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REVIEW

Pelvic Floor Dysfunction from an Orthopedic Perspective: a Review of the Literature

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Abstract
Pelvic floor dysfunction (PFD) describes a broad spectrum of clinical conditions that affect the viscera and musculature of the pelvic cavity. Though musculoskeletal pathologies have been implicated in various forms of PFD, orthopedic surgeons are not routinely consulted for the management of patients with pelvic symptomatology. Muscle dysfunction in PFD can be broadly classified into hypertonic or hypotonic conditions, each with their own associated symptoms. Pelvic musculoskeletal dysfunction may also present differently between males and female given gender differences in pelvic structure. In addition to the standard orthopedic history, physical examination maneuvers may be able to distinguish hip, spine, and sacroiliac joint dysfunction contributing to PFD. For certain etiologies of PFD, non-operative and/or operative orthopedic intervention may help to alleviate functional symptoms such as urinary incontinence and sexual dysfunction. The available research highlights the importance of a multidisciplinary approach to treating PFD that includes orthopedic expertise, as well as the need for further research to assess the impact of orthopedic intervention on concomitant PFD symptoms, develop appropriate surgical indications, and achieve better outcomes for this patient population.

Keywords Pelvic floor dysfunction · Pelvic pain · Non-operative treatment · Sacroiliac joints · Hip · Spine

Introduction

Pelvic floor dysfunction (PFD) is an umbrella term used to describe a broad spectrum of clinical conditions including bowel and bladder incontinence, pelvic organ prolapse, sexual dysfunction, and chronic pain syndromes related to the pelvic contents and musculature [1]. PFD is common among women in the United States with an estimated prevalence of 23.7% [2], though prevalence in other populations varies significantly from 2 to 42% of women [3] depending on the exact inclusion criteria used. In any case, PFD has been associated with negative impacts on health-related quality of life [4, 5].

Due to the wide variability of disorders considered with PFD, patients may seek treatment for prolonged periods from a variety of specialties including urology, gynecology, gastroenterology, and physiatry. Providers should be cognizant that there may not be a singular causal source of PFD and that dysfunction across multiple organ systems may be contributing to patient symptoms. Yet, despite the close anatomic relationship between the pelvic viscera and the musculoskeletal system about the pelvis, orthopedic surgeons are not routinely included among specialists providing care for symptomatic PFD patients. This discrepancy may stem from the traditional siloing of pelvic pathologies between orthopedic and gynecologic specialties, with pelvic bony trauma and joint disorders considered the domain of the former and pelvic pain disorders in women considered the domain of the latter. However, there is a small but growing body of evidence suggesting an association between PFD symptoms and orthopedic conditions such as pelvic trauma [6] and hip osteoarthritis [7]. Orthopedic surgeons ought to have a basic understanding of PFD since it is possible that treatment of concomitant orthopedic pathologies may lead to improved symptom alleviation in PFD patients and vice versa.

The purpose of this review is to provide an overview of pelvic anatomy as it pertains to PFD, identify female-specific anatomic considerations in the setting of PFD, discuss

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diagnostic and treatment approaches to PFD, and highlight the association between PFD and musculoskeletal pathologies encountered by orthopedic surgeons.

Methods

Articles cited in this review were identified via a comprehensive search of the PubMed and Google Scholar publication databases. Search terms included "pelvic floor dysfunction," "pelvic floor hypertonicity," "pelvic floor hypotonicity," "chronic pelvic pain," "pelvic pain disorder," "pelvic floor muscles," "pelvic floor disorder," "pelvic myofascial pain," and "pelvic floor spasm." The date range was from database inception to the present. However, older articles outside of this date range were included in this review if they were considered to be of historical value to the discussion of PFD. Historical articles were identified using the same databases, and impact factor was assessed using the citation number. In addition to primary research articles, systematic reviews and meta-analyses were included in the review if they offered insight into the current evidence for various diagnostic and treatment recommendations. For all primary and secondary research articles, strength of the evidence was assessed using University of Glasgow Evidence-Based Practice (EBP) checklists [8]. Articles were considered relevant to this review if they discussed pelvic anatomy in the context of PFD, diagnostic and treatment strategies for PFD, and/or the relationship between PFD symptoms and orthopedic conditions to any extent. The search yielded 19 articles directly pertaining to PFD which were published between 2001 and 2022.

