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Virtual Reality Mental Health Interventions in Geriatric Care for Functional or Well-being Enhancement – A Scoping Review

Virtual-Reality-Interventionen zur Verbesserung funktionsorientierter Gesundheit und Wohlbefinden bei geriatrisch Pflegebedürftigen – Ein Scoping Review

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ABSTRACT

Purpose It has become common to use Virtual Reality (VR) for mental health interventions; however, its use in care of the elederly is limited, especially regarding mood and well-being. In this review, we summarize the results of current VR-based mental health interventions for this population.

Methods Peer-reviewed journal articles on immersive VR mental health intervention in seniors, published until 2022, were included.

Results There were 2697 results found in the database search, of which 40 articles met the inclusion criteria and were included in the final analysis. Most studies did not use an experimental design with randomized controlled trials and follow-up sessions. Function-oriented and entertainment-oriented intervention studies were categorized. VR-based geriatric mental interventions have grown rapidly since 2018, especially the number of interventions that promote wellbeing. The function-oriented intervention used active interactions with varied devices. Entertainment-oriented interaction was primarily passive, seldomly using hand controllers for moving activities. Generally, VR interventions improved the mental health of older adults.

Conclusion Geriatric rehabilitation can benefit from this innovative technology to maintain cognitive functions and to improve the well-being of seniors. They have potential for use in aging care and in retirement homes. Future VR intervention may also involve promoting social interaction to combat loneliness among seniors.

ZUSAMMENFASSUNG

Ziel der Studie Virtual Reality (VR) Interventionen zur Förderung der psychischen Gesundheit können auch neue Möglichkeiten im Bereich geriatrischer Rehabilitation bieten. Bislang gibt es kaum VR in der Altenpflege, insbesondere nicht zur Wohlbefindensförderung. In diesem Scoping Review fassen wir die Ergebnisse aktueller VR-basierter Interventionen im Bereich der psychischen Gesundheit von Senioren zusammen.

Methode In die Untersuchung wurden peer-reviewed Fachartikel zu immersiven VR-Interventionen im Bereich der psychischen Gesundheit von Senioren aufgenommen, die bis zum Jahr 2022 veröffentlicht wurden.

Ergebnisse In der Datenbanksuche wurden 2697 Ergebnisse gefunden, von denen 40 Artikel die Einschlusskriterien erfüllten und in die abschließende Analyse aufgenommen wurden. Die meisten Studien verwendeten kein experimentelles Design mit randomisierten kontrollierten Studien und Nachuntersuchungen. Seit 2018 ist ein deutlicher Zuwachs von wohlbefindens-orientierten Gesundheitsinterventionen für Senioren zu verzeichnen. Die Interventionen wurden in funktionsorientierte und unterhaltungsorientierte Studien unterteilt. Die funktionsorientierten Interventionen beinhalteten aktive Interaktionen mit verschiedenen Geräten. Die unterhaltungsorientierten Interventionen waren hingegen hauptsächlich passiv und beinhalteten kaum bewegungsbezogene Aktivitäten mit Controllern. Im Allgemeinen verbesserten VR-Interventionen die psychische Gesundheit älterer Erwachsener.

Schlussfolgerung Die geriatrische Rehabilitation kann von innovativen VR-Technologien profitieren, um kognitive Funktionen zu erhalten und das Wohlbefinden von Senioren zu verbessern. Sie haben Potenzial für den Einsatz in der Altenpflege und in Seniorenheimen. Zukünftige VR-Interventionen sollten auch die Förderung sozialer Interaktionen zur Reduktion von Einsamkeitserleben bei Senioren zum Gegenstand machen.

Introduction

Over the past few decades, the proportion of the aging population has increased rapidly. The demographic shift poses a challenge to the health and social systems of many countries [1]. It is the responsibility of the social system to take care of and support the lives of older people. The aging of society is resulting in an increasing demand for geriatric rehabilitation. The aging process necessitates support from the society for seniors. As age increases, age-related physical and psychological changes might cause an increasing range of disorders for the elderly, both physically [2] and psychologically [3]. Consequently, seniors need treatment in order to maintain or regain function, as well as to improve their quality of life and well-being. In the mental health field, it is essential to develop innovative and engaging interventions [4] Therefore, research regarding innovative technologies for mental health is growing rapidly, for example, virtual reality (VR) [5, 6].

