

Application of Virtual Reality Technology in Rehabilitation Nursing: Enhancing Patient Autonomy and Advancing Collaborative Care Models

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Abstract: Rehabilitation plays a significant role in patients' reintegration into society. However, rehabilitation nursing faces the issue of low patient autonomy, which not only restricts the effectiveness of rehabilitation nursing but also hinders the transition from traditional to modern nursing models. The application of Virtual Reality (VR) technology in the field of rehabilitation nursing can provide patients with more personalized rehabilitation experience and promote the efficient conduct of rehabilitation nursing work. As a result, to introduce recent applications of VR technology in rehabilitation nursing more comprehensively, this review summarizes specific applications of VR technology in rehabilitation nursing and analyzes their effects to enhance patient autonomy, compared to traditional methods. By systematically analyzing the current application of VR technology in rehabilitation nursing both domestically and internationally, this review aims to deeply explore how VR technology enhances patient autonomy, attracting more attention on applications of VR technology on rehabilitation nursing, as well as promote further development of collaborative care models.

Keywords: VR Technology, Rehabilitation Nursing, Patient Autonomy, Collaborative Care Models

1. Introduction

According to Christoph Gutenbrunner, rehabilitation is an essential manifestation of good health and well-being within the United Nations' 2030 Sustainable Development Goals [1]. Rehabilitation not only aids in restoring patients' physical functions and rebuilding their self-confidence but also significantly enhances the quality of life. As a crucial component of the healthcare system, rehabilitation serves as a bridging phase for patients transitioning from a sick role to a socially functional role, playing an indispensable part in their return to society and normal life.

Rehabilitation nursing is primarily composed of three main components: professional rehabilitation teams, patients and their families, and rehabilitation facilities and environments. It is the key decisive factor in determining the success of rehabilitation. Existing research indicates that modern rehabilitation nursing models place greater emphasis on self-care, yet traditional rehabilitation nursing models still predominate, with hospital-centered service models being quite common. The rehabilitation process is relatively fixed, typically with doctors formulating the

rehabilitation plans, and rehabilitation nurses and therapists executing these plans, in which patients and their families have limited involvement in the formulation and adjustment of the rehabilitation plans. Nursing is a key driving force in achieving rehabilitation goals, with the main principle being to engage in care together with the patient, guiding them from a "care for me" attitude to a "I want to care" attitude [1].

In the current rehabilitation nursing model, low patient autonomy is a critical issue that urgently needs to be addressed. Enhancing patient autonomy not only helps to improve the rehabilitation outcomes but also fosters the further development of collaborative care models. The application of Virtual Reality (VR) technology in the field of rehabilitation nursing shows great promise, offering innovative ideas and methods to tackle the issue of insufficient patient autonomy.

Existing studies have shown that VR technology is applied in various medical fields such as radiology, histopathology, and rehabilitation medicine, and its effectiveness and feasibility in rehabilitation nursing have been preliminarily confirmed. VR technology possesses three major characteristics: immersion, interactivity, and imagination, interacting with users through visual, tactile, olfactory, and auditory senses [2]. As an auxiliary tool in rehabilitation nursing, VR technology can provide patients with a highly personalized rehabilitation experience. For rehabilitation nurses, VR technology allows for a more intuitive understanding of the patient's rehabilitation progress and enables them to adjust, accordingly, thereby better carrying out rehabilitation nursing work.

This review aims to provide a comprehensive review of the current application of VR technology in the field of rehabilitation nursing both domestically and internationally. By comparing relevant research data, it seeks to delve into the role of VR technology in enhancing patient autonomy and advancing collaborative care models, offering theoretical insights for the further development of VR technology in rehabilitation nursing.

2. VR Technology

2.1. Primary Elements of VR Technology

VR technology, as a significant direction in the development of simulation technology, integrates technological achievements from various fields and encompasses aspects such as simulated environments. VR technology possesses three key characteristics: immersion, interactivity, and imagination, which are interrelated and influence each other. Immersion utilizes sensory modalities such as vision, hearing, and touch, allowing users to feel close to virtual reality; interactivity ensures that users can smoothly operate virtual objects and receive timely, natural feedback [2]; imagination endows VR technology with the ability to construct diverse virtual worlds, thereby expanding the cognitive boundaries of users. These three characteristics together form the "Virtual Reality Technology Triangle"[3], with the core being a high degree of integration with the user end to provide an immersive experience, showing broad application prospects and tremendous development potential in numerous fields.

