REVIEW ARTICLE

IJPHY

Transforming Postmenopausal Healthcare: Leveraging Telemedicine and AI-Driven Predictive Analytics for Personalized Wellness – A Scoping Review

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ABSTRACT

Background: A woman is considered "postmenopausal" if she has not had a menstrual period for at least a year and is neither pregnant nor nursing. Postmenopausal hormone levels continue to fluctuate and decline, leading to common postmenopausal symptoms like hot flashes, vaginal dryness, decreased libido, mood swings, sleep disturbances, and an increased risk of osteoporosis, cardiovascular diseases, and weight gain. Estrogen deficiency can also lead to cognitive changes, urinary incontinence, back pain, and increased risk of musculoskeletal disorders, including disc degeneration and osteoporosis. Strength training and aerobic exercises have been shown to reduce back pain and disability, while anxiety, stress, and fear can exacerbate overall disability. Staying physically active is highly recommended for mitigating the effects of hormonal changes and improving overall health outcomes.

Methods: This scoping review examines the role of artificial intelligence and telemedicine in physiotherapy exercise programs for postmenopausal women. Data were gathered from peer-reviewed journals, clinical trials, and existing telemedicine and AI applications in healthcare. The methods focused on: Evaluating AI-based tools that assist in exercise monitoring, personalization, and adherence tracking for postmenopausal women and assessing telemedicine platforms that facilitate remote physiotherapy consultations and exercise guidance.

Results: The analysis revealed that AI and telemedicine offer significant benefits for managing postmenopausal symptoms through physiotherapy.

Conclusion: Regular physical activity, supported by AI and telemedicine, is essential for mitigating the risks of musculoskeletal disorders, osteoporosis, and other postmenopausal challenges. By providing personalized, accessible, and effective solutions, these technologies address common symptoms and improve quality of life.

Keywords: Postmenopausal women, Physiotherapy Exercise, Artificial Intelligence, telemedicine, Postmenopausal symptoms, Quality of life.

Received 11th November 2024, accepted 5th March 2025, published 31st March 2025

www.ijphy.com

10.15621/ijphy/2025/v12i1s/1607

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INTRODUCTION

At menopause, the normal bone turnover process is disrupted due to a lack of estrogen. Estrogen normally helps balance bone breakdown and formation [1]. Without enough estrogen, bone breakdown (by cells called osteoclasts) increases, while bone formation (by cells called osteoblasts) decreases, leading to overall bone loss. Estrogen reduction weakens its control over osteoclast activity, allowing more bone resorption. Certain chemicals, like IL-1, IL-6, TNF, and RANKL, which promote bone breakdown, increase during this time. While estrogen's role in bone formation is less clear, it may affect the genes responsible for building bone tissue [2].

The National Osteoporosis Foundation estimates that 9.1 million women have osteoporosis, with 26 million more having low bone mass, far outnumbering the 2.8 million men with osteoporosis and 14.4 million with low bone mass. The fracture risk is also higher in women [3]; a 60-year-old woman has a 44% lifetime fracture risk, compared to 25% in men. Osteoporosis prevalence rises with age, especially in women over 50, with Caucasian and Asian women being more susceptible than black women [4, 5]. Postmenopausal women may gain weight, particularly around the abdomen, which can strain the lower back. Declining estrogen levels during menopause may affect pain perception and contribute to lower back pain due to conditions like degenerative disc disease and arthritis. Hormonal changes can also lead to urogenital symptoms, including vaginal discomfort.

Role of Physiotherapy for overcoming the postmenopausal symptoms

Physiotherapy plays a vital role in addressing and alleviating the diverse symptoms experienced by postmenopausal women, contributing significantly to their overall health and well-being. This section will delve into how physiotherapy interventions can effectively manage and overcome various postmenopausal symptoms, aligning with the broader topic of revolutionizing postmenopausal health through advanced technologies like AI [12].

1. Management of Musculoskeletal Health

Postmenopausal women are particularly susceptible to musculoskeletal issues such as osteoporosis and osteoarthritis due to declining estrogen levels, which impact bone density and joint health [1,2]. Physiotherapy interventions focus on enhancing musculoskeletal health through:

Exercise Programs: Tailored exercise routines, including weight-bearing exercises, resistance training, and movement control exercises, are prescribed to improve bone density, muscle strength, and joint stability. These exercises help prevent osteoporosis-related fractures and alleviate osteoarthritis symptoms by improving joint function and reducing pain [6-8].