Anatomy of the Pelvic Floor

Musculature

The pelvic floor is composed of a dome-shaped sheet of striated muscle often described as a sling [9]. The pelvic floor musculature (PFM) includes the levator ani and coccygeus. The levator ani is comprised of 3 muscle bellies: the iliococcygeus, pubococcygeus, and puborectalis. The levator ani originates lateral to the pubic symphysis on the posterior aspect of the superior ramus and inserts on the inner surface of the ischial spine [10]. The coccygeus originates from the ischial spine's pelvic surface where it joins with the sacrospinous ligament to insert on the sacrum and coccyx [10].

Innervation

Components of the nervous system to be considered in PFD include the lumbar and sacral roots, the lumbosacral plexus, peripheral nerves, and the sympathetic chain [9]. Innervation of the PFM is provided via the nerve to the levator ani and the pudendal nerve [11]. The pudendal nerve is comprised of the anterior branches of the S2–4 ventral rami. The nerve exits the pelvis via the greater sciatic notch then re-enters through the lesser sciatic notch before terminating into three branches within the perineum. The first branch, the nerve to the levator ani, supplies motor function to the external anal sphincter and perianal sensation. The second branch, known as the perineal branch, provides sensation to vaginal tissues and perineal skin. The third branch innervates the anal sphincters [12].

The anterior divisions of the lumbar, sacral, and coccygeal nerve roots form the lumbar (L1 − 4) and sacral (L4–S4) plexus which provide sensory innervation to the skin of the lower trunk, perineum, and proximal thigh via the iliohypogastric, ilioinguinal, genitofemoral, lateral femoral cutaneous, and obturator nerves [9]. The autonomic nervous system is responsible for innervation of visceral structures within the pelvis. The sympathetic innervation to the pelvic viscera is responsible for nociception of dull ache and generalized pain, while parasympathetic innervation provides sensations of hunger, nausea, and bladder/bowel compliance [13].

The efferent and afferent pelvic visceral innervation overlaps in space with efferent and afferent somatic innervation previously described allowing for neural cross talk between systems [14]. Neural cross talk or convergence is necessary for normal regulation of bowel, bladder, and sexual function [15]; however, alteration of these neural pathways by disease or injury may play a role in the development of chronic pelvic pain via pelvic organ cross sensitization [16].

Pelvic Floor Dysfunction

Normal functioning of the pelvic floor musculature allows for structural support of the pelvic viscera, control of bowel, and bladder continence via input to the urethral and anal sphincters and maintenance of normal sexual function [17]. PFD describes pain or abnormal function of the muscular sling within the bony pelvis [9]. Symptoms of PFD have been divided into 5 groups by the International Continence Society [18].

i. Lower urinary tract: urinary incontinence, urgency and frequency, slow or intermittent stream and straining, and feeling of incomplete emptying
ii. Bowel: obstructed defecation, functional constipation, fecal incontinence, and rectal/anal prolapse
iii. Vaginal: pelvic organ prolapse
iv. Sexual function: dyspareunia and orgasmic dysfunction
v. Pain: chronic pelvic pain and pelvic pain syndrome

Muscle dysfunction in PFD has been classified into hypertonic or hypotonic conditions [9, 18]. Hypertonic or overactive PFD presents with pain and impairment of functional relaxation of the pelvic floor musculature. These conditions are associated with symptoms such as voiding problems, obstructed defecation, and dyspareunia. Hypotonic or underactive PFD involves situations where the musculature cannot voluntarily contract when appropriate. Symptoms include bowel/bladder incontinence and pelvic organ prolapse. The broad spectrum of disorders considered with PFD highlights the importance of a multidisciplinary approach in treating these patients.

