Using a VR Beerpong game in postoperative Rehabilitation: A Pilot Study on User Acceptance in a Clinical Setting

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Submitted to: JMIR XR and Spatial Computing (JMXR)
on: August 25, 2025

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Abstract

Background: Virtual reality (VR)–based rehabilitation has shown promise in neurological and musculoskeletal settings, but evidence regarding its acceptance and usability in postoperative physiotherapy remains limited.

Objective: This pilot study aimed to evaluate the usability and acceptance of a VR-based rehabilitation application among postoperative patients and physiotherapists in a clinical setting.

Methods: Thirty-five postoperative patients and seven physiotherapists participated in a usability evaluation using the System Usability Scale (SUS) and a self-developed questionnaire assessing attitudes toward VR-supported physiotherapy. Usability ratings were analyzed across age groups and genders. Descriptive statistics summarized responses on motivation, distraction, supplementation, and preferences regarding VR use.

Results: The overall mean SUS score was 73.21 (SD = 13.74), indicating ‘excellent’ usability. No significant differences in usability ratings were found between age groups or genders. Most patients (83%) agreed that the VR scenario increases motivation, and 92% viewed VR exercises as a useful supplement to conventional physiotherapy. Physiotherapists reported an average SUS score of 74.64 (SD = 10.04) and expressed positive attitudes toward VR implementation. However, only 20% of patients believed VR could replace traditional therapy entirely.

Conclusions: VR-based rehabilitation applications are generally well accepted and perceived as usable by both patients and physiotherapists in postoperative settings. These findings support further investigation through larger, controlled trials to assess long-term usability, clinical efficacy, and integration into routine care.

(JMIR Preprints 25/08/2025:82704)
DOI: https://doi.org/10.2196/preprints.82704

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Keywords: Immersive therapy; Human–computer interaction; Patient engagement; Digital health; Gamification; Technology acceptance

Introduction

Postoperative rehabilitation is of greatest importance for restoring function and relieving pain after surgery. In visceral surgery, especially, successful rehabilitation is instrumental for improving recovery and quality of life in patients (Pozzi et al., 2013). Systematic, well-tailored physical training lies at the center of these efforts. Weyhe et al. (2022), for example, demonstrated in a randomized controlled trial that supervised physiotherapy or home-based exercise prescribed after resection of pancreatic cancer is both feasible and beneficial when initiated early in the postoperative course.

In the last few years, virtual reality (VR) has emerged as a promising technology to enhance physical rehabilitation (Howard, 2017). VR exposes people to computer-generated environments that provide multimodal sensory feedback in an attempt to increase motivation, engagement, and adherence to exercise routines (Li et al., 2011). Moreover, VR is increasingly regarded as a potential solution to support the delivery of high-quality physiotherapeutic care in light of the growing shortage of skilled rehabilitation professionals (Elser et al., 2025).

Evidence for rehabilitation based on VR is increasing. A recent systematic review by Brepohl and Leite (2023) revealed several advantages, including improved balance, gait, postural control, and pain, as well as enhanced motivation and training performance (Corbetta et al., 2015; Norouzi-Gheidari et al., 2020; Sessoms et al., 2023). However, several obstacles need to be overcome: costly technology, restricted availability of suitable rehabilitation games, technical issues like sensor inaccuracy, lack of standardization, and lower familiarity for physiotherapists may hinder extensive use (Brepohl & Leite, 2023; Hoda et al., 2015; Palaniappan & Duerstock, 2018; Rutkowski et al., 2020; Tsuda et al., 2016).

To date, the majority of VR applications in rehabilitation have been introduced in neurology (54%), followed by orthopedics and trauma treatment (14%). VR-based treatments are generally intended to augment, rather than substitute for, traditional physiotherapy and are best customized to address individual patient requirements (Brepohl & Leite, 2023; Cuthbert et al., 2014).
In patients who have experienced a stroke, Alrashi et al. (2023) demonstrated that VR can support the restoration of motor functions, with benefits surpassing those of conventional therapy. Similarly, findings by Daraker et al. (2015) indicated that VR-based rehabilitation can lead to improvements in balance, mobility, walking speed, and the ability to navigate complex environments following a stroke.
A recent systematic review by Wang et al. (2024) also identified enhancements in gait and balance in individuals with spinal cord injuries as a result of VR interventions. However, the authors emphasize that the current body of evidence remains limited, highlighting the need for further research in this area.
In the context of Parkinson’s disease, Yu et al. (2023) reported a significant positive effect of VR-based therapy on balance. Moreover, a study by Lin et al. (2020) found that VR-assisted therapy led to notable reductions in pain as well as improvements in mobility and functional ability in patients with musculoskeletal disorders.

Patients perceive VR rehabilitation as more enjoyable and less taxing compared to traditional programs (Lin et al., 2020; Vernadakis et al., 2014). Despite this, gaps remain in the knowledge of user acceptance, particularly among postoperative patients and clinical end users such as physiotherapists. While prior studies have focused on effectiveness, relatively few have examined technology acceptance in surgical rehabilitation settings.

Before starting a larger intervention study at the University Hospital for Visceral Surgery, PIUS-Hospital Oldenburg, we conducted a pilot study to ascertain the usability and acceptance of a VR training application ‘Beer Pong’ in postoperative patients and physiotherapists. Usability was measured using the System Usability Scale (SUS) (Brooke, 1996), which has been validated in a number of contexts (Gao et al., 2020; Lewis & Sauro, 2018).