Virtual Reality

VR can broadly be defined as a computer-enhanced simulation experience, which creates a virtual environment. There are three types of VR: non-immersive, semi-immersive, and fully immersive. Non-immersive VR-based products have become part of our daily lives, such as digital maps (e. g. Google Maps) and video games (e. g. Dota 2). Using a computer-generated interface, they provide a virtual representation of the real world [7]. Semi-immersive VR can provide a partial immersive environment with three-dimensional (3D) graphics, but the view field is limited. By using a high-resolution display, projector, or hard simulator allow the user to focus on the more realistic visual effects [7]. The semi-immersive VR is used for educational and training purposes, such as flight simulators for flight training of airborne firefighters (e. g. [8]) or social ability training for children (e. g. [9]). Fully immersive VR provides visual and auditory stimulation in full 3D effect. Moreover, tactile (e. g. [10]) and haptically stimuli (e. g. [11]) are possible with the fully immersive VR technique [12]. The completely immersive environment makes the user feels like they have stepped into the computer-synthesized world [13] and creates a sense of presence, the sensation of being there [14]. This artificial world is assessable through the head-mounted displays (HMD, e. g. Oculus Rift) or a Cave Automatic Virtual Environment (CAVE). The user can manipulate hand consoles or use the hand-tracking technique to interact with the VR-environment (e. g. [15]). These properties provide the possibility for more sophisticated simulations [7, 12, 16].

VR-based mental health intervention in seniors

Immersive VR is increasingly being used in a variety of clinical settings as well as in mental health settings due to the characteristics described above [5, 6]. For example, a considerable amount of evidence supports the effectiveness of virtual reality exposure therapy of anxiety disorders and posttraumatic stress disorders [17], addiction (e. g. [18]), the therapy of eating disorders (e. g. [19]), as well as social skills and cognitive training in children with high-functioning autism (e. g. [20]). Immersive virtual reality is expected to become important in the field of mental health in the future [6, 17].

In terms of its application to older adults, immersive virtual reality has also been shown to have several benefits. A fully immersive environment and the sensation of presence can provide a sensitive treatment comparable to that available in the real world [21]. Moreover, VR offers a safer approach to therapy [22], and it can prevent for example exposure to adverse conditions (e. g. high noise or high temperature) in exposure therapy [23]. This feature is especially important for individuals who are vulnerable, such as the elderly. In addition, the interaction in the immersive virtual environment is natural and straightforward. Senior citizens can easily get started by putting on the headset or entering the CAVE environment. They can interact with the VR environment by using a console or, if hand tracking technology is available, by using their hands directly. This is more natural to use this method than, for example, a keyboard. Furthermore, immersive VR requires just the HDM (e. g., when using hand tracking technology), and it can be used almost anywhere, regardless of the time, place, or object [17, 24]. As a result of this adaptability, there may be considerable opportunities to address the challenges faced by elderly individuals with mobility concerns, such as in the rehabilitation and assisted living of physically disabled individuals in a nursing home.

Moreover, according to the Technology Acceptance Model (TAM), user acceptance of technology is influenced by perceived usefulness and ease of use [25]. Personal attributes and environmental factors, such as self-efficacy and facilitation, play a more

significant role in technology acceptance than perceived advantages [26]. In geriatric populations, perceived usefulness, perceived ease of use, and perceived enjoyment also positively impact the acceptance of VR interventions [27–29]. Numerous studies have indicated that immersive VR is well-received by the geriatric population [5, 29, 30]. For example, older adults' initial experiences with head-mounted VR were followed by positive participant feedback indicating a positive shift in attitude towards the technology [5]. Additionally, cybersickness is a possible side effect that needs to be considered in VR interventions. Participants were more susceptible to cybersickness when exposed for 20 minutes compared to 10 minutes [31], however, the detected symptoms were only moderate and did not lead to dropouts. In a systematic review about cybersickness in fully immersive VR [32], it was found that most of the included 39 studies reported only minor instances of cybersickness among older adult participants. This indicates that cybersickness is not a significant barrier to the application of VR and can be managed through careful design and regulation of the time spent wearing the head-mounted display (HMD). Nevertheless, it is necessary to implement changes in order to provide a user experience that is optimal for older individuals [30].