Female-Specific Anatomic Consideration for Pelvic Pain and PFD

Pelvic Girdle

The unique anatomy of the female pelvis allows for gender-specific pathology contributing to pelvic pain and dysfunction. Greater ligamentous and muscle support is warranted in the female pelvis, which is broader and shallower in males to provide adequate stability to the sacroiliac (SI) joints [9]. The term force closure, defined by Vleeming et al. [19], describes the contribution of ligaments, fascia, and muscles of the pelvic girdle to the stability of the SI joint. Force closure in conjunction with the inherent bony congruency of the SI joint surface confers maximal SI joint stability.

Pool-Goudzwaard et al. [20] conducted a biomechanical study of 18 cadaveric specimens (9 males, 9 females) which demonstrated the ability of simulated tension on pelvic floor musculature to increase the stiffness across the SI joints. The authors postulated that increased pelvic floor musculature activation may occur in patients with SI joint dysfunction in an attempt to restore load transfer through the lumbopelvic region. It should be noted the specimens were of an average age of 77 years (SD 14.4), and therefore, this biomechanical relationship may differ in younger patients.

O'Sullivan et al. [21] in a cross-sectional observational study demonstrated altered motor control of the pelvic floor muscles in 13 patients (11 females, 2 males) with SI joint pain (SIJP) compared to 13 healthy controls matched on age, sex, and BMI. The association between SI joint pain and pelvic floor muscle dysfunction was further highlighted by the presence of urinary incontinence/frequency in all 13 SIJP patients. Despite the low sample size, the authors did note a high intraclass correlation coefficient (0.95) for the pelvic floor descent measurements made during active straight leg raise test, suggesting good repeatability of their measurements.

Additionally, in the female pelvis, hormone-induced ligamentous laxity, increased abdominal girth, and alterations of load and shear stresses during pregnancy may be contributing factors to posterior pelvic and low back pain in pregnant women [22].

Hip

Female sex is a known risk factor for developmental dysplasia of the hip (DDH) [23]. The inherent joint incongruence in DDH patients can contribute to secondary pelvic pain resultant from acquired muscle imbalances necessary to provide joint stability—the muscles of the pelvic floor may become overactive and painful in an attempt to compensate for faulty movement patterns [9, 24].

Several studies report an increased incidence of acetabular labral tears in women as compared to men [25, 26], possibly due to increased rates of dysplasia among females [23]. The relationship between intra-articular hip disorders and pelvic floor pain may be partially explained by the function of the obturator internus muscle as a hip rotator and its anatomic proximity to the pelvic floor musculature, allowing for pain referral patterns between the two [24]. Hip pathology, as such, should be considered a potential contributor to female pelvic pain [24, 27].

Patient Evaluation

History

The presentation of patients with PFD can be varied due to the numerous causal etiologies across several organ systems. A thorough history can help distinguish orthopedic and non-orthopedic etiologies of pelvic symptoms and alert the provider to concomitant PFD symptoms which may warrant specialist referral. A standard orthopedic history should be obtained in patients presenting with musculoskeletal complaints including mechanism of injury, location, onset, progression, alleviating/exacerbating factors, and previous treatment. In addition to the orthopedic history, the provider should inquire about other associated symptoms involving the pelvis (Table 1) which may point to comorbid PFD. These associated symptoms may include urologic complaints (e.g., urinary hesitancy and/or frequency, urinary

Table 1 Relevant history and associated symptoms about the pelvis

a) Prior history of pelvic trauma
b) Bowel or bladder incontinence
c) Previous pregnancies/deliveries
d) History of previous pelvic disorders (infection/fibroids/endometriosis)
e) Dyspareunia
f) History of sexual abuse

incontinence), gynecologic complaints (e.g., dyspareunia), and gastrointestinal complaints (constipation, fecal incontinence) [28].

