Enfermería Global
ISSN 1695-6141 Revista electrónica trimestral de Enfermería
N°67 Julio 2022
www.um.es/eglobal/

ORIGINALES

Use of Immersive Virtual Reality on the elderly health, Systematic review

Uso de la Realidad Virtual Inmersiva en la salud del adulto mayor, Revisión sistemática

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https://doi.org/10.6018/eglobal.482751

Received: 8/06/2021
Accepted: 14/09/2021

ABSTRACT:

Introduction: Due to the increase in the number of older adults, there is an increase in the prevalence of chronic diseases, which, together with the deterioration associated to aging, lead to an early decline in physical and cognitive abilities. Within this problem, scientific evidence shows that the use of technological tools such as immersive virtual reality has positive effects on physical and cognitive health in various population groups.
Objective: Collect, review and assess interventions using fully immersive virtual reality systems in older adults.
Method: Using the PRISMA checklist guidelines, a systematic search was carried out in the following databases: PubMed, Wiley Online Library, Science Direct and Google Scholar. The FLC 3.0 platform called “Ficheros de Lectura Crítica” (Critical Appraisal Tool) was used to assess the quality of the studies.
Results: Fourteen studies were included, which provided evidence of the use, acceptance and tolerance of immersive virtual reality, as well as its effect on physical and cognitive health.
Conclusions: The studies analyzed reveal that immersive virtual reality is well accepted and tolerated by older adults, as well as being a promising tool for reversing or delaying physical and cognitive decline. However, the results are not consistent due to the great diversity among virtual reality systems and content used, as well as studies with small samples and uncontrolled designs.

Keywords: Elderly; Virtual Reality; Head Mounted Display.

RESUMEN:

Introducción: El aumento del número de adultos mayores trae consigo un incremento de la prevalencia de enfermedades crónicas, que en conjunto con el deterioro asociado al envejecimiento conducen a una disminución temprana de las capacidades físicas y cognitivas. Dentro de esta

problemática, la evidencia científica muestra que el uso de herramientas tecnológicas como la realidad virtual inmersiva tiene efectos positivos en la salud física y cognitiva en diversas poblaciones.
Objetivo: Recopilar, revisar y analizar las intervenciones que utilizan sistemas de realidad virtual totalmente inmersivos en adultos mayores.
Método: Por medio de los lineamientos del checklist PRISMA se realizó una búsqueda sistemática en las bases de datos: PubMed, Wiley Online Library, Science Direct y Google académico. La plataforma Web 3.0: Ficheros de Lectura Crítica se utilizó para analizar la calidad de los estudios.
Resultados: Se incluyeron catorce estudios los cuales aportaron evidencia del uso, aceptación y tolerancia de la realidad virtual inmersiva, así como su efecto sobre la salud física y cognitiva.
Conclusiones: Los estudios analizados revelan que la realidad virtual inmersiva es bien aceptada y tolerada por los adultos mayores, además de ser una herramienta prometedora para revertir o retrasar el deterioro físico y cognitivo. Sin embargo, los resultados no son consistentes debido a que existe una gran diversidad entre los sistemas de realidad virtual y contenido utilizado, así como estudios con muestras pequeñas y diseños no controlados.

Palabras clave: Anciano; Realidad Virtual; Pantalla Montada en la Cabeza.

INTRODUCTION

The accelerated increase in the number of older adults had increased the prevalence of chronic diseases, which, in conjunction with the deterioration associated to aging, has lead to an early decline in physical and cognitive abilities [1, 2]. Approximately 30% of adults age 60 and older have difficulty walking, 13% have posture problems, and 17% have some type of cognitive impairment [3, 4]. The importance of the loss of these abilities lies in the tendency to advance to more complex health conditions such as frailty, dementia and falls, which affect the independence and quality of life of this age group.

In order to solve this problem, several technological innovations have provided the opportunity to explore various tools in environments that were previously thought impossible [5]. One of these is Immersive Virtual Reality (IVR) systems which, although originally created for entertainment purposes, are nowadays used to promote physical and cognitive health in various population groups [6, 7]. IVR is the technology that provides an almost real or believable experience through the use of virtual reality headsets. The objective of these systems is to thoroughly immerse the user in a computer-generated world, giving the impression that he is in a VR world, in which he can perform cognitive and sensory motor activities while interacting with virtual stimuli[8].

Recently, there has been an increase in research on the implementation of IVR systems in adults aged 60 years and older, and although scientific evidence supports their application in different population groups, their use, acceptance and tolerance, as well as their effect on physical and cognitive health in older adults, are unknown. The systematic reviews found in the literature focus on synthesizing interventions using non-immersive virtual reality systems, which include video game consoles such as Xbox 360, Kinect and Nintendo Wii [9-12].

The increase in older adults with physical and cognitive impairment demonstrates the importance of incorporating effective and innovative strategies focused on reversing or delaying the loss of these abilities. Nursing can benefit from these technological tools, since with little or no care from family members, lack of long-term care units and few health programs for the elderly, simulation-supported self-management can be an alternative to treat functional impairment and its consequences.

