Using of Virtual Reality technology for the rehabilitation of patients*

Aigerim Seitnur[1,†], Miras Mustafa [1,†], Saidaly Aitymov [1,†], Zhasulan Zhaksygarin [1,†] and Yevgeniya Daineko[1,2,*,†]

[1] International Information Technology University, Manas st 34/1 050040 Almaty, Kazakhstan
[2] Institute of Applied Science and Information Technology

Abstract

Virtual reality (VR) is one of the fastest-growing technologies, attracting significant attention from researchers and specialists in the fields of medicine, education, psychology, and rehabilitation. In rehabilitation, VR offers new opportunities, complementing or replacing traditional therapeutic methods. The interactive, adaptive, and personalized nature of VR environments improves functions such as memory, attention, spatial perception, and problem-solving. Many studies have demonstrated its effectiveness in treating patients with impairments caused by stroke, dementia, traumatic brain injury, and other neurological disorders. Moreover, VR-based rehabilitation increases patient engagement, enhances motivation, and allows for objective assessment of progress.

The aim of the article is to analyze the use of VR for the rehabilitation of patients with stroke, Parkinson's disease, pediatric, respiratory, and cardiovascular conditions. As well as designing our own application using Oculus Meta Quest 3. To achieve this goal, the study focuses on analyzing existing scientific research on VR-based rehabilitation, exploring the relevant technological foundations, defining the functionality of the application, adapting training exercises to the virtual environment, designing and implementing the VR application, testing its performance, and evaluating its effectiveness.

It is shown that VR opens up new perspectives in patient rehabilitation by offering innovative recovery methods. Due to the interactivity, adaptability, and personalization of VR environments, they not only improve the effectiveness of rehabilitation but also significantly increase the motivation of patients to undergo therapy.

Keywords

virtual reality (VR), VR-based rehabilitation, personalized treatment, medical applications, Oculus Meta Quest 3

1. Introduction

Virtual reality technologies open up wide opportunities for the rehabilitation of patients with various impairments, providing significant advantages over traditional methods. VR provides full immersion in a virtual environment, simulating conditions close to real ones, which improves the perception of exercises, stimulates participation and simplifies the implementation of complex tasks.

One of the key advantages is the individualization of therapy. Unlike traditional methods, it creates realistic scenarios tailored to individual patient needs, taking into account their cognitive and physical capabilities. In addition, VR creates a safe space, minimizing the risk of injury, which is especially important for patients with impaired motor coordination, such as after a stroke or with Parkinson's disease. For example, a stroke survivor relearning hand coordination can engage in VR-based exercises that simulate everyday tasks, such as picking up objects or preparing a meal, in a risk-free environment. Similarly, patients with Parkinson's disease can practice movement control through virtual balance and gait training exercises, helping them regain confidence in their mobility.

* AIT 2025: 1st International Workshop on Application of Immersive Technology, March 5, 2025, Almaty Kazakhstan
1,* Corresponding author.
† These authors contributed equally.
a.seitnur@iitu.edu.kz (A. Seitnur); 31108@iitu.edu.kz (M. Mustafa); 31090@iitu.edu.kz (S. Aitymov); 31828@iitu.edu.kz (Zh. Zhaksygarin); y.daineko@iitu.edu.kz (Y. Daineko)
0000-0003-1058-1016 (A. Seitnur); 0000-0001-6581-2622 (Y. Daineko)
© 2025 Copyright for this paper by its authors. Use permitted under Creative Commons License Attribution 4.0 International (CC BY 4.0).

CEUR Workshop Proceedings ceur-ws.org ISSN 1613-0073

CEUR-WS.org/Vol-4014/Short1.pdf

VR technologies allow for an objective assessment of rehabilitation progress, recording parameters such as speed and accuracy of movements, which simplifies the adjustment of the treatment program. Additionally, One of the most compelling aspects of VR-based rehabilitation is its ability to boost patient motivation through gamification. VR overcomes this challenge by integrating interactive, game-like elements into therapy sessions, making the process more engaging – especially for children with cognitive impairments.

