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Implementation Challenges and Enablers of Wearable Health Technologies in Physiotherapy Among English-Speaking Participants in India: A Qualitative Study

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ABSTRACT

Introduction: Wearable medical devices are increasingly integrated in physiotherapy to enable exercise optimisation, remote monitoring of therapy progress, and tailoring of treatment plans based on individual needs. However, their current utilisation in clinical practice in India remains limited and at an early stage, as physiotherapy largely remains a manual skill-based profession in which hands-on techniques often supersede wearable devices. This study aimed to identify the potential facilitators and barriers to the adoption of these devices.

Methodology: A questionnaire with a mix of open-ended and closed-ended questions was developed to survey actively practicing clinical physiotherapists. It was developed in English, the standard language used by most physiotherapists in India and disseminated to potential participants via social media platforms. Informed consent was obtained from all participants. A total of 62 participants completed the survey.

Results: Wearable medical devices have substantial potential to improve patient care when incorporated into clinical physiotherapy practice, but time restrictions, lack of training, limited market access, concerns about data privacy and reliability, and the high cost of these devices were identified as major barriers to widespread adoption. Addressing existing barriers is regarded to be essential to facilitate effective implementation.

Conclusion: Continuous advancements and adequate implementation strategies are recommended for wearable medical devices to develop their potential to revolutionise physiotherapy practice in India by making it more efficient, personalised, and outcome-driven.

Keywords: Wearable technology, physiotherapy, medical devices, remote monitoring, digital health

1. INTRODUCTION

Wearable medical devices are compact, sensor-integrated systems worn by patients on their limbs, torso, or head and neck, depending on clinical indication. These devices help healthcare providers' continuous monitoring of physiological and biomedical parameters, facilitating precise diagnosis and therapeutic intervention. Some examples include fitness trackers, smartwatches, and specialised medical monitors. These devices monitor a range of parameters including heart rate, blood pressure, respiratory rate, oxygen saturation (SpO_2), glucose levels, energy expenditure, posture, gait, and location (via GPS). Certain devices can also modulate physiological function, such as refractory cardiac arrhythmias (Lu et al., 2020). With the integration of IoT (Internet of Things), cloud computing, and artificial intelligence (AI), wearable medical devices can now autonomously acquire, process, and transmit patient data, facilitating timely clinical decisions. This data-driven approach aids in early detection of health issues, minimising hospital admissions and enabling personalised interventions. These devices are revolutionising healthcare by facilitating continuous health monitoring beyond conventional clinical environments. Applications extend beyond health monitoring to disease diagnosis, chronic disease management and rehabilitation, however, therapeutics usage remains limited (Dias & Cunha, 2018; Lu et al., 2020). A recent systematic review (Lu et al., 2020) emphasises that wearable medical devices are extremely useful for remote health monitoring of vulnerable populations such as elderly, young children, pregnant women, and patients with chronic disease conditions. Real-time data transmission ensures continuous clinical oversight, supporting proactive care (Dias & Cunha, 2018; Lu et al., 2020). Age-related musculoskeletal fragility increases fall risk in older adults. Wearable devices quantitatively assess fall risk and alert emergency contacts immediately, facilitating rapid clinical intervention (Chen et al., 2022; Dias & Cunha, 2018; Lu et al., 2020). Although wearable sensors demonstrate efficacy for fall prediction, accuracy depends on sensor placement, data quality, and analytical methods, necessitating further validation (Chen et al., 2022). In maternal and child health, wearable devices can monitor children's location and physical activity, track mood and behaviour, enabling early detection of anxiety or depression. During pregnancy, device allow continuous monitoring of maternal and foetal physiological parameters, providing actionable feedback on gestational complications (Dias & Cunha, 2018; Lu et al., 2020).