Currently, VR applications in physical rehabilitation, such as motor control and balance training for the elderly, are the most extensively researched (e. g. [33]). It is important to note, however, that most of these studies used a non-immersive or semi-immersive VR experience [23, 34]. The number of immersive VR-based psychological studies conducted on the geriatric population is still limited, especially in terms of the improvement of well-being and mood [6, 35]. A systematic review of the VR intervention on mental health in senior was published by Skurla et al. [6].This review focused on the evidence and experimental methods used in these studies, as well as on the mental disorders that they investigated. Furthermore, they identified three categories of VR indications in these studies: screening, testing, and training. In this present review, we focus on VR-based interventions that are classified as training initiatives, due to the fact that they are relevant for geriatric rehabilitation. Otherwise, Skurla et al. [6] covered all of the immersion gradations, including non- immersive and semi-immersive, of VR-interventions for seniors. For this scoping review, we will focus on immersive VR interventions that use HMDs or CAVEs.

Review question

The review question is: Which types of intervention studies and evidence exists regarding immersive VR-interventions supporting mental health of the elderly?

This review provides an in-depth analysis, systematization, and classification of immersive VR-intervention studies, and assess their effectiveness for mental health. We are interested whether there has been any advancement in VR interventions not only training functions, but enhancing well-being and quality of life of seniors, which could be utilized in geriatric rehabilitation. The systematized information may also serve as a reference for future research in this area.

Inclusion Criteria

This scoping review will concentrate on research that focuses on older adults. The age of participants in the reported studies was on average older than 60 years. The studies point out that they focus on the older population or age-related effects. This scoping review examines VR-interventions and its outcomes for elderly people with the intention of improving their mental health, such as psychotherapies, cognitive function training, or well-being and quality of life. HMD or CAVE environment should be used in the VR intervention to provide a fully immersive experience. To assess how different interventions and how these factors affect different outcomes, we obtained detailed findings regarding experiment design, content of VR interventions, and forms of VR interaction from the studies. This will enable us to observe the development of VR-based interventions that will be used in the future for the ageing care.

The focus is on VR-interventions or therapies to improve the mental health of seniors worldwide in a variety of settings, such as a nursing home, or rehabilitation centre.

This scoping review will consider designs including randomized controlled trials, non-randomized controlled trials, before and after studies, and interrupted time-series studies. In addition, analytical observational studies including prospective and retrospective cohort studies, case-control studies and analytical cross-sectional studies will be considered for inclusion. Qualitative studies, reviews, and text and opinion papers will not be considered (adapted from JBL-Manual, [36]).

Methods

The proposed scoping review is conducted in accordance with the JBI methodology for scoping reviews [36, 37].

Search strategy

We used a Boolean search following: (“virtual” OR “virtual reality”) AND (“older” OR “older adults” OR “geriatric” OR ”elderly” OR “senior”). The year of publications was not filtered to ensure all relevant studies are included.

The databases to be searched include PubMed, Scopus, PsychNet, PsyJournals, PubPsych (a database synthesized from nine portals: PSYNDEX, PASCAL, ISOC-Psicologia, MEDLINE, ERIC, NARCIS, NORART, PsychOpen, PsychData), and Google Scholar published up to 2022. Based on the language skills of the authors, studies published in English, German, and Chinese are included. The reference list of all included sources of evidence were screened for additional studies (adapted from JBL-Manual). When the full text of possible targeted studies was not available, we contacted the authors to request it.

Evidence selection

Once the search has been conducted, all identified citations were uploaded into Zotero [38]. Duplicates were removed. After deduplication, the authors screened and selected the titles of the records. The excluded studies were rechecked independently by trained research assistants. We created a matrix and re-examined records that had the potential to be targeted with more details from the abstract or detailed information from the main text.

The articles we selected need to have fulfilled the following conditions: 1) Use of immersive virtual reality, environment, or game application, 2) primary outcomes in the area of mental health (e. g. cognitive training, psychological therapy, well-being, etc.), 3) focus on older adults population, average age > 60 years, 4) peer-reviewed journal article and presenting experimental data. The exclusion criteria were as follows: 1) review and meta-analyse, 2) full-text not available, 3) article not available in English, German or Chinese, 4) not focus on the geriatric population, 5) Use non- or semi-immersive VR, 6) outcome does not focus on mental health, 7) VR indication as screening and testing, not for training and intervention, 8) result or with less quantitative analysis.