Due to the steadily decreasing availability of physiotherapists in postoperative mobilization, digital support systems such as VR are expected to play an increasing role in guiding rehabilitation exercises. As a first step towards such implementation, this study aimed to investigate patient usability and acceptance of VR-based training. Secondary outcomes included patient attitudes towards VR compared to video-based exercises, reasons for acceptance or rejection, and the feasibility of conducting a full-scale clinical trial in the future.

Methods

Ethical Considerations

The study was carried out in accordance with national regulations, the principles of the Declaration of Helsinki (1975), and the guidelines of Good Clinical Practice (ICH-GCP). Approval was obtained from the responsible Medical Ethics Committee (reference number 2024-164), the Data Protection and Information Security Management Unit at the University of Oldenburg, and the staff council at PIUS-Hospital. Written informed consent was obtained from all participants prior to inclusion. Participation was voluntary, and no compensation was provided. Recruitment was carried out by medical staff from the Department of Visceral Surgery at the University of Oldenburg, located at PIUS-Hospital in Oldenburg, through personal communication. All data were treated with strict confidentiality. The pseudonymized dataset was stored securely on a password-protected computer system, with access restricted to authorized personnel only.

Participants

The data was collected between November and December 2024. A total of 35 patients being hospitalized during this time (see Table 1) and 7 physiotherapists (4 female, 3 male) participated in the study and were categorized into three age groups for analysis: under 40 years, 40 to 60 years, and over 60 years.

Table 1: Patient Characteristics: Gender, Physical Activity, Diagnosis, Treatment Type, and VR Experience

	<40 years (n=10)	40 – 60 years (n=12)	>60 years (n=13)	Patients (n=35)
Gender				
Female	3	8	6	17
Male	7	4	7	18
Physical Activity				
None	3	4	3	10
Various *	7	8	10	25
Category of Condition (Topographical)				
Abdominal [a]	5	6	7	18
Upper extremity [b]	1	1	3	5
Lower extremity [c]	3	4	2	9
Collum [d]	0	0	1	1
Regio gluteales [e]	1	1	0	2
Type of Therapy (Invasiveness)				
Minimally invasive	6	6	4	16

Open	3	5	8	16
Other [f]	1	1	0	2
Previous Experience with VR				
<5min	1	0	0	1
>20min	6	1	1	8

*Fitness, cycling, hiking, Hot Iron, Qi Gong, tennis, golf, swimming, yoga, rowing, squash, football, Pilates

[a] *Appendicitis, pancreatic carcinoma, cholecystolithiasis, rectal carcinoma, malignant perforation of internal organs, gastric carcinoma, metastatic breast carcinoma, adrenal adenoma, unclear abdominal pain;* [b] *Shoulder joint arthrosis, biceps tendon rupture, finger fracture;* [c] *Femoral head necrosis, dislocated knee prosthesis, knee joint arthrosis, coxarthrosis, ankle joint fracture;* [d] *Thyroid nodules;* [e] *Pilonidal sinus/abscess;* [f] *Abscess incision*

Among the physiotherapists, three reported prior experience with virtual reality: two had used VR for less than five minutes, and one for more than twenty minutes. Recruitment proved challenging, primarily due to patients reporting a subjectively poor general condition, significant disease-related distress, or acute pain at the time of recruitment. Additional reasons for non-participation included a general lack of interest in research studies and, less frequently, concerns about potential side effects such as dizziness.

Participants were eligible for inclusion if they were at least 18 years old, currently receiving postoperative inpatient care in the departments of visceral surgery or orthopedics at PIUS-Hospital Oldenburg, and undergoing physiotherapeutic treatment. Further inclusion criteria included the ability to perform physical exercises and medical clearance for mobilization by a physiotherapist. For physiotherapists, eligibility required employment at PIUS-Hospital or another clinic in Oldenburg and provision of written informed consent.

Exclusion criteria for patients included pre-existing neurological conditions (e.g., stroke, multiple sclerosis, Parkinson's disease, ALS, epilepsy) or muscular disorders (e.g., muscular dystrophy, myasthenia gravis) that could affect physiotherapy participation. Additional exclusion criteria included the inability to tolerate VR headsets (e.g., due to dizziness or nausea), severe postoperative complications (e.g., sepsis, significant bleeding requiring reoperation, bowel obstruction, or respiratory failure requiring intensive care), as well as insufficient German language proficiency or the inability or unwillingness to provide written informed consent. For physiotherapists, the same exclusion criteria applied regarding VR intolerance, language proficiency, and consent.

Procedure

Participants were introduced to the VR system (Meta Quest 3) and the application 'Beer Pong' developed by apoQlar medical (Figure 1). After brief verbal instructions, they wore the headset and engaged with the app for five minutes. In the game, users were required to grasp a virtual ball and throw it into cups. Before each throw, the application prompted them to perform a squat, which was verbally reinforced by research staff if necessary. The VR display was mirrored to a laptop to allow for real-time monitoring and support by the experimenter.

