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Application progress of virtual reality technology in symptom management of senile mild cognitive impairment

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Abstract: *Mild cognitive impairment (MCI) is an intermediate transitional stage between healthy aging and dementia, and is an important problem affecting healthy aging. As a key industry of digital economy, virtual reality technology has a positive impact on the medical field. This paper reviews the concept classification, advantages and application of virtual reality technology in cognition, bad mood, fall and self-care ability of mild cognitive impairment in the elderly, in order to provide reference for clinical practice.*

Keywords: *Mild cognitive impairment; Virtual reality; the elderly; Symptoms management*

As the global population is aging, having an independent and healthy lifestyle for the elderly has become a critical social issue [1]. Dementia is one of the leading causes of disability and dependence among older people around the world, and WHO reports that it is expected to reach 152 million in 2050 [2]. With the advent of aging society, the number of people with dementia in China is also increasing year by year and is expected to reach 28 million by 2050 [3]. Mild cognitive impairment (MCI) is a transitional stage between healthy aging and dementia, and studies have shown that 5%-20% of patients with mild cognitive impairment develop dementia every year [4-5], and cognitive interventions at the stage of MCI can effectively delay and prevent their development into dementia [6]. Virtual reality (VR) technology has been widely used in screening, prevention and cognitive rehabilitation of mild cognitive impairment in foreign countries.In 2021, China released the "14th Five-Year Plan" for national economic and social development, which formally takes VR technology as one of the key industries of digital economy. The progress of the application of VR technology in mild cognitive impairment in the elderly at home and abroad is summarized as follows.

1. The concept of virtual reality technology, classification

VR technology, which arose in the 1960s, is a simulation system that creates a multi-sensory (visual, vestibular, etc.) sense of reality through a human-computer interface system with the three main features of immersion, interaction, and imagination, which enables patients to be immersed in a virtual world environment, and it is an excellent platform for realizing interpersonal interaction [7]. According to the concept, VR systems can be divided into: virtual reality, augmented reality, and mixed reality; according to the immersion angle, VR systems can be divided into: fully immersive, partially immersive, and non-immersive; according to the presentation method and the form of patient participation, VR systems can be divided into: desktop, immersive, augmented, and distributed [8-9]. At present, there are two types of VR systems clinically applied to elderly patients with mild cognitive impairment. One category is non-immersive, which uses a computer as a window through various interactive devices, such as joysticks and keyboards. In different neurological disorders show the potential to promote cognitive [10] and motor improvements [11-13]. Another category is immersive, where patients are head-mounted with a display that immerses them in a particular virtual environment to stabilize their cognitive function and improve their psychological state [14]. Currently, there is a large proportion of non-immersive VR systems in clinical cognitive intervention studies.

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2. Comparison of virtual reality technology and traditional cognitive training

VR technology has been widely social in various fields.In recent years, VR technology has been increasingly used in domestic clinical nursing research fields, including symptom management of breast cancer patients [15], cardiac rehabilitation [16], pain relief [17], care of critically ill patients in ICU [9], physical rehabilitation [13], and cognitive rehabilitation [18]. Among them, it has received attention from domestic and international researchers in cognitive rehabilitation. Compared with traditional cognitive training, VR has the advantages of (1) being more fun and engaging; (2) being able to create a safe and controllable simulation environment; (3) being able to improve clinical staff's understanding and support of elderly patients with MCI; and (4) the VR setup, like other computerized tests, is able to provide timely feedback, which allows for personalization of environments and activities [18].Manera et al [19] applied VR technology to patients with mild cognitive impairment, and this study showed that VR technology-based interventions can be considered as an interesting training modality that improves adherence to cognitive training in older adults with cognitive impairment.