For chronic disease management, patients are often in prolonged, multidisciplinary care. Wearable medical devices facilitate remote monitoring, adjustment of treatment plans, and lifestyle guidance, empowering patients in self-management, thereby improving outcomes (Chen et al., 2022; Dias & Cunha, 2018; Lu et al., 2020). In respiratory medicine, these technologies support early detection of pulmonary function decline, including chronic obstructive pulmonary disease (COPD) by correlating environmental exposures with physiological responses to inform preventive strategies (Althobiani et al., 2023; Lu et al., 2020). With the progressive advancements in sensor technology, wearable systems possess the capacity to intricately correlate an individual's environmental exposure with physiological responses, thereby facilitating the identification of potential triggers and contributing factors underlying pulmonary pathophysiology. This synergistic integration of real-time health monitoring and environmental surveillance offer granular insights into the mechanistic pathogenesis of respiratory disorders, ultimately paving the way for precision-targeted and prophylactic healthcare interventions (Althobiani et al., 2023; Lu et al., 2020). In cardiology, the deployment of a wearable cardioverter defibrillator (WCD) served as a protective modality against sudden cardiac arrest for patients undergoing treatment in non-hospital environments. The WCD ensures uninterrupted cardiac monitoring and intervention during the interval preceding the reimplantation of an implantable cardioverter defibrillator (ICD), thereby maintaining continuous electro-physiological support in ambulatory or home-based contexts (Bouzid et al., 2022). Electrocardiograms (ECG) enable the real-time acquisition and analysis of myocardial electrical activity, providing a crucial diagnostic window into diverse cardiac pathologies. Although the 12-lead ECG remains the clinical gold standard for the comprehensive assessment of cardiac diseases beyond arrhythmogenic conditions, its implementation necessitates specialised personnel and controls clinical environments, constraining its accessibility. To mitigate these limitations, novel wearable and remote ECG devices have been developed, allowing individuals to self-record cardiac activity through simplified, user-friendly interfaces. These devices predominantly employ single-lead ECG architectures, optimising reduction while preserving clinically relevant diagnostic capacity. Empirical evidence from Bouzid et al. (2022) demonstrates that wearable ECGs exhibit high diagnostic fidelity for continuous cardiac monitoring, particularly when integrated with real-time alert algorithms. These devices are efficacious for detection of arrhythmias, atrial fibrillation, and, in some cases, may surpass traditional 12-lead ECGs in early identification of paroxysmal or intermittent arrhythmogenic events. Although wearable ECGs cannot entirely replace standard 12-lead ECGs in all diagnostic scenarios, their ability for longitudinal monitoring and enhanced patient accessibility underscores their pivotal role in early detection and management of cardiovascular disorders (Bouzid et al., 2022; Dias & Cunha, 2018; Lu et al., 2020). In a seminal study (Lee et al., 2017) a specialised wearable sensor designed to support cardiac rehabilitation (CR) was developed to optimise therapeutic exercise interventions. The device employs algorithmically driven recommendations for exercise intensity by continuously comparing the patient's instantaneous heart rate (HR) with a predefined target heart rate zone (THRZ). The CR programme is structured into pre-exercise, guided exercise, and post-exercise phases. During the pre-exercise phase, parameters such as THRZ, exercise type, sequencing, and duration are configured via a customised smartphone interface compatible with iOS and Android with data transferred to the dedicated CR wearable sensor (DCRW) via Bluetooth. In the guided exercise phase, multichannel wrist-based optical photoplethysmography sensors capture HR in real time, while singular value decomposition (SVD) is applied for signal noise reduction, techniques attenuate signal noise, enhancing measurement precision. Post-exercise, data are transmitted back to the smartphone application, facilitating longitudinal tracking and rehabilitation outcome evaluation (Lee et al., 2017).

In individuals with neuromuscular disorders, gait deficits impose substantial detriments on quality of life, promoting sedentary behaviour, muscular deconditioning, and secondary complications associated with immobility. Accordingly, restoration of ambulation remains a central objective of early rehabilitation protocols, aimed at enhanced mobility and overall functional capacity. In recent years, wearable powered lower-limb exoskeletons have emerged as transformative assistive technologies for robotic gait rehabilitation (Rodríguez-Fernández et al., 2021). Systematic evaluations, such as those by Antonio Rodríguez-Fernández et al. (2021), provide critical analyses of these devices, highlighting their efficacy in promoting locomotor recovery among patients with neuromuscular impairments. Technological innovations have concurrently produced intelligent rehabilitation aids that greatly enhance the lives of people with disabilities. Examples include AI-powered smart glasses for the visually impaired, advanced hearing aids, and robotic prosthetics as some of the most impactful innovations. AI-powered smart glasses facilitate environmental awareness and decision-making, integrating with smart home ecosystems to augment independence. Similarly, AI-enhanced hearing aids improve auditory perception, while robotic prosthetics replicate biomechanical movement patterns, thereby restoring mobility and functional dexterity. These examples of innovations step by step revolutionise rehabilitative care, enabling greater autonomy and improving quality of life of patients, and often also therapists (Black et al., 2020; Chiew et al., 2022; Rodríguez-Fernández et al., 2021).

The convergence of wearable devices, with immersive modalities such as virtual reality (VR), augmented reality (AR), and mixed reality (MR), is reshaping sport rehabilitation. These technologies provide quantitative monitoring and high-resolution assessment of athletic recovery, delivering immediate feedback on physical performance and biomechanical parameters. In addition to performance tracking, VR and AR foster engagement, motivation, and adherence to rehabilitation protocols, while promoting injury prevention and optimising overall athletic output (De Fazio et al., 2023). Integrating wearable technology with immersive experience constitutes a critical strategy for enhancing both recovery trajectories and performance outcomes in athletic populations (De Fazio et al., 2023). The market for wearable medical devices in India has shown tremendous growth in the recent years. In India the wearable medical devices market reached USD 1,040 million in 2024 and is projected to grow at a compound annual growth rate of 15.5% between 2025–2033, reflecting increased digitisation and emphasis on personalised healthcare (IMARC, 2025). Despite global adoption, clinical utilisation in Indian physiotherapy remains limited, with traditional hands-on approaches predominating. There is also a lack of localised research on Indian physiotherapists' perceptions, competencies, and training regarding wearable device integration. Understanding these factors is essential to guide policy, optimise training, and improve patient outcomes.

Our study aimed to investigate facilitators and barriers perceived by Indian physiotherapists regarding the recommendations, prescription, and clinical use of wearable medical devices, addressing three research questions:

1. What are the facilitators to the use of wearable medical devices as perceived by Indian physiotherapists for improving patient care and outcomes?
2. What are the barriers to the use of wearable medical devices as perceived by Indian physiotherapists for improving patient care and outcomes?
3. What can be done to improve the perceived barriers to the use of wearable medical devices in physiotherapy practice in India?

2. METHODS

The methodological approach of this study is described below.

Study design and participants

The present investigation employed a cross-sectional, descriptive survey design to examine the perceived facilitators and barriers influencing the adoption of wearable medical devices among actively practicing physiotherapists in India. The target population comprised licensed physiotherapists currently engaged in active clinical practice across urban regions in India. Urban physiotherapists were considered as they were more likely to have exposure to and experience with wearable health technology, making them a relevant population for this exploratory study.

Undergraduate students, interns not independently practicing, and retired professionals were excluded to ensure that responses reflected contemporary clinical experience.

