Qualitative Study

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Perceptions and experiences of commercial virtual reality games in early postoperative rehabilitation among cardiac surgical patients: A qualitative study

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Abstract

Background: Although numerous studies have focused on the outcomes of virtual reality games for early rehabilitation in postoperative cardiac surgical patients, research on these patients' perceptions and experiences with virtual reality games has been limited.

Objectives: The aim of this qualitative study was to provide insights into the perceptions and experiences of postoperative cardiac surgery patients in using commercial virtual reality games during early rehabilitation.

Methods: A cohort of postoperative cardiac surgery patients ($n = 12$) who used the same VR games during the early rehabilitation period at the cardiac surgery intensive care unit (ICU) of a tertiary hospital in Nanjing, China, was enrolled in this study, conducted between January 2023 and December 2023. Data were collected through individual in-depth interviews and analyzed using Colaizzi's phenomenological method.

Results: Two themes emerged from the interviews: (1) the benefits of virtual reality games for rehabilitation, including (i) enhancing enthusiasm for rehabilitation, (ii) helping patients to focus attention, (iii) increasing individual exercise, (iv) providing enjoyment, and (v) regulating negative emotions; (2) shortcomings in the use of virtual reality games, including (i) producing stress, (ii) insufficient operating space, (iii) discomfort while wearing, (iv) difficulty in mastering the application, and (v) individualized needs.

Conclusion: Cardiac patients believed that the use of commercial virtual reality games during early postoperative rehabilitation was beneficial to rehabilitation, but they highlighted some shortcomings that require improvement. The results of this study provide a certain theoretical basis for the further promotion and application of commercial virtual reality games in clinical practice in the future.

Keywords

Virtual reality, cardiac surgery, rehabilitation, experience, qualitative study

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Introduction

Cardiac surgery remains the standard treatment option for a wide range of heart diseases, and despite decades of medical advances, there is still a high rate of complications following cardiac surgery.[1] Studies[2] have shown that even after these patients are discharged from the intensive care unit, 50% to 75% exhibit persistent cognitive dysfunction,

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physical weakness, and post-traumatic symptoms. Therefore, rehabilitation is important for patients who have undergone cardiac surgery. Currently, cardiac rehabilitation programs[3] include exercise therapy, secondary prevention medication, nutritional support, psychological management, and cognitive interventions. These programs are mostly led by healthcare professionals, with varying results owing to a lack of active participation and immersion of patients.[4,5]

Virtual reality (VR) technology allows participants to be immersed in a virtual world of three-dimensional (3D) dynamic views and physical behavioral interactions through the use of head-mounted displays, headsets, motion-tracking systems, and interactive devices.[6] The technology has been applied to cardiac patients to enhance their motivation and engagement.[7,8] Over the past few years, there has been a growing adoption of VR games in clinical settings, both those available commercially and those developed by healthcare systems. Studies have indicated that these VR games can significantly benefit patients' rehabilitation.[9–11] However, there are some weaknesses in the use of VR in the field of rehabilitation, such as potential side effects on patients and cost-effectiveness issues associated with developing VR technology.[12] These factors have hindered the widespread implementation of VR in most rehabilitation centers.[13] In recent years, the actual clinical implementation has not been satisfactory.[14]

In contrast to commercial VR systems focused on entertainment and high-quality user experiences, VR rehabilitation games are typically tailored to individual patient needs.[15–18] Nonetheless, as commercial VR games advance, offering diverse difficulty levels and customizable features, they are becoming more appealing for clinical use, with lower costs and improved technical capabilities.[15,19] Studies have shown that Oculus and HTC commercial VR systems are feasible alternatives for VR-based health applications,[17] the current weight of the Oculus Quest 2 is approximately 500 g, and it features a monocular display resolution of 1832×1920 and a binocular resolution of 3664×1920, which has good graphics processing capabilities, the picture is extremely clear, providing a realistic immersive experience.[20] These systems not only fulfill the needs of patients for gaming, exploration, and exercise rehabilitation in VR space but also exhibit minimal side effects.[21,22]

Presently, domestic and international studies on the use of VR technology for patients with cardiac disease primarily focus on the observation of endpoints. Studies on patients' actual cognition and experience of VR games are few. To address the paucity of research on this topic, this study utilized qualitative interviews to understand the real experiences and perceptions of postcardiac surgery inpatients regarding the use of commercial VR games in their rehabilitation. The aim is to provide a theoretical foundation for enhancing VR technology intervention programs in rehabilitation and to promote the integration of commercially available VR technology into clinical rehabilitation settings.