3. Effectiveness of virtual reality technology in mild cognitive impairment in the elderly

3.1 Improvement of cognitive function

MCI is an early stage of cognitive impairment, and studies have shown that exercise [20], music [21], cognitive behavioral therapy [22], acupuncture [23], and transcranial magnetic stimulation [24] interventions can help improve cognitive impairment. With the development of computer technology, VR technology has led to higher patient satisfaction and engagement because it is fun, easy to operate, and can be used at home.Man et al [25] conducted a 4-week virtual reality cognitive training for 31 patients with MCI, and the results showed that the cognitive function of elderly patients with MCI was improved. In China, Xue Jinggang et al [26] explored the rehabilitative effects of virtual reality technology on the cognitive function of elderly patients with MCI, and the results showed that the VR group could improve the cognitive function of the patients. Sun Zhicheng et al [27] observed the effects of virtual reality (VR)-based Baduanjin on the cognitive function, somatic function, and quality of life of elderly patients with mild cognitive impairment (MCI) in nursing homes, and the results showed that all of the above indexes in the VR group were better than those in the control group after intervention, and the differences were all statistically significant ($P<0.05$), suggesting that VR-based Baduanjin exercises can effectively improve the cognitive function and somatic function of elderly nursing home MCI patients' cognitive and somatic functions and improve their quality of life. At this stage, domestic research on the clinical intervention of VR technology in elderly MCI patients mostly focuses on cognitive training, in which the combination with China's traditional qigong has also received more and more attention. Baduanjin is a kind of traditional qigong in China, which is a suitable physical and mental exercise method for elderly MCI patients. Especially in the context of China's vigorous development of traditional Chinese medicine and the aging of society, the combination of VR technology and traditional qigong has led to the promotion and development of traditional qigong in community-based elderly patients with MCI by providing immediate guidance and feedback on the accuracy of the exercise movements, increasing its fun and safety.

3.2 Relieving bad mood and promoting mental health

3.2.1 Depression

Depressive symptoms are more common among MCI patients, and studies have found [28] that 16% to 27% of MCI patients experience depression. Korean researchers conducted a longitudinal research study [29], which included 4,547 community-dwelling older adults, and showed that depressive symptoms with cognitive dysfunction were associated with a higher risk of cognitive impairment. Another study [30] showed that in patients with MCI, depression is an early sign of neurodegeneration, which reduces brain reserve capacity and thus allows for a more rapid progression of Alzheimer's disease neuropathology. Therefore, healthcare professionals should pay close attention to elderly patients with MCI when accompanied by depressive symptoms .VR technology offers the possibility of non-pharmacological interventions for depressive symptoms in elderly patients with MCI. In a 6-month randomized controlled trial [31] (n=36), the VR group received immersive computer-generated virtual reality memory training via a head-mounted display, using a combination of auditory (music) and visual stimuli to create a virtual environment. The control group was given a music therapy intervention, which showed a decrease in MMSE scores and an improvement in cognitive functioning in the VR group.In addition, in terms of

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mental status, the Geriatric Depression Scale (GDS) was administered, and compared to baseline data, patients in the VR group showed a decrease in scores, and depressive symptoms improved after the intervention.The effect of VR technology on the depressive symptoms of elderly Research on the effect of VR technology on depressive symptoms in MCI patients has not been found in domestic clinical studies, which may be related to the lack of knowledge about neuropsychiatric symptoms and disease progression in elderly MCI patients.

3.2.2 Anxiety

Anxiety is a common neuropsychiatric symptom in patients with MCI, with a prevalence of 26.3% [32]. A longitudinal study found that anxiety significantly increased the rate of progression from mild cognitive impairment to dementia risk [33]. Currently, common non-pharmacologic therapies used to reduce anxiety in patients with MCI are reminiscence therapies. In the context of the global epidemic of novel coronaviruses, VR technology has attracted the attention of researchers Yahara et al [34] studied the effectiveness and safety of reminiscence therapy using VR technology in elderly patients with MCI, which demonstrated that when the implementation of traditional face-to-face reminiscence therapy was impeded, remote reminiscence therapy based on VR technology was equally effective in reducing the anxiety of elderly MCI patients and no side effects were observed. This study provides a new direction for the intervention of elderly patients with MCI in epidemic situations, but it is a case study that only included two elderly patients with MCI, and in order to further validate the effect of VR-based reminiscence therapy on the anxiety of elderly patients with MCI, a randomized controlled study with a large sample and more rigorous results is needed.