2.2. Application of VR Technology in Rehabilitation Nursing

Rehabilitation processes of a variety of diseases. However, the current literature primarily focuses on rehabilitation research in areas such as cerebrovascular accidents (stroke), head trauma (brain injury), and psychological disorders.

2.2.1. VR Technology Intervention in Stroke

Stroke, as an acute cerebrovascular disease, causes brain tissue damage due to the rupture (hemorrhagic) or blockage (ischemic) of blood vessels in the brain, often accompanied by neurological deficit symptoms such as limb weakness, speech disorders, and cognitive impairments. From the perspective of motor learning theory, task-oriented training with high intensity and repetitiveness plays a crucial role in enhancing neural plasticity and the recovery of motor function [4]. Rehabilitation programs built on the framework of motor learning have a significant potential to assist stroke patients in reestablishing the motor function of their impaired limbs. In this rehabilitation process, VR technology can leverage the principles of neural plasticity to advance the rehabilitation process [5]. Concurrently, the real-time visual feedback mechanism inherent in virtual rehabilitation can effectively enhance patients' enthusiasm and engagement throughout the entire rehabilitation plan.

2.2.2. VR Technology Intervention in Brain Injury

Brain injuries, triggered by various external factors, can lead to cognitive dysfunction (such as memory loss, inattention), motor dysfunction (such as paralysis, difficulty with balance and coordination), speech and language disorders (such as aphasia, dysarthria), and emotional and behavioral changes (such as mood swings, personality changes), among other clinical manifestations. These challenges make it difficult for patients to return to work as they affect a range of skills needed for employment, including cognitive execution, insight, communication, social interaction, physical skills, fatigue management, and emotional personality [6]. The early rehabilitation research program framework for adults with brain injury proposed by Kerrin Watter and colleagues incorporates VR as a component of the client's interdisciplinary rehabilitation plan. This plan involves a multidisciplinary rehabilitation team that includes occupational therapy, speech pathology, social work, and physical therapy, along with professionals from clinical psychology and neuropsychology as needed, as well as external stakeholders (employers, funders, support coordinators, employment support services), clients, their families, and community networks. Through VR, these various resources can be integrated, promoting not only the restoration of physical functions but also rebuilding patients' confidence in reintegrating into society.

3. Enhancing Patient Autonomy with VR Technology

3.1. Passivity in Traditional Rehabilitation Nursing

Traditional rehabilitation nursing typically follows established processes and protocols, which include educational outreach, guidance on precautions, and emotional support [7]. Nursing plans are often unilaterally determined by medical staff. For instance, in the arrangement of rehabilitation training, medical personnel rely on their professional knowledge and experience to set the rehabilitation exercises, intensity, and duration, with patients having limited opportunities to participate in decision-making. In this model, patients are in a passive position, mechanically executing rehabilitation tasks as instructed by medical staff, which hinders the full exercise of their proactivity and is not conducive to joint decision-making with professionals regarding their care. This approach may not adequately meet patients' personalized needs and preferences [8]. Furthermore, traditional rehabilitation nursing focuses more on the recovery of the disease itself, favoring physical interventions over educational ones [9], and pays insufficient attention to patients' psychological and social needs. Patients exhibit passivity in emotional and social aspects, which may reduce their enthusiasm and initiative for rehabilitation, affecting the overall outcomes and experience of their recovery process.

3.2. Mechanisms of VR Technology Stimulating Patient Autonomy

In the field of rehabilitation nursing, numerous VR-based rehabilitation design schemes have been proposed by researchers, targeting the core objective of enhancing patient autonomy through the more efficient use of VR technology.

