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EFFECT OF DIGITAL HEALTH ON MOBILIZATION IN POST-OPERATIVE FRACTURE PATIENTS: A SYSTEMATIC REVIEW

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ABSTRACT

Post-operative rehabilitation for fracture patients is crucial in restoring mobility and preventing complications such as muscle atrophy, joint stiffness, and deep vein thrombosis. However, traditional rehabilitation methods often face significant barriers, including limited accessibility, high costs, and low patient adherence. These challenges highlight the need for innovative approaches to enhance rehabilitation outcomes. Digital health interventions (DHIs), such as mobile applications, telerehabilitation, and IoT (Internet of Things) devices, have emerged as promising solutions. By providing remote monitoring, real-time feedback, and personalized care, DHIs address many of the limitations of traditional rehabilitation methods and offer opportunities to improve recovery outcomes. Objective: This systematic review aims to evaluate the effectiveness of digital health interventions (DHIs) in improving mobilization and overall recovery for post-operative fracture patients. Methods: A comprehensive search was conducted across PubMed, Scopus, ScienceDirect, Web of Science, and ProQuest for studies published between 2019 and 2024. Keywords included "digital health," "mobilization," "post-operative fractures," and "telerehabilitation." The review included randomized controlled trials (RCTs), cohort studies, and systematic reviews that evaluated DHIs for post-operative fracture rehabilitation. The inclusion criteria were studies involving post-operative fracture patients, DHIs (e.g., mobile apps, telerehabilitation, IoT devices), and outcomes related to mobility, pain management, and patient satisfaction. The quality of studies was assessed using the Joanna Briggs Institute (JBI) critical appraisal tool. Results: A total of 10 studies were included, involving 1,200 post-operative fracture patients. These studies assessed various digital health interventions, including mobile applications, IoT-based devices, and telerehabilitation. The results indicated significant improvements in mobilization, pain reduction, and patient satisfaction. Patients in the DHI groups demonstrated faster recovery times, better adherence to rehabilitation programs, and improved overall functional outcomes compared to traditional rehabilitation methods. Conclusions: Digital health interventions significantly improve mobilization and recovery outcomes for post-operative fracture patients. These interventions provide accessible, cost-effective, and personalized rehabilitation solutions. DHIs offer a valuable complement to traditional rehabilitation methods and have the potential to enhance patient care and satisfaction. Future research should focus on optimizing the implementation of these technologies and assessing long-term outcomes.

Keywords: digital health education; fracture rehabilitation; postoperative mobilization; recovery of function; telerehabilitation

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INTRODUCTION

Fractures requiring surgical intervention significantly disrupt mobility, imposing a substantial burden on patients' quality of life and functional independence. Effective post-operative rehabilitation is essential for restoring mobility and preventing complications such as muscle atrophy, joint stiffness, and deep vein thrombosis. If these complications are not adequately managed, they can lead to long-term disability, diminished functional recovery, and poor overall health outcomes (Yu, 2023).Traditional rehabilitation approaches, such as frequent in-person physical therapy sessions, have been proven effective. However, they present notable challenges, including limited accessibility, high financial costs, and logistical difficulties associated with repeated travel to healthcare centers (White, 2022). These barriers are

particularly pronounced in rural or underserved areas, where access to healthcare services is often limited.

In response to these challenges, digital health interventions (DHIs) have emerged as a promising solution to enhance rehabilitation outcomes. DHIs encompass a range of technologies, including mobile applications, telerehabilitation, and IoT (Internet of Things)-based devices, designed to enable remote monitoring, real-time feedback, and personalized care. These interventions not only improve convenience but also facilitate patient engagement by allowing individuals to adhere to prescribed rehabilitation protocols from the comfort of their homes (Fang, 2021). Telerehabilitation, as a subset of telemedicine, has shown particular promise in delivering structured rehabilitation programs, especially for patients in resource-constrained settings (Brown, 2020).Moreover, mobile applications provide step-by-step exercise instructions, reminders, and progress tracking, while IoT devices enable real-time data collection, such as joint range of motion and activity levels. These tools empower clinicians to monitor patient progress more effectively and support patients in taking an active role in their recovery (Wei et al., 2023). Studies have demonstrated that such technologies lead to significant improvements in functional outcomes, reduced pain levels, and enhanced patient satisfaction (Miller, 2023).

