RESEARCH PAPER

Integrating Physiotherapeutic Interventions with Controlled Drug Delivery Systems in Women's Health Management

Dr. Shivangi Joshi*[1], Dr. Shalaka Dhankar[2], J. Binu Clara[3], Dr. Jwalit Jatinkumar Mehta[4], Diksha Thakur[5], T Kavya[6]

[1]Assistant Professor, Department of Community Physiotherapy, VSPM's College of Physiotherapy & Lata Mangeshkar Hospital, Digdoh Hills, Nagpur Email ID: shivangijoshi1507@gmail.com, Orcid ID: 0009-0008-4287-8707
[2] Associate Professor, Department of Community Physiotherapy, VSPM'S College of Physiotherapy, Nagpur Email I'd: shalakad92@gmail.com, ORCID ID- https://orcid.org/0000-0003-4588-8536
[3] Assistant Professor Department of Science and Humanities Specialization: Healthcare University Agni College of Technology, Tamil Nadu, 600130, Email ID: binuclara.sh@act.edu.in ORCID ID: 0009-0003-6425-4798
[4]Professor, Department of Physiology M.D. Physiology, Dr N D Desai, Faculty of Medical Science and Research, Dharmsinh Desai University (DDU), Gujarat, Nadiad, 387001, Email ID: adms.medical@ddu.ac.in, Orcid ID: 0009-0002-3223-8032
[5] MPT Student, MPT Musculoskeletal Conditions, Department of Physiotherapy, Chhatrapati Shahu Ji Maharaj University, Kanpur, Email ID: dikshagautam00726@gmail.com, ORCID ID 0009-0006-4492-2690
[6]Assistant Professor, Faculty of Physiotherapy, Dr. M.G.R Educational and Research Institute, Maduravoyal, Chennai - 600095, Tamil Nadu, India, Email ID: kavya.phd2430@gmail.com, ORCID ID: 0009-0005-6673-4837

Abstract
Women's health disorders often involve overlapping reproductive, hormonal, musculoskeletal, pelvic, neurological, and psychological factors that require integrated therapeutic strategies. This review examines the potential role of combining physiotherapeutic interventions with controlled drug delivery systems in women's health management. Controlled drug delivery platforms, including vaginal rings, intrauterine systems, transdermal patches, injectable depots, hydrogels, mucoadhesive films, and nanoparticle-based carriers, provide localized, sustained, and targeted therapeutic effects for pain, inflammation, hormonal imbalance, infection, tissue repair, and reproductive dysfunction. Physiotherapeutic interventions, including pelvic floor muscle training, manual therapy, biofeedback, breathing retraining, postural correction, scar mobilization, therapeutic exercise, and functional rehabilitation, address pelvic floor dysfunction, continence problems, pain-related movement restriction, postpartum weakness, sexual discomfort, and reduced quality of life. The integration of these approaches may be especially useful in chronic pelvic pain, endometriosis, urinary incontinence, pelvic organ prolapse, postpartum dysfunction, menopausal genitourinary syndrome, vulvodynia, and gynecological oncology rehabilitation. By combining biological symptom control with functional restoration, integrated care may improve adherence, reduce systemic adverse effects, enhance rehabilitation tolerance, and support patient-centered recovery. Current evidence remains fragmented, with limited direct trials evaluating combined protocols. Future research should establish standardized, condition-specific, and outcome-based models to support safe, effective, and multidisciplinary women's health care.

Keywords: Controlled drug delivery, Endometriosis, Pelvic floor rehabilitation, Physiotherapy, Postpartum recovery, Women's health

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Introduction

An integrative approach is necessary for managing women's health issues, focusing on all aspects of their care, such as reproduction, hormones, musculoskeletal system, neuromuscular function, pelvis, psychology, and functional aspects, instead of disease management only [1]. The problems related to pregnancy and gynecology do not end even after diagnosis or birth, causing various disabilities like pain, urinary incontinence, pelvic floor disorder, abdominal weakness, fatigue, limited movement, sexual dysfunction, and poor quality of life [2]. New findings about postnatal rehabilitation suggest that individualized and multidisciplinary treatment approaches are critical for postpartum recovery and avoiding future disability issues [1]. The use of patient-reported outcomes has also gained importance since it helps detect physical symptoms, functional abilities, mental well-being, and overall experience, which may not be identified from conventional clinical assessment [2]. The importance of physiotherapy in the management of women's health has become apparent due to its role in managing movement, pelvic floor muscle function, posture, breathing, pain regulation, scarring, continence, and functional ability [3]. The inclusion of exercise and pelvic and abdominal rehabilitation courses in obstetrics training is becoming common, and it is evident from the growing acknowledgment of the relevance of physiotherapy to maternal health [3]. However, needs assessment in obstetrics professionals reveals that there are deficiencies in knowledge, referral practices,