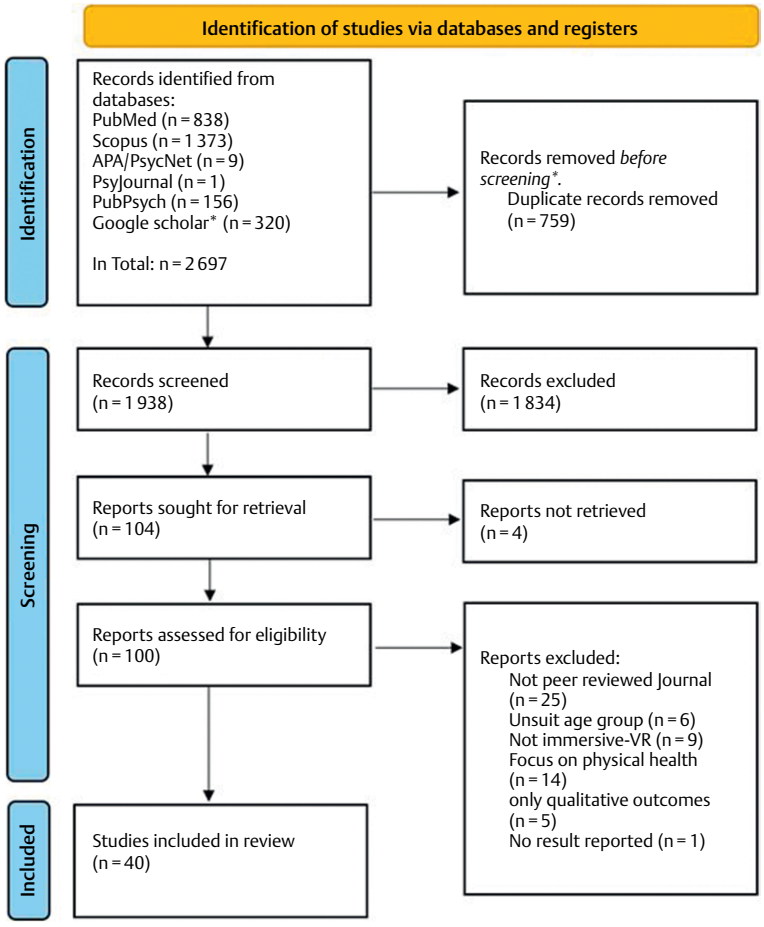
Data extraction

Following the selection process, author 1 extracted data from the full text of the articles included in the review. Microsoft Excel [39] was used for the initial data extraction and a matrix was developed for categorizing the evidence collected. This data extraction will include specific information about the participants, the year of publication, the concept, the context, the study methods, the VR-Intervention, and the key findings relevant to the review question. Whenever we were unable to locate certain information in the full text, we contacted the research team directly. At the end, author 2 rechecked all the data. If there are disagreements between the reviewers at any stage of the selection process, they were resolved through discussion. The results of the search and the study inclusion process will be presented in a Preferred Reporting Items for Systematic Reviews and Meta-analyses extension (PRISMA) flow diagram which was adapted from Moher et al. [40].

Results

Search results

▶ **Fig. 1** shows the complete selection process in a PRISMA flowchart. A total of 2697 records were collected from the seven databases during the phase of literature research until 2022. There were 759 duplicate records that were removed. As a result of examining the headlines and information in the abstracts, 1834 records have been excluded due to misfit to the inclusion criteria. Excluded were studies which did not contain VR interventions, or VR was focused on physical training, young populations, caregivers for the elderly,



* Google Scholar Records were first screened on the website. Studies with relevant titles have been manually saved in a list and downloaded. In this case, 320 is the number of records in the list that have been saved.

▶ **Fig. 1** The PRISMA flow chart of the article selection adapted from Moher et al. [40].

or screening and assessment. Overall, 104 articles were determined to be potentially eligible. The full-text of four of those reports was not available despite full-text requests sent to the authors. Consequently, 100 full-text reports were reviewed to ensure that they were in accordance with our objectives "VR-based interventions focusing on mental health outcomes for the elderly". Additionally, 60 articles were removed because they were not published in peer-reviewed journal articles (25), the population studied was not suitable (6), immersive VR training or intervention was not provided (9), mental health outcomes were not reported (14), outcomes were not statistically analysed (5), and no results were reported (1). In the end, 40 articles were selected for review.