Another advantage of VR is its potential for remote rehabilitation. Patients who live in rural areas, have mobility limitations, or struggle with transportation can access therapy sessions from home using VR headsets. This increased accessibility reduces barriers to consistent treatment, leading to better long-term recovery outcomes. VR technologies show high potential for the rehabilitation of patients after stroke, with Parkinson's disease and children with cognitive disorders, combining safety, effectiveness and an innovative approach.

This article is devoted to the development a novel VR-based respiratory rehabilitation system that integrates Strelnikova breathing exercises into an interactive virtual environment using Meta Quest 3.

2. Related works

VR is transforming the landscape of patient rehabilitation by offering immersive, interactive, and adaptive environments that enhance traditional therapeutic methods. This study highlights the effectiveness of VR-based rehabilitation in addressing motor and cognitive impairments, particularly in the treatment of stroke, Parkinson's disease, pediatric, respiratory, and cardiovascular conditions. These areas have shown the highest potential for VR-assisted therapy, demonstrating significant improvements in motor function, coordination, balance, respiratory control, and patient motivation.

Rehabilitation of Patients After Strokes

The application of virtual reality (VR) in stroke rehabilitation has gained significant attention due to its potential to enhance recovery outcomes. VR provides an immersive environment that allows patients to engage in therapeutic exercises that mimic real-world activities, which can significantly improve motor function and cognitive abilities. For instance, a systematic review by Febriani and Theresia highlights that VR is more effective than traditional rehabilitation methods in developing physical and cognitive skills in post-stroke patients [1]. Furthermore, studies have shown that VR training can lead to significant improvements in upper extremity functions, as evidenced by Gill and Dudonienė, who found that VR interventions resulted in notable clinical improvements in motor function measures among stroke survivors [2]. Additionally, Turolla et al. reported that VR systems could adapt the intensity and difficulty of tasks, promoting effective brain reorganization and enhancing rehabilitation engagement [3]. Moreover, immersive VR experiences have been shown to increase motivation and reduce the monotony often associated with conventional rehabilitation exercises. Cheng et al. emphasized that VR rehabilitation training not only improves gait and balance but also enhances patient compliance and engagement during therapy sessions [4]. This is crucial for stroke patients, as maintaining motivation is often a barrier to successful rehabilitation.

Rehabilitation of Patients with Parkinson's Disease

The use of VR in the rehabilitation of Parkinson's disease (PD) patients has also shown promising results. Research indicates that VR can effectively address motor symptoms associated with PD, such as balance and gait impairments. Basharat et al. noted that VR-based interventions, including exergaming, have demonstrated safety and efficacy in improving motor functions in PD patients [5]. Additionally, Rodríguez-Mansilla et al. conducted a systematic review that confirmed significant improvements in balance and gait outcomes among PD patients who participated in VR interventions, attributing these enhancements to the cognitive and sensory engagement provided by the VR environment [6]. Li et al. further supported these findings, indicating that VR training not only improves balance and quality of life but also positively impacts daily living activities and

depressive symptoms in PD patients [7]. The immersive nature of VR allows patients to practice real-life activities in a controlled setting, which can enhance their functional independence. Furthermore, the gamification aspect of VR has been shown to increase patient motivation, making rehabilitation more enjoyable and less burdensome [8].

Rehabilitation of Children

VR applications are also being explored for pediatric rehabilitation, particularly for children with neurological conditions. The engaging nature of VR can be particularly beneficial for younger patients, as it transforms rehabilitation into a game-like experience. This approach can significantly enhance motivation and participation in therapy. For instance, studies have shown that VR can effectively improve motor skills and cognitive functions in children with cerebral palsy and other developmental disorders [9]. The interactive and immersive elements of VR provide a unique platform for children to engage in therapeutic exercises that may otherwise be perceived as tedious or challenging. Moreover, the adaptability of VR environments allows therapists to customize rehabilitation tasks to suit the individual needs of each child, thereby promoting a more personalized rehabilitation experience. This adaptability is crucial in pediatric rehabilitation, where engagement and motivation are key factors influencing recovery outcomes.