*Author for Correspondence: shivangijoshi1507@gmail.com

interdisciplinary teamwork, and education about maternity exercise and pelvic and abdominal rehabilitation [4]. The deficiency is clinically relevant since failure to recognize issues such as pelvic floor dysfunction, lumbopelvic pain, abdominal weakness, and postpartum disability can result in chronic disabilities [4]. Pregnancy, childbirth, menopause, and gynecological disorders can cause significant physiological and biomechanical alterations that can impact tissue loading, pelvic stability, hormone levels, nociception, and neuromuscular function [5]. Hormonal alterations, joint laxity, abdominal stretch, body weight gain, postural changes, pelvic floor loading, gait alterations, and increased loading on the lumbo-pelvic region occur during pregnancy and parturition [5]. While such physiological changes occur during pregnancy, there are chances that the individual could develop problems like low back pain, pelvic girdle pain, bladder disturbances, decreased functional ability, and slow recovery from the activity of pregnancy and childbirth [2]. Hence, an exercise-based approach will be required in such scenarios [5].

Controlled drug delivery systems provide an additional approach to achieve local, sustained, and targeted therapeutic effects in cases of pain, inflammation, hormonal disturbances, infections, tissue repair, and reproductive disorders [6]. Vaginal rings, intrauterine devices, transdermal patches, depot injections, hydrogel formulations, mucoadhesive films, and nanoparticulate drug carriers can enhance drug absorption, minimize systemic side effects, and increase treatment compliance for chronic or recurrent female health disorders [6]. In combination with physiotherapy, these technologies can address biological causes of symptoms, while physiotherapy helps restore pelvic floor tone, muscle control, mobility, and active participation in everyday activities [7]. Such an integrated approach is highly applicable in cases of chronic pelvic pain, endometriosis, urinary incontinence, pelvic organ prolapse, postpartum disorders, genitourinary syndrome of menopause, and gynecological oncology disorders [8].

Combining controlled delivery of drugs and physiotherapy is important from a clinical perspective since problems affecting women's health can often be associated not only with tissue damage but also with functional disability [7]. For instance, local delivery of pharmacotherapy could help to decrease pain, inflammation, mucosal irritation, or hormone deficiency, thus helping patients to tolerate pelvic floor exercises, manipulations, progressive exercises, and functional training better [6]. In turn, physiotherapy may increase the effectiveness of pharmacotherapy through building muscle strength, enhancing coordination, improving body posture, achieving continence, increasing mobility, and promoting self-management skills [8]. It has also been found that women prefer a coordinated approach, open communication, and useful advice in maternal care settings [9].

Rehabilitation is strongly related to psychological health, particularly in situations where pain, incontinence, immobility, changes in self-image, sexual dysfunction, or delayed recovery processes impact an individual's ability to engage in activities [10]. The clinical recommendation on the subject of perinatal mental health encourages a holistic approach, especially for patients with physical impairments or disabilities [10]. Physiotherapy does not substitute psychological or pharmaceutical interventions, although it can facilitate independence, mobility, pain management, and reintegration into activities when used in combination with other therapeutic techniques [10]. Thus, the combination of physiotherapeutic methods and controlled release systems represents a promising woman-centered strategy that addresses both physiological factors and recovery processes [3].

This review attempts to explore how physiotherapy treatment approaches and controlled drug delivery techniques can be integrated to improve patients' health conditions. This review will consider how these two approaches can work together to enhance pelvic health, reduce pain, improve reproduction, post-partum recovery, and ultimately help patients lead a more fulfilling life.

1. Controlled Drug Delivery Systems in Women's Health

Controlled drug delivery systems have been seen as a significant advance in women's healthcare because they provide controlled release of drugs within the body, at a particular target site, and for an extended period [11]. This type of technology is highly appropriate in gynecology, obstetrics, urogynecology, and pelvic problems, where normal drug administration via the oral route would cause inconsistent absorption, side effects, low adherence, or insufficient local drug delivery [12]. Controlled drug delivery has been applied in disorders characterized by hormonal disturbances, pain, inflammation, infections, contraceptive needs, endometriosis, menopause, and other reproductive tract disorders using vaginal, intrauterine, transdermal, injectable, implantable, hydrogel, mucoadhesive, and nanotechnology-based routes [13].