Immediately after t assess perceived usability. In addition to the SUS tered to assess acceptance and motivation among l oint Likert scale ranging from ‘strongly disagree’ t

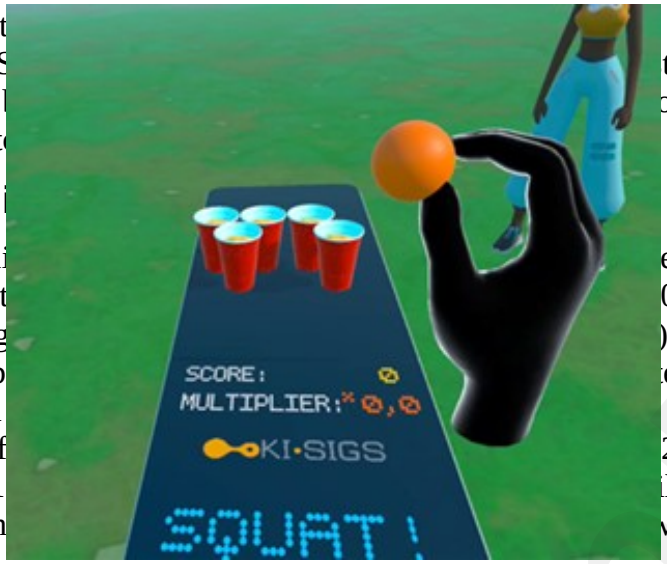


Figure 1: Illustration of the virtual reality application ‘Beer Pong’ used in the study. The game was designed to promote upper body movement and coordination through interactive, game-based tasks in a simulated environment.

System Usabili

The SUS is a vali erceived learnability and user satisfaction of new t 0 items, each rated on a 5-point Likert scale ranging). For odd-numbered items, the score is adjusted b ems, the score is adjusted by subtracting the item value between 0 and 4 for each item. The scores of 2.5 to yield a total SUS score ranging from 0 to 1 lity Score (Brooke, 1996). It is important to note th while scores of 80 or above fall within the top 10 percentile. Based on these thresholds, scores can be categorized as follows: 0–51.6 = poor, 51.7–62.6 = ok, 62.7–72.5 = good, 72.6–78.8 = excellent, and 78.9–100 = the best imaginable (Gao et al., 2020). The full SUS questionnaire is provided in the appendix. In this study the SUS was employed to assess the usability of both the VR headset and the accompanying application.

Statistics

The quantitative SUS data were analyzed descriptively and using ANOVA to examine the effects of age and gender. Open-ended responses were analyzed qualitatively, with a focus on therapy motivation, user satisfaction, and individual experiences such as pain perception or prior physical activity. Data analysis was conducted using SPSS (version 28.0.1.0; IBM Corp.), MATLAB (version R2022a; The MathWorks, Inc.) and Microsoft Excel (version 2408, Microsoft Corporation, 2024).

Results

The SUS was used to assess the perceived usability of the VR application across all participants. The overall mean SUS score was 73.21 (SD = 13.74), indicating a ‘excellent’ level of usability. When stratified by age group, participants under 40 years reported a mean SUS score of 75.75 (excellent) (SD = 12.36), those aged 40–60 years had a mean score of 77.71 (excellent) (SD = 15.54), and participants over 60 years reported 67.12 (good) (SD = 11.54). A visual comparison of SUS scores across age groups is provided in Figure 2. To examine whether there were statistically significant differences in usability ratings between age groups or between genders, a two-way ANOVA was performed. The ANOVA revealed no significant effect of gender on the SUS score, $F(1, 29) = 0.30$, $p = .590$, partial $\eta^2 = .010$. Similarly, there was no significant effect of age group on patients’ SUS scores, $F(2, 29) = 2.72$, $p = .082$, partial $\eta^2 = .158$.

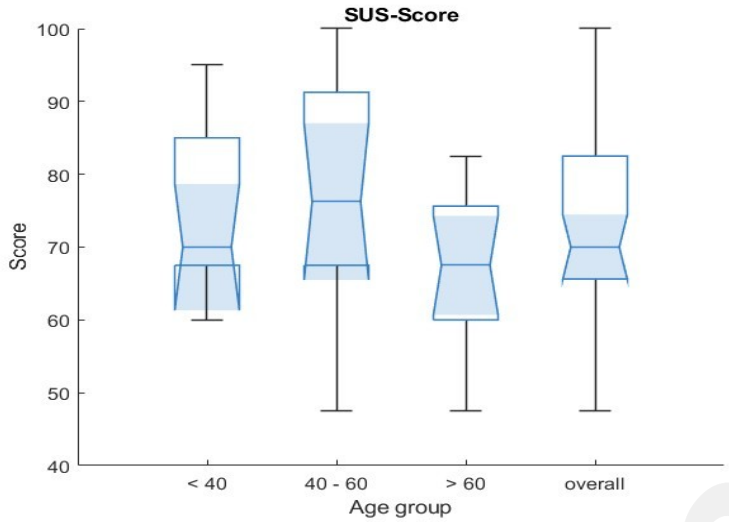
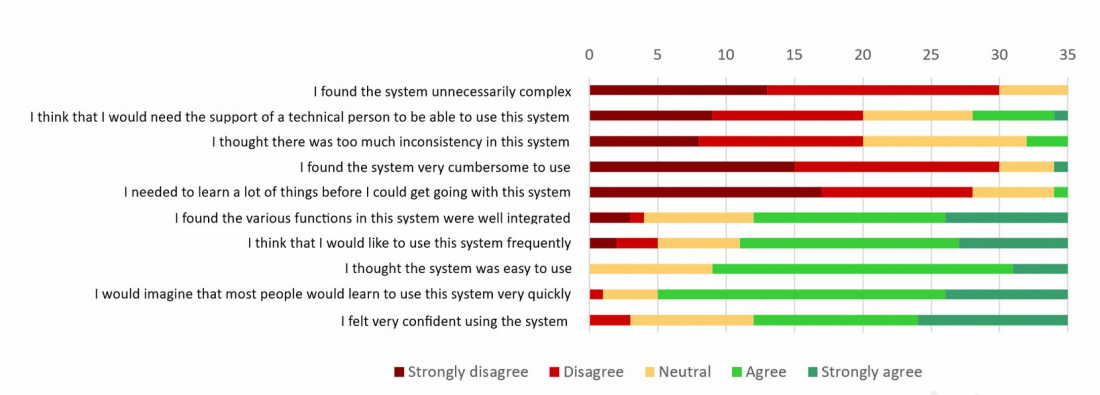


Figure 1: Boxplots of SUS scores across age groups (<40 years, 40–60 years, >60 years) and for the total sample. The plots illustrate the median, interquartile range (IQR) in each group.