Sampling: A non-probability convenience sampling strategy was adopted, reflecting the exploratory nature of the study and the absence of a centralised national registry for potential probabilistic sampling. While convenience sampling does not guarantee representativeness of the broader physiotherapy workforce in India, this approach was considered appropriate for an exploratory investigation of the key themes surrounding wearable technology adoption in clinical practice. Digital dissemination done via professional networks and online platforms facilitated recruitment from diverse geographical regions and clinical settings. Data were collected from the participants over a one-month period. Incomplete submissions were excluded to maintain analytical rigor. Ethical considerations were prioritised throughout the research process. A detailed study proposal outlining objectives, methodology, and participant safeguards was prepared prior to data collection. Participation was voluntary, and informed consent was obtained electronically through a structured consent form embedded at the beginning of the questionnaire. The consent statement clarified the purpose of the study, assured confidentiality and anonymity, and emphasised the participant's right to withdraw prior to submission. No personal identifiable information was collected, and all data was stored in password-protected digital repositories accessible only to the research team.

Instrument development and data collection

A structured questionnaire was specifically developed for the present study following an extensive review of literature from major electronic databases, including PubMed, Google Scholar, and ScienceDirect. The literature search included peer-reviewed English-language publications between 2015 and 2025 that addressed wearable medical devices, digital health technologies, and rehabilitation applications. Insights derived from this review informed the conceptual framework and guided the formulation of survey items.

The questionnaire was constructed in English. In accordance with the National Physiotherapy Curriculum prescribed by the National Commission for Allied and Healthcare Professions (NCAHP), Ministry of Health and Family Welfare (MoHFW), Government of India, English is the designated medium of instruction for both undergraduate and postgraduate physiotherapy education in India (Ministry of Health and Family Welfare, Government of India, 2023). Participation required respondents to be able to read and understand English, as the questionnaire was administered in English. A functional level of English proficiency was reasonably assumed, given that professional education and clinical training in India are predominantly conducted in English. To ensure accurate comprehension, the questionnaire items were designed using clear, simple, and non-technical language and were reviewed for clarity prior to data collection.

However, restricting participation to English-speaking respondents may have excluded physiotherapists with limited English proficiency, particularly those from rural or semi-urban settings and older age groups, thereby reducing the diversity of perspectives. Worth mentioning, approximately 10.7% of India's population speaks English to some extent (2011 Census data), indicating that a substantial portion of the target population may have been excluded from the study. Given that only a minority of the population is proficient in English, this criterion may limit the generalisability of the findings. Furthermore, English-speaking professionals in India often have greater access to digital resources and technologies, which may introduce sampling bias by overrepresenting a more technologically advantaged subgroup.

The questionnaire incorporated dichotomous (Yes/No) items, multiple-choice questions, five-point Likert scale items, and open-ended questions.

The survey questionnaire included the following types of questions:

1. General questions about the demographic and professional background of the participants, including their age group, primary area of specialisation, experience, and the type of setting they primarily worked in, i.e. private clinic/hospital/academic institution, etc.

2. Questions that examine the views and perceptions of physiotherapists, related to their awareness, general usage and acceptance of wearable devices in clinical practice. Some examples of these questions were as follows:
   - "What types of wearable devices are you familiar with?"
   - "Have you ever used wearable devices in your practice?"
   - "How often do you recommend wearable devices in your practice?"
3. Several questions on factors that could potentially be considered as 'facilitators' and 'barriers' in recommending wearable devices were also included in this questionnaire. Some examples of these questions were as follows:
   - "What do you think are the advantages of using wearable devices in clinical practice?"
   - "What do you believe are the main challenges in using wearable devices in your practice?"

The participants were also asked to rate the significance of those factors on a Likert scale ranging from 1 to 5, where a score of '1' meant no significance, and a score of '5' meant very high significance.

4. Some questions regarding the perception of physiotherapists towards the future application of wearable devices in clinical practice were included towards the end of the questionnaire:
   - "In your opinion, how can wearable devices enhance the practice of physiotherapy in India?"
   - "What features do you consider essential in a wearable device for physiotherapy?"
   - "Would you consider adopting wearable medical devices in your practice in the next five years?"

The survey was conducted with the aim of gathering responses from as many participants as possible.

Data analysis

A total of 62 complete responses were obtained and deemed eligible for inclusion in the final analysis. The dataset was subjected to a rigorous analytical process incorporating both quantitative and qualitative methodologies to ensure comprehensive interpretation and methodological robustness. Quantitative data derived from structured, closed-ended items were systematically coded and exported to Microsoft Excel and Google Sheets for statistical processing. Descriptive statistical techniques, including frequency distributions, percentages, and measures of central tendency, were computed to characterise participant demographics, levels of awareness, utilisation patterns, and perceived determinants influencing the adoption of wearable medical devices. Where applicable, Likert-scale responses were analysed by calculating the mean scores and relative rankings to determine the comparative significance of identified facilitators and barriers. Qualitative data obtained from open-ended responses were analysed using a structured thematic analysis approach. Responses were carefully reviewed, coded, and categorised to identify recurrent patterns, emergent concepts, and context-specific insights. These themes were subsequently synthesised into broader conceptual domains to enhance interpretive coherence and analytical depth. To strengthen contextual validity, the study findings were critically examined in relation to existing literature. Comparative analysis with prior empirical studies facilitated identification of convergent and divergent trends, as well as the generation of novel insights relevant to wearable technology integration within physiotherapy practice. The analytical process culminated in a comprehensive synthesis of results, emphasising principal findings, theoretical and practical implications, and evidence-informed recommendations for future research.