Regarding women's health, localized drug delivery becomes especially relevant since the vagina and uterus offer direct contact with reproductive organs without subjecting the drugs to the first-pass effect in the liver [15]. For instance, vaginal rings or mucoadhesive films could deliver a continuous flow of hormones, antibiotics, anti-inflammatories, or analgesics, while intrauterine devices would continuously deliver hormones over time for contraceptive needs, abnormal bleeding, and pain in the pelvis [6]. Such techniques might be used in conjunction with physiotherapy in cases where pain, irritation, inflammation, and hormonal imbalance become obstacles to pelvic floor exercises, manipulative treatment, graded exercises, and rehabilitation [3]. Likewise, physiotherapy can improve results by managing movement disorders, pelvic floor dysfunction, urinary and fecal incontinence, postures, scar tissue mobility, and physical activities that cannot be corrected through drug therapy alone [1]. Consequently, controlled drug delivery systems should be considered as part of a

coordinated pathway of care rather than being limited to stand-alone pharmacologic treatments in women's health [9]. Table 1 indicates that controlled drug delivery systems can deliver localized and sustained treatments for prevalent conditions among women.

Table 1. Controlled Drug Delivery Systems Relevant to Women's Health Management

Drug delivery system	Route of application	Main therapeutic purpose	Potential women's health application	Reference
Vaginal rings	Intravaginal	Sustained release of hormones, antimicrobials, or analgesics	Contraception, menopausal symptoms, pelvic pain, vaginal infections	[11]
Intrauterine systems	Uterine cavity	Long-term localized hormonal delivery	Contraception, abnormal uterine bleeding, and endometriosis-associated symptoms	[12]
Transdermal patches	Skin	Controlled systemic absorption while avoiding first-pass metabolism	Hormone therapy, pain control, and menopausal symptom management	[14]
Mucoadhesive films and gels	Vaginal or mucosal surface	Prolonged local contact and improved drug retention	Vaginal infections, local inflammation, mucosal dryness, dyspareunia	[15]
Nanoparticle-based carriers	Local or systemic delivery	Targeted delivery with improved bioavailability and reduced toxicity	Reproductive disorders, inflammation, infection, tissue repair	[6]
Injectable depot systems	Intramuscular or subcutaneous	Long-acting drug release with reduced dosing frequency	Hormonal therapy, contraception, and chronic pain-related management	[10]

2. Physiotherapeutic Interventions in Women's Health

Therapy in women's health aims to rehabilitate the pelvis, musculoskeletal system, neuromuscular function, lungs, and functional ability during pregnancy, post-partum recovery, reproductive issues, menopause, and gynecological physiotherapy [16]. Pelvic floor muscle training is among the commonly administered therapies due to its effectiveness in enhancing the pelvic floor muscles' strength, endurance, coordination, and continence control in women suffering from urinary incontinence, pelvic floor dysfunction associated with pregnancy, and postpartum pelvic weakness [17]. Physiotherapy also comprises pelvic floor muscle relaxation training, biofeedback, electrical stimulation, hands-on techniques, myofascial release, scar tissue mobilization, postural correction, breathing exercises, and functional exercises according to the woman's complaints and physical assessment findings [18]. It is essential to note that women's health issues often cause pain, aberrant movement patterns, overactive or weak pelvic floor muscles, abdominal muscle dysfunction, sexual problems, and functional limitations [5].

Antenatal and postnatal physiotherapy becomes very critical due to the mechanical load that is placed on the lumbar spine, pelvis, abdomen, and pelvic floor during pregnancy and childbirth [19]. Exercise programs, posture training, mobility enhancement, and pelvic floor rehabilitation can minimize low back pain during pregnancy, pelvic girdle pain, urinary problems, and delayed functional recovery [1]. After childbirth, physiotherapy facilitates mobility, core-pelvic synchronization, cesarean scar healing, diastasis recti repair, continence restoration, and gradual resumption of physical activities [3]. Chronic pelvic pain, endometriosis-associated pelvic dysfunction, dyspareunia, and menopausal urogenital symptoms can be effectively managed by physiotherapy [8].

