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The role of virtual reality on physical and psychological health among older adults: A systematic review

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Abstract: To synthesis and appraise the existing research about the effect and outcomes of virtual reality (VR) interventions among older adults. A systematic review. This systematic review was conducted following the PRISMA guidelines and including multiple databases: Scopus, CINHAL, PubMed, Medline, and Web of Science, from 30 March 2014 to 30 March 2024. A total of 13 studies from 424 articles were included in the review. Seven studies were randomized control trial (RCT) and five studies were quasi-experimental study for feasibility trial with one for longitudinal study. The intervention group showed positive outcomes on physical activity and cognitive function ($p<0.001$) among older adults. This review concluded that the use of virtual reality intervention can promote cognitive function, physical health, mental health, well-being, and reduce the risk of falls among older people. VR technology plays the role to improved physical and psychological health among older adults. Future research can study the standardized VR intervention on health promotion for the effect and sustainability among older people.

Keywords: *Ageing, Geriatric nursing, Older people, Systematic reviews, Virtual reality.*

1. Introduction

The population ageing is a global phenomenon. One in six people in the world will be aged 60 years or over by 2030, it is expected that the number of persons aged 80 years or older will be triple between 2020 and 2050 to reach 426 million. People are living longer and need better ageing care. Geriatric nursing (GN) is important and essential to provide quality of care to older people. As technology advanced, virtual reality (VR) has been adopted into geriatric nursing with positive effects in learning experiences. Moreover, there are different studies used VR to improve ageing care across countries. In this review, the broad outcomes and effects in using VR of GN were discussed and reviewed.

Virtual Reality (VR) is the use of various technologies to digitally simulate or recreate an environment in which the participant can realistically hear, see, and/or feel as though they are a part of the simulation. Virtual reality provides an immersive experience for participants to learn by engaging and interacting with the software on a physical, emotional and cognitive level.

VR applied through technologies uses such as wearable head-mounted displays (HMDs), noise-cancelling headphones, and other multimodal stimuli to immerse the wearer in the virtual atmosphere. VR has been a critical training tool in the fields of aviation, military combat, and surgery, it has recently shifted towards clinical health care, training and education. VR technique has been increasingly used in the treatment of physical and mental health disorders, such as depression, anxiety, and other mood disorders among older population. VR has significant potential in reconstructing conventional approaches to patient care with the decreasing costs and increasing accessibility of digital media. VR was concluded as the safe equipment for Canadian older adults with varying degrees of cognitive and physical impairment. VR programme increased the feelings of pleasure and alertness among dementia residents in Australia nursing home. VR technologies can reduce isolation and aid in the health recovery

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of older adults. VR has demonstrated positive outcomes in applying to older populations and ageing care, the link of VR application in older people care should be further studied and explored for the evidence into future health care.

Virtual reality has been shown to have a variety of benefits and a growing body of research involves the use of virtual reality in aged care settings. Due to the lack of further knowledge for VR in aged care, a systematic review on the VR for the use to older population and the characteristics and their relationships has been studied from 2014 to the present. It should be known the relationships between characteristics of older people and VR use for the magnitude and significances, and further to understand the direction to future studies. This review included studies across country and area. The characteristics of older population and the use of VR situation may differ among countries and areas, therefore the results of VR application among older adults may not be the same outcomes. Nevertheless, it is important to understand the characteristics of older adults for the role and outcomes of VR technology use, and to conclude the common link between older population and the VR use.

2. Methods

A systematic review was conducted to ascertain the impact of VR use on physical and psychological health among older adults. This review is reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. As this study comprised a systematic review, ethical approval was not required.

2.1. Search Strategy

The following databases were used in the search conducted on 30 March 2024 (Table 1): Scopus, Web of Science, PubMed, Medline complete and CIHAHL complete.

This study followed JBI's three-step search strategy:

Firstly, for the purposes of this systematic review, the initial Web of Science search included keywords, index terms, titles and abstracts.

