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REVIEW

Emerging Technologies in Pelvic Floor Rehabilitation: A Comprehensive Literature Review for Physiotherapy Practice.

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Abstract:

Introduction (including objective): Pelvic Floor Dysfunction is a common issue seen in both men and women with a higher prevalence rate in women, which significantly affects quality of life. Pelvic floor dysfunction presents itself when the muscles of the pelvic floor become in-coordinated i.e. it might become too loose or too tight. The conventional pelvic floor muscle training plays a crucial role in physiotherapy practice however there is a gap in adherence, feedback accuracy and accessibility which requires integration of emerging technologies. The study aims to review and evaluate the current emerging technologies in pelvic floor rehabilitation in physiotherapy practice.

Methods: This study is a literature-based synthesis of evidence on the emerging technologies utilized in pelvic floor rehabilitation within physiotherapy practice and its role in patient reported outcomes. The methodology follows a structured process, articles were sourced from peer-reviewed journals across various databases, published between 2015–2025, focusing on clinical trials, pilot studies and randomized trials. The inclusion criteria included studies that focused on technological interventions integrated into physiotherapy management of Pelvic Floor Dysfunction, such as biofeedback devices, mobile health applications, wearable and wireless sensors and virtual reality applications. Studies that were not related to technological interventions in pelvic floor rehabilitation were excluded.

Results: According to the results obtained the articles reviewed in this study suggest that technology assisted pelvic floor rehabilitation significantly improves muscles strength, adherence and patient-reported outcomes.

Conclusion: This study concludes that emerging technologies are reshaping pelvic floor rehabilitation by improving precision, adherence and accessibility.

Keywords: Pelvic floor rehabilitation, urinary incontinence, biofeedback, artificial intelligence, virtual reality, mobile applications.

INTRODUCTION

The pelvic floor is a layered structure, it is formed of different anatomical structures such as fascia, muscles and ligaments. These structures span across the pelvic outlet and supports the abdominal and pelvic organs in the abdominopelvic cavity at its base [1]. Pelvic floor dysfunction is not limited to one single condition, it encompass a range of highly prevalent and disabling group of medical problems characterized by compromised pelvic floor function, including urinary and fecal incontinence, pelvic organ prolapses, and pelvic discomfort or pain [2]. Pelvic floor dysfunction is a common condition among men and women; however it is more widespread among women with a prevalence of 19.3 % to 58% in India alone [3]. These conditions significantly cause physical discomfort and emotional distress thereby reducing the quality of life and also impacting public health systems as

it creates considerable societal burdens [2, 3]. Urinary incontinence is the most prevalent condition, and it solely affects approximately ~200 million people worldwide, creating substantial personal, social, and economic burdens and emphasizes on pelvic-floor care as a major public-health priority [4]. Management of pelvic floor conditions especially for female urinary incontinence includes many options such as treatment options focusing on behavioural approaches by modifying habits, pelvic floor muscle training (PFMT) i.e. exercise for strengthening, nerve stimulation, pharmacological interventions, injectable bulking agents, surgical interventions, a botulinum toxin injection to the bladder wall, vaginal continence pessaries and the use of containment products, such as pads and catheters [5]. The Conservative physiotherapy management — principally pelvic floor muscle training (PFMT) in physiotherapy practice remains the first-line intervention recommended by international guidelines because it is low-risk. It can improve muscle strength, symptom severity, and function when taught and adhered to appropriately. However, there are typical barriers to optimal outcomes including poor technique, low adherence, limited access to trained clinicians, and difficulties in objectively assessing pelvic-floor muscle performance. These limitations have driven the rapid development and clinical evaluation of emerging technologies that augment traditional physiotherapy approaches [4, 6]. In recent years, integrating advancements such as games, smartphone connectivity and AI driven guidance can potentially improve adherence and outcomes [3]. Here comes the role of emerging technologies in pelvic-floor rehabilitation, these technologies fall into several overlapping categories: I] biofeedback and sensor systems i.e. intra-vaginal/intra-anal sensors, surface EMG, and wearable inertial or pressure sensors, they provide objective, real-time feedback to patients and clinicians; II] digital health tools i.e. mobile apps, tele-rehabilitation platforms, and virtual coaching that support remote delivery, adherence monitoring, and behaviour change; III] neuromodulation and electrical/magnetic stimulation i.e. sacral neuromodulation, tibial nerve stimulation, transcutaneous electrical stimulation offering alternatives or adjuncts for refractory cases; and IV] advanced imaging and analytic approaches i.e. real-time ultrasound, 3D imaging, signal processing and AI models that improve assessment precision and personalize therapy [6-8]. This comprehensive literature review summarizes growing evidence for these modalities while noting heterogeneity in device types, study designs, and outcomes.