Physiotherapy becomes more significant when associated with multidisciplinary women's health care services since it facilitates personalized assessment, teaching, symptom tracking, and functional development [20]. In conjunction with pharmacological management, physiotherapy might contribute to translating biological symptom regulation into functional gains in terms of mobility, continence, pain alleviation, autonomy, and overall quality of life [14]. According to Table 2, physiotherapeutic treatment can be helpful in pelvic floor function improvement, pain management, mobility enhancement, postpartum healing, and quality of life.

Table 2. Physiotherapeutic Interventions and Their Role in Integrated Women's Health Care

Physiotherapeutic intervention	Primary clinical target	Key therapeutic role	Possible integration with drug delivery systems	Reference

Pelvic floor muscle training	Pelvic floor weakness and urinary symptoms	Improves strength, endurance, coordination, and continence control	May be combined with local hormonal or bladder-directed therapy	[21]
Pelvic floor relaxation training	Pelvic floor overactivity and dyspareunia	Reduces muscle guarding, pain, and sexual discomfort	May follow local analgesic or anti-inflammatory delivery	[20]
Biofeedback-assisted training	Poor pelvic floor awareness or coordination	Improves contraction accuracy, relaxation, and adherence	May complement sustained symptom-control therapies	[24]
Manual therapy and myofascial release	Myofascial pelvic pain and restricted tissue mobility	Improves soft-tissue flexibility, pain modulation, and movement tolerance	May be combined with localized pain-relieving formulations	[35]
Postpartum rehabilitation	Postnatal weakness, scar discomfort, and functional limitation	Supports pelvic floor recovery, abdominal control, and graded activity return	May be supported by wound-healing or analgesic delivery systems	[36]
Therapeutic exercise	Low back pain, pelvic girdle pain, deconditioning	Improves mobility, strength, posture, and functional independence	May be paired with controlled pain or hormone therapy when indicated	[34]

3. Mechanistic Basis for Combining Physiotherapy and Controlled Drug Delivery

The mechanism by which the combination of physiotherapy and controlled drug delivery systems is justified is through the notion that many gynecological disorders are characterized not only by pathophysiology but also by functional impairment [21]. The drug delivery system may have a biological effect through mechanisms like inflammation, hormonal imbalances, infections, pain pathways, mucosa irritation, and failure to heal, whereas physiotherapy will take care of the musculoskeletal, neuromuscular, and behavior-related consequences of the disease [22]. The combination is applicable in diseases such as chronic pelvic pain, endometriosis, urinary incontinence, postpartum problems, dyspareunia, and genitourinary syndrome during menopause, where there is a persistent presentation of multiple mechanisms [8]. The delivery can be local through vaginal, intrauterine, transdermal, hydrogel, and nanoparticles, among others [15].

Physiotherapy helps by improving pelvic floor strength, relaxation, coordination, posture, breathing, scar mobility, confidence in movement, and progressive return to everyday activities [23]. The use of pain control and the elimination of pain, inflammation, and tissue sensitivity via controlled medication delivery can make physiotherapy, such as pelvic floor strengthening, manipulation, exercise, and functional training, more tolerable for women [6]. However, physiotherapy may help improve pharmacotherapy in terms of pain control by lowering the guarding effects of muscles, improving blood flow, managing pressure, and preventing recurrence of the condition [18].

Incorporated treatment modalities also ensure the success of patient-centered treatment since controlled administration of medication enhances adherence due to sustained release, and physical therapy encourages self-management and restoration of function over the long run [24]. This method will prevent relapse of symptoms, ensure quality of life, and prevent excessive dependence on systemic medications [25]. Mechanism-specific models enable physicians to identify interventions based on the key mechanisms that include inflammation, hormones, myofascia, neuromuscular system, surgery, and sensitivity [20].

4. Clinical Applications in Women's Health Disorders

The combination of physiotherapy with drug delivery is clinically significant for several gynecological conditions, as these diseases may need not only pharmacologic treatment but also functional rehabilitation [26]. In case of urinary incontinence or pelvic organ prolapse, pelvic floor exercises will strengthen muscles, increase endurance, and assist in managing symptoms, while localized administration of hormones or other drugs will ensure good condition of tissue, decrease urge sensations, and allow for successful rehabilitation in certain patients [17]. For instance, chronic pelvic pain and dyspareunia may be successfully managed through physiotherapy that aims to relax muscles, eliminate myofascial points, and overcome pain-induced guarding, while administration of analgesics or anti-inflammatory agents will relieve nociceptive stimulation [27].