Physical Exam

For female patients, a standardized vaginal palpation of the pelvic floor muscles is generally considered the reference test for PFD [29], but orthopedic surgeons may lack familiarity with performing urogenital exams outside of the trauma setting. Complicating matters, a 2022 systematic review by Kapurubandara et al. [29] failed to identify an alternative diagnostic test for PFD equivalent or superior to the reference test, due in large part to a lack of high-quality comparative studies with which to compare the sensitivity and specificity of various exam maneuvers. Nonetheless, some components of the orthopedic physical exam, in combination with the patient history, may assist in the diagnosis of PFD [30]. Provocative tests and physical exam findings for commonly implicated musculoskeletal structures in PFD are listed in Table 2. Of the orthopedic exam maneuvers that have studied for use in the diagnosis of PFD, the flexion-abduction-external rotation (FABER) test has reported sensitivity ranging from 4 to 77% and specificity ranging from 16 to 100%, and the posterior pelvic pain provocation test (P4 test) has sensitivity ranging from 36to 93% and specificity ranging from 50 to 100% [31]. In addition, the active straight leg raise (ASLR) test is significantly correlated with the P4 test and can be used in its place [32].

Conservative Management Options for PFD

Physical Therapy

Physical therapy remains a first-line treatment option for PFD and aims to address various pelvic muscle imbalances contributing to pain and dysfunction [27]. Various manual modalities have been described for treatment of PFD symptoms, including myofascial release, acupressure, muscle energy, strain-counterstrain, and joint mobilization [33]. Weiss [33] reported an 83% rate of symptom resolution among a cohort of 42 patients with urgency-frequency syndrome following treatment with manual physical therapy, though his analysis lacked a comparison group. Biofeedback training regimens to reestablish normal muscle awareness and relaxation have also been described for PFD. A retrospective cohort study by Richmond et al. found that a cohort of 47 women with urinary incontinence (31 stress type, 16 mixed type) who underwent pelvic floor biofeedback therapy experienced a decrease in Urinary Distress Inventory-6 (UDI-6) score following treatment [34]. While good outcomes and symptom alleviation with physical therapy have also been reported for non-urinary PFD symptoms including chronic pelvic pain [35] and sexual dysfunction [36], the evidence base is largely comprised of retrospective observational studies. By contrast, more robust evidence exists to support the use of physical therapy as a curative measure for urinary PFD symptoms, including a 2018 Cochrane review by Dumoulin et al. [37] that examined 31 randomized or quasi-randomized clinical trials involving urinary incontinence patients and found that pelvic floor muscle training (PFMT) was associated with a five times higher likelihood of complete symptom resolution versus no treatment or inactive control treatments.

Table 2 Physical examination tests for commonly implicated structures in pelvic floor dysfunction

Spine	• Motor/sensory/reflex examination
	• Straight leg test
	• Contralateral straight leg test
Hip	• Painful restricted range of motion (ROM)
	• Impingement/flexion-abduction-internal rotation (FADIR) test
	• Resisted straight leg test
Sacroiliac joints	• Distraction/compression tests
	• Flexion-abduction-external rotation (FABER) test
	• Gaenslen's test

Injection Therapy

Commonly associated with myofascial pain syndromes implicated in chronic female pelvic pain and PFD [38], trigger points are discrete nodular hyperirritable areas found within a taut band of skeletal muscle [39]. Two studies have evaluated trigger point injections for the treatment of PFD. Kang et al. [40] performed transanal injections of levator ani trigger points with triamcinolone and lidocaine in 104 patients and found 36.8% of patients were pain-free at 3 months [40]. Langford et al. performed a similar study using a transvaginal technique in 18 patients and found a similar 33% pain-free rate among patients at 3 months [41]. A limitation of both studies is the absence of a comparison group that was administered a placebo injection.

Botulinum toxin injection directly into the pelvic floor muscles has also been investigated for alleviation of PFD symptoms. Abbott et al. [42] performed a randomized controlled trial to assess the effect of botulinum toxin injection into the pelvic floor musculature as compared to a saline placebo. Thirty patients with PFD were randomized to each group, and pelvic floor pressures were assessed pre- and post-injection along with VAS pain scores. The botulinum toxin injection group demonstrated reduced pelvic floor pressures post-injection compared to the placebo group but failed to show any significant difference in pain scores.