3. RESULTS

Demographic analysis: Age group

The survey data demonstrate a pronounced age-related skew in respondent distribution. A substantial majority (85.5%) of participants were within the 20–30-year age cohort, whereas 8.1% fell within the 31–40-year range, and only 6.5% were aged 41–50 years. This marked predominance of younger respondents indicates an imbalanced age distribution, with comparatively limited representation from older age groups. Consequently, the findings are likely to be disproportionately reflective of younger populations, potentially constraining the generalisability and external validity of the study outcomes.

Area of specialisation in clinical practice:

Table 1. **Area of specialisation in physiotherapy**

Primary Specialisation	% Participants
Musculoskeletal	**51.6**
Cardiopulmonary	**19.4**
Neurological	**12.9**
Sport	**3.2**
Oncology rehabilitation	**3.2**
Paediatrics	**3.2**
Community (women's health, geriatrics, etc.)	**3.2**
Not specialised	**1.6**

Table 1 illustrates the distribution of primary clinical specialisations among participants. Musculoskeletal physiotherapy was the most prevalent (51.6%), followed by cardiopulmonary (19.4%) and neurological physiotherapy (12.9%). Other domains – paediatrics, onco-physiotherapy, sport, and community (women's health) – each accounted for 3.2% of the sample.

Clinical experience (in years): The survey revealed that most participants (75.8%) had 0–5 years of experience, while 6–10 years and 16–20 years each comprised 11.3%, and 11–15 years accounted for 6.5%, indicating a predominance of early-career physiotherapists.

Work settings: Most participants worked in private clinics (40.3%), followed by hospitals (25.8%), home-based practice (17.7%), academic institutions (12.9%), and a small fraction as freelancers or in general surgery clinics (1.6% each).

General awareness about wearable medical devices: A substantial proportion of participants (90.3%) reported awareness of wearable medical devices in clinical practice, whereas 9.7% were uncertain. This high level of awareness may reflect the predominantly younger, technologically literate demographic of the sample.

Table 2. **Types of devices**

Types of Devices	% Participants
Activity trackers (Fitbit, Garmin, smartwatches, etc.)	**90.3**
Oxygen saturation sensors	**90.3**
Blood pressure sensors	**70.9**
Gait analysis devices	**69.3**
Posture correction wearables	**61.2**
Muscle stimulation devices	**80.6**
Range of motion sensors	**61.2**
Mobile applications	**80**

Table 2 summarises participants' awareness of various wearable medical devices, highlighting familiarity with technologies used in physiotherapy and healthcare. Physical activity trackers, including Fitbit, Garmin, and smartwatches, were recognised by 90.3% of the respondents, alongside oxygen sensors. Over 70% were aware of wearable blood pressure monitors, while 80.6% recognised electrical muscle stimulation (EMS) devices. Smartphone-based health applications were acknowledged by 80% of participants. Awareness of gait analysis devices was moderate at 69.3%, reflecting familiarity with tools used to assess locomotor patterns and detect early musculoskeletal or neurological abnormalities. A comparatively lower percentage (61.2%) of participants were familiar with posture correction devices, which are designed to help maintain spinal alignment and prevent musculoskeletal issues. The findings reveal varying levels of awareness regarding wearable medical technology.

Usage and recommendation of wearable devices in clinical physiotherapy practice: A substantial majority, 77.4%, reported integrating some of these devices into their practice. Meanwhile, 22.6% stated that they do not utilise or suggest wearable technology. The findings indicate that wearable devices are utilised in physiotherapy, likely due to their effectiveness in tracking patient progress and enhancing treatment strategies. However, the presence of a group that refrained from using them suggests potential challenges, which need further investigation.

Frequency of recommending/using wearable devices in clinical practice: The data indicate heterogeneous adoption of wearable devices among participants. Weekly use was reported by 25.8%, daily use by 17.7%, and monthly use by 14.5%, while 17.7% had never incorporated such devices into practice. Overall, 43.5% of participants used wearables regularly, whereas 41.9% employed them infrequently or not at all, reflecting considerable variability in clinical integration.

Benefits of using wearable medical devices in clinical practice: Table 3 presents participants' perceptions of the benefits of wearable medical devices in clinical practice. Majority (88.7%) highlighted real-time feedback as a key advantage, facilitating data-driven treatment adjustments. Improved documentation was noted by 74.2%, enabling accurate, automated record-keeping.

Table 3. **Benefits of using wearable medical devices in clinical practice**

Benefits	% Participants
Real-time feedback for patients	**88.7**
Effective documentation	**74.2**
Objective assessment	**67.7**
Enhanced patient engagement and motivation	**67.7**
Improved outcomes	**66.1**
Medico-legal aspects	**24.2**

Additionally, 67.7% reported enhanced objective assessment and patient engagement, while 66.1% acknowledged improved patient outcomes through personalised interventions. Medico-legal benefits were identified by 24.2% of respondents, reflecting the utility of wearables in supporting treatment accountability.

Likelihood of recommending wearable devices to patients in clinical practice: The survey data indicate participants' inclination to recommend wearable medical devices to patients. Among 62 respondents, 21.0% were very likely and 37.0% likely to recommend them, reflecting overall positive perception. Sixteen percent were somewhat likely, 23.0% remained neutral, and only 1.6% each were unlikely or very unlikely to recommend, indicating minimal outright rejection. These findings suggest broad acceptance of wearable devices, albeit with some residual hesitancy warranting further investigation.