Inclusion of sources of evidence

All 40 selected studies were peer-reviewed and published between 2010 and 2022. Throughout these studies, fully immersive VR technology was used with a major focus group of seniors recruited from clinical settings, nursing homes, or source portals of universities or organizations. The study locations include North America, South America, Asia, Australia, and Europe (details are provided in ▶ **Online-Table 1,2**). Different types of studies are included, such as randomized controlled trials, quasi-experiments, and case studies. Inclusion is limited to studies that provide quantitative measurements and outcomes.

The articles were classified based on whether they focused on entertainment (e. g. relaxation, for fun) or function training (e. g. cognitive training). We extracted and summarized the 40 included reports based on the above required information (see data extraction and analysis). In ▶ **Online-Tables 1** (entertainment-oriented) and **2** (function-oriented) with detailed descriptions of the content and procedures of each study, as well as outcomes. In total, 12 studies reported applications for seniors that were entertainment-oriented, while 28 papers reported applications that were function-oriented.

Included studies: Publications years

In the research area of entertainment-oriented VR, all studies were published since 2019 and their number is growing. In the function-oriented area, there is a sharp increase from five in 2020 to fourteen in 2021.

Included studies: Methods and study designs

VR applications that were designed for senior citizens were primarily targeted at those aged 65 to 80. A total of 18 studies reported the mean age within this range. There were only four out of 28 papers that examined the age group below 65 (mean age) years, and four papers that examined the age group over 80 (mean age).

One out of twelve studies for entertainment used a special sample group consisting of individuals suffering from dementia or mild cognitive impairment [49]. In these entertainment-oriented studies, the majority of participants were from nursing homes (83 %), and the remaining participants came from university recruitment portals (17 %). There were no studies that recruited seniors from a clinical setting in order to conduct entertainment-oriented research.

There were 19 out of 28 studies in the function-oriented category that focused on therapies or training for the elderly with depression, cognitive decline, or pain. In the function-oriented study, participants were recruited from clinical settings (32 %), nursing homes (25 %), or announcements on university portals (43 %).

Only ten studies used a randomized controlled trial design. Among entertainment-oriented studies, the rate of experimental design is 17 %, while in function-oriented studies, the rate is 29 %. There were only eleven follow-up sessions scheduled for 40 studies. In 30 out of 40 studies, a comparison between two groups was conducted. The proportion of studies with a comparison group in the entertainment-oriented category is 58 % compared to the total number of studies in this category, while 82 % in the function-oriented category. A total of 20 studies compared a control group with an experimental group. In other studies, comparisons have been made between younger and older individuals, or between seniors with mild cognitive impairment and those with dementia (▶ **Online-Table 1, 2**).

Included studies: VR intervention content and measurement

Nearly all of the studies used a HMD for immersive experiences, with the exception of Sultana et al. [49] that used a special projector to create immersion in a room. In the entertainment category, all twelve projects shared the same goal of relaxation and enjoyment for older people. They used majorly rating scales for well-being, mood, and quality of life. There were 15 of 28 programs that focused on cognitive training in the function-oriented studies. There were two programs designed specifically for the purpose of memory training (e. g. [54]). Eleven other studies focused on different treatment goals, such as fear of falling(e. g. [56]), depression(e. g. [58]), vestibular rehabilitation exercises (e. g. [59]), or pain management(e. g. [67]). A total of five out of twelve (42 %) entertainment-oriented studies contained only one VR session, while there is only one study on function-oriented VR interventions [61] (▶ **Online-Table 1,2**).

In eight entertainment-oriented VR studies, the interaction form was passive, which means that seniors did not need additional control over other technical devices to complete the VR session. In contrast, 21 of 28 function-oriented studies utilized the active interaction method. In general, 14 of the 21 studies chose hand consoles as their primary interaction device. Moreover, other active VR applications interacted with motion trackers (e. g. [72]), pedals and wheels (driving games [70], or control pads [69, 81].

Included VR studies: Mental health outcomes

All twelve entertainment-oriented VR studies had significant positive effects on the mental health of seniors. According to seven of these studies, VR sessions had a positive impact on mood, well-being, or quality of life. Four of these results were examined in follow-up sessions. Of the 28 function-oriented studies, 24 showed at least one positive effect for the achievement of the treatment goal. Among those articles with positive outcomes, six were examined by a follow-up session. Moreover, seven studies involving function-oriented interventions assessed whether mood, well-being, or quality of life had changed. However, only two of them showed significant improvements. There was no long-term follow-up on any of them.