Secondly, this used the following terms for the full review in the following databases: ("older people*" or "older people" or "geriatric*" or "gerontology*" or "geriatric*" or "ageing*" or "geriatric*" or "elderly*") and ("virtual simulation*" or "virtual immersion*" or "instructional virtual*" or "virtual reality*" or "virtual realit*"): Scopus, Web of Science, PubMed, Medline complete and CIHAHL complete, using "virtual reality in geriatric care settings" or "long-term care" in phrases such as "virtual reality" to search Google for grey literature (e.g. student theses and university dissertations and other articles not included in library databases). The first and second authors worked together to refine the search strategy. We used the reference management tool endnote 20 to collate all references and articles selected for our review, removing duplicates. We sorted the selected articles by paper title, author(s), year, country or region, study aim, research design and methods, main results.

Table 1.
Results of literature search and databases used (Accessed on 2024-03-30).

Database or further sources (Results) Search string
Web of Science (123) (TI= ("older people" OR "older people*" OR "geriatric*" OR "gerontology" OR "ageing*" OR "elderly*")) AND (TI= ("virtual simulation*" OR "virtual immersion*" OR "instructional virtual*" OR "virtual reality*" OR "virtual realit*")) AND PY= (2014–2024)
Scopus (123) TITLE ("older people" OR "older people*" OR "geriatric*" OR "gerontology" OR "ageing*" OR "elderly*") AND TITLE ("nursing" OR "care" OR "nurse" OR "nurs*") AND TITLE ("virtual simulation*" OR "virtual immersion*" OR "instructional virtual*" OR "virtual reality*" OR "virtual realit*") AND (PUBYEAR. 2014)

PubMed (85) (((((virtual simulation*[Title]) OR (virtual immersion*[Title])) OR (instructional virtual*[Title])) OR (virtual reality*[Title])) OR (virtual realit*[Title])) AND ((((((older people [Title]) OR (older people*[Title])) OR (geriatric*[Title])) OR (gerontology [Title])) OR (ageing*[Title])) OR (elderly*[Title])) Filters: from 2014 – 2024
MEDLINE Complete (30) TI ("older people" OR "older people*" OR "geriatric*" OR "gerontology" OR "ageing*" OR "elderly*") AND TI ("virtual simulation*" OR "virtual immersion*" OR "instructional virtual*" OR "virtual reality*" OR "virtual realit*") Date: from 2014 to 2024; apply equivalent subjects
CINAHL Complete (63) TI ("older people" OR "older people*" OR "geriatric*" OR "gerontology" OR "ageing*" OR "elderly*") AND TI ("virtual simulation*" OR "virtual immersion*" OR "instructional virtual*" OR "virtual reality*" OR "virtual realit*") AND TI ("nursing" OR "care" OR "nurse" OR "nurs*") Publication Date: 20140330-20240330; apply equivalent subjects

2.2. Selection Criteria

All titles and abstracts founded in this searched were examined by two authors, searching for the study aims, population, methods of VR intervention, and outcomes of VR use in older population. Discrepancies were studied by researchers. Finally, 13 published studies were included for full-text review that met inclusion and exclusion criteria. The inclusion criteria for this full-test review were: (1) studies that included participants who were aged 60 or older; (2) studies on the uses of virtual reality (VR) among older people; (3) studies mentioned of any facilitators or barriers to VR implementation; (4) relevant studies published in journal articles, full reports, case studies, user reports in English. The exclusion criteria were: (1) focused on users who were aged younger than 60; (2) studies that did not focus on virtual reality (VR) and VR related implementations to older adults; (3) studies that full text was not in English; (4) theses and dissertations; (5) studies published before April 2014.

2.3. Data Extraction

The various interpretations were subjected to critical analysis in order to identify and resolve any conflicts. The extracted data were collectively evaluated, refined, and collated into categories in order to develop the final themes. Each paper was read by two researchers, who then collaborated to create a graphical representation of the data. Please refer to Figure 1, which depicts the PRISMA flow diagram, for a detailed illustration of the review process.

2.4. Assessment of Quality

The included studies were evaluated using a standardized critical appraisal tool. Standard Quality Assessment Criteria (SQAC) to evaluate the quality of studies. Authors independently evaluated the methodological quality of the included studies. Thus, the methodological quality of the studies that met the inclusion criteria was assessed using the evaluation criteria developed by Kmet et al. (2004).