Another significant field where integration could be used is endometriosis and adenomyosis. This condition involves delivery of hormonal or anti-inflammatory therapy to alleviate symptoms caused by lesions, along with physical therapy to treat pelvic floor dysfunction, abdominal guarding, low back pain, hip restriction, and functional limitations [28]. In pregnancy and postpartum recovery, physical therapy would help improve pelvic floor performance, abdominal and pelvic coordination, flexibility, posture, breathing, and graded return to physical activities, while the appropriate use of local and

sustained therapies can help alleviate pain, enhance healing, and restore tissues [1]. In cases of genitourinary syndrome associated with menopause, vaginal drug delivery will help achieve adequate mucosal hydration and hormonal balance, while physical therapy can help address symptoms, pelvic floor coordination, and sexual function [29].

Combined methods can also improve gynecological oncology rehabilitation because surgery, radiotherapy, chemotherapy, and hormonal therapies could lead to problems such as pelvic pain, fibrosis, lymphedema, fatigue, sexual dysfunction, and decreased mobility [30]. In such a way, an integrated approach can provide patients with both pharmacological treatment of symptoms and the restoration of functionality and independence [9]. Figure 1 describes how physical therapy and controlled medication use can be used to treat major women's diseases via symptom control and rehabilitation.

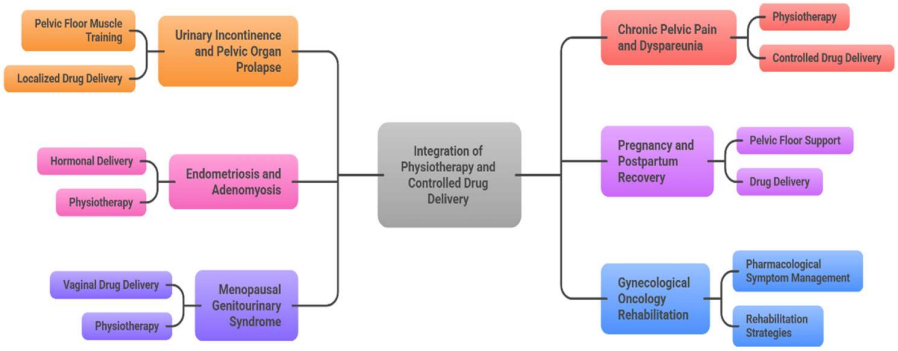

Figure 1. Integration of Physiotherapy and Controlled Drug Delivery in Women's Health Disorders

5. Proposed Integrated Management Framework

The integrated management approach for women's health would start with a thorough evaluation, which would comprise gynecological diagnosis, reproductive history, nature of pain, pelvic floor dysfunction, bladder and bowel complaints, sexual well-being, posture, mobility, scar healing, mental state, and functional objectives [31]. The evaluation would assist in determining if the predominant clinical factor is hormonal, inflammatory, neuromuscular, myofascial, surgical, postpartum, or sensitization-related. As such, therapy can be tailored for each patient rather than being solely focused on symptoms [20]. Drug delivery technology would be determined using the disease etiology, target tissue, therapeutic longevity, safety concerns, fertility considerations, pregnancy or breastfeeding status, and patient compliance [14]. Physiotherapy intervention would be guided by pelvic floor strength or hypertonicity, pain response, movement limitation, incontinence issues, abdomino-pelvic coordination, and the woman's capacity to engage in therapy [18].

The sequence of treatment is a vital element of an integrated approach [32]. If pain, inflammation, irritation of the mucosa, or hormonal deficiency prevents one from participating, localized or sustained medication therapy may be initiated before extensive physiotherapy [27]. In cases where the dysfunction results from weak pelvic floor muscles, poor coordination, scarring, postural, or deconditioning issues, physiotherapy may be started earlier and combined with medications [33]. The cooperation of gynecologists, physiotherapists, pharmacists, nurses, pain management experts, psychologists, and reproductive medicine practitioners is essential for ensuring safe medication prescriptions, appropriate rehabilitation stages, adverse effect surveillance, and patient education [9].

Outcome measurement should encompass pain severity, urination, and bowel symptoms, pelvic floor muscle function, sexual performance, quality of life, compliance with therapy, side effects, and return to normal activity levels [34]. Outcome measures that depend on patients' reports are highly relevant for their recovery since their progress depends on the impact of symptoms, self-confidence, expectations, and involvement in meaningful tasks [2]. The use of a standardized approach enables personalized, biological, and multidisciplinary intervention aimed at restoring bodily functions.