An overview of the response distribution for each of the ten items of the SUS is presented in Figure 3. The bar chart differentiates between negatively worded items (items 1 to 5) and positively worded items (items 6 to 10). The figure illustrates the number of participants selecting each response option on the 5-point Likert scale, ranging from *strongly disagree* to *neutral* to *strongly agree*, thereby providing insight into specific aspects of perceived usability.



Thirty out of 35 patients disagreed with the statement that the system is unnecessarily complex. Twenty-three patients agreed that they felt confident using the system, while only three disagreed. Additionally, 24 patients expressed willingness to use the system more frequently, with six remaining neutral.

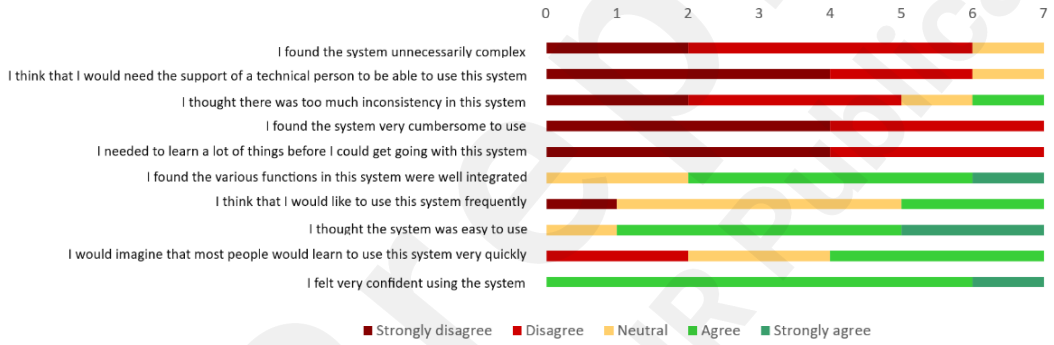


Figure 4: Distribution of responses given by the seven physiotherapists to each of the ten SUS items, distinguishing between negatively and positively worded statements and illustrating their agreement levels on a 5-point Likert scale.

The SUS scores obtained from the participating physiotherapists yielded a mean score of 74.64 (SD 10.04) indicating a generally ‘excellent’ level of usability for the VR system. These results suggest that the application was perceived as user-friendly and acceptable in a clinical rehabilitation context. The evaluation of the SUS responses from the participating physiotherapists is illustrated in Figure 4, which displays the distribution of responses to each of the ten items.

As with the patient data, the first five items represent negatively worded statements, while the lower

five items are positively phrased. The figure provides insight into how consistently the physiotherapists perceived the usability of the VR system across individual aspects, ranging from ‘strongly disagree’ to ‘strongly agree’. Six out of seven disagreed with the statement that the system is unnecessarily complex. All seven physiotherapists agreed that they felt confident using the system. Regarding the intention to use the system more frequently, two physiotherapists agreed, while four remained neutral, neither agreeing nor disagreeing.

The majority of patients (83%) agreed or strongly agreed that diverse VR scenarios would enhance their motivation to practice. Most participants (94%) found VR exercises to be a welcome distraction from the hospital routine. Additionally, 92% could envision using VR-based exercises as a supplement to conventional physiotherapy. However, only 20% agreed that VR could replace traditional physiotherapy, with a considerable portion remaining neutral or disagreeing. Furthermore, 77% expressed willingness to perform VR-supported physiotherapeutic exercises at home. These results, obtained from a self-developed questionnaire, are summarized in Table 2.

Table 2: Patient responses to statements regarding the use of VR for physiotherapeutic exercises. Percentages reflect the distribution of agreement levels across six key items assessing motivation, distraction, supplementation, replacement, preference, and willingness to use VR at home.

Question	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Different VR scenarios for practicing would increase my motivation.	1 (2,9%)	1 (2,9%)	4 (11,4%)	19 (54,3%)	10 (28,6%)
Performing exercises using VR provides a welcome distraction from everyday hospital routines.	-	1 (2,9%)	1 (0,03%)	13 (37,1%)	20 (57,1%)
I can imagine using VR-based exercises as a supplement to conventional physiotherapy.	-	1 (0,03%)	2 (5,7%)	15 (42,9%)	17 (48,6%)
I can imagine using VR-based exercises as a replacement for conventional physiotherapy.	4 (11,4%)	9 (25,7%)	15 (42,9%)	6 (17,1%)	1 (2,9%)
I prefer VR over traditional alternatives, such as watching exercise videos.	3 (8,6%)	4 (11,4%)	13 (37,1%)	13 (37,1%)	2 (5,7%)
I would also be willing to perform VR-supported physiotherapeutic exercises at home.	-	2 (5,7%)	6 (17,1%)	20 (57,1%)	7 (20,0%)