2.5. Data Synthesis

Figure 1 illustrates the PRISMA chart, which outlines the process of literature search and study screening. The initial search yielded 424 papers from the database, with 267 papers ultimately retained after duplicates were removed. The screening phase was conducted in a randomised manner within the study, with 157 papers excluded after two authors independently reviewed the titles and abstracts to determine if they met the PICO criteria. Inconsistencies were resolved by a third author. A total of 27 trials were selected for full-text review. Of the remaining 27 studies, 14 were excluded after applying the inclusion and exclusion criteria. Thirteen studies met the predefined inclusion criteria. Finally, 13 studies were included in the content analysis. Although the identified retrospective studies were not

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included in the results, they were used as references for comparison with the results. Table 3 lists information about the included studies.

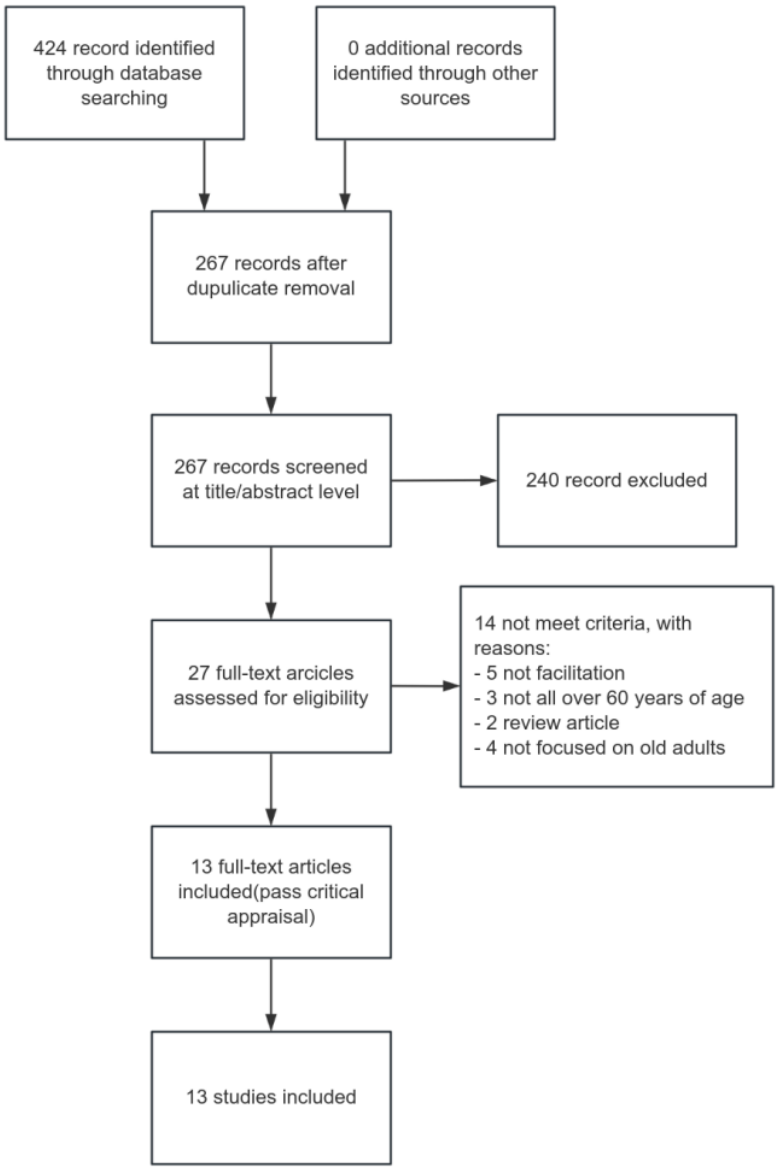

Figure 1.
PRISMA 2024 flow diagram for new systematic reviews which includeed searches of databases and registers only.
Source: Aromataris E, Lockwood C, Porritt K, Pilla B, Jordan Z, editors. JBI Manual for Evidence Synthesis. *JBI*; 2024. Available from: https://synthesismanual.jbi.global.

3. Results

3.1. Study Selection

A literature search yielded 13 articles meeting the eligibility criteria. The initial search in March 2024 identified 424 potentially relevant studies, with 157 studies removed before screening. The

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remaining 267 studies were screened for abstracts and 240 studies were excluded. After full-text screening of the remaining 27 studies, 14 were excluded, the most common reasons were 1) not all participants were over 60; 2) no accommodations/reporting; 3) no focus on older adults; or 4) review articles. This left 13 studies available for analysis. The screening process is shown in Figure 1. All studies were published after 2018, with 12 of the 13 studies (92%) published within the last five years. For further details, please refer to Table 2.