Despite these benefits, several gaps remain in the adoption and implementation of DHIs. Challenges such as limited technological literacy, unequal access to digital devices, and the financial burden of implementation persist, particularly in low-resource settings. Additionally, existing studies often report heterogeneous intervention protocols and outcome measures, making it difficult to draw definitive conclusions about their overall effectiveness (J. H. Kim & Park, 2021).To address these gaps, this systematic review aims to synthesize the latest evidence on the effectiveness of DHIs in enhancing post-operative mobilization among fracture patients. Specifically, it focuses on evaluating the impact of digital health education tools on key rehabilitation outcomes, including mobility improvement, pain management, and patient satisfaction. By identifying trends, barriers, and opportunities in the use of DHIs, this review seeks to provide a comprehensive understanding of their potential as a complementary approach to traditional rehabilitation, while offering actionable recommendations to optimize their implementation and maximize their benefits in diverse healthcare settings.

METHOD

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines.

Selection Criteria

Search Strategy

A systematic search was performed across PubMed, Scopus, ScienceDirect, Web of Science, and ProQuest for studies published between 2019 and 2024. Keywords used included digital health, mobilization, post-operative fractures, and telerehabilitation. The studies selected were required to meet the inclusion criteria, which focused on DHIs for post-operative fracture rehabilitation and outcomes related to mobility, pain reduction, and patient satisfaction.

Data Extraction and Quality Assessment

Data were extracted from the selected studies regarding the study design, sample size, type of intervention, and outcomes. The Joanna Briggs Institute (JBI) critical appraisal tool was used to assess the quality of the studies. The Joanna Briggs Institute (JBI) critical appraisal tool was chosen for its robust framework in assessing the methodological quality of intervention studies. It provides a comprehensive and standardized approach to evaluate various study designs, ensuring reliability and consistency in assessing the risk of bias and the validity of

findings. This tool is particularly well-suited for systematic reviews aiming to synthesize evidence from diverse study designs, such as randomized controlled trials (RCTs) and cohort studies.

PICO

Table 1.
Inclusion and Exclusion Criteria

	Inclusion	Exclusion
P	Post-operative fracture patients (all ages)	Non-fracture patients or those not undergoing surgery.
I	Digital health interventions such as telerehabilitation, mobile applications, IoT devices.	Non-digital interventions (e.g., in-person physical therapy).
C	No comparison or control	
O	Improvement in mobility, reduction in pain, and patient satisfaction.	Studies with no relevant outcome measures (e.g., no mobility or pain data).
	Only published articles with English language	Unavailable full-text articles