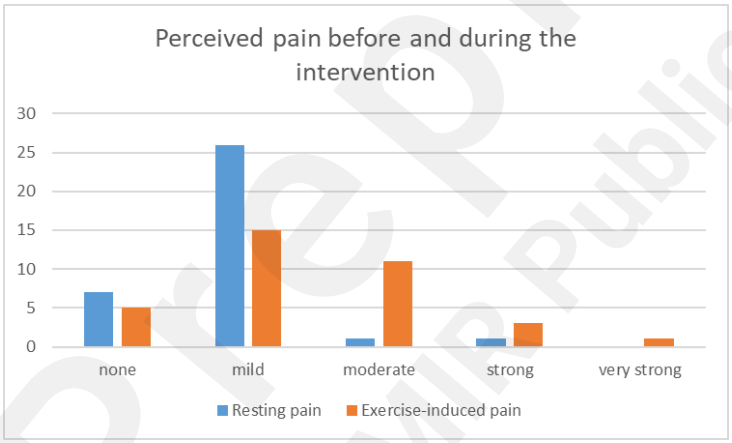


Figure 5 illustrates the patients' reported pain levels before and during the exercises. Prior to the exercises, 26 patients experienced mild pain, which decreased to 15 during the exercises. One patient reported moderate pain before the exercises, increasing to 11 during the exercises. Similarly, one

patient reported strong pain before the exercises, which rose to three during the exercises. Only one individual reported very strong pain during the exercises. Additionally, seven patients reported no pain before the exercises, while five reported no pain during the exercises.

The responses from the seven participating physiotherapists to a self-developed questionnaire are summarized in Table 3. The majority expressed a positive attitude toward VR-supported physiotherapy applications, with six participants indicating openness to such technologies and five envisioning their use in clinical practice. Regarding the potential of VR exercises to alleviate staffing shortages, most responses were neutral, while opinions on whether VR could reduce daily clinical workload varied between neutral and disagreement. Most physiotherapists agreed that, following adequate patient introduction, they could provide appropriate care using VR physiotherapy. Responses concerning VR's ability to accommodate patient preferences were also predominantly neutral. Lastly, preferences between VR and more traditional alternatives, such as exercise videos, were mostly neutral among participants.

Table 3: Responses from physiotherapists to a self-developed questionnaire assessing attitudes toward VR-supported physiotherapeutic applications. The table shows the number and percentage of respondents selecting each response option on a 5-point Likert scale ranging from 'Strongly disagree' to 'Strongly agree' across seven statements related to usability, implementation, workload, and preferences.

Question	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I am open to a VR-supported physiotherapeutic application.	-	-	1 (14,3%)	2 (28,6%)	4 (58,1%)
I can imagine working with VR in my practice.	-	1 (14,3%)	2 (28,6%)	2 (28,6%)	2 (28,6%)
I believe that VR-supported exercises could help address understaffing within the team.	1 (14,3%)	1 (14,3%)	4 (58,1%)	-	1 (14,3%)
I believe that VR-based physiotherapy could reduce workload in daily clinical routines.	-	3 (42,9%)	3 (42,9%)	-	1 (14,3%)
I believe that, following an appropriate patient introduction to VR physiotherapy, I could provide adequate patient care.	-	-	5 (71,4%)	1 (14,3%)	1 (14,3%)
I believe that VR physiotherapy could help accommodate patients' preferences.	-	-	4 (58,1%)	2 (28,6%)	1 (14,3%)
I would prefer a more traditional alternative (e.g., an exercise video) over VR.	-	1 (14,3%)	5 (71,4%)	1 (14,3%)	-

Discussion

Findings and Implications

This pilot study provides initial evidence that VR–based rehabilitation is generally well accepted by both postoperative patients and physiotherapists in a clinical setting. The average SUS scores for both groups indicated an 'excellent' level of usability, suggesting that VR applications such as the one tested 'Beer Pong' may offer a viable and user-friendly addition to conventional postoperative care. Interestingly, no significant differences in perceived usability were found between age groups or with respect to gender, indicating broad applicability across diverse patient populations. Notably, even participants over the age of 60 provided favorable ratings, which challenges the common assumption that older adults are less open to digital or immersive technologies.

These findings are in line with previous studies that report high levels of user satisfaction with VR interventions in other rehabilitation contexts, particularly neurological and musculoskeletal disorders (Alrashidi et al., 2023; Lin et al., 2020; Yu et al., 2023). While most of the existing literature focuses on clinical effectiveness, this study adds to the limited body of research addressing technology acceptance and usability in surgical rehabilitation settings. By incorporating both patients and clinical staff in the evaluation process, the study highlights the dual necessity of acceptance on both ends for successful clinical implementation.

From a clinical perspective, these results are highly relevant. Early mobilization and physiotherapy are critical components of recovery after abdominal surgery (Weyhe et al., 2015) or orthopedic surgery (Okamoto et al., 2016), and the integration of engaging, technology-supported interventions

may enhance adherence and motivation. Furthermore, the application was also perceived positively by physiotherapists, who play a central role in selecting and delivering therapeutic interventions. Their openness to VR is encouraging, especially in light of the growing shortage of trained physiotherapy professionals in many healthcare systems. According to the World Health Organization and recent reports from national health agencies, the demand for rehabilitation services is increasing rapidly due to demographic aging, rising rates of chronic conditions, and a strained workforce (Mills et al., 2018; Rauch et al., 2019; World Health Organization, 2010, 2024). Digital tools such as VR-based training may help to bridge this gap by supporting therapists in repetitive or motivational aspects of care, thereby allowing them to allocate their time more effectively.