3.2. Quality Assessment

The included studies were appraised using Quality Assessment Criteria Scores for Quantitative Methodologies. The study designs included quantitative and mixed-methods approaches to assess various outcomes such as fall risk, cognitive functioning, and well-being in cognitively impaired older adults through VR training.

The methodological diversity of the studies is reflected in their experimental designs, which include quasi-experimental studies, within-subject studies with pre- and post-intervention measures, and randomized controlled trials, alongside a descriptive feasibility study. Among these, one study employed a single-blind (assessor) randomized controlled trial design, and another utilized a non-blinded randomized controlled trial design.

All studies included in this review met a rigorous quality assessment standard, scoring above 75, as outlined in Table 3. This indicates a well level of methodological rigor across the included studies, supporting the reliability of the findings regarding the use of VR in geriatric care.

3.3. Study Characteristics

The included studies were conducted in Australia (n=1), Taiwan (n=2), Japan (n = 1), Iran (n= 2), Egypt (n = 1), Poland (n = 1), Germany (n = 1), Korea (n=1), France (n = 1), and China (n=2). 7 studies were randomized control trial (RCT), 5 studies were quasi-experimental study for feasibility trial and one study was longitudinal study. The studies collectively included 445 participants, with the sample size from 10 to 116. The mean age of the participants ranged from 60 to 87 years. The majority of participants was female (16.7~100%) including one study only involved female participants.

3.4. Description of the VR Intervention

Table 4 presents a summary of the VR type, intervention dosage (duration, frequency, session duration, and setting.)

3.4.1. VR Type and Function

Five VR equipment were analyzed in this study, including VR wander application for photos and videos (n=1), Microsoft Xbox Kinect for physical activity (n=4), HTV VIVE to promote cognitive function (n=2), Off-the-shelf application for video (n=1), and self-designed VR for cycling and images (n=6) . The function of VR were including reminiscence (n=2), to improve physical activity and balance (n=7), cognitive function improvement (n=6), and fall prevention (n=1). It is noted that VR function of two studies involved physical activity and cognitive improvement among older people.

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Table 2.
Summary of included studies in this review.

Study (Year), Place	Participants	Study design/ Setting	Intervention	Duration	Outcome measures	Results
Abd El Fatah et al.(2024), Egypt	N=60 Mean age=66.7 Female=53.3 %	RCT/Elderly home	1. VR group to provide more personalized reminiscence interventions. 2. Reminiscence interventions (RT)group3. Control group.	30-45mins session, twice a week, over six weeks	1. The mini-mental state examination (MMSE) 2. Revised riff's psychological well-being scale (RPWBS) 3. Cyber sickness in virtual reality questionnaire (CSQ-VR) 4. Experience in immersive virtual environment questionnaire	VR and RT groups were efficacious in improving cognitive function and psychological well-being among institutionalized older adults.
Babadi & Daneshmandi (2021), Iran	N=36 Mean age=66.9 Female=52.8 %	RCT/Nursing home	1. VR training (VRT) program included boxing, table tennis, and soccer from the sports Pack 1. 2. Conventional balance training (CBT). 3. Control group.	A 60-min session, 3 times per week, for 9 weeks	To assess the participants' balance, the balance tests 1. single-leg stance (SLS) with open and closed eyes, 2. Functional reach test (FRT), 3. Timed up and Go Test (TUG), 4. Fullerton Advance Balance Scale (FABS).	VRT and CBT training groups were superior to improve the elderly's balance in daily programs of nursing homes.
Barsasella et al.(2021), Taiwan	N=60, 7 age groups from 60 to 94, Female=76% .	RCT/older adults visited the active ageing center at the university	1. VR group received VR experience sessions from VR apps to improve the physical activity and well-being. 2. The comparative group received no sessions	15 min twice a week for a duration of 6 weeks.	1. EQ-5D-3L questionnaire for quality of life. 2. Mini version of the Chinese Happiness Inventory (CHI). 3. Functional fitness tests:weight(kg), body-mass index (BMI), waist circumference (WC; in cm), waist-to-hip ratio, diastolic blood pressure (BP;mmHg) and systolic BP (mmHg).	Older adults showed significant improvements in quality of life (Pain/Discomfort and Anxiety/Depression), happiness and some functional fitness components in VR group.