Challenges faced in recommending wearable medical devices to patients: Table 4 summarises the challenges encountered by participants in recommending wearable medical devices. The primary barrier was high cost (74.2%), followed by insufficient training or knowledge (51.6%).

Table 4. **Challenges faced in recommending wearable medical devices to patients**

Challenges Faced	% Participants
High cost of devices	**74.2**
Lack of training or knowledge	**51.6**
Time constraints in incorporating the devices into sessions	**29.0**
Limited access in the market	**41.9**
Patient resistance or lack of interest	**43.5**
Personal preference for manual techniques	**29.0**
Data protection and confidentiality issues	**8.1**
Reliability	**1.6**

External factors included patient resistance (43.5%) and limited device availability (41.9%). Time constraints and preference for manual techniques were reported by 29.0%, while data protection concerns affected 8.1% of participants. Reliability was the least cited challenge (1.6%), indicating minimal concern regarding device accuracy or dependability.

Training in the use of wearable medical devices in physiotherapy:

Figure 1. **Training in the use of wearable medical devices in physiotherapy**

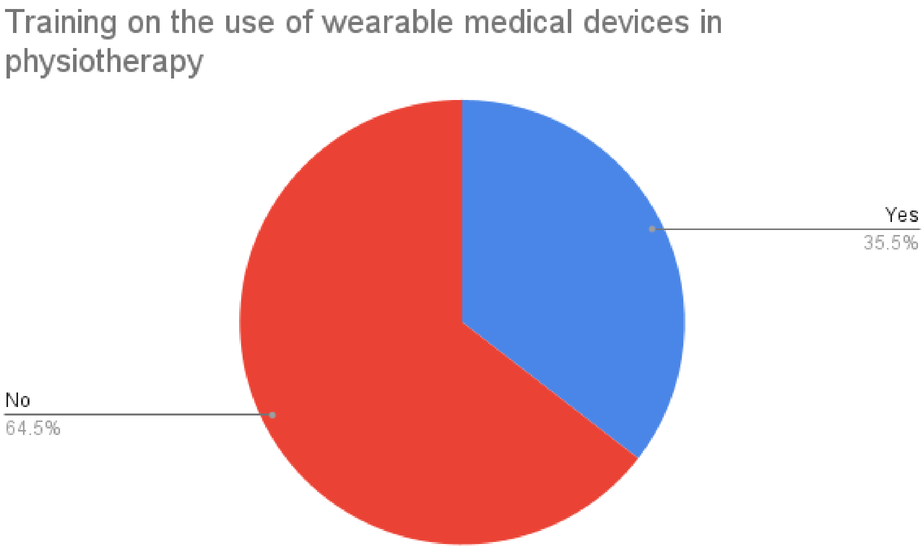
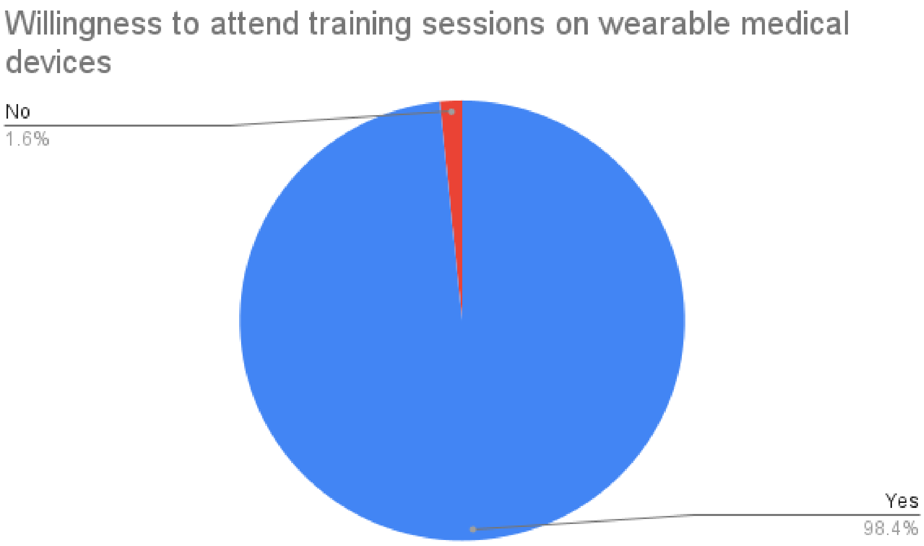


Figure 1 illustrates participants' training in the use of wearable medical devices. The majority (64.5%) reported no formal training, while only 35.5% had received instruction. This indicates a substantial training gap, highlighting the need for structured education on device usage, maintenance, and data security in clinical practice in India.

Willingness to attend training sessions on wearable medical devices:

Figure 2. **Willingness to attend training sessions on wearable medical devices**



As per the survey data shown in Figure 2, a vast majority of all participants, nearly 98.4%, showed an openness and willingness to learn and be formally instructed about wearable medical devices. Only a small minority (1.6%) of the participants were not willing to undergo further training in this area.

Most favoured forms of training methods:

Table 5. **Most favoured forms of training methods**

Training Methods	% Participants
Hands-on workshops	**79.0**
Online courses/webinars	**58.1**
Reading materials/guides	**46.7**
General orientation regarding use	**17.7**
Peer learning and mentoring	**25.8**

Table 5 summarises participants' preferred training methods for wearable medical devices. Practical hands-on workshops were most favoured (79.0%), followed by web-based learning platforms (58.1%) and written resources (46.7%). Peer collaboration or mentorship was preferred by 25.8%, while basic orientation programmes were considered beneficial by only 17.7%, indicating that in-depth, interactive training is strongly preferred over introductory formats.