While trigger point and botulinum toxin injections offer minimally invasive treatment options for PFD patients, they appear to provide only modest benefit based on the most recent clinical studies. Due to a lack of level I evidence, the role of injection therapies in the PFD treatment algorithm remains unclear, but they may be of most value to patients whose symptoms have failed to resolve with physical therapy yet are unwilling to undergo any type of surgical intervention.

PFD-Associated Symptoms and Orthopedic Conditions

Our initial database search yielded no articles specifically discussing PFD in the context of orthopedic pathologies, but an expanded search identified some studies that explored the connection between specific symptoms that may be present in PFD (urinary incontinence and sexual dysfunction) and orthopedic conditions. It should be noted that these symptoms may be present in other pelvic disorders besides PFD.

Urinary Incontinence and Lower Back Pain

Though literature on the relationship between lower back pain and PFD is extremely limited, the association between lower back pain and urinary incontinence has been demonstrated in several clinical studies. Eliasson et al. surveyed 200 Swedish patients receiving physical therapy for lower back pain and found that 78% reported concomitant urinary incontinence symptoms [43]. In a cross-sectional observational study of 2341 women, Bush et al. calculated an adjusted odds ratio of 1.4 for stress urinary incontinence in patients with chronic back pain versus those without [44]. In a case series of 12 patients with urinary incontinence undergoing lumbar spinal fusion, Eisenstein et al. found improvement in incontinence symptoms post-operatively in 11 patients [45]. The contribution of pelvic floor muscle function to both urinary continence mechanisms and spinal stability has been suggested as a causal link between these two symptoms [46], though the Eliasson et al., Bush et al., and Eisenstein et al. studies are incapable of demonstrating a causal link since they are observational in nature.

Ghaderi et al. [47] evaluated 60 patients with chronic non-specific lower back pain and urinary incontinence in a randomized controlled trial that compared treatment with routine physical therapy (consisting of transcutaneous electrical nerve stimulation, hot pack, therapeutic ultrasound, and regular exercises) against routine therapy with pelvic floor muscular (PFM) stabilization exercises. The stabilization exercises involved the deep abdominal and lumbar muscles and targeted the PFM at 30% of voluntary contraction. Pharmacologic (e.g., injections) and surgical treatments were not employed in either group. Both groups exhibited significant improvement ($p < 0.05$) in functional disability and pain after treatment as measured by the Oswestry Disability Index (ODI), but only the PFM stabilization group experienced significant improvement in urinary incontinence symptoms (11.26 to 7.90, $p < 0.05$) as indicated by the International Consultation on Incontinence Questionnaire-Urinary Incontinence Short Form (ICIQ-UI SF). The clinical significance of these changes in outcome scores could not be ascertained as the authors did not report the proportion of patients in each group that achieved a specific cutoff score such as the minimum clinically important difference (MCID).

Urinary Incontinence and Hip Osteoarthritis

Hip pathology has been surmised to contribute to stress urinary incontinence through dysfunction of the obturator internus muscle [48]. Atrophy of the muscle secondary to hip joint dysfunction may contribute to impairment of normal urethral function due to its intimal association with the levator ani muscle and urethral sphincter [48]. While a causal link between hip osteoarthritis and PFD has not been conclusively established due to the scarcity of literature on the topic, there is some evidence to support a link between hip osteoarthritis and urinary incontinence.

Tamaki et al. [49] prospectively evaluated 189 female patients undergoing total hip arthroplasty (THA) using the International Consultation on Incontinence Questionnaire Short Form (ICIQ-SF). Eighty-one patients reported symptoms of stress urinary incontinence pre-operatively. At 3 months, post-op mean ICIQ-SF had improved from 6.0 to 3.5 ($p = 0.0002$). Okumura et al. [50] performed a prospective analysis of 51 female patients with stress, urge, and mixed urinary incontinence undergoing anterior THA using various validated incontinence questionnaires. At 3 months after surgery, 72% of patients reported improvement in symptoms. Both the Tamaki et al. and Okumura et al. studies provide evidence that treatment of hip osteoarthritis may address some of the urinary symptoms associated with PFD, though a lack of a non-operative comparison group hinders both studies.