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Study (Year), Place	Participants	Study design/ Setting	Intervention	Duration	Outcome measures	Results
Brimelow et al. (2022), Australia	N=25 Mean age=74 Female=88.23%	A feasibility trial/ Aged care facility	To measures Pre and Post Individual VR Sessions (Twenty-five residents grouped into 5 groups. Groups viewed 360-degree videos on a wireless head-mounted display to provide fully immersive VR experiences)	60 mins session, twice weekly for 3 weeks.	1. The cornell scale for depression in dementia, 2. Generalized anxiety disorder 7-item, 3. Cohen mansfield agitation Inventory eShort 4. The person-environment apathy rating apathy subscale, 5. Observed emotions rating scale 6. A visual analog scale (Smileometer)	VR reduced depressive symptoms and apathy, and induced a positive emotional response in most residents in aged care facility.
Kaminska et al.(2018), Poland	N=23 Mean age=75.7 Female=82%	One group for intervention/ daytime social welfare institution	one group for 30-day VR training using an Xbox 360 Kinect, including warm-up, football, bowling, and downhill skiing games in the Kinect Sports series.	30 minutes, 3 times a week, 4 weeks.	1. The 6-minute walking test (6MWT), 2. The Dynamic Gait Index (DGI), 3. The tandem stance test (TST), 4. The tandem walk test (TWT), 5. The Beck Depression Inventory (BDI), Spring hand dynamometer.	VR increases the possibilities of motor training and can help reduce the risk of falls by improving the static and dynamic balance.
Kim et al.(2021), Korea	N=10 Mean age=85.8 Female=100 %	A feasibility study/nursing home	One group for two phases: 1. To identify activities that alleviated the behavioral and psychological symptoms of dementia, 2. The second phase: a fully immersive, interactive, easy-to-use VR platform for patients with dementia experienced the VR content.	20-30 minutes for 1-2 sessions	1. The level of the participants' immersion, preference, and interactionwith the VR. 2. The participants' tolerance for VR: Need assistance, length of experience (min), participants reaction, VR sickness.	VR increased immersion, preference, interaction, and tolerance, these findings support the potential use of VR-based intervention programs to treat patients with dementia.

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Study (Year), Place	Participants	Study design/ Setting	Intervention	Duration	Outcome measures	Results
Kwan et al. (2021), China	N=17 Mean age=74 Female=88.2 %	RCT/an elderly community center	1. Intervention group received cognitive training (ie, cognitive games) and VR motor training (ie, cycling on an ergometer). 2. Control group involved providing motor and cognitive without VR.	30 minutes twice a week for 8 weeks.	1. Cognitive function: the MoCA, 2. Physical frailty level: the phenotypes of frailty, 3. Walking speed: Timed Up-and-Go (TUG) test 4. Feasibility was measured by adherence, adverse outcomes, and successfullearning.	VR simultaneous motor-cognitive training was effective and safe at enhancing the cognitive function of older people with cognitive frailty.
Li et al. (2024), Germany	N=116 Mean age=80.7 Female=69.8 %	A longitudinal study with VR interventions/14 nursing homes	Older adults completed at least 3 VR interventions that they would not be able to do in real life, such as gardening and making pizza.	30 minutes, once a week for 4 weeks.	1. Mini-ICF-Rating for Impairment in Psychological Activities 2. Capacities (Mini-ICF-APP) scale	VR intervention concluded as a meaningful group activity in nursing homes to support social group interaction, activity level, and well-being.
Liao et al.(2020), Taiwan	N=34 Mean age=74.3 Female=67.6 %	RCT/Communities and day care centers	1. A VR-based physical group and cognitive training (VR) group, 2. A combined physical and cognitive training (CPC) group	60 minutes each visit, three times a week for 12 weeks.	1. Global cognition, 2. Executive function: Executive Interview 25 (EXIT-25), 3. Verbal memory: The Chinese version of the Verbal Learning Test (CVVLT), 4. Functional status: IADL 5. Brain activation: A 16-channel NIRS device (OEG-16, Spectratech Inc., Yokohama, Japan)	VR-based physical and cognitive training improved cognitive function, IADL and neural efficiency in older adults with mild cognitive impairment (MCI).