Discussion

General result

This scoping review investigated recent studies that applied fully immersive VR technology to mental health in older adults. Following an extensive literature search in the databases, as well as subsequent selection and filtering, we reviewed 40 relevant full articles. According to the purpose of the interventions, we classified the evidence into two categories: function-oriented and entertainment-oriented VR interventions. Twelve of the 40 studies are entertainment-oriented, while 28 are function-oriented.

Publications year

By the end of March 2020, Carroll et al. [82] reported that only six studies had utilized fully immersive VR technology in both the physical and psychological domains among older adults. As a result of the increasing number of studies presently available, it is apparent that research into immersive VR for the health of older people is becoming increasingly popular. Additionally, the findings confirm the limitation of the review presented by Skurla et al. [6] that VR intervention research is a rapidly developing field and may require updating as more studies are published. Moreover, Skurla et al. [6] found that there was limited research on VR techniques for older adults to improve well-being and mood until 2019. As shown in our present review, the number of studies on immersive VR interventions for the elderly that are specifically targeted at improving their mood, well-being, and quality of life increased sharply after 2020. Thus, the research gap on VR for improving well-being in older adults has been filled. Further, VR-interventions for seniors are becoming increasingly important in recent years to enhance their mental capabilities as well as their level of well-being.

Evidence of VR interventions

There was evidence that VR interventions enhanced at least one study target in 36 out of 40 selected papers, both in functional and entertainment areas. This suggests that the use of fully immersive technology in geriatric rehabilitation and ageing care could be a viable and effective method of intervention in the future.

Only four out of the function-oriented VR studies reported on mood and well-being after training. Among these, only two showed a significant impact of function-oriented VR training on mood and well-being. There may have been a lack of attention paid by VR designers to the enjoyment of the task in function-oriented training. Combining joy of the task with functional training effects may, however, be beneficial, it may reduce potential aversion to intense training on the part of the participant [83]. Thus, in developing function-oriented VR training programs, VR designers should also consider the task enjoyment and the senior-centred design in addition to the training effects.

Moreover, the stability of the results of VR interventions needs to be demonstrated, particularly in entertainment-oriented studies that aim to improve well-being and quality of life. As well-being may be strongly influenced by the environment [84], it may be that the positive impact of VR on well-being disappears once the intervention is completed. Long-term follow-ups have been done only in a few studies. Until now, there is insufficient evidence on positive long term-effects.

Furthermore, it's important to note that only a limited number of studies in this review employed an experimental design, many of the studies reviewed did not meet the quality criteria expected for rigorous research. Therefore, it is imperative that future research on VR interventions in geriatric rehabilitation places a stronger emphasis on conducting randomized controlled trials (RCTs). This approach would not only enhance the validity of the evidence but also provide a more robust foundation for assessing the true impact and effectiveness of VR interventions in improving the well-being and cognitive abilities of older adults.

Function-oriented and entertainment-oriented VR studies

Two critical aspects of geriatric mental health rehabilitation are the maintenance of mental and cognitive function and the improvement of well-being and quality of life. Thus, we classified VR studies as function-oriented and entertainment-oriented. In this section, we provide a scoping view by summarizing and discussing the current state of affairs in these two categories.

As a result of our scoping review, referred to as function-oriented research, VR efforts are aimed at improving a function or reducing an impairment. In these studies, the primary objective is to evaluate whether abilities can be enhanced in result of a VR intervention or training. The primary objective of this study is to identify the training effect. An example of a function-oriented VR intervention task is memory training [54]. In an exemplary VR supermarket scenario, the elderly participants are provided with a shopping list containing six objects. Following this, the virtual cashier engages them in a conversation to interference them by asking short questions such as "How is the weather today?" After this interaction, the elderly participants are tasked to remember the objects from the list and to locate them within the virtual supermarket environment. Our results indicate that the assessment of mood and well-being of older people is rarely and merely a by-product of this function-oriented study (e. g. [70]). Compared to studies focused on entertainment-oriented VR, studies focused on function-oriented VR appeared earlier and are currently more numerous in geriatric research. Conversely, entertainment-oriented VR interventions do not have a clearly defined goal for functional improvement, but rather prioritize relaxation and enhancing positive emotions among seniors. An example of such an intervention task is a virtual travel experience. For example, seniors were immersed [41] in a virtual environment for a VR tour of Hong Kong. The seniors reported their levels of positive and negative emotions before and after the virtual tour. Important for rehabilitation is that until now, entertainment-oriented VR interventions have not taken into account functional improvements, such as social participation.