METHODS

Literature Search Methodology

The study is designed as a literature based synthesis of evidence on the emerging technologies in pelvic floor rehabilitation. Search Strategy- Databases included PubMed, PubMed Central, Science Direct, Google Scholar, and Research Gate. Out of 50 articles, 19 articles were selected on the basis of inclusion and exclusion criteria defined for this study.

Study Selection

The data was collected based on type of study, intervention or technology applied, outcome measures used, effectiveness of intervention based on P-value and results. The articles were divided and arranged based on the domain of technology used.

Inclusion Criteria

Recent articles from 2015 to 2025; Peer Reviewed Journals- RCT's and Clinical Trails; Studies involving participants across women's health populations; Interventions that used biofeedback devices, mobile health or app based PFMT, virtual reality, AI and motion-sensing digital therapeutics, electromagnetic stimulation; Outcomes measuring muscle strength, symptom improvement, adherence, engagement and quality of life; English and full text articles.

Exclusion Criteria

Studies prior to 2015; Narrative reviews, Systematic reviews and Meta-analysis; Studies involving male population or non-human subjects; Studies not related to technological interventions in pelvic floor rehabilitation; Studies written in languages other than English and unavailable in full text; Duplicate studies.

RESULTS

A total of 19 studies have been evaluated and arranged thematically. The results of the review are summarized based on the analysis of the studies and the findings are presented based on the type of intervention applied in the studies.

Table 1: Mobile Health and App-based PFMT

Sl. No	Study (Author, Year)	Type	Technology/ Intervention	Results	Interpretation
1	de Araujo et al., 2024 [9]	RCT	App-guided PFMT	Decrease in Urinary Incontinence (UI) severity	Significant symptom reduction
2	Perrier & Aumont, (Perifit), 2024 [10]	Pragmatic clinical trial	App-linked PFM device	UI symptom reduction (real world data)	Significant symptom and adherence improvement
3	Kijmanawat et al., 2023 [11]	RCT	Animated app PFMT vs Instruction pamphlet	UI improvement	Significant reduction in stress UI
4	Jaffar et al., 2022 [12]	RCT (Pilot)	KEPT app based PFMT	Adherence, feasibility	Feasibility and adherence improved
5	Loohuis, Anne M M et al., 2021 [13]	RCT	URinControl Trail App-based UI management	ICIQ-SF score reduction	App significantly improved UI vs Usual care.
6	Sherina Mohd Sidik et al., 2021 [14]	RCT	mHealth PFMT in primary care and KEPT- App (mobile PFMT).	UI symptom reduction (ICIQ- SF score)	Significant improvement in app group.
7	Bernard S et al., 2021 [15]	Experimental	In Home PFMT (Elvie trainer in special population- endometrial cancer survivors)	Symptom score change	Significant improvement in symptoms
8	Czyrnyj et al., 2020 [16]	Validation study	Elvie Trainer	Device validation and Reliability	Excellent reliability; valid device

Table 1 suggests the results for Mobile Health and App-based PFMT (Pelvic Floor Muscle Training), these articles state that using mobile app linked devices like Perifit, KEPT, mHealth, URinControl and Elvie trainer has successfully helped with reducing symptoms of urinary incontinence and improving feasibility and adherence.