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Study (Year), Place	Participants	Study design/ Setting	Intervention	Duration	Outcome measures	Results
Loggia et al.(2020), France	N=12 Mean age=75.3 Female=16.7 %	Prospective crossover proof of concept study/Nursing home	Two stationary cycling sessions with with and without VR.	30 mins for one activity.	1. Cycling distance, pedalling duration, average speed, mean pedalling cadence 2. The modified Borg rating of perceived exertion scale.	The use of VR helped to achieve physical activity recommendations for able-bodied people living in nursing homes, even with moderate cognitive impairments.
Niki et al.(2021), Japan	N=10 Mean age=87 Female=60%	A pilot RCT/a single nursing home	Two groups (A or B) in equal numbers, and they alternately viewed two types of VR images (LA and CG) through iVR Reminiscence themed on the mid- to late Showa era (A.D. 1955–1980) in Japan.	30 mins for one activity.	1. The Mini-Mental State Examination (MMSE) Japanese version 2. The numerical rating scale (NRS) 3. State-Trait Anxiety Inventory (STAI)	iVR reminiscence reduced anxiety in the oldest-old without causing serious side effects. Furthermore, the impacts might be better with LA images.
Qiu et al. (2022), China	N=14 Mean age=68.8 Female=57.1 %	A descriptive feasibility study/hospital	A single group: Cognitive training with a VR-based program consisting of five games for cognitive training.	90 mins for one activity	1. Recognition: Global cognition (MMSE) 2. Visuospatial function (CDT) 3. Executive function (STT) 4. Attention (SDMT) 5. Verbal memory (AVLT)	VR-based cognitive training was well tolerated by Chinese older adults, without major or severe adverse events.
Zahedian-Nasab et al.(2021), Iran	N=60 Mean age=70.8 Female=45%	RCT/Nursing home	1. Intervention group received VR exercises based on Xbox Kinect Xbox Kinect in form 2. Control group received routine exercises of the nursing homes	Two 30–45-min sessions held on a weekly basis for 6 weeks	Included a demographic questionnaire, the Berg Balance Scale (BBS), the Timed Up and Go (TUG) test, and the Falling Efficacy Scale (FES)	VR balance exercises enhanced the balance and decrease fear of falling among elderly people living in nursing homes.

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Table 3.
Quality assessment criteria scores for quantitative methodologies (Kmet et al., 2004).

Question	Abd El Fatah et al.,2024/ Egypt	Babadi & Daneshmandi, 2021/ Iran	Barsasella et al., 2021/ Taiwan	Brimelow et al., 2022/ Australia	Kaminska et al., 2018/ Poland	Kim et al., 2021/ Korea	Kwan et al., 2021/ China	Li Y et al., 2024/ Germany	Liao et al., 2020/ Taiwan	Loggia et al., 2020/ France	Niki et al., 2021/ Japan	Qiu et al., 2022/ China	Zahedian-Nasab et al., 2021/ Iran
1.Question/objective sufficiently described?	2	2	2	2	1	2	2	2	2	2	1	2	2
2. Study design evident and appropriate?	2	2	1	2	1	2	2	2	2	2	2	2	2
3. Method of subject/comparison group selection or source of information/input variables described and appropriate?	2	2	1	1	2	2	2	2	1	1	1	2	1
4.Subject (and comparison group, if applicable) characteristics sufficiently described?	2	2	2	1	1	1	2	2	1	1	1	1	2
5.If interventional and random allocation was possible, was it described?	2	2	2	2	1	1	1	1	2	1	1	2	1
6. If interventional and blinding of investigators was possible, was it reported?	1	N/A	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2
7. If interventional and blinding of subjects was possible, was it reported?	2	1	2	2	1	2	2	2	2	1	1	1	2