Methods

Study design

This qualitative study employed Colaizzi's phenomenological method[23] to explore the real experiences of postcardiac surgical patients following their engagement with commercial VR games. Colaizzi's method of analysis is centered on comprehending the fundamental structure and significance of human experiences,[23] with the aim of extracting the shared attributes of participant experiences as a whole, rather than focusing solely on individual characteristics. Therefore, this method is valuable for analyzing participant experiences without introducing distortions. The scientific approach ensures the authenticity of the collected experiences of the participants and adheres to scientific standards. The findings of this study were reported following the guidelines outlined by the Consolidated Criteria for Reporting Qualitative Research (COREQ).[24]

Setting and patient recruitment

Participants were recruited from January 2023 to December 2023 in the cardiac surgery intensive care unit (CICU) of a tertiary hospital in Nanjing, China. This facility primarily admits adult patients who have undergone open-heart surgeries, including coronary artery bypass grafting, valve replacements, and repairs of ventricular septal defects, among others. The participants were patients who had undergone open-heart surgery and used the same VR game during their postoperative rehabilitation. The VR device was applied when the patients began bedside sitting training. VR training was conducted using a commercial head-mounted VR system (Oculus Quest 2), which provides a fully immersive virtual 3D experience, allowing room-scale tracking and interaction with the virtual environment via a headset and haptic hand controllers. Before applying VR, we conducted a comprehensive assessment of each patient's vital signs, hearing, vision, head and facial trauma, fractures, and other relevant factors to ensure they met the application criteria for VR equipment. Afterward, each participant was introduced to five games: Beat Saber, Angry Birds, Fruit Ninja, Dart Wars, and VoctoR PsydMind. All investigators were nurses currently in service. They invited patients in person to inquire whether they were willing to be interviewed about their experiences with VR gaming applications. After explaining the purpose and significance of the study, all patients agreed to participate.

Inclusion and exclusion criteria

The inclusion criteria were as follows: (1) patients who had undergone open-heart surgery; (2) patients who used the Oculus Quest 2 commercial VR head-mounted system to play VR games for at least three sessions (30–45 minutes each); (3) patients who voluntarily participated in the experiment and signed an informed consent form; (4) patients aged 18 years or older; and (5) patients with a clear mental state and the ability to communicate normally. Exclusion criteria: (1) Richmond Agitation Sedation Scale (RASS) score less than −1 point; (2) the presence of mental or cognitive impairment or delirium; and (3) patients with unstable vital signs, such as fatal arrhythmia, hemodynamic instability, or hypoxemia. Additionally, patients who dropped out for any reason were excluded.

This study employed purposive sampling to recruit patients of various genders, ages, education levels, and employment statuses, among other factors, ensuring a rich diversity of samples and increasing the study's applicability. The general information of the patients is presented in Table 1, and recruitment continued until theoretical saturation was reached, with no new topics emerging. A total of 12 patients were included in this study.

Interview outline

We developed the interview outline by reviewing relevant literature and consulting experts in the field. The main interview questions were as follows: (1) How do you feel about using virtual reality games during your postoperative rehabilitation? (2) What aspects of virtual reality games do you enjoy? (3) Have you encountered any difficulties while using them? (4) Did you experience any discomfort during the use of VR games? (5) Would you be interested in continuing to use these VR games if given the opportunity? Finally, an open-ended question was posed: "Do you have any other suggestions or ideas regarding the use of virtual reality games?"

Data collection

Data were collected through face-to-face individual in-depth interviews. The interviews were scheduled at each patient's convenience. For patients not in a single-room ward, a curtain was drawn to prevent interference. Each interview lasted for 30 to 40 minutes, and patients participated in 1 to 2 interviews depending on the data collection needs. If the researchers had differing interpretations of the interview content, participants were re-interviewed to clarify their statements. The researcher typically interviewed patients on the same day that they met the inclusion criteria, with a maximum interval of no more than 3 days. All interview conversations were recorded, and the recordings included nonverbal cues such as laughter, silence, and sighs. The audio recordings were transcribed verbatim within 24 hours of the interviews and subsequently reviewed by the interviewer to ensure the accuracy of the transcripts. The researchers endeavored to reflect on participant experiences and thoughts without distorting them with their own biases. They maintained a neutral perspective throughout the study to avoid influencing the results.