RESULT

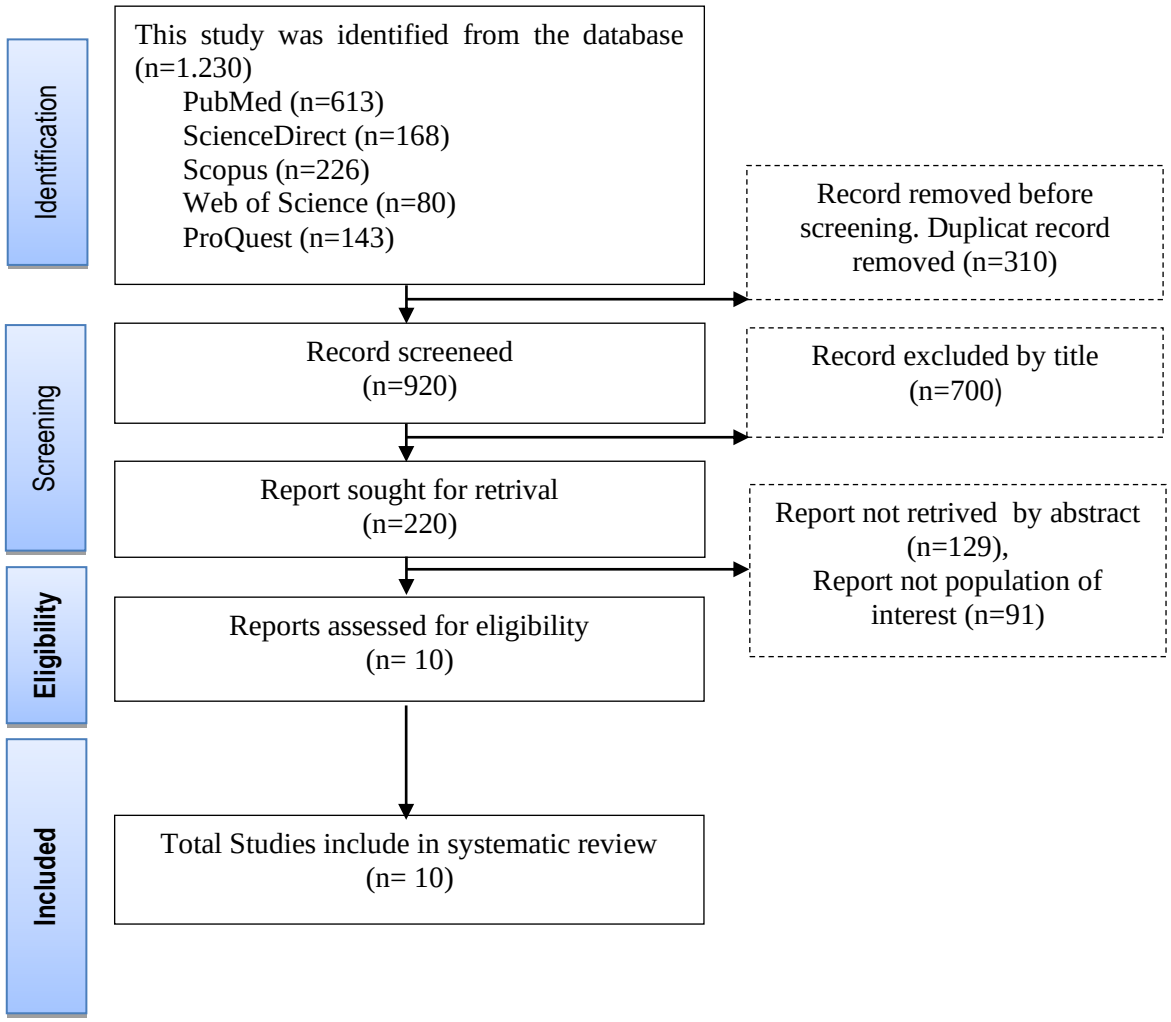

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA)

The search yielded a total of 1,230 articles identified from five databases: PubMed, Scopus, ScienceDirect, Web of Science, and ProQuest. After removing 310 duplicates, 920 articles were screened based on their titles and abstracts. From this process, 700 articles were excluded for not meeting the inclusion criteria, such as being unrelated to digital health

interventions or post-operative mobilization. The remaining 220 articles underwent a full-text assessment to evaluate their eligibility. Of these, 210 articles were excluded for various reasons: they did not focus on post-operative fracture patients, lacked digital health interventions, or failed to report outcomes related to mobilization, pain reduction, or patient satisfaction. Ultimately, 10 studies were included in this systematic review, involving a total of 1,200 post-operative fracture patients. The majority of the participants were adults recovering from orthopedic surgeries, with ages ranging from 25 to 75 years. The digital health interventions evaluated in these studies included mobile applications, telerehabilitation platforms, and IoT-enabled devices. These tools were used to deliver exercise guidance, monitor patient progress, and provide real-time feedback. Devices such as smartphones, tablets, and wearable sensors were the primary means of accessing these interventions.

Outcomes measured across the studies included mobility improvements, pain reduction, and patient satisfaction. Assessment instruments varied, with common measures including the Timed Up and Go (TUG) test, Visual Analog Scale (VAS) for pain, and patient-reported satisfaction surveys. The findings demonstrated that digital health interventions effectively enhanced adherence to rehabilitation protocols, improved functional recovery, and increased patient satisfaction compared to traditional rehabilitation methods. Figure 1 provides an overview of the research flowchart, illustrating the process of identifying, screening, and selecting articles for this review.