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Question	Abd El Fatah et al.,2024/ Egypt	Babadi & Daneshmandi, 2021/ Iran	Barsasella et al., 2021/ Taiwan	Brimelow et al., 2022/ Australia	Kaminska et al., 2018/ Poland	Kim et al., 2021/ Korea	Kwan et al., 2021/ China	Li Y et al., 2024/ Germany	Liao et al., 2020/ Taiwan	Loggia et al., 2020/ France	Niki et al., 2021/ Japan	Qiu et al., 2022/ China	Zahedian-Nasab et al., 2021/ Iran
8. Outcome and (if applicable) exposure measure(s) well defined and robust to measurement / misclassification bias? Means of assessment reported?	2	1	1	1	2	2	1	1	1	1	1	1	2
9. Sample size appropriate?	2	2	2	2	1	2	1	2	2	1	2	2	2
10. Analytic methods described/justified and appropriate?	2	2	1	1	2	2	2	2	2	2	2	2	2
11. Some estimate of variance is reported for the main results?	2	2	2	2	2	2	2	2	2	2	2	1	2
12. Controlled for confounding?	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13. Results reported in sufficient detail?	2	2	2	2	2	2	2	2	2	2	2	2	2
14. Conclusions supported by the results?	2	2	2	2	2	2	2	2	2	2	2	2	2
Score	25	22	22	20	18	22	21	22	21	18	18	20	24
Max.	26	24	26	24	24	24	24	24	24	24	24	24	26
%	96	91	84	83	75	91	87	91	87	75	75	83	92

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Table 4.
Description of the VR intervention.

Study (year)	Abd et al. (2024)	Babadi & Daneshmandi (2021)	Barsasella et al. (2021)	Brimelow et al. (2022)	Kaminska et al. (2018)	Kim et al. (2021)	Kwan et al. (2021)	Li et al. (2024)	Liao et al. (2020)	Loggia et al. (2020)	Niki et al., (2021)	Qiu et al. (2022)	Zahedian-Nasab et al. (2021)
VR equipment													
VR Wander application	☐												
Microsoft Xbox Kinect		☐			☐				☐				☐
HTC VIVE app			☐						☐				
Off-the-shelf application				☐									
Self designed VR						☐	☐	☐		☐	☐	☐	
VR Function													
Reminiscence interventions	☐										☐		
Physical activity		☐	☐		☐		☐	☐	☐	☐			
Cognitive function	☐			☐		☐	☐		☐			☐	
Fall prevention													☐
Dosage													
Duration													
Once						☐				☐	☐	☐	
3-4 weeks				☐	☐			☐					
6-8weeks	☐		☐				☐						☐
9-12 weeks		☐							☐				
Frequency													
1 time per week								☐					
2 times per week	☐		☐	☐			☐		☐				☐
3 times per week		☐			☐								
Session duration													
15-30 mins			☐			☐					☐		
30-60 mins	☐			☐	☐		☐	☐		☐			☐
60 mins		☐							☐				
90 mins												☐	
Setting													
Nursing home or institution	☐	☐		☐		☐		☐	☐	☐	☐		☐
Research center			☐				☐					☐	
Hospital					☐								

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3.4.2. Dosage

The duration of the VR intervention ranged from one time to 12 weeks. The frequency of the group activities ranged from one to three times per week, with each ranged from 15 to 90 mins. Four studies applied one time of VR intervention with duration from 20 to 90 mins.

3.4.3. Intervention formats and setting

All studies address the procedure of intervention and group sessions. Three studies reported that the VR interventions were conducted at research center and one study was applied at the hospital. All studies reported the attendance rate was fulfilled the research purpose.

3.4.4. Control

Three studies received no session for control groups. Three studies received cognitive training or routine exercise without VR. One study used different VR images into control group.

3.5. Effect of VR intervention

The outcomes of studies were including cognitive function improvement, physical activity advanced, balance and fall prevention.

3.5.1. Mental Health and Cognitive Function Improvement in Older Adults

Two studies concluded that VR reminiscence improved cognitive function and well-being among older adults. One study reported that MMSE (The Mini-Mental State Examination) was increased after VR intervention from 14.15 to 21.2 ($p<0.001$). The VR reminiscence was including photos and videos to reduce anxiety to promote cognitive function. Studies concluded group-based VR reduced psychological symptoms and promote positive emotional response especially in older people with dementia.

3.5.2. Virtual Reality (VR) on Physical Activity in Older Adults

VR intervention demonstrated the improvements of fitness and quality of life with active ageing. VR cycling promoted physical spontaneous activity among dementia older adults in nursing home. The VR group-based activity provided the positive impact on physical activity level and enhanced the social intervention and well-being among older people in nursing home.

3.5.3. Virtual Reality (VR) on Balance and Fall Prevention in Older Adults

The virtual reality training programmes can be used as a new training method to improve the balance of older adults in daily programmes in nursing homes. Two studies concluded that VR intervention used Microsoft Xbox Kinect as intervention that improved motor and physical balance and reduced the risk of fall among older adults in community and nursing home.