6. Implementation Considerations for Integrated Care

Physiotherapy treatment in combination with the delivery of drugs through controlled mechanisms must be meticulously planned clinically because women's health problems have their roots in biological, functional, psychological, and/or lifestyle causes [36]. Successful integration of these modalities hinges on determining the dominant clinical mechanism, which may be inflammatory processes, hormonal imbalances, pelvic floor dysfunction, excessive muscle activation, sensitivity of tissue after surgery, sensitization of pain receptors, and/or postpartum deconditioning [20]. Determination of the clinical mechanism can help determine which intervention to implement first [37].

The choice of patients plays an important role in this model since controlled drug delivery systems can vary in terms of mode of delivery, duration, dose, reversibility, biological tolerance, and acceptability [38]. Vaginal, intrauterine, transdermal, injection, hydrogel, and nanoparticle systems must be chosen based on

diagnosis, reproductive plans, hormone levels, pregnancy or lactation status, intensity of symptoms, and patient preferences [14]. In addition, physiotherapy must be tailored to pelvic floor muscle tone, urinary continence, pain behaviors, posture, core stability, scar mobility, strength, and physical activity level [18]. Interdisciplinary cooperation is vital due to the inability of any one discipline to tackle all aspects of women's health rehabilitation [39]. Gynecologists, physiotherapists, pharmacists, nurses, specialists of pain treatment, psychologists, and specialists in reproductive health should cooperate to synchronize pharmacology timings, progress of rehabilitation, patient safety measures, and follow-up assessment [9]. Equally important is education since women require information regarding proper use of devices, proper exercise, side effects, and expectations from recovery [4].

The evaluation of outcomes needs to cover aspects like pain intensity, urinary/bowel symptoms, pelvic floor strength/relaxation, sexuality, mobility, quality of life, adherence, and resumption of normal life activities or work [40]. Hence, a structured implementation framework will enhance continuity of care and facilitate safe and customized management of female patients' health from a functional perspective [1]. The diagram in Figure 2 illustrates the main clinical considerations and major mechanisms that play a role in designing the integrated therapy regimen in women's health care.

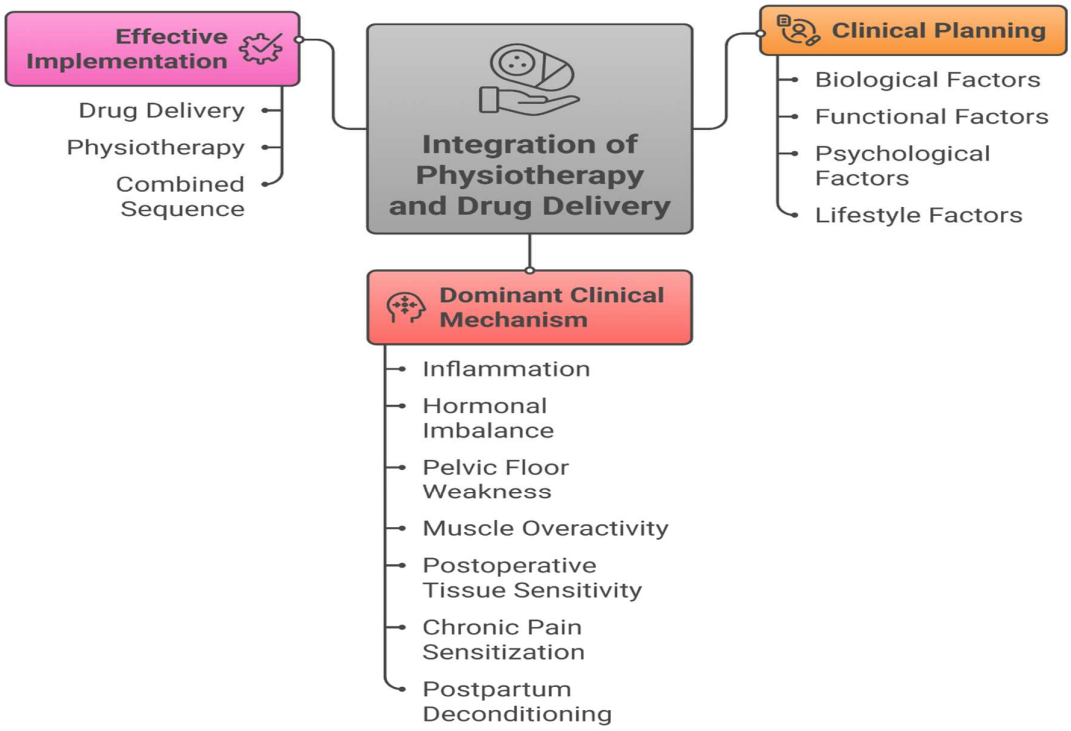

Figure 2. Implementation Framework for Integrating Physiotherapy and Drug Delivery

