing the current research conclusions, vaginal delivery may have a greater impact on pelvic floor function. Blomquist *et al*. [19] reported that after the first delivery, 34.3% and 30% of women developed SUI and POP respectively, which was significantly higher than nulliparous women. The authors also pointed out in another study [20] that compared with cesarean delivery, the risk of developing SUI, overactive bladder and POP in women with vaginal delivery was significantly increased. In addition, the risk of pelvic organ prolapse was the highest in women with vaginal delivery assisted by instruments.

During the process of vaginal delivery, factors such as excessive fetal weight, prolonged labor duration, episiotomy, operative and instrumental assistance in delivery may all cause damage to the perineal nerves, levator ani muscles, fascia and other pelvic support tissues, resulting in a reduction in perineal muscle strength following delivery [21]. A meta-analysis showed that compared with cesarean section, vaginal delivery significantly weakened in terms of postpartum pelvic floor muscle strength, vaginal muscle voltage and maximum urine flow rate [22]. Grinbaum *et al*. [23] reported after analyzing the ultrasound examination data of 326 women that compared a nulliparous group and a cesarean section group, that the area of the levator ani hiatus in the vaginal delivery group and the instrumental-assisted delivery group increased significantly. Some long-term follow-up studies have also revealed the long-term impact of the delivery method on pelvic floor function. A study that included 1528 women with a follow-up period of up to 9 years [20] showed that compared with cesarean section delivery, the risk of long-term UI and POP in women with vaginal delivery increased significantly, with instrumental-assisted delivery being an independent risk factor for AI.

4. Prediction of Postpartum Pelvic Floor Dysfunction

Pregnancy and delivery are closely related to the occurrence of PFD, and different types of PFD have various risk factors [24]. We can identify and analyze these risk factors to predict the high-risk population for PFD. In a meta-analysis based on 19 studies on UI and 9 studies on AI [2], the risk factors for postpartum UI were summarized as follows: urinary incontinence during pregnancy, instrumental-assisted delivery, medio-lateral episiotomy, perineal laceration and constipation. The risk factors for postpartum AI encompassed: AI during pregnancy, maternal age $>$35 years, pre-pregnancy body mass index (BMI) $>$30 kg/m^2, instrumental-assisted delivery, vaginal delivery and newborn weight $>$4000 g.

Pelvic organ prolapse has more complex causes of disease compared with UI and AI, but it also has a certain relationship with pregnancy and delivery. In earlier study, Chen *et al*. [25] reported that the significantly related risk factors for its onset were a higher BMI in the early stage of pregnancy and POP during pregnancy. A recent prospective study [26] summarized the risk factors as: a more caudal position of the anterior vaginal wall at 21 weeks of pregnancy (point Ba measured by POP-Q), a longer distance from the urethral orifice to the anus, a more relaxed levator ani muscle at 21 weeks of pregnancy (measured by transperineal ultrasound as the change in the area of the levator ani hiatus from rest to the Valsalva maneuver), and medio-lateral episiotomy.

In addition to the methods for identifying and analyzing the previously mentioned risk factors, some scholars recommend screening in the 2nd trimester of pregnancy through means such as evaluating bladder neck mobility, digital examination to assess the contractility of the pelvic floor muscles, and detailed inquiry of medical history (such as using the Urinary Incontinence Impact Questionnaire) [27]. Some scholars also recommend the use of endoanal ultrasound (EAUS). They believe that in addition to identifying anal sphincter injuries, EAUS can also be used to assess the length of the pelvic floor muscles (such as the transverse perineal muscle, puborectalis muscle, and pubococcygeus muscle) and the perineal body, thereby better evaluating and screening high-risk populations [7]. Currently, many institutions are developing scoring prediction systems based on risk factors and various examination indicators, aiming to provide personalized prenatal and postpartum rehabilitation advice for women to reduce the incidence of PFD and thereby reduce the need for future surgeries [28].