Manual Therapy: Techniques such as mobilizations, manipulations, and soft tissue techniques reduce pain, improve joint mobility, and restore standard movement patterns. These therapies are particularly beneficial for managing symptoms of osteoarthritis and other joint-related issues [8]

2. Management of Cardiovascular Health

Postmenopausal women face an increased risk of cardiovascular diseases, partly due to hormonal changes and lifestyle factors. Physiotherapy interventions aimed at cardiovascular health include:

Aerobic Exercise: Structured aerobic exercise programs help improve cardiovascular fitness, lower blood pressure, and reduce the risk of heart disease. Regular aerobic activity also aids weight management and improves endurance and stamina [6].

3. Management of Pelvic Health

Hormonal changes during menopause can lead to pelvic floor dysfunction, resulting in symptoms such as urinary incontinence and pelvic organ prolapse. Physiotherapy addresses pelvic health issues through:

Pelvic Floor Muscle Training: Specific exercises targeting the pelvic floor muscles strengthen these muscles, improve bladder control, and reduce urinary incontinence episodes. These exercises are essential in managing and preventing pelvic floor disorders.

4. Management of Psychological and Functional Well-being

Menopausal symptoms such as hot flashes, mood swings, and sleep disturbances can significantly impact psychological well-being and daily functioning. Techniques such as progressive muscle relaxation, deep breathing exercises, and mindfulness-based stress reduction help alleviate symptoms like hot flashes and reduce stress levels. These interventions promote relaxation, improve sleep quality, and enhance psychological resilience. Physical therapies improve muscle strength and ability to move and resume physical activity and exercise, psychological and social support to help people manage their pain and return to activities they enjoy, reducing strain during physical work, lifestyle changes including more physical activity, healthy diet, and good sleep habits. The essential roles of physiotherapy are initial reassurance, proper guidance to stay active, avoiding bed rest, and guiding self-management. Self-management can include self-exercises and education from reading booklets or being involved in online education for low back pain. Primary conservative physical treatment may include exercises, superficial heat, and manual therapy [7,8]. Guidance to return to normal activities, or referral for an individual or group exercise program, The McKenzie method of mechanical diagnosis and therapy [9], low-level laser therapy, and movement control exercise [10]. Relaxation techniques, breathing exercises, and strategies for stress management can help alleviate hot flashes. The pelvic floor exercises to improve vaginal muscle tone and reduce symptoms of dryness and discomfort. The pelvic floor muscle training helps to strengthen the muscles that support the bladder and urethra, reducing episodes of incontinence. The exercises

and stretches are designed to improve joint flexibility, reduce stiffness, and alleviate pain associated with arthritis or osteoporosis. The weight-bearing exercises and resistance training promote bone health and reduce the risk of osteoporosis-related fractures. The physiotherapy interventions can enhance overall physical function and mobility, enabling postmenopausal women to remain active and independent [11].

Below, we can see how physiotherapy integrates with AI in postmenopausal healthcare. It can significantly enhance accessibility, personalization, and outcomes, offering a comprehensive approach to wellness through technology-driven solutions.

1. AI-Driven Personalized Physiotherapy Programs

- Predictive Analytics for Fall Risk Assessment: AI algorithms can analyze patient data to predict fall risks and suggest tailored physiotherapy exercises to improve balance and strength.
- Customized Exercise Plans: AI can design individualized physiotherapy regimens to consider hormonal changes, bone density, and muscle mass loss in postmenopausal women.
- Progress Tracking and Adaptation: AI-powered tools can monitor progress during physiotherapy and dynamically adjust programs based on real-time feedback and patient performance.

2. Virtual Physiotherapy Sessions with Telemedicine

- Remote Monitoring with AI Sensors: Smart wearable devices or motion capture technology can track body movements during exercises, providing instant feedback to ensure proper form and avoid injury.
- Telemedicine Integration: AI-driven virtual physiotherapy platforms can facilitate guided exercises through video consultations, reducing barriers to access for women in remote areas.

3. Pain Management and Rehabilitation

- AI-Assisted Pain Management: AI can analyze patient-reported pain levels and physiological data to recommend physiotherapy techniques for alleviating musculoskeletal pain commonly seen post-menopause.
- Rehabilitation after Injuries: AI can provide predictive models to optimize recovery time and enhance rehabilitation outcomes for injuries or surgeries.

4. Improved Bone Health through AI-Assisted Therapy

- Bone Density Analysis: AI algorithms can analyze DEXA scan results and recommend weight-bearing and resistance exercises tailored to improve bone health.
- Early Detection of Osteoporosis: Predictive analytics can flag early signs of osteoporosis, allowing timely intervention with targeted physiotherapy.

5. Behavioural Insights and Motivation

- Gamification of Physiotherapy: AI can incorporate gamification elements into physiotherapy exercises, making them more engaging and encouraging adherence.
- Behavioural Analytics: AI can identify patterns in patient behavior and suggest motivational strategies to enhance commitment to physiotherapy regimens.