Data analysis

Data were analyzed through the phenomenological method proposed by Colaizzi.[23] Participants' experiences were analyzed through multiple readings of interview transcripts to extract relevant statements and form general themes. The researchers offered a detailed description of each theme generated by clustering and included exemplary original statements from the participants. Similar themes and their descriptions were grouped for iterative comparisons to identify and extract shared views. Brief phrases were then formulated to represent each theme. To ensure that these themes accurately reflected the participants' original experiences as conveyed, they were repeatedly cross-checked against the patient transcripts. We reviewed the analysis steps to ensure they accurately captured participants' experiences. The interviews, original transcripts, and data analyses were conducted in the Chinese language. The theme categories and quotations were established through consensus among the team during discussions. All quotes were translated to English and back to Chinese by two researchers to preserve original meaning.

Trustworthiness

The findings of this study were evaluated according to the following four criteria: credibility, transferability, dependability, and confirmability.[25] Credibility was ensured by allowing participants to review the interview descriptions to verify that the transcripts accurately conveyed their intended meaning. Transferability was ensured through reflection on all the steps involved in the research process and the procedure used for data transformation. Furthermore, dependability and confirmability were enhanced through comprehensive documentation of the research process's logical foundation, allowing two reviewers to trace the data and their sources, as well as understand the final interpretations.

Ethics approval

This study was approved by the Institutional Review Board of the researchers' hospital (No. KY20220713-02). Before the interviews, researchers informed participants about their identities and explained the study's main content and process, after which patients decided whether to participate. In accordance with the International Council of Nurses (ICN) Code of Ethics for Nurses,[26] we ensured that participants' personal information remained confidential during

Table 1. General information of the participants ($n = 12$).

Code	Gender	Age	Name of surgery	Education level	Occupational status	Whether having experiences of VR games	Cumulative time of VR games (minutes)
N1	Male	45	CABG	High school	Working	NO	90
N2	Male	39	MVR	College	Working	NO	120
N3	Female	51	AVR	High school	Working	NO	90
N4	Male	25	MVP	University	Working	NO	125
N5	Female	24	VSD	University	Working	NO	95
N6	Male	38	ASD	College	Working	NO	180
N7	Female	53	CABG	High school	Not working	NO	140
N8	Male	48	MVR	High school	Not working	NO	100
N9	Male	59	CABG	High school	Not working	NO	90
N10	Female	34	CABG	College	Not working	NO	200
N11	Female	39	AVR	College	Working	NO	95
N12	Male	20	ASD	University	Not working	YES	160

ASD: atrial septal defect; AVR: aortic valve replacement; CABG: coronary artery bypass grafting; MVP: mitral valvuloplasty; MVR: mitral valve replacement; VR: virtual reality; VSD: ventricular septal defect.

their hospital stay, as the interviewers were staff in the Cardiac Surgery Unit. Participants were assured of the confidentiality of their responses, with numbers used in place of names. The data were used solely for academic research purposes.

Results

All participants ($n = 12$) completed the interviews, and none withdrew during the study period. The mean age of participants was 39.6 ± 12.3 years, and 41.6% were female. Only one participant had previously used head-mounted VR gaming. Most participants had a high school degree or above. Participants had experienced the VR game at least three times, with each session lasting between 30 and 45 minutes. The general information of the respondents is shown in Table 1, and 2 themes and 10 subthemes were extracted (Table 2).

Perceived benefits of virtual reality games for rehabilitation

Enhancing the enthusiasm for rehabilitation. Participants interviewed had a positive attitude toward the use of VR games, which they found helpful in their recovery from surgery. Although only one of the interviewees had prior experience using VR games, most participants expressed willingness to try them. After using the applications, they found the VR games very interesting and expressed a desire to try them again.

I have never experienced a game like this before, the graphics were very three-dimensional, as if I was transported to another dimension.

N1: (Male, 45 years, coronary bypass operation)

Although I don't like to play computer games, I think this [VR game] is a bit of fun, it makes me happy and allows my arms to get some exercise!

N5: (Female, 24 years, ventricular septal defect)

I want to play that Angry Birds game again!

N6: (Male, 38 years, atrial septal defect)

Helping to focus. Although these VR games mainly focused on exercising patients' upper limb abilities, participants also expressed perceived benefits in other areas. For example, they noted that the VR games effectively captured their

Table 2. Overview of themes and subthemes.