3.2.3 Apathy

The prevalence of apathy in patients with MCI is approximately 39.5% [35]. A 4-year longitudinal study abroad found that MCI patients with apathy had almost 7 times the risk of progression to dementia than MCI patients without apathy [36]. No randomized controlled studies of VR technology in elderly MCI patients with apathy have been identified in national and international studies. In a study conducted by Manera et al [19] to verify the feasibility of VR technology use in patients with mild cognitive impairment and dementia, participants with apathy were found to show a stronger preference for virtual reality conditions than non-apathetic participants. This study focused on the acceptance of VR technology in elderly MCI patients with apathy, but did not make an effect on the effect of VR technology on apathy in elderly MCI patients; therefore, studies to verify the effect of VR technology on elderly MCI patients should also be conducted in future studies.

3.3 Enhance body balance and reduce the occurrence of falls

Falls are a common health problem faced by older adults worldwide and can cause serious harm to the elderly population, including physical and psychological injuries such as fractures and cranio-cerebral injuries, which may lead to death in severe cases. Studies have shown [37] that falls occur in about 33.3% of older adults each year, and Taylor et al [38] conducted a one-year prospective study that found that the incidence of falls in elderly MCI patients was twice as high as that in cognitively normal older adults, and that poor balance increased the risk of falls in elderly patients with mild cognitive impairment. In a randomized controlled study abroad [39], the researchers, in order to clarify the effect of kayaking exercise based on VR technology on the balance ability of elderly patients with MCI, the patients in the VR group performed paddling exercise in a virtual environment 2 times/week for 6 weeks. The study found that balance and muscle strength were significantly improved in the VR group. In another randomized controlled study Li et al [40] evaluated the effectiveness of VR-based tai chi in preventing falls in elderly patients with MCI, randomly assigning a tai chi group (n = 15) and a stretching group (n = 15), with both groups taking part in 60-minute virtual exercise sessions through the Zoom platform, 2 times/week for 24 weeks. As a result of the study, patients in the tai chi group had better balance than the stretching group. This study suggests that a virtual interactive tai chi program for community-based elderly patients with MCI could be an intervention to prevent their falls. VR technology is widely used in preventing falls in elderly patients with MCI with good results. Meanwhile, medical professionals should adjust and develop the ways and methods of daily training for elderly patients with MCI in order to adapt the application of VR technology in elderly patients with MCI in the new era.

3.4 Improving instrumental activities of daily living ability and quality of life

Di et al [41] conducted a prospective study over a period of 8 years and showed that instrumental activities of daily living (IADL) could be a predictor of progression to dementia in elderly patients with

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MCI.IADL as an evaluation index provides a clinical basis for the development of cost-effective interventions provides a basis for the clinical development of cost-effective interventions, and VR technology, as an emerging computer industry, offers more possibilities to researchers. Researchers Liao et al [42] conducted a randomized controlled study that included 34 community-based elderly patients with MCI, with the VR group undergoing somatic and cognitive training based on VR technology and the control group undergoing conventional cognitive training 3 times/week for 12 weeks, with assessment of cognitive function and IADL before and after the intervention, and the results of the study were that the overall cognitive ability and IADL scores of the VR group were statistically different and improved significantly. The study suggests that VR-based training can improve the cognitive ability of elderly MCI patients, but also improve their IADL and quality of life. VR technology is effective in both daily exercise and cognitive training for elderly MCI patients, but the acceptance of VR technology and its headset wearable devices as an emerging industry should also be considered.

4. Summary

At present, with China's "14th Five-Year Plan" taking VR technology as one of the key industries in the digital economy, the medical industry is also applying it more in clinical research. Researchers should also pay attention to problems such as nausea, dizziness, headache, and addictiveness in the use of elderly MCI patients; few evaluation indexes for clinical studies have been rated on psychiatric symptoms (depression, anxiety, and apathy). In the future, in order to strengthen the promotion of the use of VR technology in the elderly population, the following aspects can be considered: in terms of research sites, clinical studies on VR technology in the community and nursing homes can be increased to confirm its safety and feasibility; in terms of research design, mixed studies can be tried, making it more acceptable to the elderly and enabling the researchers to make a program with personalized interventions; in terms of the research population, qualitative studies can be conducted on medical personnel applying VR technology, and based on the findings, targeted training can be done to provide better services to patients.

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