6. Educational Tools and Support

- AI-powered Virtual Assistants: These can educate about the benefits of physiotherapy, guide proper exercise techniques, and answer queries in real time.
- Community Building via Telemedicine: AI can connect patients with similar conditions, enabling shared physiotherapy experiences and mutual support.

7. Long-Term Monitoring and Preventive Care

- AI-Powered Predictive Models for Chronic Conditions: Physiotherapy regimens can be optimized to prevent or manage chronic conditions such as arthritis or cardiovascular diseases in postmenopausal women.
- Integration with Wearables: Continuous tracking of vital signs and movement patterns through wearables can alert healthcare providers to potential issues early, enabling preventive physiotherapy.

The healthcare industry is rapidly advancing, with modern technology playing a key role in improving services [12]. AI facilitates secure data exchange between healthcare providers, improving care coordination and reducing unnecessary tests [13]. AI can help investigate personalized treatment options in postmenopausal care by analyzing symptom variations and treatment responses. It can support the development of non-hormonal treatments for symptoms like hot flashes and vaginal dryness. Additionally, studying the impact of diet, exercise, and lifestyle on postmenopausal health can inform preventive strategies. AI can also evaluate the effectiveness of digital health technologies, such as mobile apps and wearables [14], in helping women manage their symptoms and access care. Lastly, it may aid in understanding the biological mechanisms behind postmenopausal symptoms, guiding more effective treatments and interventions.

AI technology can help address disparities in postmenopausal healthcare by improving access, diagnosis, treatment, and outcomes across diverse populations, including women of different racial, ethnic, and socioeconomic backgrounds [15]. It can facilitate community-engaged research, culturally sensitive interventions, and policy advocacy. It also supports preventive strategies such as lifestyle interventions, early screening, and vaccinations to reduce the risk of postmenopausal symptoms and related health conditions [16,17]. Additionally, it can evaluate the effectiveness of integrative healthcare models that combine conventional medicine with complementary therapies to manage symptoms. By examining healthcare delivery models and provider practices, blockchain helps optimize care for postmenopausal women. Integrating AI with physical exercise programs supports managing low back pain by combining physical therapy with digital health

technologies to improve strength and flexibility, reducing pain for postmenopausal women. Digital platforms can also aggregate anonymized data from users managing back pain. Machine learning can analyze this data to identify trends and develop personalized exercise programs based on individual needs and treatment responses [18].

Integration with Technological Advances [21, 22].

In revolutionizing postmenopausal health through advanced technologies like blockchain and AI, physiotherapy is crucial in providing personalized and effective care. The integration of technologies can enhance physiotherapy practice by:

***Data-Driven Personalization*:** AI algorithms can analyze patient data to tailor exercise programs and treatment plans based on individual health profiles and progress metrics.

Remote Monitoring and Telehealth: Blockchain technology ensures secure and transparent health data management, facilitating remote monitoring and telehealth consultations for physiotherapy sessions.

***Enhanced Treatment Outcomes*:** By combining traditional physiotherapy approaches with technological advancements, healthcare providers can achieve improved treatment outcomes, better patient adherence, and enhanced overall wellness for postmenopausal women.

Physiotherapy emerges as a cornerstone in the comprehensive management of postmenopausal symptoms, addressing musculoskeletal, cardiovascular, pelvic health, and psychological well-being. Integrating physiotherapy with advanced technologies enhances care delivery and empowers women to manage their health effectively during this transitional phase of life. This holistic approach ensures that postmenopausal women receive personalized, evidence-based care that improves their quality of life and promotes long-term health outcomes.

In the concept of interoperability, a patient visiting multiple specialists, including a physical therapist, can grant permission for each provider to access their unified record on the blockchain. This eliminates redundant assessments and provides a comprehensive view of the patient's health status [19,20]. Challenges like scalability and regulatory compliance require collaboration among healthcare stakeholders to realize AI's potential in postmenopausal carefully. Future advancements could lead to better longitudinal data analysis, interoperable healthcare systems, and decentralized trials, ultimately improving the quality of life for postmenopausal women. Additionally, combining AI with physical therapy for managing low back pain offers an innovative approach. Low-impact exercises, which strengthen core muscles and improve flexibility, can be tracked using blockchain technology. This ensures tailored care for postmenopausal women, addressing musculoskeletal changes and back pain while promoting overall wellness.

CONCLUSION

In conclusion, AI technology enables secure and transparent health data exchange between patients, healthcare providers, and other stakeholders in managing low back pain. Patients maintain control over their data, enhancing collaboration among care teams and improving care coordination. Some blockchain platforms also support collecting real-world evidence, enabling researchers to analyze data and refine clinical guidelines for treating postmenopausal women. Overall, the combination of Physiotherapy and digital health technologies has the potential to revolutionize healthcare delivery, particularly in postmenopausal care, offering more effective and sustainable treatment solutions.

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