Themes	Subthemes
The benefits of virtual reality games for rehabilitation	Enhancing enthusiasm for rehabilitation
	Helping patients to focus attention
	Increasing individual exercise
	Providing enjoyment
	Regulating negative emotions
Shortcomings in the use of virtual reality games	Producing stress
	Insufficient operating space
	Discomfort while wearing
	Difficulty in mastering the application
	Individualized needs

attention. Participants reported feeling sleepy before, but their attention became instantly focused, and their cognitive engagement increased when using the VR games.

Originally, I was drowsy, but when I played it, I felt that I was not sleepy at once, and I found the three-dimensional picture particularly attractive.

N2: (Male, 39 years, mitral valve replacement)

When playing, I felt that I forgot my worries, became deeply engrossed in the images in front of me, and felt my mind racing.

N7: (Female, 53 years, coronary bypass operation)

It felt like time passed quickly, the game was over in a flash, I was foggy in the head before but I was refreshed all of a sudden, I didn't feel tired at all while playing, I was completely immersed in the VR games.

N11: (Female, 39 years, aortic valve replacement)

Increasing individual exercise. Some participants indicated that playing VR games significantly increased their activity levels compared with their usual exercise methods, such as bedside seating and bedside walking.

I feel that my activity volume has increased by using the VR equipment, and I exercise more than I did yesterday when I was not playing it.

N2: (Male, 39 years, mitral valve replacement)

I think it can not only increase my brain's reaction speed but also increase the amount of motion of my upper limbs, which I have never experienced before.

N3: (Female, 51 years, aortic valve replacement)

My hands and arms keep moving, and I get a bit sweaty when playing.

N4: (Male, 25 years, mitral valvuloplasty)

Providing enjoyment. When playing games, almost all patients had also engaged in other forms of exercise rehabilitation, including the use of exercise equipment such as grippers and bicycles. Participants found that using VR games made them feel happier than the traditional exercise methods.

I feel like it's more interesting than mobile phone games, and it feels immersive.

N3: (Female, 51 years, aortic valve replacement)

My favorite game is "Angry Birds." Every time I shoot a bird, I feel a special sense of achievement.

N6: (Male, 38 years, atrial septal defect)

It's my first time experiencing this kind of equipment, and it feels very novel and especially interesting.

N8: (Male, 48 years, mitral valve replacement)

Wow, this picture is so realistic. It feels like I'm really holding a sword in my hand. It's so interesting!

N12: (Male, 20 years, atrial septal defect)

Regulating negative emotions. Participants reported that VR games made them feel happy. When they focused on earning rewards in the game, seeing themselves advance provided a sense of accomplishment and served as a positive incentive to momentarily distract them from their worries.

I felt so much fun that it took my mind off my troubles.

N5: (Female, 24 years, ventricular septal defect)

It was so rewarding to advance in the game, I would like to play again if I have the chance. Can you extend the time for me next time? I would like to continue to pass the level!

N1: (Male, 45 years, coronary bypass operation)

After playing the game, I feel that my mood has changed, and I will recall the images of the game.

N8: (Male, 48 years, mitral valve replacement)

Shortcomings of VR gaming applications

Producing stress. In addition to their strong interest in VR technology, patients may also encounter negative emotions, such as stress induced by the fear of making mistakes or not being able to learn how to use the technology.

At first, the nurse taught me how to use it, but when I operated it independently, I still felt a bit nervous.

N5: (Female, 24 years, ventricular septal defect)

When I first learned it, I was a bit worried that I would be disliked if I didn't operate it in the right way.

N8: (Male, 48 years, mitral valve replacement)

Fear of damaging hospital equipment if I operate it incorrectly and having to be careful.

N12: (Male, 20 years, atrial septal defect)

Insufficient operating space. Upon the introduction of VR games in the ward, patients commonly observed the limited operating space. Furthermore, some patients suggested that playing VR games while lying in bed could help conserve their stamina.

It would be nice if VR games could be played while lying on the hospital bed; it would feel more comfortable and save strength.

N7: (Female, 53 years, coronary bypass operation)

When applying the equipment, I need to move my upper limbs to cooperate, and I feel that the operating space is a bit small when I sit on the bedside, and I can't stretch out, which sometimes leads to operating errors.

N4: (Male, 25 years, mitral valvuloplasty)

When operating the equipment, I was a little worried that my limbs would touch the tables and chairs around me because I couldn't see the surrounding reality.