Table 2: Virtual Reality (VR) - Assisted Training

Sr. No	Study (Author, Year)	Type	Technology/ Intervention	Results	Interpretation
1	Lin et al., 2022 [17]	Experimental study	VR in pelvic movement training.	Knowledge + motor control	Significant improvement in understanding and technique
2	Martinho NM et al., 2016 [18]	RCT	VR vs Gym-ball PFMT	Increase in pelvic floor strength	VR training superior to gym-ball PFMT
3	Botelho S et al., 2015 [19]	Experimental	VR for PFMT	PFM strength, EMG activity	VR- guided PFMT significantly improved outcomes.

Table 2 suggests the results for use of virtual reality (VR) in pelvic movement training, the outcome of the studies state that there was improvement in motor control and knowledge when it comes to patient education there was significant improvement in understanding and execution of the technique.

Table 3: Biofeedback and Sensor-Based PFMT

Sl. No	Study (Author, Year)	Type	Technology/ Intervention	Results	Interpretation
1	Wang X et al., 2024 [20]	RCT	Pressure-mediated biofeedback + PFMT vs PFMT	Reduction in incontinence episodes,	Statistically significant improvement with biofeedback.

				increase in muscle strength	
2	Paasch C et al., 2023 [21]	RCT	ACTICORE 1 Biofeedback-based training	UI symptom reduction	Significant reduction in leakage episodes
3	Paasch C et al., 2022 [22]	COHORT Pilot study	ACTICORE 1 Biofeedback PFMT	FI frequency reduction	Statistically significant improvement.

Table 3 suggest the results of the articles that used biofeedback and sensor-based PFMT, these articles state that use of biofeedback based training along with PFMT shows significant reduction in symptoms, it reduces the frequency of urinary incontinence (UI) and fecal incontinence (FI) episodes, it also helps strengthen the muscles of the pelvic floor.

Table 4: Artificial Intelligence and Motion-Based Digital Therapeutics

Sl. No	Study (Author, Year)	Type	Technology/ Intervention	Results	Interpretation
1	El-Sayegh & Dumoulin et al., 2024 [23]	Validation	AI-based quality assessment	Validation metrics	Conceptual/ model validation, no clinical p-value
2	Weinstein MM et al., 2021 [24]	RCT	Motion-based digital therapeutic (Leva-type)	UI improvement vs standard PFMT	Highly significant outcome improvement

Table 4 suggest the results of using AI (Artificial Intelligence) and motion based digital therapeutics in rehabilitation and these articles state that use of AI shows significant improvement in the condition of urinary incontinence (UI) compared to using standard PFMT (Pelvic Floor Muscle Training).

Table 5: Electromagnetic and Electrical Stimulation

Sl. No	Study (Author, Year)	Type	Technology/ Intervention	Results	Interpretation
1	Silantyeva, Elena et al., 2021 [25]	Clinical Trial (Comparative)	Electromagnetic chair therapy (HIFEM) Vs Electrostimulation	UI symptom scores	Both are effective with HIFEM slightly superior
2	Silantyeva E, Dragana Z et al., 2020 [26]	Experimental study (Comparative)	HIFEM vs Electrostimulation	EMG activity, muscle strength and function	HIFEM group showed increase in EMG activity and pelvic floor muscle strength
3	Hlavinka TC, et al., 2019 [27]	Multi-center pilot trial	High Intensity Focused Electromagnetic (HIFEM) technology applied for pelvic floor stimulation.	Muscle strength and sexual function	HIFEM treatment significantly improved pelvic floor muscle strength and sexual function in women. It is an effective non-invasive therapy for pelvic floor.

Table 5 suggests the results of using electromagnetic and electrical stimulation in rehabilitation and these articles state that use of HIFEM (High Intensity Focused Electromagnetic) technology for pelvic floor stimulation significantly improves strength, function and EMG (Electromyography) activity of pelvic floor muscles and reduces the symptoms of urinary incontinence and additionally also improves sexual function in women.