Perception on the future role of wearable devices in physiotherapy practice in India:

Figure 3. **Perception of participants on the future role of wearable devices in physiotherapy practice in India**

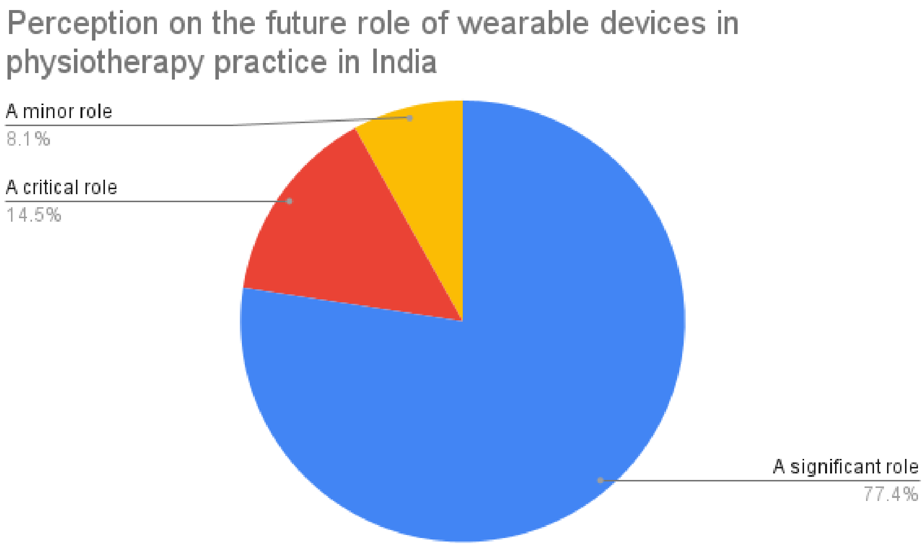


Figure 3 illustrates participants' perception of the future role of wearable devices in Indian physiotherapy practice. A majority (77.4%) anticipated a significant impact, while 14.5% expected a critical role, reflecting an overall positive outlook towards the adoption of these technologies in clinical practice.

Adopting wearable devices into practice in the next five years: Survey data indicate that 66.1% of participants expressed willingness to adopt wearable devices regularly in their practice over the next five years, while 12.9% were already using them and intended to continue. Approximately 21.0% remained uncertain about future adoption, reflecting some hesitancy within the cohort.

4. DISCUSSION

This study aimed to explore the utilisation, facilitators, and barriers of wearable health technologies among physiotherapists in urban India, with the overarching objective of optimising patient-centred care and functional outcomes. The findings revealed that the participants predominantly belonged to the 20–30-year age cohort (85.5%), suggesting a demographically early-career sample. Musculoskeletal physiotherapy constituted the principal domain of specialisation (51.6%), followed by cardiopulmonary physiotherapy (19.4%) and neurological physiotherapy (12.9%). The majority of the participants (75.8%) reported 0–5 years of professional experience, indicating early-stage clinical practice exposure. All participants were from urban clinical settings, distributed across heterogeneous practice environments including private clinics (40.3%), hospitals (25.8%), academic/teaching institutions (12.9%), home-based physiotherapy (17.7%), and a small proportion in freelancing.