Respiratory Rehabilitation

In the context of respiratory rehabilitation, VR has been utilized to enhance the rehabilitation process for patients with respiratory conditions, including those recovering from COVID-19. The immersive nature of VR can facilitate breathing exercises and physical activities that are essential for improving lung function and overall physical health. Studies have indicated that VR can provide a safe and controlled environment for patients to practice respiratory exercises, which can lead to improved outcomes in lung capacity and endurance [10]. Furthermore, VR can simulate various environments that challenge patients' respiratory systems, allowing for a more comprehensive rehabilitation experience. This innovative approach not only aids in physical recovery but also addresses psychological aspects of rehabilitation, such as anxiety and motivation, which are often prevalent in patients with chronic respiratory conditions [11].

Rehabilitation After Operations for Cardiovascular Diseases

The integration of virtual reality into cardiac rehabilitation has shown significant promise in enhancing recovery for patients following cardiovascular surgeries. VR technology provides an engaging and immersive environment that can maximize goal-directed training and build self-efficacy among cardiac rehabilitation patients. Zhang's systematic review indicates that VR interventions can improve exercise capacity and reduce negative emotions in patients undergoing cardiac rehabilitation [12]. This is particularly important, as emotional well-being is closely linked to recovery outcomes in cardiac patients. Moreover, Bouraghi et al. found that VR applications in cardiac rehabilitation not only enhance physical training but also improve patients' knowledge and cognitive skills regarding their health conditions [13]. The interactive nature of VR allows patients to engage in educational activities that complement their physical rehabilitation, thereby fostering a holistic approach to recovery. Cacau et al. further support the efficacy of VR in cardiac rehabilitation, noting that it aids in the postoperative recovery process by providing a safe and controlled environment for patients to engage in physical activities [14]. The use of VR can also help alleviate anxiety and stress, which are common in patients recovering from cardiac surgery, thereby promoting a more positive rehabilitation experience [15]. In addition to the aforementioned methods in [16] explored the gamification of hand rehabilitation using Leap Motion and virtual reality. Their approach demonstrated that motion-tracking VR interfaces can significantly improve patient engagement and fine motor function recovery by turning rehabilitation tasks into game-like experiences.

In addition, the use of AR in educational contexts has been actively explored. For instance, [17] developed a mobile e-learning platform that employs augmented reality for teaching physics, demonstrating improved student engagement and understanding of complex scientific concepts through interactive visualizations.

The integration of virtual reality into rehabilitation practices offers a promising avenue for enhancing recovery outcomes across various patient populations, including those recovering from strokes, Parkinson's disease, respiratory conditions, and cardiovascular surgeries. The immersive and engaging nature of VR not only improves physical and cognitive functions but also addresses motivational barriers often encountered in traditional rehabilitation settings. As technology continues to advance, further research is essential to optimize VR applications and establish best practices for their implementation in clinical settings.

3. The Architecture of the Application for Respiratory Conditions Rehabilitation

Extensive research has demonstrated the effectiveness of VR technology in rehabilitation for various medical conditions. Based on this evidence, this study focuses on the development of a VR-based application designed to enhance the efficacy and accessibility of respiratory therapy. The primary objective is to transform breathing exercises into an engaging, interactive, and comfortable experience for patients, thereby improving adherence and therapeutic outcomes.

The development of this VR-based respiratory rehabilitation system is being carried out in collaboration with the Research Institute of Cardiology and Internal Medicine (Almaty, Kazakhstan). This institution initiated the idea of virtualizing breathing exercises, recognizing them as the primary and most essential rehabilitation activity following cardiac surgery. Given the critical role of respiratory training in postoperative recovery, this project aims to provide a more effective, interactive, and scalable alternative to traditional rehabilitation approaches.

The proposed methodology is grounded in Strelnikova’s Gymnastics [18], a well-established respiratory therapy technique that has been widely recognized for its effectiveness in treating respiratory diseases.

Research findings indicate that these exercises not only enhance respiratory function but also contribute to the stabilization of breathing patterns, reduction of stress levels, and increased physical endurance.

The original Strelnikova method consists of 11 structured exercises aimed at restoring and improving pulmonary function. However, for the purposes of this project, three core exercises —"Pump," "Cat," and "Head Turns"—were selected for integration into the VR-based rehabilitation system. These exercises were chosen based on their optimal balance between breathing techniques and movement coordination, making them particularly suitable for virtual implementation.