Due to the aforementioned, this work was carried out with the aim of collecting, reviewing and assessing interventions that use fully immersive virtual reality systems (virtual reality headsets) in older adult users.

METHODS

A systematic review was conducted following the guidelines established in the PRISMA 2010 statement for conducting systematic reviews and meta-analyses [13].

Eligibility Criteria

All primary studies implementing immersive virtual reality systems (virtual reality headsets) in users aged 60 years or older were included.

Sources of information and search

The electronic databases consulted were: Medical Literature Analysis and Retrieval System Online (PubMed), Wiley Online Library, Science Direct and Google Scholar; searches were performed from February to May 2021, with an established search strategy (Table 1).

Table 1: Search strategy

Data Base	Search Strategy	Records obtained
PubMed	(Aged, older adults **OR** elderly) **AND** (virtual reality **OR** head mounted display **Limits:** Last 5 years	82
Wiley Online Library		258
Science Direct		79
Google Scholar		141

Selection of studies

The results of the searches were downloaded into the EndNote Web bibliographic organizer, where duplicates were eliminated. The remaining studies were then checked by title and abstract to identify those that met the inclusion criteria, as well as to eliminate irrelevant articles. Articles that met the eligibility criteria were fully checked to verify whether or not they were going to be included in the review.

A critical reading of the methodological quality of the studies that met the inclusion criteria was carried out using the application FLC 3.0 “Fichas de Lectura Crítica”.

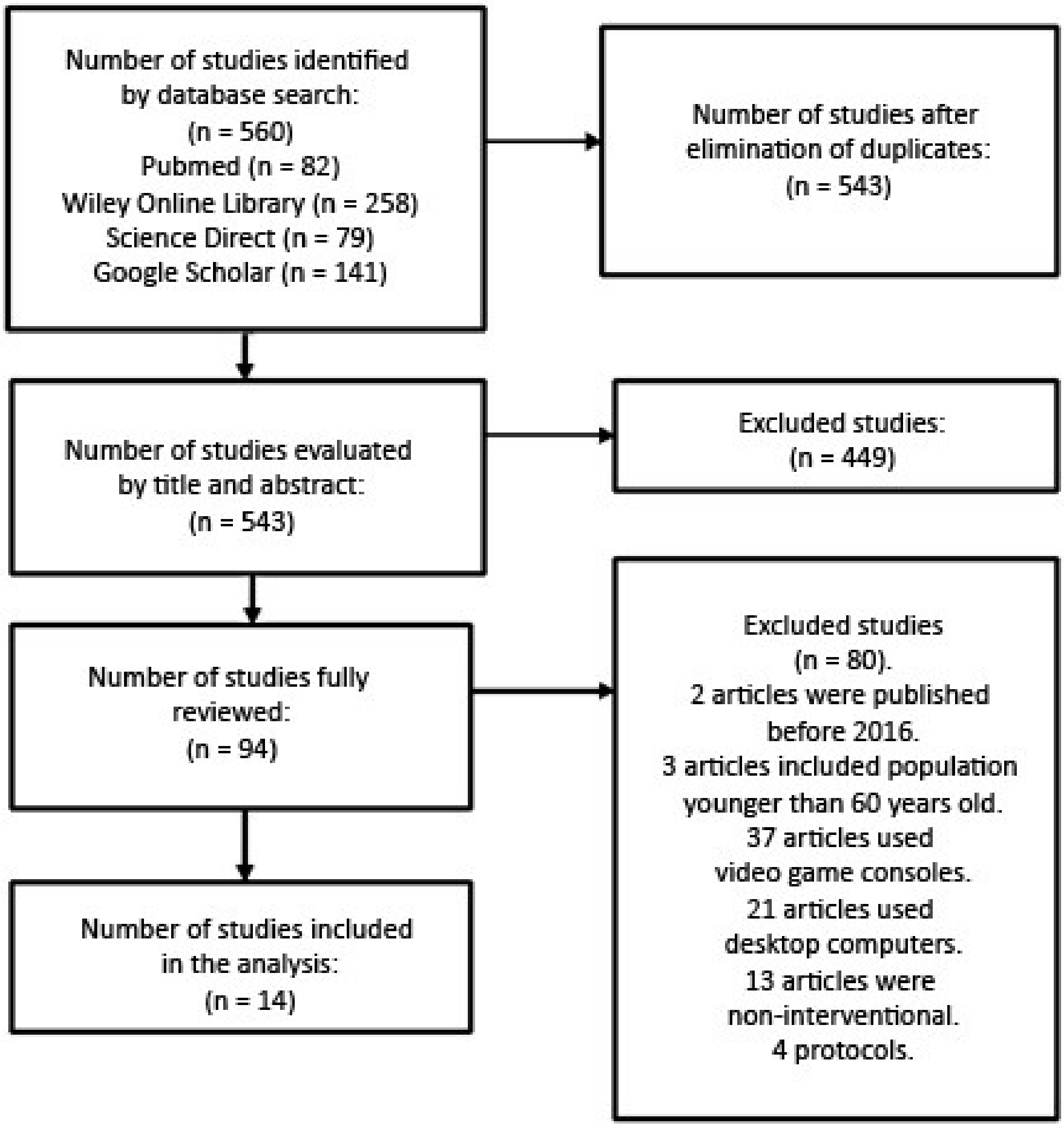
Data extraction process

From the articles included in the review, data extraction was carried out by making tables and the following data were recorded: Author, year, place, design, population group, sample, duration of the study, virtual reality system and content used.