DISCUSSION

The application of technological advancements in rehabilitation is gaining increasing importance within physiotherapy in recent years, as it bridges the gap between traditional and advance physiotherapy rehabilitation, offering better and personalized care. This review aims to critically evaluate and analyze the current emerging technologies in pelvic floor rehabilitation in physiotherapy practice, with the objective to understand the effectiveness of biofeedback, mobile applications, virtual reality and AI- assisted pelvic floor muscle training in terms of symptom reduction, muscle strength and function, adherence and patient reported outcomes in pelvic

floor rehabilitation and to identify feasibility, clinical relevance and potential for integration of these technologies in physiotherapy practice.

The novelty of this study is that it reviews various technologies used in pelvic floor rehabilitation across various conditions faced by women due to pelvic floor dysfunction in order to comprehend the resources available and understand how it could be useful towards a holistic approach at improving patient reported outcomes/quality of life.

This study highlights the effectiveness of technology assisted pelvic floor rehabilitation interventions such as biofeedback devices, mobile applications, virtual reality and AI in improving muscle strength, continence and quality of life. Findings from previous articles consistently indicate that use of these emerging technologies enhance patient engagement, adherence, feasibility and accessibility making it superior to conventional training alone.

For better understanding these studies were divided and grouped on the basis of the technology used such as mobile health apps, virtual reality, AI, biofeedback devices and electromagnetic stimulation. 8 studies were reviewed to check the effectiveness of mobile health and app based PFMT. Among these studies de Araujo et al., (2024) and Kijmanawat et al., (2023) stated that compared to conventional supervised PFMT programs, the assistance of mobile applications in rehabilitation enhanced pelvic floor muscle strength and reduced severity of urinary incontinence [9, 11].

Loohuis et al., (2021) used an app based treatment in primary care settings which also showed improvement in patient engagement and reduction in UI symptoms [13].

Perrier and Aumont (2024) used real world data to state that Perifit app is effective beyond controlled research conditions [10]. These studies prove that digital delivery of PFMT is effective not just in controlled research conditions but they actually perform well in community and real- world conditions. Perifit uses game-based training in which pelvic floor contractions control the game.

Jaffar et al., (2022) and Sidik et al., (2021) conducted a study on pregnant women population, to assess the adherence outcomes of PFMT through mobile apps [12, 14].

Technology enhanced PFMT, highlights the importance of behavioral reinforcement through reminders, progress tracking and feedback within app-interface, this feature helps overcome the main barrier in pelvic health rehabilitation which is poor exercise adherence.

Bernard et al., (2021) emphasized on the importance of pelvic floor muscle training in special populations such as endometrial cancer survivors, and also indicates the need for feasibility in special populations such as oncology related pelvic dysfunction where daily in-person therapy is difficult due to fatigue, immune status or logistical barriers, proving that use of mobile applications shows adaptability to remote rehabilitation and symptom improvement [15].

Czyrnyj et al., (2020) checked for the validation of the app Elvie Trainer and proved it as a reliable and valid tool in pelvic floor rehabilitation [16]. The Elvie Trainer app uses guided and structured exercise programs with visual cues and focuses strongly on performing the correct technique.

Both Perifit and Elvie trainer apps require to insert a silicon device in the vagina, the device connects to the app on the phone via Bluetooth, sensors in the device detect pelvic floor activity and provide real-time visual feedback.

3 studies were reviewed to check for the effectiveness of using the virtual reality approach in pelvic floor rehabilitation, Lin et al., (2022) Martinho et al., (2016) and Botelho et al., (2015) emphasized on the educational benefits of VR-based pelvic training. Most patients struggle with the understanding of performing pelvic muscles contraction and relaxation, this barrier can be addressed by using VR in clinical practice, making VR an innovative and novel approach in enhancing proprioception, awareness and engagement [17-19].