Several methodological considerations should be noted. The small sample size and single-center design limit the generalizability of the findings. Additionally, the study population may be subject to self-selection bias, as individuals more comfortable with technology might have been more willing to participate, potentially inflating usability ratings. The brief exposure time of five minutes to the VR application may not have allowed participants to fully familiarize themselves with the system, thus potentially impacting their subjective evaluations. Long-term acceptance and usability under routine clinical conditions remain to be explored.

While the VR application demonstrated good usability, the lack of medical device certification could pose a barrier to broader clinical adoption. Technical issues, including hardware limitations and software stability, were not extensively evaluated but may affect usability and integration into clinical workflows. Furthermore, adaptations might be necessary to accommodate diverse patient needs, particularly for older adults or those with physical impairments, to ensure equitable access and benefit.

Successful clinical implementation of VR-based rehabilitation requires appropriate training for both physiotherapists and patients to maximize engagement and therapeutic benefit. The positive reception among physiotherapists suggests openness to integrating VR tools into existing rehabilitation protocols, which may help address workforce shortages by supporting repetitive or motivational tasks. The integration of VR must be carefully designed to complement rather than disrupt standard care pathways.

Future studies should investigate the long-term efficacy and user acceptance of VR rehabilitation over extended periods and larger, more diverse populations. Randomized controlled trials comparing VR-based interventions with traditional and alternative digital therapies are warranted to establish clinical effectiveness and best practice guidelines.

Conclusions

This pilot study demonstrates that VR-based rehabilitation is generally well accepted by both postoperative patients and physiotherapists, with usability ratings indicating an excellent level of user-friendliness across age groups and genders. The findings suggest that VR applications can serve as a feasible and engaging supplement to conventional physiotherapy in clinical settings. Physiotherapists’ positive attitudes toward VR highlight its potential to support clinical workflows, especially amid workforce shortages.

However, the limited sample size, brief exposure time, and single-center design indicate the need for further research. Larger, randomized controlled trials with extended intervention periods are necessary to confirm these findings and evaluate long-term usability, clinical effectiveness, and cost-benefit aspects.

Overall, VR-based rehabilitation shows promise as a valuable tool for enhancing patient motivation and adherence, supporting physiotherapists, and potentially improving postoperative recovery outcomes.

Acknowledgments

We sincerely thank the physiotherapy team at Pius-Hospital Oldenburg for their valuable support and collaboration throughout this study. We would like to thank apoQlar medical for developing and providing the app, which was originally created within the KI-SIGS application project (AP390) ‘Bewegungstraining’.

Conflicts of Interest

Sirko Pelzl reports a potential conflict of interest as the managing director of apoQlar medical, the company that developed and provided the app used in this study. All other authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Data Availability

The data presented in this study are available on request from the corresponding author.

Author Contributions

Merle Schlender and Tim Schneider contributed equally to the study design, conceptualization, data analysis, and writing of the manuscript. Nomi Kreß was involved in the conception and design of the study, as well as in data collection. Verena Uslar and Navid Tabriz also contributed to the study's design and concept. Sirko Pelzl was also involved in the study design and, in particular, in the development of the app. Dirk Weyhe were the primary idea generators for the study and were both involved in its conception and design. All authors contributed to the drafting of the manuscript and approved the final version for publication.

Abbreviations

VR: virtual reality
SUS: System Usability Scale

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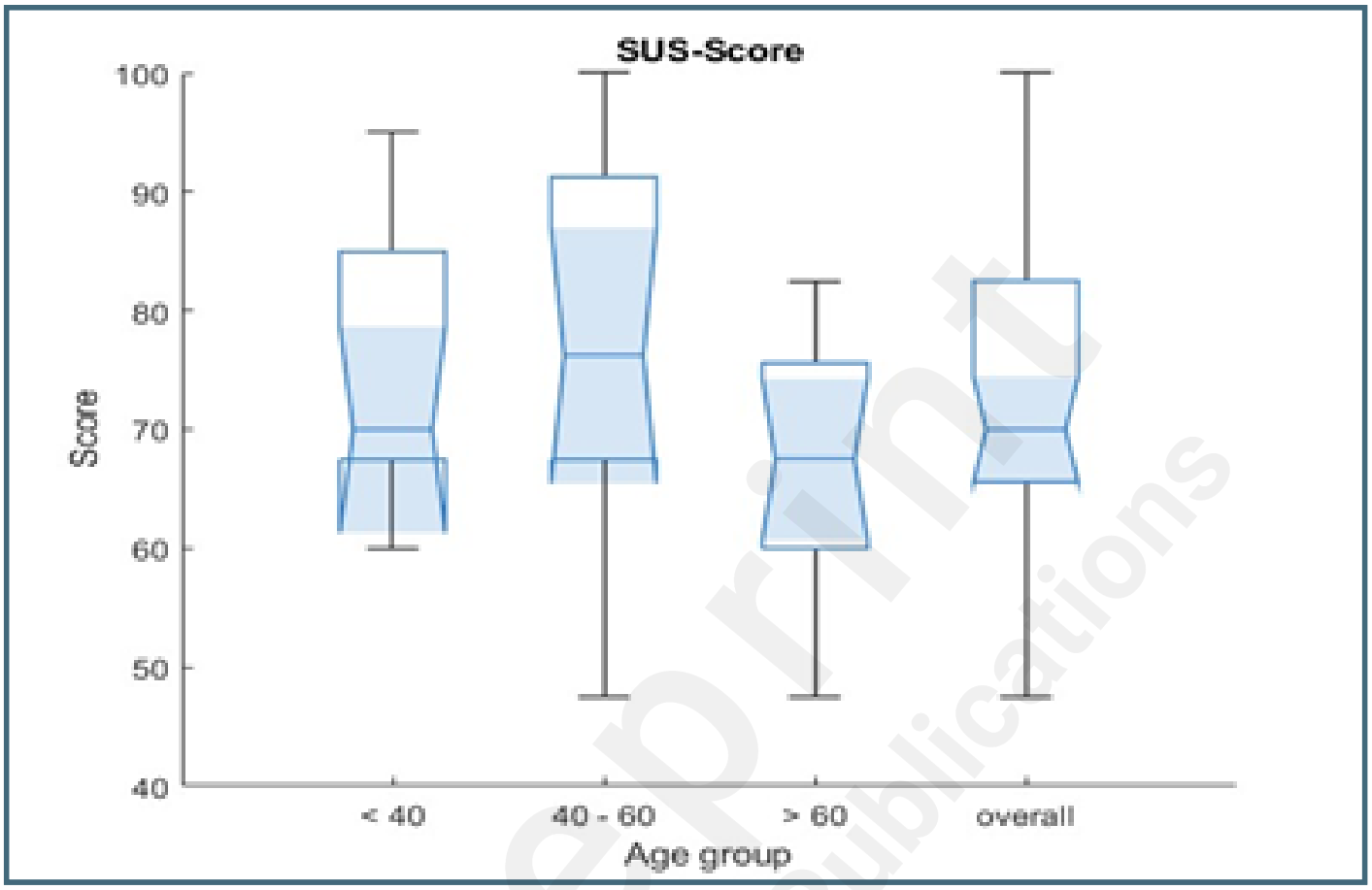
Supplementary Files