N9: (Male, 59 years, coronary bypass operation)

Discomfort in wearing the device. The discomfort experienced during VR gaming, as expressed by most patients, primarily included the heaviness of the head-mounted device, which led to fatigue. Additionally, some patients reported feeling tired after VR gaming and needed to rest for a while afterward.

It would be nice if this machine could be a bit lighter, I find it a bit heavy.

N4: (Male, 25 years, mitral valvuloplasty)

I feel a bit tired after wearing it on my head for a long time, and post-surgical patients are easily fatigued because they don't have much stamina.

N7: (Female, 53 years, coronary bypass operation)

I don't feel tired when I play, but I feel fatigued after I finish it, and I fall asleep when I go to bed.

N9: (Male, 59 years, coronary bypass operation)

Difficulty in mastering the application. Although the participants included in the interviews were patients who had undergone the entire VR training, they still expressed difficulty in mastering the use of the equipment or feeling unskilled in its operation.

I have not come into contact with VR equipment in my normal life, and I rarely even play computer games, so it was difficult to learn, and although I could operate it in the end, it did not feel very smooth.

N1: (Male, 45 years, coronary bypass operation)

The whole process involves playing several games, each with a different method of operation; fortunately, I'm still relatively young, with a strong learning ability.

N2: (Male, 39 years, mitral valve replacement)

Although I used to use computer or mobile phone games a lot, I felt that I was slower to learn and get used to them as I had just recently had surgery.

N8: (Male, 48 years, mitral valve replacement)

It would be nice to have an instructional video on how to use it, I wasn't quite able to operate the handle proficiently at first.

N9: (Male, 59 years, coronary bypass operation)

Individualized needs. Participants described that although VR games are very interesting, not all of them are their favorite games. They noted that only when they find the right game and the appropriate level can they experience a corresponding sense of achievement.

My favorite game is Rhythm Lightsaber, which is not only easy to operate but also exercises my hand–eye coordination.

N2: (Male, 39 years, mitral valve replacement)

I prefer fruit-cutting games, but I can only play the beginner's level, and I keep failing when the level is upgraded.

N6: (Male, 38 years, atrial septal defect)

When I am more tired, I still like to experience games that don't require much strenuous activity, like that 3D animation with music that relaxes my mind and body.

N9: (Male, 59 years, coronary bypass operation)

Discussion

Some studies[15] have indicated that Oculus and HTC commercial VR systems are viable options for VR-based health applications. These systems not only fulfill patients' needs for gaming, exploration, and exercise in VR for rehabilitation but also have no significant side effects. Consistent with the results of the current study, VR gaming on commercial systems can enhance the motivation of postcardiac patients for rehabilitation, increase the amount of exercise, and improve adverse emotions. However, it is also crucial to select the patient's favorite games and appropriate difficulty levels according to their individual condition. In future clinical applications, patients can explore the resource library independently and choose their favorite VR games for repeated use. Additionally, considering that commercially available VR games offer extensive resources and are regularly updated, healthcare providers should carefully screen the resources before recommending them for rehabilitation purposes. Avoiding games with violent content or inappropriate guidance is crucial. As the price of commercial VR equipment continues to decrease and the quality of the visuals improves, along with the constant updates to VR games and video resources, the difficulty and cost of developing VR programs or games in-house by healthcare institutions have decreased. This greatly enhances the feasibility of widespread adoption of VR technology in clinical settings.

The current study revealed that patients also experience some negative effects, such as stress and anxiety, when using VR games. Patients may feel stressed and worried about being disliked by medical staff if they struggle to master the VR operation methods taught by the staff or if they learn slowly. Additionally, some participants provided feedback that they found it challenging to become proficient in operating VR games and expressed a desire for more detailed teaching instructions. Previous studies[27,28] have indicated that patients are more likely to master the use of VR games or devices, which differs from the results of this study. This discrepancy may be related to factors such as the participants' ethnic and cultural backgrounds, education levels, and the direct application of commercial VR devices for gaming. Therefore, in future clinical applications, medical staff should provide thorough explanations of VR applications before teaching participants and demonstrate sufficient tolerance and patience during the teaching process to alleviate the pressure and stress experienced by patients when using VR games. Additionally, medical staff can consider recording instructional videos on the use of VR equipment for patients to watch and learn in advance or repeatedly. This approach aims to improve the success rate of VR game applications and enhance patients' confidence and participation.