3 studies were reviewed to check the use of biofeedback and sensor-based devices in pelvic floor rehabilitation, Wang et al., (2024) and Paash et al., (2022, 2023) highlighted the clinical significance of biofeedback devices with respect to real-time feedback and improvement in motor learning. It recognizes the versatility of biofeedback devices in addressing various pelvic floor dysfunctions [20-22].

2 studies were reviewed to check the effectiveness of AI in pelvic floor rehabilitation. El-Sayegh et al., (2024) explored the use of AI in assessment system to assess the quality of pelvic floor contractions and help with accuracy and feedback. Weinstein et al., (2021) explored the use of AI in clinical intervention in comparison with conventional training, and emphasized the potential for remote, accessible, and patient-centred. Collectively these studies prove that evidence-based digital therapy with AI and sensor technologies can improve quality, adherence and patient-reported outcomes [23, 24].

3 studies were reviewed to check the effectiveness of Electromagnetic and Electrical Stimulation. Hlavinka et al., (2019) and Silantyeva et al., (2020, 2021) respectively checked the potential benefits of HIFEM (High-Intensity Focused Electromagnetic) technology. HIFEM chair has proved to be a safe and effective approach in rehabilitation, it is an excellent approach for patients who have weak pelvic floor muscle strength as it uses focused electromagnetic pulses to stimulate involuntary muscle contraction. An additional advantage of this approach is that it is non-invasive, making it a comfortable approach for the patients [25-27].

CONCLUSION

This study concludes that integration of emerging digital and biofeedback technologies in pelvic floor rehabilitation are reshaping physiotherapy practice and represents a transformative advance. Biofeedback and sensor-guided PFMT yield better muscle activation and continence outcomes. Mobile applications and VR improve adherence, feasibility, accessibility and patient engagement. AI and motion-detection systems provide real-time feedback and helps improve accuracy of movements and muscle activation. Electromagnetic stimulation is an alternative for patients unable to perform voluntary contractions of pelvic muscles effectively.

LIMITATIONS-

There are limited clinical trials in this sector. Studies have short-term follow ups and long term effects are unclear. There is heterogeneity in interventions, outcome measures and sample sizes. Small sample sizes in most studies. Although effective the high cost of the technology limits its accessibility.

FUTURE RECOMMENDATIONS-

Studies can be done to compare between different technology-assisted interventions. Funding can be acquired to improve affordability. Researchers can use long-term follow-up measures to examine the durability of the intervention's sustained effects in improved pelvic floor strength, function and continence. Studies can be done in diverse age groups and broader populations in different conditions.

Author contributions

A. Conception and design, or design of the research; or the acquisition, analysis, or interpretation of data: Carol Daniel Dsouza and Pinky Dutta
B. Drafting the manuscript or revising it critically for important intellectual content: Carol Daniel Dsouza
C. Final approval of the version to be published: Carol Daniel Dsouza and Pinky Dutta
D. Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved: Carol Daniel Dsouza and Pinky Dutta

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Conflict of interest

We do not have any conflict of interest.

AI disclosure

AI tools were used solely for language editing, grammar improvement and structural clarity of the manuscript. The authors take full responsibility for the accuracy, originality and integrity of the content.

Ethical approval:

Not Applicable.
This study is a review article based on existing literature and it does not involve human or animal subjects. No human participants, patient data or identifiable information were directly involved.

List of acronyms

AI- Artificial Intelligence

PFMT- Pelvic Floor Muscle Training

UI- Urinary Incontinence

EMG- Electromyography

RCT- Randomized Controlled Trial

KEPT- Kegel Exercise Pregnancy Training

mHealth - Mobile Health

ICIQ-SF- International Consultation on Incontinence Questionnaire Short Form

FI- Fecal Incontinence

VR- Virtual Reality

PFM- Pelvic Floor Muscle

HIFEM- High Intensity Focused Electromagnetic technology

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