In terms of awareness, 90.3% of the participants demonstrated cognizance of wearable medical devices and their application within physiotherapeutic contexts, indicating a high baseline technological literacy. This may plausibly be attributable to generational familiarity with digital ecosystems and enhanced technological adaptability among younger clinicians. Urban practice settings are likely to further facilitate exposure and access to technological innovations. When asked about the most common types of devices the respondents were familiar with, they mentioned being well aware of activity trackers like Fitbit, Garmin, and smartwatches (90.3%) that track heart rate, number of daily steps, oxygen saturation level (SpO_2), sleep duration, and number of daily calories burned. In India, like around the world, smartwatches and activity trackers are mainly marketed by technology giants such as Samsung, Google, Apple, Xiaomi, etc. and several other niche brands like Amazfit and Noise. These devices demonstrate sustained market penetration and increasing consumer adoption trajectories. This trend likely reflects multifactorial determinants. Consumer preference has shifted towards digital wearables due to enhanced functionality and utility. Concurrently, heightened health awareness has motivated individuals to increase daily physical activity, including step count and caloric expenditure (Gulati et al., 2024). Fuller et al. (2020) demonstrated that activity trackers effectively monitor and enhance overall daily physical activity. Katzmarzyk et al. (2021) demonstrated that physical inactivity constitutes a major global health burden, accounting for approximately 8% of non-communicable diseases and >7% of cardiovascular mortality. Middle-income countries bear a disproportionate burden due to larger populations. These data underscore the need to integrate physical activity promotion into both clinical practice and public health strategies (Katzmarzyk et al., 2021). Wearable activity trackers have demonstrated reliability and accuracy for quantifying physical activity, although further studies are required to validate reproducibility and long-term applicability (Katzmarzyk et al., 2021; Singh et al., 2024). Pulse oximeters were highly utilised (90.3%) among participants, reflecting their widespread adoption during the COVID-19 pandemic in India for daily monitoring of oxygen saturation in both clinical and home quarantine settings, particularly amid high patient loads and limited healthcare infrastructure (Singhal et al., 2023). Their use extended beyond respiratory pathology, as ambulatory pulse oximetry enables assessment of aerobic capacity during routine exercise, making it the preeminent modality for continuous oxygen saturation monitoring (Seffah et al., 2023; Singhal et al., 2023). Muscle stimulation devices were the third most utilised wearable modality (80.6%). They are widely employed in musculoskeletal and neurorehabilitation, including interferential therapy (IFT), transcutaneous electrical nerve stimulation (TENS), and portable multi-stimulators. These devices provide targeted analgesia for peripheral and visceral pain, facilitate postoperative rehabilitation in athletes, and support chronic pain management in palliative care, representing an effective non-pharmacological therapeutic intervention (De Fazio et al., 2023; Dutta et al., 2024; Paley et al., 2021). Mobile health applications were utilised by 80% of participants. Modern mobile applications integrate artificial intelligence to analyse, track, and longitudinally store physiological and lifestyle data, including sleep patterns, physical activity, menstrual cycles, dietary habits, and intermittent fasting (Merolli et al., 2024; Szabo et al., 2023). Platforms such as Apple Health and Samsung Health exemplify seamless smartphone integration for personal health monitoring and emergency data storage. In physiotherapy, app-based goniometric tools enable rapid, reproducible, and accurate joint range-of-motion assessment, reducing operator-dependent variability inherent in manual goniometry (Merolli et al., 2024; Szabo et al., 2023). Wearable blood pressure sensors were utilised by 70.9% of participants. Traditional Holter monitors and sphygmomanometers, though standard for ambulatory cardiac and blood pressure monitoring, are limited by bulk and reduced feasibility for continuous monitoring. Contemporary wearable devices are lightweight, user-friendly, and provide continuous, clinically relevant cardiovascular data (Sana et al., 2020). Gait analysis (69.3%) and posture correction wearables (61.2%) were less familiar to participants. Conventional gait assessment relies on manual observation or laboratory-based tools, both prone to error and cost-intensive. Wearable systems facilitate objective, reproducible gait evaluation and have enabled advances in gait rehabilitation and prosthetic design (Prasanth et al., 2021). Our findings indicate a critical need for formal training and increased awareness regarding wearable device integration in clinical practice. Further research on the reliability and validity of device-generated data is required to address clinician concerns. The majority of participants (77.4%) reported recommending wearable devices, whereas 23.0% did not, with usage patterns varying: 43.5% used them weekly or daily, 41.9% rarely or never, and 17.7% had never employed them. Barriers included limited exposure, inadequate training, concerns over data reliability, and lack of standardised protocols, underscoring the necessity for enhanced education, accessibility, and structured implementation strategies to optimise patient outcomes. Participants identified multiple benefits of wearable medical devices: 88.7% reported real-time patient feedback, 74.2% noted enhanced documentation, 67.7% indicated objective assessment and improved patient engagement/motivation, and 66.1% observed better clinical outcomes. A smaller proportion (24.2%) recognised potential utility in medico-legal contexts.

Physiotherapy traditionally relies on manual techniques for functional assessment and treatment, evaluating parameters such as muscle strength, joint range of motion, voluntary control, flexibility, mobility, and exercise exertion using standardised grading systems. Wearable medical devices offer the potential to reduce clinician effort, minimise observer bias, and enhance documentation accuracy (Merolli et al., 2024). Effective rehabilitation, particularly for injuries and chronic conditions, requires consistent multidisciplinary interventions, and patient adherence improves when sessions are engaging and interactive. Wearables can increase patient motivation and engagement by providing real-time performance feedback, creating a closed-loop system that allows movement adjustments and potentially optimises long-term rehabilitation outcomes (De Fazio et al., 2023; Fuller et al., 2020; Gulati et al., 2024; Katzmarzyk et al., 2021; Merolli et al., 2024; Seffah et al., 2023; Szabo et al., 2023). In this study, 46 participants were likely to recommend wearable devices, 14 were neutral, and two were unlikely, highlighting existing barriers and the need for targeted strategies to facilitate adoption. The primary barrier to wearable device integration was cost, reported by 74.2% of participants, reflecting limited accessibility in many clinics and private practices. This is compounded by the predominant out-of-pocket model for physiotherapy in India, where most health insurance plans do not cover rehabilitation services. Consequently, both providers and patients bear substantial expenses, which may also contribute to patient reluctance or low engagement (43.5%), particularly among those unfamiliar with technology or sceptical of device efficacy. Insufficient training and knowledge among physiotherapists (51.6%) limit effective integration of wearable devices into clinical practice. Formal training was largely lacking, with 64.5% reporting no prior instruction and 35.5% only basic exposure, representing a major barrier in India. Notably, 98.4% of participants expressed willingness to receive formal training, whereas 1.6% were reluctant. Preferred modalities included hands-on workshops (79.0%), online courses/webinars (58.1%), reading materials (46.7%), and peer mentoring (25.8%), while general orientation sessions were least favoured (17.7%). These data underscore the importance of experiential, interactive, and flexible training to build proficiency, confidence, and adoption of wearable medical devices in physiotherapy.

Limited market availability (41.9%) of regulatory delays in approvals and time constraints during clinical sessions posed a challenge amongst 29.0% of the participants, as incorporating these devices requires additional effort for setup, data interpretation, and patient education, suggesting that busy healthcare environments may struggle to integrate new technologies into established workflows. Some physiotherapists prefer traditional manual therapy techniques to digital (29.0%). Concerns about data security, privacy, and reliability also contribute to reluctance in adoption of these devices (8.1%), as wearable devices may not always provide accurate readings, raising medico-legal and ethical concerns (Volpato et al., 2021). Despite these barriers, 66.1% of participants anticipated routine use within five years and 77.4% of participants predicted transformative impact on physiotherapy practice in India. When they were asked to respond subjectively in this regard, the participants mentioned the following reasons:

- "Objective outcome measures."
- "Improve the effectiveness of assessments and act as tool to measure progress, increasing motivation of the patient as well as guiding the therapist for their rehab plan."
- "Wearable medical devices have the potential to significantly enhance physiotherapy practice in India by improving patient monitoring, adherence, and treatment outcomes."
- "It would definitely bring a lot of patient engagement to their own health."
- "In my opinion, patient's point of view in exercising and training would rise, as it will help either side to monitor their progress."
- "Handy outcomes and can have better track on their basic health information."
- "Make patients self-aware of their activities."