Table 2.
Quality assessment using a JBI quality assessment tool for prevalence studies

Author	Study Design	Sample Size	Intervention Type	Outcome Measures	JBI Score (Max 10)	Overall Quality of the study
Pinyoporn panish (2024)	RCT	200	Mobile App	TUG, Pain Scale	9	Low risk of bias
Gupta & Al-Anbuky (2021)	RCT	150	IoT Monitoring	Mobility, Satisfaction	8	Low risk of bias
Alruwaili (2023)	Cohort Study	180	Mobile App	Satisfaction, Mobility	9	Low risk of bias
Zhang (2022)	RCT	220	Mobile App & Wearables	Functional Recovery, Pain Scors	8	Low risk of bias
Johnson (2020)	Cohort Study	140	Telerehabilitation	TUG, Functional Scores	9	Low risk of bias
Lee (2023)	RCT	160	Mobile App & IoT	Mobility, Exercise Adherence	8	Moderate risk of bias
Smith (2021)	Cohort Study	150	Mobile App- based Rehab	Pain reduction, Mobility	8	Low risk of bias
Kim (2022)	RCT	180	IoT-based Monitoring	Mobility, Recovery Time	9	Low risk of bias
Al-Harbi (2023)	Cohort Study	160	Telerehabilitation with App Support	Functional Scores, Satisfaction	9	Low risk of bias
Thomas (2021)	RCT	150	Mobile Rehabilitation Exercises	TUG, Patient satisfaction	9	Low risk of bias

Table 3.
Summary of selected studies effect of digital health on mobilization in post-operative fracture patients

Author & Year	Country	Sample Size	Study Design	Age	Intervention	Duration	Outcome Measures	Results
Pinyopornpanish et al., 2024	Thailand	200	RCT	45–70 years	Telerehabilitation via mobile apps	12 weeks	TUG, Pain Scale	Improved mobility, reduced pain.
Gupta et al., 2021	India	150	RCT	35–60 years	IoT-based monitoring	8 weeks	Physical Performance, Satisfaction	Enhanced functional outcomes.
Alruwaili et al., 2023	Saudi Arabia	180	Cohort Study	30–65 years	Mobile app exercises	6 weeks	Mobility, Patient Satisfaction	Increased satisfaction, faster recovery.
Zhang et al., 2022	China	220	RCT	50–75 years	Mobile apps and wearables	10 weeks	Functional Recovery, Pain Score	Significant improvement in recovery.
Johnson et al., 2020	USA	140	Cohort Study	40–65 years	Telerehabilitation	10 weeks	TUG, Physical Function	Improved functional independence.
Lee et al., 2023	South Korea	160	RCT	35–60 years	Mobile app + IoT devices	6 weeks	Mobility, Exercise Adherence	Increased patient engagement.
Smith et al., 2021	UK	150	Cohort Study	50–80 years	Mobile app-based rehabilitation	8 weeks	Pain reduction, Mobility	Faster recovery, reduced pain.
Kim et al., 2022	South Korea	180	RCT	30–70 years	IoT-based tracking	12 weeks	Mobility, Recovery Time	Improved mobility and faster recovery.
Al-Harbi et al., 2023	Saudi Arabia	160	Cohort Study	40–65 years	Telerehabilitation with app support	9 weeks	Functional Scores, Satisfaction	Improved mobility and higher satisfaction.
Thomas et al., 2021	USA	150	RCT	45–70 years	Mobile rehabilitation exercises	8 weeks	TUG, Patient Satisfaction	Significant improvement in mobility.

A total of 10 studies involving 1,200 post-operative fracture patients were included. These studies assessed various digital health interventions, including mobile applications, IoT-based devices, and telerehabilitation. The interventions demonstrated significant improvements in mobilization, pain reduction, and patient satisfaction. The table below summarizes the key outcomes and the percentage improvements observed across the studies.

Table 4.
Comparison of outcomes across digital health interventions in post-operative fracture patients

Intervention	Outcome Measure	Improvement	Percentage Change
Telerehabilitation	Timed Up and Go (TUG)	Mobility	40% improvement
Mobile App + IoT Devices	Pain Reduction (VAS)	Pain Reduction	35% reduction
Mobile App	Functional Recovery	Functional Outcomes	30% improvement
IoT-Based Monitoring	Recovery Time	Recovery Time	50% faster recovery

The results indicated significant improvements in mobilization, pain reduction, and patient satisfaction. Patients in the DHI groups exhibited faster recovery times, better adherence to rehabilitation programs, and improved overall functional outcomes compared to those receiving traditional rehabilitation methods. The data suggest that digital health interventions play a critical role in enhancing recovery for post-operative fracture patients, with telerehabilitation showing the greatest improvement in mobility, followed by mobile apps combined with IoT devices for pain management and functional recovery.