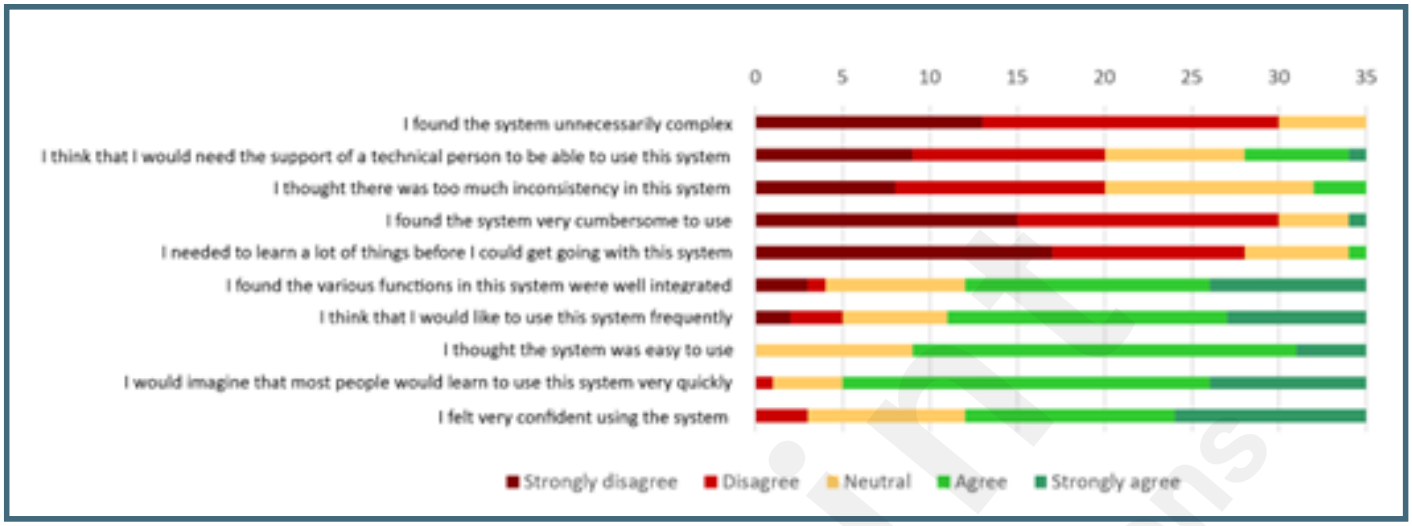
Figures

Illustration of the virtual reality application ‘Beer Pong’ used in the study. The game was designed to promote upper body movement and coordination through interactive, game-based tasks in a simulated environment.

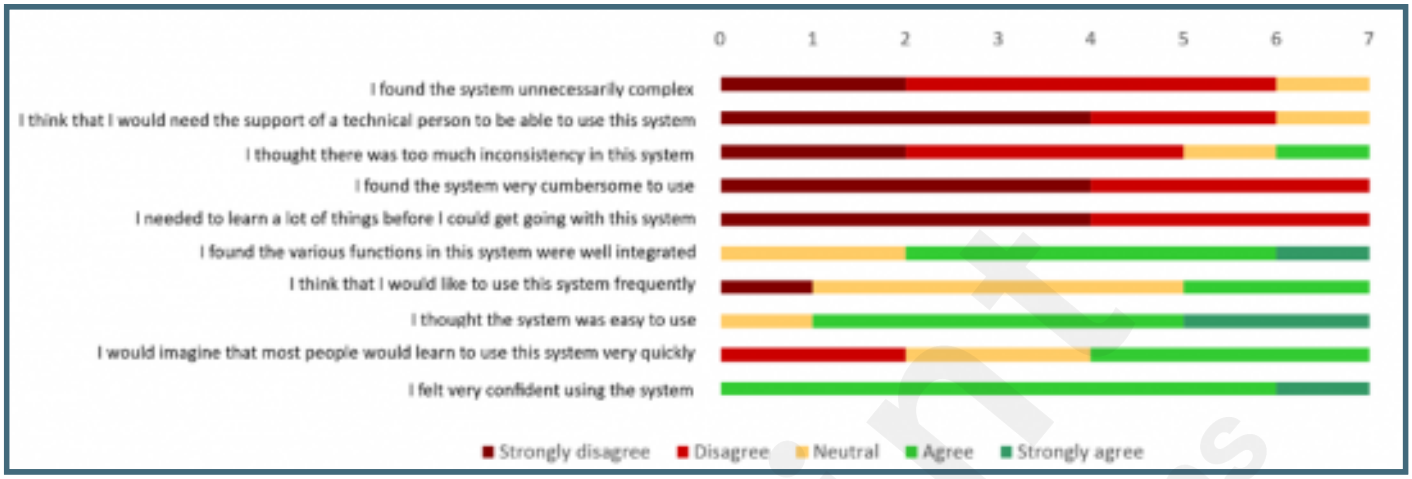
Boxplots of SUS scores across age groups (60 years) and for the total sample. The plots illustrate the median, interquartile range (IQR) in each group.