By incorporating motion tracking, real-time feedback, and adaptive interaction, the developed VR application facilitates correct breathing techniques, improved motor coordination, and muscle relaxation within a virtual rehabilitation environment. To ensure a structured and efficient interaction between the patient and the VR system, a Use Case Diagram was developed. This diagram visually represents the functional architecture of the application, detailing the user's interactions with key system features and ensuring a user-centered design approach (Figure 1).

This study advances the field of digital rehabilitation by leveraging VR technology to enhance traditional respiratory therapy, thereby offering a more effective, engaging, and scalable solution for patients with respiratory conditions.

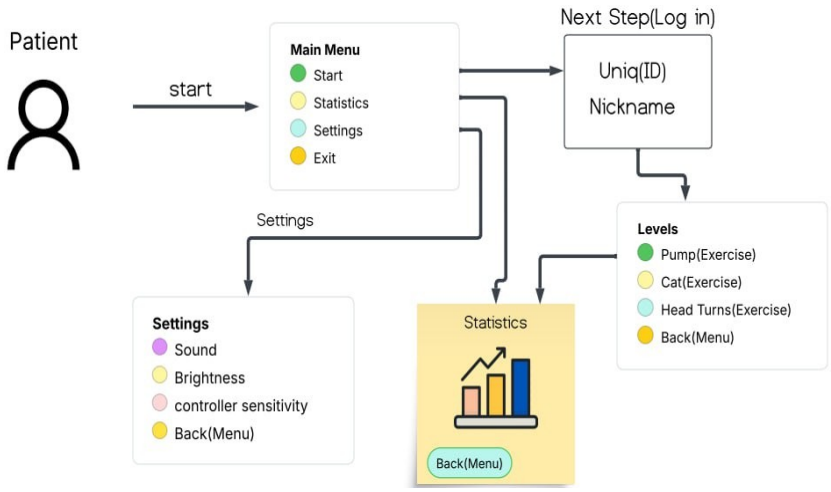

Figure 1: Use Case Diagram

Upon launching the VR rehabilitation application, the patient is presented with a main menu comprising four primary sections: Start, Statistics, Settings, and Exit. This structured navigation system ensures intuitive user interaction, facilitating seamless access to essential functions within the application.

1. Personalized User Identification and Data Entry

- Before initiating a rehabilitation session, the patient is required to enter their nickname and a unique identifier (ID) that will be generated by the system.
- This step is repeated for every session to ensure accurate progress tracking.
- The recorded data is stored locally on the device and synchronously transmitted to a centralized database, enabling comprehensive monitoring of individual rehabilitation progress.

2. Exercise Selection and Session Execution

- Following data entry, the user selects an exercise level from the available three breathing exercises: "Pump," "Cat," and "Head Turns."
- Once an exercise is selected, the system initiates the session, guiding the patient through structured breathing techniques under real-time system monitoring.

3. Automated Data Recording and Synchronization

Upon completion of each exercise, the system automatically logs all relevant session data, including:

- Patient nickname, date, and time of completion
- Type of exercise performed
- Exercise parameters and performance metrics

The collected data is stored locally and simultaneously synchronized with the database, ensuring efficient record-keeping and progress tracking accessible through both the application and a web interface.

4. Progress Analysis and Statistical Overview

- The "Statistics" section allows users to review their workout history, analyze performance trends, and monitor progress over time.
- To enhance accessibility, a web-based interface is developed, enabling patients to access their progress data without requiring direct interaction with the VR system.

5. User Preferences and Customization

- The "Settings" section provides options for modifying audio, brightness, and controller sensitivity, allowing users to tailor the application environment to their individual needs.

6. Session Termination and Exit

- Upon completing a rehabilitation session, the user can exit the application via the main menu, ensuring a controlled and seamless user experience.

The integration of a unique identifier system, combined with real-time data synchronization, enhances the personalization, efficiency, and accessibility of the rehabilitation process. The database structure is designed to ensure secure storage and retrieval of patient records and rehabilitation statistics. It consists of two primary entities:

- Patient Records – Stores essential user identification details (ID, name, registration date) to track individual progress.
- Training Statistics – Logs exercise sessions, timestamps, and performance parameters, ensuring longitudinal progress monitoring and adaptive therapy optimization (Figure 2).

This structured approach facilitates a data-driven rehabilitation framework, enabling clinicians and patients to analyze progress trends, personalize therapy regimens, and improve overall rehabilitation outcomes.