7. Emerging Opportunities in Integrated Women's Health Care

A combination of physiotherapy treatment and drug delivery systems can bring about multiple possibilities to enhance the management of female patients' health care [41]. The first one involves the creation of care models that will unify pharmacotherapy-based symptom relief with physical recovery methods rather than applying them independently of each other [12]. This approach would benefit those areas, such as chronic pelvic pain, urinary incontinence, endometriosis, postpartum conditions, menopausal genitourinary syndrome, and gynecological oncology rehabilitation, which suffer from physiological abnormalities and functional disorders [42].

Technical innovation could also add to the clinical relevance of integrated care via smart vaginal rings, bioactive hydrogels, nanotechnology, wearables, digital biofeedback, and rehabilitation using applications [43]. They might be able to assist with individualized therapy through tracking the symptomatology, drug release profile, pelvic floor behavior, tissue reactions, compliance, and outcome measurements [24]. In future healthcare settings, controlled delivery technology would lower instances of pain, inflammation, hormonal imbalance, or mucosal irritation, while physical therapy enhances strength, relaxation, coordination, mobility, and participation in daily life activities [44].

A further avenue could be the design of age-specific pathways of care in adolescence, reproductive-aged women, pregnant women, postpartum women, peri-menopausal women, and female cancer survivorship care [2]. Fertility considerations, hormonal status, tissue health, pregnancy and lactation safety, sexuality, psychological state, exercise needs, and cultural compatibility would need to be incorporated in the

pathways [31]. Education of patients and multidisciplinary teamwork will also play an essential role in the process [40]. Hence, integrated care for women could progress toward being more personalized, mechanism-oriented, and rehabilitation-centered.

Limitations and Future Directions

The main drawback of this topic is the lack of data on clinical research involving a combination of physiotherapy and medication delivery. Many studies only focus on either of these two techniques individually; therefore, defining the appropriate sequence of the interventions, doses, duration, safety monitoring, and their effectiveness is hard. The differences in the patients' health status, age, hormonal profile, reproductive needs, causes of pain, obstetric history, and pelvic floor function complicate the matter even more. Finally, other factors such as accessibility, social stigmatization, costs, and availability of specialized physiotherapists should also be considered.

Future investigations should examine randomized control trials between integrated care and physiotherapy only and drug delivery only models. Future studies should formulate disease-specific models for chronic pelvic pain, endometriosis, urinary incontinence, post-partum dysfunction, menopause symptoms, and gynecologic oncology rehabilitation programs. Possible future inventions will be smart vaginal rings, biodegradable hydrogels, wearable biosensors, biofeedback technologies, and personalized drug release models.

Conclusion

The potential benefits of combining physiotherapeutic management with controlled drug delivery systems are discussed in this review, as part of a multi-modal approach to managing women's health conditions. Many women's health problems related to gynecology, obstetrics, urogenital medicine, and the pelvis have pathological aspects as well as functional components. This necessitates the use of a comprehensive management approach involving various modalities to ensure long-lasting improvement of symptoms and functions. A controlled drug delivery system could deliver therapeutic benefits through local targeting of pain, inflammation, hormonal abnormalities, infections, tissue regeneration, and reproductive dysfunctions, while physiotherapy would address pelvic floor dysfunction, musculoskeletal control, posture correction, mobility restoration, incontinence, scar tissue flexibility, and physical functioning. The integration of two different modalities is highly desirable to address the following conditions: chronic pelvic pain, endometriosis, urinary incontinence, prolapse of pelvic organs, postpartum recovery, genitourinary syndrome of menopause, and rehabilitation after gynecological cancer treatment. This approach appears to be highly promising as it allows for the integration of pharmacotherapy with active rehabilitation and the achievement of better results. Despite limited scientific evidence at present, further research and development are recommended.

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