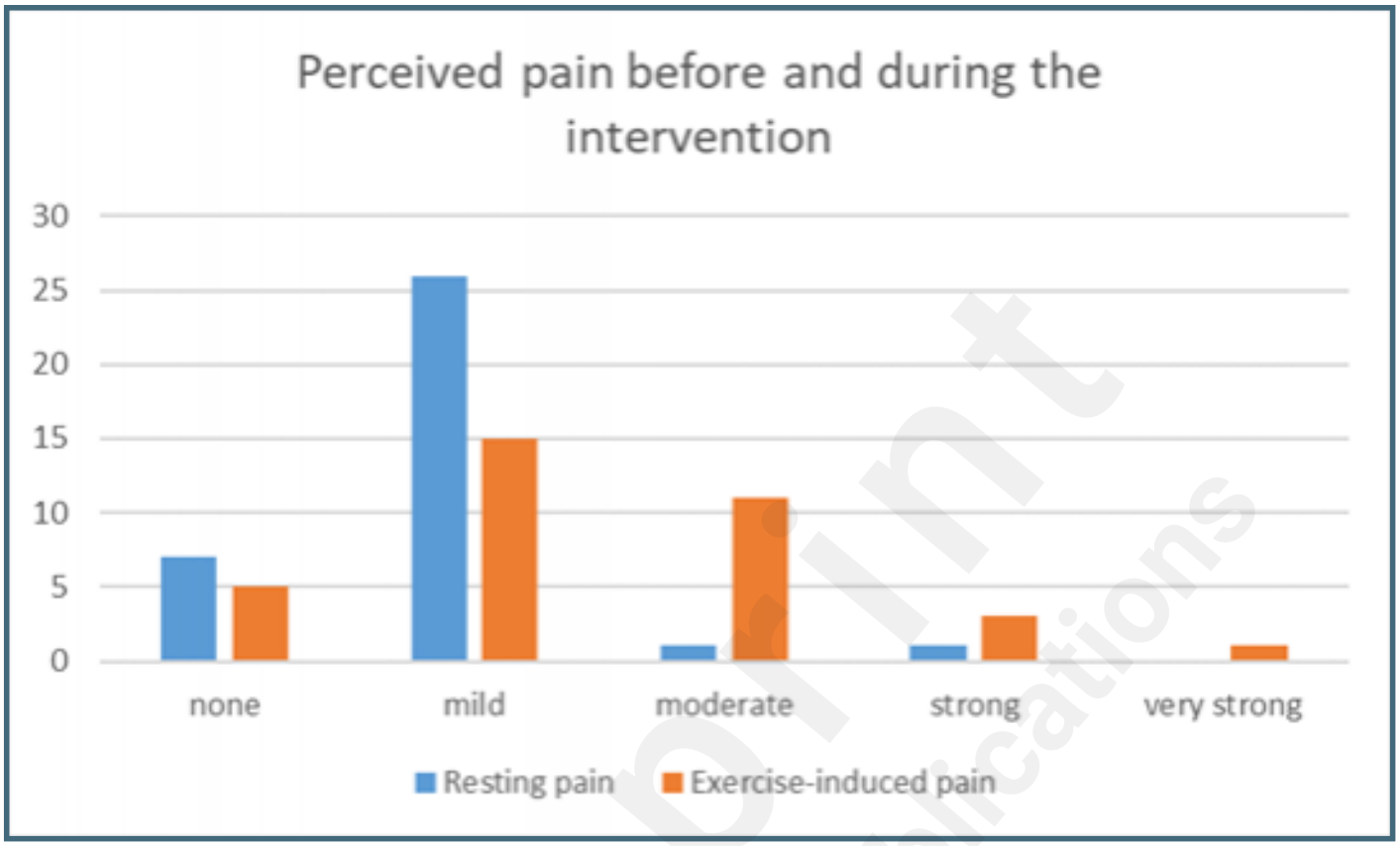
Distribution of responses given by the 35 patients to each of the ten SUS items, distinguishing between negatively and positively worded statements and illustrating their agreement levels on a 5-point Likert scale.



Distribution of responses given by the seven physiotherapists to each of the ten SUS items, distinguishing between negatively and positively worded statements and illustrating their agreement levels on a 5-point Likert scale.



Patient-reported pain intensity levels before and during the exercises.



TOC/Feature image for homepages

TOC image for homepage.