4. Discussion

The aim of this study is to synthesis and appraise the existing research about the effect and outcomes of virtual reality interventions among older adults. The systematic review showed that VR intervention improved physical and cognitive function of older people including dementia older adults, as well as enhanced balance and safety to older adult. The effects of VR technology on the physical activity and cognitive function among older adults were significant improved but high heterogeneity. The high heterogeneity was due to variation in place, sample size, VR intervention type, duration, frequency, setting, and outcome measure. The positive outcomes of VR on reducing behavior symptom, anxiety, apathy and depressive symptoms were also significant, with a moderate effect size. It's effect on the outcomes, including balance, physical activity, physical frailty, mental status, cognitive function, quality of life.

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The effect sizes of flexibility reported in the current review are different, the reason may be related to the difference in inclusion criteria of studies. Due to VR intervention is relatively updated in ageing care, this review also included quasi-experimental studies for the overall comprehensive review. Therefore, this review summarized and provided more broaden evidence supporting the VR intervention on the effects and outcomes among older adults. However, the effects of standardized VR software and hardware remained unclear and the existing evidence was inconsistent. More studies are needed to design and examine the standardized VR in ageing care further to study the effects in older adults.

As VR has been applied in geriatric nursing education with positive effects among nursing students in learning experiences, the included studies concluded VR has positive effects and outcomes among older adults in ageing care. The studies generally showed a high attendance rate for the VR intervention as the accessibility for the setting in nursing home. It was noted that the female was the dominant gender among the participants in the included studies, especially one study involved female only as participants. The possible reasons for this situation: Female has a long life expectancy, only female residents in the nursing home, and older males are generally more resistant to group activities . In future studies, VR related study should provide more information about the technology, activity, benefits of VR intervention, and sessions exclusively for male participants that might be attracting more male participants for gender balance in the study.

Regarding to the VR intervention, the older participants complained of limited vision and too heavy when wearing the headset. It is suggested that software and hardware of VR should be advanced in the future for better application in health care. The minor adverse effects of VR intervention from wearing the device for the dizziness and disconformable were reported. It is needed to decrease dizziness through increasing image resolution in VR device that can provide a better experience for participants. The severity of adverse effects depended on the type of VR immersion technology used in the study, validated VR device and software are crucial and important for the future study. Moreover, the robust financial support and advanced VR devices are essential in the future study.

5. Conclusion

This review examines the existing literature on the facilitating and hindering role of virtual reality technology in aged care. Existing evidence supports virtual reality intervention as a useful intervention to reduce the risk of falls and improve well-being and cognitive function in older people. This review concluded that the use of virtual reality intervention can promote cognitive function, physical health, mental health, and well-being, and reduce the risk of falls among older people. Future research can study the standardized VR intervention on health promotion for effect and the sustainability among older people.

5.1. Limitation

Due to VR intervention is relatively updated in ageing care, this review also included quasi-experimental studies for the overall comprehensive review, which might have a high risk of bias in the study design leading to an overestimation of the intervention's effects. This review concluded the role and effects of VR intervention among older adults, some concerns of the included studies showed intervention bias in the quality assessment. Specifically, several limitations were concluded. First, the included studies did not report theoretical framework for guiding the study. The conceptual or theoretical framework is essential and important to guide the development of research hypotheses and VR intervention. Second, the software and hardware, content, and dose of VR intervention varied across studies, and the VR intervention development process was not explained. It is unclear to what extent the VR intervention design was supported by evidence. Third, evidence about the sustained effects is unclear as a lack of follow-up assessment after the completion of the VR intervention. Fourth, the small sample sizes were noted that could affect the effectiveness of the outcomes in VR intervention.

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5.2. Implications for Future Research and Practice

This review highlights the necessity for further consideration and contemplation of the role of virtual reality in aged care settings. Further research is required in the following areas: staff training, identification of potential roles, involvement of family members, and obtaining organisational and policy support. As mentioned, a stable financial support for VR hardware and software ae well as further for the maintenance are essential and important. Future research should priorities the integration of users' experiential knowledge with the needs and preferences of older people and care givers in the design process. The implementation of evidence-based frameworks provides guidance throughout the process. It is recommended that future studies can be conducted to evaluate the sustainability and impact of standardized VR programmes among older adults.

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