Furthermore, the results indicated the content of function-oriented VR is usually more practice-oriented than that of entertainment-oriented VR. Function-oriented VR interventions are always designed with a clear purpose. There is a more specific target population for them. The recruitment may focus only on one gender or on seniors suffering from specific diseases, such as dementia, and may also occur within a clinical setting. In contrast, entertainment-oriented VR interventions are always aimed at seniors in general. VR sessions geared towards entertainment are less intense, with approximately half containing only one session. Eight of twelve

entertainment-oriented VR studies used a passive interaction model in terms of VR content and interaction. In this sector, VR applications do not require the older user to interact with the VR scene or use an interaction device. Even when interacting with the VR environment was required, the remaining four studies used very simple task content with no training objectives and fewer challenges, for example, gardening games [52]. Only hand consoles were used for interaction. It was more common for function-oriented VR research to involve active interaction with the VR environment. Among the 28 function-oriented VR studies, 21 chose this format. When used, interactive devices can be of a variety of types. Aside from the consoles, there are also motion trackers, steering wheels, pedals, and infrared lasers. It can be concluded that most of the entertainment-oriented VR studies rely on passive interaction with lower technical requirements, while most of the function-oriented VR studies use active interaction with a variety of interactive devices. Indeed, the precise selection of VR intervention tasks and interaction forms, whether they are function-oriented or geared towards entertainment, plays a pivotal role in the successful application of VR design in geriatric rehabilitation. Striking the right balance in interaction form and complexity is an important factor. On one hand, it is essential to recognize that human cognitive capacity is limited, and seniors often have reduced cognitive function. Therefore, VR designs should be mindful of the cognitive load placed on seniors. Complex interactions or an overload of information can overwhelm users, especially seniors with reduced cognitive function. Designers should strive to minimize unnecessary complexity to ensure that seniors can process information and complete tasks effectively. On the other hand, selecting suitable interaction forms and complexity levels can enhance the perceived ease of use for seniors. This is significant because an interface that is perceived as easy to use can substantially improve the acceptance of VR interventions among seniors. In essence, striking the right balance in interaction design is a key factor in making VR interventions more accessible, effective, and well-received by older adults in geriatric rehabilitation.

VR intervention design in geriatric rehabilitation

Two reviewed studies have compared the impact of VR cognitive training between younger and older adults. VR is a feasible and powerful tool for engaging the physical and cognitive abilities of older adults [73], with seniors reporting a similar level of enjoyment compared to younger adults. The average cognitive function of seniors was lower than that of younger people [61]. VR cognitive training had a greater impact on the older group than the younger one, coming along with significant activation of the parietal lobe. These studies comparing age groups suggest that seniors may have stronger requirements for and improvement after cognitive training. There was also a comparative study to explore the differences in technology acceptance between older and younger adults [85]. The results showed that both groups reported similar perceived usefulness and perceived ease of use, and that these play significant roles in technology acceptance. These findings highlight that the success of such studies is not solely dependent on the age of the participants, but on their specific requirements. Whether it's for functional training or entertainment, understanding and meeting the unique needs of seniors is crucial for designing effective VR interventions in geriatric rehabilitation. For example, VR training for seniors with dementia should take their cognitive level into account and avoid complex interactions. Seniors living in nursing homes may benefit more from meaningful activities and group events that enhance social engagement against inactivity and loneliness [86, 87]. Careful consideration should be given to the social context and cultural background of the participants. Many of the studies included in our review had a global scope, and while most did not explicitly emphasize cultural backgrounds, language use, or daily habits, some incorporated culturally specific content into their designs. For example, Chan et al. [41] created a VR tour of Hong Kong tailored to seniors in that region, providing entertainment that resonated with their cultural experiences. Another study introduced traditional Chinese Tai Chi as a form of cognitive training, aligning with the cultural background of the participants [57].

In sum, the design of VR interventions for geriatric rehabilitation should take into account both the individual requirements and the socio-cultural context of the seniors participating in the program. This personalized and culturally sensitive approach can enhance the effectiveness and acceptance of VR interventions among older adults.