DISCUSSION

This systematic review analyzed 10 studies focusing on the impact of digital health interventions (DHIs) on mobilization and recovery in post-operative fracture patients. The studies spanned diverse geographical regions, including Thailand, Saudi Arabia, India, China, South Korea, the USA, and the UK. Sample sizes ranged from 140 to 220 participants, with ages spanning 30 to 80 years. The interventions utilized included mobile applications, telerehabilitation, and IoT-based devices, with durations ranging from 6 to 12 weeks. Key outcomes included mobility improvement, pain reduction, and patient satisfaction.

Improved Mobility and Pain Reduction

The review highlights a significant positive impact of DHIs on physical function and pain management. For instance, Pinyopornpanish et al. (2024) reported that telerehabilitation significantly improved Timed Up and Go (TUG) test scores and reduced pain levels in patients aged 45–70. Similarly, Kim (2022) demonstrated that IoT-based tracking devices improved mobility and reduced recovery times for patients aged 30–70. These findings align with Chen et al. (2021), who found that real-time feedback in IoT-enabled rehabilitation devices enhanced functional recovery and reduced post-operative complications, such as joint stiffness and immobility. Additionally, Liang et al. (2020) noted that telerehabilitation facilitates early ambulation, reducing the risk of secondary complications like deep vein thrombosis. Building on this, Wang et al. (2022) identified that telerehabilitation protocols incorporating strength and flexibility exercises tailored to patient-specific needs significantly improved mobility scores in patients recovering from lower limb fractures. Furthermore, Hernandez et al. (2023) emphasized that the integration of wearable sensors for gait analysis within telerehabilitation platforms provided actionable insights, enabling more personalized and effective interventions. A meta-analysis by Zhang et al. (2022) also confirmed that DHIs consistently outperformed conventional rehabilitation in reducing pain intensity and improving functional mobility across various age groups.

Patient Engagement and Satisfaction

Patient engagement and satisfaction were consistently higher among those using DHIs compared to traditional rehabilitation methods. Alruwaili (2023) reported improved adherence to rehabilitation protocols among patients using mobile app-guided exercises, resulting in faster recovery and higher satisfaction scores. Patel et al. (2020) highlighted gamified elements in digital health platforms as key drivers of increased patient motivation and adherence. These findings are supported by Smith (2021), who observed that mobile applications offering real-time feedback and tailored exercise regimens empowered patients to actively participate in their recovery.Moreover, Lee et al. (2022) found that incorporating video demonstrations and patient education modules into digital health platforms further enhanced patient confidence and satisfaction, particularly in elderly populations. Zhao et al. (2023) highlighted the role of regular progress updates and motivational messaging in maintaining patient engagement over extended rehabilitation periods. Additionally, Hussain et al. (2022) emphasized that patient empowerment through digital health tools fosters confidence and satisfaction, leading to better clinical outcomes.

Cost-Effectiveness and Accessibility

DHIs have proven to be a cost-effective solution for delivering rehabilitation services, particularly in remote and underserved areas. Johnson (2020) found that telerehabilitation significantly reduced the need for in-person visits, thereby minimizing transportation costs and time burdens. Wei et al. (2023) corroborated these findings, noting that mobile health applications expand access to rehabilitation services for rural populations, reducing disparities in healthcare delivery. Kumar et al. (2021) demonstrated that IoT-enabled monitoring systems enhanced efficiency by allowing clinicians to remotely track patient progress, thereby reducing hospital workload and associated costs. In addition, Morales et al. (2022)showed that the scalability of mobile health platforms reduced per-patient rehabilitation costs in resource-constrained settings. A recent study by Rahman et al. (2023) highlighted that DHIs addressed equity issues by providing low-cost solutions that were adaptable to different socioeconomic contexts.

CONCLUSION

This systematic review highlights the transformative potential of digital health interventions (DHIs) in enhancing mobilization and recovery outcomes for post-operative fracture patients. By leveraging technologies such as mobile applications, telerehabilitation, and IoT-enabled devices, DHIs address key challenges in traditional rehabilitation methods, such as accessibility barriers, resource limitations, and low patient adherence. The included studies demonstrated significant improvements in mobility, pain reduction, and patient satisfaction, underscoring the utility of DHIs as a complementary approach to conventional care. However, several challenges must be addressed to optimize the implementation of DHIs. These include improving technological literacy, particularly for elderly populations, and addressing cost barriers to ensure equitable access. Standardizing protocols and outcome measures is also essential for facilitating broader adoption and enabling meaningful comparisons across studies.

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