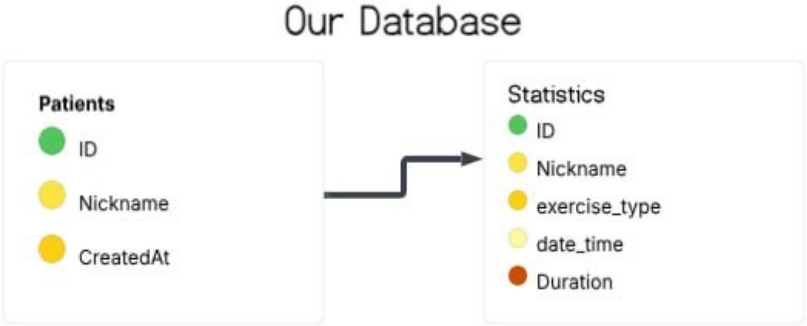

Figure 2: ER Diagram

The patient database table is designed to store essential user identification data, including a unique identifier (ID), first name, last name, and registration date. This structure ensures the precise identification of each patient and enables accurate tracking of individual rehabilitation progress.

The training statistics table systematically records data for each rehabilitation session. The stored information includes:

1. A unique session identifier,
2. The patient ID,
3. The type of exercise performed,
4. The date and time of completion.

This data is automatically saved upon session completion and synchronously transferred to a centralized database, allowing for real-time progress tracking and comprehensive analysis. The integration of this structured data management system facilitates both in-application and web-based access, enabling healthcare professionals and patients to monitor rehabilitation dynamics, evaluate performance trends, and optimize therapy plans.

This centralized approach to data storage enhances efficiency, accessibility, and accuracy in rehabilitation monitoring, ensuring that patient progress can be assessed in a structured and data-driven manner.

4. Technological Framework for VR-Based Respiratory Rehabilitation

The development of a VR-based respiratory rehabilitation system requires the integration of modern technologies that ensure precise motion tracking, an intuitive user interface, and full immersion in the virtual environment. The selected technological tools facilitate the adaptation of Strelnikova's Gymnastics exercises into an interactive VR rehabilitation format, enhancing patient engagement and therapy effectiveness.

The implementation of the project is based on the following key technologies:

1. Unity 3D – Serves as the primary development platform for creating the virtual environment and managing user interactions.
2. Meta Quest 3 – A VR headset that provides high-fidelity immersion and precise motion tracking, ensuring accurate execution of breathing exercises.
3. C# – The programming language used to develop game logic, process real-time data, and implement core system functionalities.
4. SQLite – A lightweight database solution for local storage of training results, patient progress, and statistical data. It integrates with Unity via SQLite4Unity3d or Mono.Data.Sqlite, ensuring efficient in-application data management.
5. Next.js and Prisma – These technologies support the development of a web-based interface for accessing patient exercise statistics.

- Next.js enables efficient server-side rendering, ensuring the application runs smoothly.
- Prisma simplifies database interactions, allowing for structured data retrieval by patient ID, date, and exercise level.

The integration of these technologies facilitates the creation of a user-friendly, interactive, and data-driven VR rehabilitation system. This approach ensures optimal patient experience, providing an effective, engaging, and personalized environment for performing respiratory therapy exercises. The following sections provide a detailed discussion of each technology and its role in the system's implementation.

5. Scientific Novelty of the Research

The study presents a novel approach to VR-based rehabilitation, focusing on the development of a specialized VR application for respiratory rehabilitation. The scientific novelty of this research can be summarized as follows:

1. Integration of Strelnikova Breathing Techniques into a VR Environment

- Unlike traditional rehabilitation methods, this study implements proven respiratory exercises from Strelnikova's Gymnastics into a fully immersive and interactive VR application.
- This is one of the first attempts to adapt these specific exercises for VR-based rehabilitation, making the therapeutic process more engaging, personalized, and effective.

2. Development of a Personalized VR Rehabilitation System

- The VR system utilizes Meta Quest 3 to provide full-motion tracking and real-time feedback for respiratory training.
- A personalized patient tracking system is implemented, where user performance is stored in a database for analysis and progress monitoring.