5. Prevention of Postpartum Pelvic Floor Dysfunction

In order to prevent PFD, should there be a more liberal use of cesarean section for delivery? The answer is not so simple, as there are still numerous contradictions in the existing clinical evidence. Reimers *et al*. [26] proposed in the study that for primiparas, although cesarean section can reduce the risk of UI, it has no clear protective effect on AI and POP. Even if it is merely for the prevention of UI, the price to be paid seems rather high. In the average-risk primipara model, at least 9 cesarean sections needed to be performed to prevent 1 case of UI [2] (this model can be obtained at http://riskcalc.org/UR_CHOICE/). Therefore, we believe that based on the existing evidence and considering other possible complications of cesarean section, clinicians still need to be cautious when deciding whether to perform cesarean section for delivery.

Since the hasty choice of cesarean section for delivery cannot prevent PFD, and most of the risk factors that induce this disease are unchangeable, this further emphasizes the importance of preventive measures. At present, the main preventive measure is pelvic floor muscle training (PFMT), and this measure has shown significant preventive effects during pregnancy and after delivery [29]. PFMT includes active exercises to enhance the strength, endurance, explosive power and relaxation ability of the pelvic floor muscles. A meta-analysis [30] indicated that training for 10 to 45 minutes each time, 3 to 7 days per week, can achieve better results.

Watkins *et al*. [31] reported that exercise during pregnancy is safe, and patients who are more physically active during pregnancy have a shorter duration of active labor. The research of Wang *et al*. [32] indicated that by changing lifestyle during pregnancy (such as controlling weight and limiting caffeine intake) and combined with PMFT, gestational UI can be effectively prevented, thereby reducing the risk of UI in the future. The results of a randomized

controlled trial involving 722 participants show that regular prenatal exercise, including PFMT, can significantly reduce the incidence of UI within 3 months after delivery [33]. Based on this evidence, we recommend that pregnant women should actively control their weight, and if the physical conditions permit, PFMT can be carried out.

In the postpartum period, a meta-analysis of randomized controlled trials showed that PMFT was significantly effective in reducing the POP-Q stage and improving the self-reported symptoms of patients [34]. There is also a research report that for women who started PFMT on the second day after delivery, regardless of whether they have undergone episiotomy or experienced a second-degree perineal laceration, after combined vaginal electrical stimulation therapy at 6 weeks postpartum, their symptoms of POP and UI can be significantly ameliorated [35]. A study by Gluppe *et al*. [36] showed an exercise program containing curl-ups for women with diastasis recti abdominis did not aggravate diastasis recti abdominis, nor did it change the severity of pelvic floor dysfunction or lower back, pelvic girdle or abdominal pain, but it did enhance abdominal muscle strength and increase abdominal muscle thickness.

Therefore, we recommend that high-risk populations should start PFMT as early as possible and combine the utilization of various rehabilitation devices at 6 weeks postpartum, such as vaginal low-voltage and low-frequency electrical stimulation, transvaginal electrical stimulation, electromyogram-triggered neuromuscular stimulation, electrical stimulation combined with biofeedback therapy, sacral nerve modulation, and bipolar vaginal radiofrequency devices. Furthermore, we advocate that in the future, more studies with high quality, significant standardized characteristics and longer follow-up periods need to be conducted, so as to further explore the most reasonable rehabilitation programs during pregnancy and after childbirth.

6. Conclusions

Pregnancy and delivery are closely associated with PFD. As clinicians, it is essential to possess a profound comprehension of the relevant risk factors and identify high-risk patients through diverse means. During pregnancy, lifestyle modifications and PMFT should be actively advocated. After delivery, PMFT should be initiated as early as feasible, and for high-risk groups, a variety of rehabilitation devices can be employed in combination. Through this array of measures, the incidence of PFD and their negative influence on the quality of life of women can be effectively mitigated.

Author Contributions

XX and WG designed the research study and performed the research. XX wrote the manuscript. Both authors contributed to editorial changes in the manuscript. Both authors read and approved the final manuscript. Both authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

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Conflict of Interest

The authors declare no conflict of interest.

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