The VR rehabilitation framework designed by Chengjie Zhang and colleagues is clinically oriented, adapting game rules according to the needs of patients at different stages of rehabilitation [10]. This purposeful integration of gaming and education effectively addresses the issue of patients abandoning training due to boredom from long-term rehabilitation exercises. During the rehabilitation training process, the framework not only introduces game elements traditionally to enhance patient immersion but also focuses on enriching the narrative content of the games, thereby creating a more personalized and efficient rehabilitation plan for patients.

Yujun Lai and colleagues proposed an upper limb rehabilitation framework—Game Adaptive Virtual Reality Rehabilitation (GAVRe2) [11]. This framework innovatively combines VR technology with haptic robotic arms. By utilizing VR technology for remote connection, it overcomes the traditional rehabilitation model's limitation that requires patients and therapists to interact face-to-face. This method not only enhances the work efficiency of rehabilitation therapists but also effectively alleviates the psychological discomfort that patients may experience due to direct physical interaction with therapists, thereby increasing patient participation in the rehabilitation process.

Nicola Marotta and colleagues conducted research on the impact of VR technology and remote rehabilitation interventions on cognitive outcomes for Parkinson's disease (PD) patients [12]. The study found that compared to traditional rehabilitation methods, VR rehabilitation significantly improved patients' cognitive functions, particularly in areas such as attention dispersion, multitasking, inhibitory responses, and sustained attention. VR technology constructs a safe and stable environment for rehabilitation and enhances the interactivity between patients and their artificial surroundings. Moreover, the study suggests that within VR rehabilitation programs, patients can view themselves as active participants and central agents in the treatment process, altering their relatively passive role in conventional rehabilitation.

These studies, whether refining VR rehabilitation design schemes or exploring the effects of VR technology in rehabilitation applications, highlight the pivotal significance of VR technology in enhancing patient autonomy in rehabilitation.

4. Advancing Collaborative Care Models with VR Technology

4.1. Role Positioning in Traditional Rehabilitation Nursing

In traditional rehabilitation nursing, nurses take on multiple roles, including being the formulators of nursing plans, assistants in rehabilitation training, and educators of health knowledge. They are required to develop detailed nursing plans based on the patient's condition, assist in rehabilitation training, and provide health education to patients and their families. Patients, on the other hand, often find themselves in a passive position, as adherers to the rehabilitation plan, mechanically completing various rehabilitation tasks according to established procedures. They lack the ability to actively explore and make personalized adjustments to their own rehabilitation process and, as recipients of information, are highly dependent on the professional judgment and instructions of medical staff, with limited subjective initiative. Nowadays, with the renewal of medical concepts and the diversification of patient needs, the limitations of traditional nursing models are becoming increasingly apparent. The role of nurses is shifting from traditionally meeting basic needs to a more proactive direction, focusing more on stimulating patient autonomy and guiding them to actively

participate in the rehabilitation process, to jointly create personalized rehabilitation plans that better fit the actual situation of patients[1].

4.2. New Roles and Interactions in VR Technology-Enhanced Nursing

In traditional rehabilitation nursing models, nurses primarily formulate care plans based on physicians' diagnostic results and their own clinical experience. However, with the advancement of technology, the standardized characteristics and reliable data support of VR technology inject new vitality into the rehabilitation process of patients [11]. VR technology systems, with their robust data collection and analysis capabilities, can conduct more comprehensive and accurate assessments of patients' physical conditions and motor abilities. In this context, the role of nurses is gradually shifting towards becoming technical instructors for VR rehabilitation training. Previous research has indicated that achieving an ideal balance between motor and educational interventions during implementation is challenging [1]. Yet, the emergence of VR technology has provided an innovative solution to this dilemma by skillfully integrating health education knowledge into rehabilitation exercise segments, allowing patients to immerse themselves in health knowledge dissemination while engaging in rehabilitation exercises. Consequently, VR technology has propelled nurses from being providers of nursing services to active co-interveners, deeply integrating them into the patient's rehabilitation process. At the same time, in VR technology-supported rehabilitation training, patients can autonomously select suitable training scenarios and modes based on their conditions. This shift transforms patients from a traditionally passive treatment model to active participants in their own rehabilitation process. Patients can also use detailed data feedback to more intuitively and accurately grasp their rehabilitation status, thereby actively engaging in self-management. Furthermore, the application of VR technology has optimized the nurse-patient communication model, making it timelier and more efficient. Nurses can also leverage remote VR systems to overcome spatial limitations and provide nursing guidance services, effectively enhancing the accessibility and coverage of rehabilitation nursing services.