Limitations

Despite our literature search lasting until 2022, the number of studies in the field of immersive VR for geriatric mental health continues to grow. It is therefore possible that some articles published recently in 2023 have not been considered. The list of articles will need to be updated regularly as suggested by Skurla et al.[6]. Moreover, in order to enhance the focus on our core research question, other interesting topics have been given less attention. A VR-intervention may have different effects on older people depending on their age (e. g., the youngest, the middle-aged, the oldest). Additionally, it is important to examine the influence of experimental design aspects, such as the type of control group or cluster randomization.

Conclusions and recommendations

Conclusions

During the last few years, research on immersive VR for the mental health of older people has surged rapidly, with an increased number of function-oriented and newly emerging entertainment-oriented fields aimed at enhancing well-being. Most VR interventions showed a positive effect on mental health among older adults. Using immersive virtual reality (VR) technology can be an innovative and promising method for maintaining mental and cognitive functions, as well as for promoting well-being, activity and quality of life in geriatric rehabilitation and in retirement homes. It is common for function-oriented VR interventions to target specific populations of seniors and make use of active interaction as well as a variety of interactive devices. Conversely, entertainment-oriented VR interventions are aimed at the general senior population and use less active interaction, i. e. older persons are less likely to interact with VR environments. Moreover, the VR intervention design

in geriatric rehabilitation should consider the clinical requirements of the target population, not only focusing one the age.

Implications of the findings for research

Recent research studies on VR mental health interventions for seniors provide a first attempt to combine seniors with VR technology, demonstrating the significance of this topic. In order to gain a better understanding of how VR can be used for rehabilitation purposes, more studies focusing on social interaction and participation outcomes are needed. Follow-up measurements are needed in determining whether there are long-term effects or whether the effects are limited to the VR sessions themselves in the elderly. Also, interventions should integrate both function-orientation and well-being/entertainment. In the case of functionally oriented VR training, research should also focus on how the exercises affect the well-being of older people, namely how much enjoyment they receive during the functional training. As a result, training may also be more effective. Further, the study or meta-analysis of the effective intensity and duration of VR-intervention may provide useful advice for future studies, more specifically according to different categories (function- and entertainment-oriented). Finally, VR design concepts that focus on the experience of older users should be explored and adopted in special populations and their social context, for example, the seniors in nursing home.

Implications of the findings for practice

The findings of this scoping review underscore the value of VR as a tool in geriatric rehabilitation. It is evident that VR interventions in this field are still relatively novel, with only a limited number of studies conducted, including one in Germany. While the reviewed VR interventions provide valuable insights into the design of such programs, it is essential to emphasize the importance of conducting a thorough needs task analysis before embarking on VR interventions in aging care. Careful consideration should be given to the design of interactions and language use, ensuring they are adapted to the specific needs of older adults. Additionally, the successful implementation of VR interventions in geriatric rehabilitation necessitates an understanding of how these interventions can be effectively integrated into the cultural and social contexts of the target population. In conclusion, VR holds great promise as a tool for improving the well-being and cognitive abilities of older adults in geriatric rehabilitation. However, to maximize its benefits, a thoughtful and contextually relevant approach to VR intervention design is crucial. For example, in requirement for the senior in nursing home, VR mental health interventions for older adults may combine entertainment and function aspects and emphasize social interaction. A potential of VR intervention could be offered in a nursing home as a group event in which seniors participate in activities they cannot perform anymore (e. g. gardening, making pizzas, setting up a holiday home). In this way, cognitive functions can be practiced in an enjoyable manner, the well-being can be improved as well, experiences can be exchanged, and social interaction can be enhanced within a group. It is also possible that this will reduce the work-load of nursing home staff. With these novel concepts, more options will be available for geriatric rehabilitation, thereby preventing seniors from being left behind by advances in technology.

Data availability

Data are the 40 original articles on which this review is based on. They are accessible via public databases or from the authors upon request.

Statement of Ethics

Ethical approval was not obtained, because no human beings have been investigated directly.

Description of authors' roles

Y. L. conducted literature search and literature analysis, prepared the tables, and wrote the manuscript. B. M. designed the research question and supervised the research process, and contributed to writing and revision of the manuscript.

Conflict of Interest

The authors have no conflicts of interest to declare.

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