3. Gamification of Respiratory Therapy

- The study introduces gamification elements, such as interactive VR environments, adaptive difficulty levels, and performance-based feedback, to improve patient motivation and therapy adherence.
- By transforming routine breathing exercises into an engaging VR experience, the study enhances patient compliance compared to traditional rehabilitation.

4. Use of Motion Tracking and Biofeedback for Real-Time Adaptation

- The VR system incorporates motion tracking and biofeedback mechanisms to analyze user breathing patterns and provide instant adaptive feedback.
- This real-time adjustment ensures that exercises are performed correctly and safely, improving their therapeutic efficiency.

5. Creation of a Cloud-Connected Patient Monitoring System

- The VR application synchronizes data with a cloud-based database, allowing healthcare professionals to remotely monitor and adjust therapy programs based on patient progress.
- This approach enhances accessibility and continuity of care, making VR rehabilitation available outside clinical settings, including home-based therapy.

6. Multimodal Interaction for Comprehensive Rehabilitation
- The study combines visual, auditory, and haptic feedback to create a multi-sensory rehabilitation experience that enhances neuroplasticity and motor-cognitive integration.
- Unlike conventional VR rehabilitation applications, this system not only focuses on motor recovery but also improves respiratory control and cognitive engagement.

7. Application of AI-Based Adaptive Learning Algorithms
- The study proposes the use of AI-driven adaptive difficulty adjustment, where the VR system analyzes user performance and dynamically adjusts exercise intensity.
- This personalized approach ensures that each patient receives an optimal level of challenge without overwhelming their physical capacity.

This research contributes to the growing field of digital therapeutics and establishes a new direction for respiratory rehabilitation using immersive VR technology.

6. Conclusion

The integration of VR technology into rehabilitation presents a transformative approach to enhancing patient recovery, engagement, and accessibility. This study proposes the development a VR-based respiratory rehabilitation system that leverages Strelnikova breathing exercises, motion tracking, biofeedback, and AI-driven adaptation to create a personalized and immersive therapy experience.

By combining proven respiratory therapy techniques with cutting-edge VR technology, this study contributes to the advancement of digital rehabilitation solutions. Future research should focus on long-term clinical validation, expanded patient trials, and integration with broader telemedicine platforms to further enhance the impact of VR-assisted rehabilitation.

This work lays the foundation for scalable, effective, and engaging rehabilitation programs, demonstrating that virtual reality can revolutionize the way rehabilitation therapy is delivered and experienced.

Declaration on Generative AI

The author(s) have not employed any Generative AI tools.

References

[1] Febriani, D. and Theresia, S. (2019). The effect of virtual reality on rehabilitation post stroke patients: an integrative review. Kne Life Sciences. https://doi.org/10.18502/kls.v4i13.5232

[2] Gill, G. and Dudonienė, V. (2020). Virtualiosios realybės terapija rankų funkcijai po insulto. sisteminė straipsnių apžvalga. Reabilitacijos Mokslai Slauga Kineziterapija Ergoterapija, 2(21). https://doi.org/10.33607/rmske.v2i21.826

[3] Turolla, A., Dam, M., Ventura, L., Tonin, P., Agostini, M., Zucconi, C., … & Piron, L. (2013). Virtual reality for the rehabilitation of the upper limb motor function after stroke: a prospective controlled trial. Journal of Neuroengineering and Rehabilitation, 10(1), 85. https://doi.org/10.1186/1743-0003-10-85

[4] Cheng, L., Sunzi, K., Dai, F., Liu, X., Wang, Y., Zhang, B., … & Ju, M. (2019). Effects of virtual reality rehabilitation training on gait and balance in patients with parkinson's disease: a systematic review. Plos One, 14(11), e0224819. https://doi.org/10.1371/journal.pone.0224819

[5] Basharat, A., Anum, A., Rashid, I., Naz, K., & Waqar, Z. (2023). Effect of exer gaming on rehabilitation of patient with parkinson's disease. International Journal of Health Sciences, 7(S1), 1280-1294. https://doi.org/10.53730/ijhs.v7ns1.14343

[6] Rodríguez-Mansilla, J., Bedmar-Vargas, C., Garrido-Ardila, E., Torres-Piles, S., González-Sánchez, B., Rodríguez-Domínguez, M., … & Jiménez-Palomares, M. (2023). Effects of virtual

reality in the rehabilitation of parkinson's disease: a systematic review. Journal of Clinical Medicine, 12(15), 4896. https://doi.org/10.3390/jcm12154896