4.3. The Relationship Between VR Technology and Collaborative Care Models — Taking the 5A Nursing Model as an Example

The 5A nursing model, as a patient-centered comprehensive care approach, aims to change behavior and achieve self-management [13]. It includes five key stages: Assessment, Advice, Agreement, Assist, and Arrange. The first stage is Assessment, where various health information about the patient, including physiological, psychological, social relationships, and medical history, is systematically collected. Following this is the Advice stage, where professional and targeted health guidance is formulated for the patient based on the information obtained from the assessment, covering medication guidance during the treatment process, key points of cooperation, and optimization of daily habits. In the Agreement stage, healthcare staff engage in in-depth and comprehensive communication with the patient and their family to negotiate the most suitable care plan together. Subsequently, in the Assist stage, nursing personnel are fully involved in the patient's treatment and rehabilitation process, providing detailed support in multiple aspects. Finally, the Arrange stage involves continuous follow-up and guidance after the patient is discharged. The 5A nursing model fundamentally aligns with the collaborative care model's advocacy for multi-party cooperation and joint participation, thus it can be recognized as a specific practical form within collaborative care models.

In the context of the 5A nursing model, the application of VR technology is of great value. During the Assessment phase, VR technology can accurately assess patients' motor functions, balance, and reaction speeds within a virtual environment, thereby enriching the basis for healthcare staff

assessments. In the Advice phase, based on assessment data, healthcare providers can formulate personalized rehabilitation recommendations for patients and use VR technology to present these recommendations visually, helping patients understand training methods and objectives. During the Agreement phase, patients can experience the rehabilitation scenarios constructed by VR in advance, fully understand the content and effects of the rehabilitation plan, and discuss the plan together, promoting communication between medical staff, patients, and families, enhancing trust, and facilitating consensus. In the Assist phase, the VR system monitors patients' movements in real-time and provides immediate feedback; healthcare providers can remotely view training conditions and offer timely guidance and adjustments to the plan. VR technology enhances the fun and challenge of training, increasing patient engagement and aiding in the completion of assistance tasks. When arranging follow-ups, VR technology supports remote observation by healthcare providers of patients' rehabilitation progress, continuously records home training data, and provides support for adjusting rehabilitation plans, ensuring the effectiveness of patients' recovery after discharge.

5. Conclusion

This review has systematically explored the application of VR technology in rehabilitation nursing and analyzed its role in enhancing patient autonomy and advancing collaborative care models. Through a comprehensive analysis of relevant literature, it has been found that VR technology, by providing personalized and immersive rehabilitation experiences, has stimulated patients' enthusiasm for actively participating in rehabilitation training, thus changing the relatively passive situation of patients in traditional rehabilitation nursing. In terms of collaborative care models, VR technology has effectively integrated various resources in the rehabilitation process, promoted interaction and collaboration between patients and healthcare staff, optimized the workflow of rehabilitation nursing, and thereby improved the efficiency of rehabilitation nursing work.

During the research process, several issues were identified that require resolution. In terms of technology application, the cost of VR equipment remains a significant factor limiting its widespread adoption [14], especially in primary healthcare facilities and economically underdeveloped regions. Additionally, while there is some research on the short-term effects of VR technology in rehabilitation nursing [15], assessments of its long-term effects are insufficient, necessitating further long-term follow-up studies for validation. Despite these limitations, the prospects for VR technology in the field of rehabilitation nursing are still very promising. Future research directions should focus on enhancing the patient experience during VR rehabilitation processes, thereby optimizing the application of VR technology in rehabilitation nursing scenarios. It is particularly important to strengthen research on the long-term rehabilitation effects of VR technology to comprehensively evaluate its lasting impact on patients' physical and psychological recovery [16]. Concurrently, conducting cost-benefit analyses and exploring viable application models could address the issue of high application costs of VR technology, enabling it to benefit a broader range of people.

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