The vast majority of patients reported that they felt their brain and limbs were exercised simultaneously when using VR games, and that this feeling helped with concentration. This is consistent with the findings of Sutton et al.,[29] by manually manipulating the VR controllers, patients improved their neurological responsiveness and hand–brain coordination. This not only alleviated their anxiety but also helped them feel more relaxed while using the VR controllers. This approach effectively mobilized the patients' subjective initiative and provided valuable support for the rehabilitation process.[30] However, they also noted feeling hardly tired while playing, which is consistent with the findings of Stewart et al.[31] The perceived exertion during a VR game may be lower than the actual exertion, and it may be related to the difficulty setting of the game. However, some patients in this study reported feeling very fatigued after using the VR game. This suggests that healthcare professionals need to appropriately control the usage duration during clinical application, rather than solely relying on patients' personal complaints. To prevent excessive fatigue among postoperative cardiac patients during rehabilitation, medical staff must prioritize patient safety. They should gradually implement exercise and prevent complications associated with excessive physical exertion.

Finally, participants expressed some preferences regarding VR devices and the operating environment when using VR games. They hoped that the device could be lighter, possibly because they had not fully recovered their physical strength after undergoing major surgery. The current weight of the Quest 2 is approximately 500 g, in contrast, the upgraded Quest 3 is 40% thinner than Quest 2. Healthcare organizations may consider acquiring

lighter VR wearable devices for future clinical applications to better meet patients' needs. Additionally, participants expressed a desire to use the game in a more open space and to have company while using it, which would reduce the likelihood of physical collisions and alleviate concerns about damaging the VR devices. Medical institutions should consider providing patients with suitable spaces for VR applications, ensuring that the patient's operating area is free of obstacles. During renovations, cushioning pads can be installed on the floor or walls to prevent patients from accidentally falling or bumping into objects during operation. Patients must be accompanied by a medical professional throughout the use of VR games, and cardiac monitoring should be implemented for patients when necessary. This ensures the safety of patients during VR gaming and helps alleviate their concerns about their safety during operation.

Limitation

Despite the contributions of this qualitative study, it has some limitations. First, the interviewees were all from the same cardiac surgery center. One of the inclusion criteria for this qualitative study was that patients must have successfully used commercial VR during the postoperative rehabilitation stage. Although efforts were made to select patients of varying ages to ensure sample diversity, there are still some limitations regarding age groups, as pediatric and elderly patients were ultimately not included. Second, owing to limited scientific research funding and the need to reduce the training costs for clinical VR application, only one brand of commercial VR equipment was used in this study. This may limit the generalizability of the findings and introduce a degree of bias in the final results. Thirdly, the researchers were nurses working in this cardiac surgery center. Although patients were informed prior to the interviews that the content would be kept strictly confidential, it cannot be ruled out that some interviewees refrained from expressing more negative feedback owing to their collaborative relationship with the nurses. Finally, although we applied standardized criteria to evaluate whether patients were suitable for VR application ensuring their status before using the VR device, differences in recovery rates and other influencing factors (such as medication use and changes in patients' perceptions of treatment) may have affected their real perceptions and experiences when using commercial VR games.

Implications for practice and future research

Designing an improvement plan based on the findings of this study for the clinical use of commercial VR, and evaluating the efficacy of the intervention, would be beneficial for further promoting the use of commercial VR systems in clinical settings. In future research, conducting multicenter, large-scale cohort studies that compare different VR device brands could help gather objective metrics on the impact of commercial VR on postcardiac surgery patients, including vital signs, mobility, and cognitive function. This would facilitate the selection of the most suitable VR device specifically tailored for postcardiac surgery patients. Furthermore, this approach would generate more comprehensive and objective data to support the integration of commercial VR into the early postoperative rehabilitation process. Additionally, exploring the potential expansion of commercial VR technology for home rehabilitation or for pre-rehabilitation in patients with pre-existing comorbidities prior to surgery warrants further investigation.

Conclusion

Postoperative adult cardiac surgical inpatients believe that the use of commercially available VR games can facilitate their early postoperative rehabilitation by increasing motivation to participate in exercise, enhancing the quality of exercise, and improving mood. Moreover, lighter VR wearable devices, spacious and safe areas for use, professional staff accompaniment, and comprehensive instructions could enhance patients' experience of the benefits of VR games in their rehabilitation.

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Data availability: The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Declaration of conflicting interests: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval: The studies involving human participants were reviewed and approved by NanJing First Hospital, Nursing Research Ethics Subcommittee. The patients provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

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