[7] Li, R., Zhang, Y., Jiang, Y., Wang, M., Ang, W., & Lau, Y. (2021). Rehabilitation training based on virtual reality for patients with parkinson's disease in improving balance, quality of life, activities of daily living, and depressive symptoms: a systematic review and meta-regression analysis. Clinical Rehabilitation, 35(8), 1089-1102. https://doi.org/10.1177/0269215521995179

[8] Santos, P., Scaldaferri, G., Santos, L., Ribeiro, N., Neto, M., & Melo, A. (2019). Effects of the nintendo wii training on balance rehabilitation and quality of life of patients with parkinson's disease: a systematic review and meta-analysis. Neurorehabilitation, 44(4), 569-577. https://doi.org/10.3233/nre-192700

[9] Cemim, J., Corrêa, P., Pereira, B., Souza, J., & Cechetti, F. (2022). Virtual reality as an intervention tool for upper limbs in parkinson's disease: a case series.

[10] Berton, A., Longo, U., Candela, V., Fioravanti, S., Giannone, L., Arcangeli, V., … & Denaro, V. (2020). Virtual reality, augmented reality, gamification, and telerehabilitation: psychological impact on orthopedic patients' rehabilitation. Journal of Clinical Medicine, 9(8), 2567. https://doi.org/10.3390/jcm9082567

[11] Stankiewicz, T., Gujski, M., Niedzielski, A., & Chmielik, L. (2020). Virtual reality vestibular rehabilitation in 20 patients with vertigo due to peripheral vestibular dysfunction. Medical Science Monitor, 26. https://doi.org/10.12659/msm.930182

[12] Zhang, M. (2024). Effectiveness of virtual reality in cardiac rehabilitation patients for exercise capacity and negative emotions: a systematic review and meta-analysis. Medicine, 103(49), e40812. https://doi.org/10.1097/md.0000000000040812

[13] Bouraghi, H., Mohammadpour, A., Khodaveisi, T., Ghazisaeedi, M., Saeedi, S., & Familgarosian, S. (2023). Virtual reality and cardiac diseases: a systematic review of applications and effects. Journal of Healthcare Engineering, 2023(1). https://doi.org/10.1155/2023/8171057

[14] Cacau, L., Oliveira, G., Maynard, L., Filho, A., Júnior, W., Neto, M., … & Santana-Filho, V. (2013). The use of the virtual reality as intervention tool in the postoperative of cardiac surgery. Brazilian Journal of Cardiovascular Surgery, 28(2), 281-289. https://doi.org/10.5935/1678-9741.20130039

[15] Maciołek, J., Wąsek, W., Kamiński, B., Piotrowicz, K., & Krzesiński, P. (2020). The impact of mobile virtual reality–enhanced relaxation training on anxiety levels in patients undergoing cardiac rehabilitation. Kardiologia Polska, 78(10), 1032-1034. https://doi.org/10.33963/kp.15528

[16] Alimanova, M., Borambayeva, S., Kozhamzharova, D., Kurmangaiyeva, N., Ospanova, D., Tyulepberdinova, G., Gaziz, G., & Kassenkhan, A. (2017). Gamification of hand rehabilitation process using virtual reality tools: Using leap motion for hand rehabilitation. Proceedings of the 2017 1st IEEE International Conference on Robotic Computing (IRC), 336–339. https://doi.org/10.1109/IRC.2017.76

[17] Daineko Y.A.; Tsoy D.D.; Seitnur A.M.; Ipalakova M.T. Development of a Mobile e-Learning Platform on Physics Using Augmented Reality Technology. International Journal of Interactive Mobile Technologies, 2022, Vol. 16(5), pp. 4–18. DOI: 10.3991/ijim.v16i05.26961

[18] A. N. Strelnikova, "Strelnikova Gymnastics: 11 Breathing Exercises," Sharkovshchina Central Regional Hospital, Vitebsk Region, Belarus. Jan. 15, 2025. [Online]. Available: https://www.shcrb.by/index.php/stati/gimnastika-strelnikovoj-11-dykhatelnykh-uprazhnenij