Baba et al. surveyed 76 female patients with urinary incontinence pre- and post-operatively using an incontinence questionnaire form and compared results between anterior and posterior THA approaches. Twenty-two percent of patients reported improvement in urinary incontinence symptoms within 1.5 years post-op in the anterior approach group versus only 2.5% in the posterior approach group. The authors postulated that sparing of the short external rotators with the anterior approach along with correction of external rotation contracture and leg length discrepancy allowed for improved tension of the obturator internus indirectly increasing tension on the pelvic floor, which may have contributed to urinary incontinence symptom alleviation [48].

Sexual Dysfunction and Femoroacetabular Impingement

The pudendal nerve, the primary sensory innervation to the vulva, lies in close proximity to the hip joint musculature and may be responsible for referred vulvar pain from hip pathology. Chronic hip discomfort such as from femoroacetabular impingement (FAI) can provoke postural and gait changes, which place the hip external rotators and pelvic floor musculature on abnormal tension. Over time, dystrophic changes may occur in the musculature which can lead to compression of pudendal nerve branches [17, 51].

Coady et al. [51] reported on a series of patients with vulvodynia and FAI undergoing hip arthroscopy. Vulvodynia symptoms were evaluated with a questionnaire post-operatively. Twenty out of 26 patients reported initial improvement of vulvodynia in the immediate post-operative period, but at longer post-operative follow-up intervals ranging from 36 to 58 months, only 6 out of 26 (23%) patients reported lasting resolution of vulvar symptoms. Older age and longer duration of vulvar symptoms pre-operatively were associated with lack of improvement following hip arthroscopy. While this study highlights the potential association between FAI and vulvodynia, the lack of randomization as well as inability to control for concomitant vulvodynia therapy during the study period prevents definitive conclusions from being made regarding the effect of hip arthroscopy on vulvodynia symptoms in patients with co-existing pathologies.

Limitations

As this was a literature review and not a systematic review, we did not use PRISMA guidelines or quantify the strength of the available evidence through a meta-analysis. As such, this review should be considered a high-level summary of the recent literature on the orthopedic perspective of pelvic floor dysfunction rather than a critical examination of current practices.

Conclusion

The literature on the comorbidity of PFD and musculoskeletal disorders is extremely limited, but there is tentative evidence that some symptoms of PFD such as urinary incontinence and sexual dysfunction may be associated with common orthopedic conditions such as lower back pain, hip osteoarthritis, and FAI. However, there is a dearth of high-quality evidence in the form of randomized clinical trials and prospective comparative studies with which to establish a causal link between PFD and specific orthopedic conditions or to guide a diagnostic and treatment approach in the orthopedic clinic. Future studies in the orthopedic literature can elucidate this relationship by collecting patient-reported outcome data on the full spectrum of PFD-associated symptoms—musculoskeletal, gynecologic, genitourinary, and gastrointestinal—and determining how these symptoms change in response to non-operative and operative treatments. This information will be vital for helping surgeons assess the impact of orthopedic interventions on concomitant PFD symptoms, develop appropriate surgical indications, and achieve better outcomes for this patient population as part of multidisciplinary approach with other specialties.

Author Contribution Dhruv Shankar was responsible for reviewing the existing literature, drafting over 50% of the manuscript content, drafting the tables, organizing the references, editing and proofreading the final manuscript for grammar and clarity, and completing revisions as requested by the journal. Nicholas Ramos, Andrew Dold, and Thomas Youm (principal investigator) were responsible for conception of the original idea for this manuscript, drafting the manuscript content, and approval of the final manuscript. Kimberly Cichelli was responsible for reviewing the existing literature, drafting the manuscript content, and approving the final manuscript.

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Declarations

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