- "It will make documentation and patient education easier."
- "More awareness among patients of their health and thus more motivation towards rehab."

This reflects professional readiness to align with digital health transformation. Accuracy, validity, data security, usability, and accessibility were deemed essential device attributes. Targeted cost reduction, regulatory facilitation, structured training, and patient education are essential to optimise integration into physiotherapy practice.

Important considerations

The integration of wearable medical devices into healthcare systems introduces complex medico-legal and ethical considerations. Real-time health data generated by these systems may serve as objective evidence in medical and legal contexts such as malpractice claims or insurance disputes, yet concerns on data validity and algorithmic transparency persist. Privacy protection and cybersecurity compliance are paramount, necessitating adherence to regulatory governance like HIPAA (Health Insurance Portability and Accountability Act) (USA) or GDPR (General Data Protection Regulation) (European Union). Robust informed consent processes are mandatory to ensure patient autonomy and transparency in data utilisation. Questions of liability arise in scenarios involving device malfunction or erroneous readings, requiring clear delineation of responsibility among manufacturers, clinicians, and users. As wearable technology continue to evolve within increasing digitised healthcare infrastructures, multidisciplinary governance frameworks must be developed to ensure ethical deployment, regulatory compliance, and equitable patient protection while maximising clinical utility and innovation potential (Volpato et al., 2021).

5. CONCLUSIONS

Wearable medical devices demonstrate substantial transformative potential to enhance patient-centred outcomes when systematically integrated into clinical physiotherapy practice, yet multiple structural, economic, and educational barriers continue to limit their large-scale implementation. Time restrictions, limited access to structured competency-based training programmes, restricted market penetration, concerns regarding data privacy and device reliability, and significant financial burden associated with procurement and maintenance of these systems remain the principal impediments to adoption. Despite these challenges, the advantages of wearable technology are compelling and scientifically substantiated. The findings hold significant implications for physiotherapy practice in India. By identifying key facilitators and barriers to adoption, this research provides a strategic framework for enhancing the acceptance and sustained integration of wearable medical devices. The survey findings reveal a strong willingness among healthcare professionals to learn and adopt wearable medical devices, with 98.4% expressing interest in receiving formal training. Hands-on workshops emerged as the preferred training method. This pattern underscores the urgent need for standardised, practice-oriented, and clinically immersive educational frameworks that prioritise experiential learning and technological literacy. The integration of wearable technology modules into undergraduate and postgraduate physiotherapy curricula, along with continuing professional development initiatives, may significantly enhance practitioner confidence and facilitate seamless clinical adoption. To maximise the impact of wearable medical devices in clinical physiotherapy, it is essential to address existing barriers through strategic cost-reduction, improved supply chain accessibility, institutional funding mechanisms, and insurance reimbursement reforms. Concurrently, regulatory bodies must prioritise improvements in device validity, reliability, and algorithmic transparency through rigorous validation studies and standardised calibration procedures. Establishing comprehensive regulatory frameworks that ensure robust cybersecurity protocols and patient data protection is imperative to maintain ethical integrity and public trust.

Limitations and future scope of research: The research presented certain methodological limitations that warrant consideration.

The predominance of younger participants and the underrepresentation of older age groups may limit the generalisability of the findings. Given that younger clinicians are typically more familiar with digital technologies, the results may disproportionately reflect their perceptions and readiness for adoption. Consequently, the views of senior practitioners – who may face distinct practical, experiential, or attitudinal barriers – may not be fully represented. Broader demographic inclusion in future investigations is therefore essential to ensure balanced and comprehensive insights.

Gender distribution of participants was not analysed in this study. Future research should examine gender-related differences in the adoption and perception of wearable health technologies among physiotherapists.

Although 75.8% of the participants were early-career physiotherapists, their exact educational qualification (Bachelor's/Master's/PhD) and graduation year was not recorded in this study, which is acknowledged as a limitation, as education level and the time of graduation may influence familiarity with and attitudes towards wearable technology.

The restriction to English-speaking participants may have inadvertently excluded physiotherapists from rural or semi-urban settings with limited English exposure, and this should be considered when interpreting the generalisability of the findings.

The use of relatively modest sample size of 62 participants is an acknowledged limitation of this study. The findings should therefore be interpreted as exploratory, and caution should be exercised in generalising the results to the wider physiotherapy population in India. Future research employing larger, randomly selected samples across diverse geographic regions would strengthen the evidence base.

Future research should also examine wearable device utilisation across specific disease populations and specialised domains such as sport rehabilitation, cardiopulmonary conditioning, and neuromuscular recovery. Rigorous evaluation of reliability, validity, responsiveness, and cost-effectiveness in real-world clinical and athletic environments is necessary. Longitudinal and multicentre studies would further strengthen the evidence base and support the development of standardised clinical guidelines.

With strategic implementation and interdisciplinary collaboration, wearable technologies can redefine physiotherapy practice, advancing it towards a more precise, personalised, preventive, and performance-driven model that supports long-term health and wellbeing.

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