RESULTS

A total of 543 articles related to the topic of interest were identified, 449 were discarded because they did not meet the inclusion criteria, subsequently 94 studies were fully reviewed, eliminating 80 because they did not use immersive systems, were not intervention studies, did not meet the criteria of age (≥ 60 years) and/or year of publication. As shown in Figure 1, only 14 met the inclusion criteria and were included in the analysis.

Figure 1: Flow chart of the search and selection of the articles included in the systematic review:



Characteristics of the studies

Of the fourteen articles reviewed, most were conducted in Taiwan [16, 19, 21, 22] and China [23-25]. Five studies were controlled clinical trials [16, 18, 21, 22, 26], four employed uncontrolled experimental designs [14, 19, 25, 27] and five mixed methods [15, 17, 20, 23, 24].

Most interventions were performed in older adults without neurological diseases and without motor limitations [14, 15, 17, 18, 20, 23-25, 27], only one study was implemented in older adults with Sarcopenia [19] and three in adults with mild cognitive impairment [21, 22, 26].

The duration of the interventions ranged from 2 to 12 weeks [15-17, 19, 20- 22, 25, 26]; four of the studies consisted of a single session [14, 18, 23, 24]. The average actual exposure time to the Immersive Virtual Reality (IVR) systems was 17 minutes per session.

The most commonly used IVR systems were the Oculus Rift [15, 19, 26, 27] and HTC Vive [16, 17, 22, 25]. The content displayed to the older adults was classified into two types: 1) non-interactive, which consisted in observing images of nature, landscapes and various places of the world in 360° [14, 18, 23-25], and 2) interactive content, through games that promoted limb movement [15-17, 19, 20] and applications with simulated instrumental activities of daily living [21, 22, 26, 27] (Table 2).

Table 2: Characteristics and quality of the studies

Reference	Population/Sample (n)	Duration/exposure time to IVR	IVR System	IVR content
Appel et al., 2020 [14] Location: Canada Design: Non-randomized multisite intervention study. Quality of evidence: Medium	Adults ≥ 18 years, without visual impairment, open wounds or skin conditions on the face or chronic neck pain/injury. n= 66	1 session of 3 to 20 minutes	Samsung S7 Smartphone, Samsung Gear VR headset, Sennheiser HD 221 earphones.	Images of nature in 360°.
Baker et al., 2019 [15] Location: Australia Design: Multi-method qualitative Quality of evidence: High	n= 5	2 weeks. 4 sessions of 60 minutes.	Oculus Rift headset, sensors and touch controls.	Quill, Google Earth, Ocean Rift, Toy Box, Power Solitaire.

Barsasella et al., 2020 (16) Location: Taiwan Design: Randomized clinical trial Quality of evidence: High	Adults ≥ 60 years of age, without serious illness and able to perform instrumental activities of daily living. n= 29 intervention /31 control	6 weeks. 2 sessions of 15 minutes per week.	HTC Vive headset.	Applications that promoted physical activity.
Benham; Kang; Grampurohit, 2018 (17) Location: Philadelphia Design: Exploratory mixed-methods pre- and post-test study. Quality of evidence: High	Adults with self-reported pain, intact or corrected vision. No history of seizures, vertigo and/or epilepsy. n= 12	6 weeks 12 sessions of 15 to 45 minutes.	HTC Vive headset.	Interactive games: pets, animal exploration, travel and music.
Chan et al., 2020 (18) Location: Hong Kong Design: Multicenter randomized clinical trial Quality of evidence: High	Adults ≥ 60 years old, normal vision without glasses, dizziness before intervention, glaucoma and/or cataract. n= 92 intervention /85 control	1 session of 20 to 25 minutes.	VR headset (no brand specified)	360° landscape photographs
Chen et al., 2021 (19) Location: Taiwan Design: Quasi-experimental study without control group. Quality of evidence: Medium	Adults ≥ 60 years of age, with Sarcopenia; without cardiopulmonary disease, uncontrolled hypertension and/or recent infection. n=30	12 weeks. 2 sessions of 30 minutes per week.	Oculus Rift headset	Games: Leap Motion Blocks, Slum Ball VR, Tournament, VR Super Sports.
Li et al., 2020 (20) Location: Japan Design: Mixed methods Quality of evidence: Medium	Adults without cognitive impairment and/or depression, falls in the last 6 months. Will walk independently. n= 10 intervention /10 control	4 weeks. 3 sets of 15 minutes 3 times a week.	VR headsets and controls (No brand specified).	Games with activities such as feeding animals.
Liao et al., 2019 (21) Location: Taiwan Design: Single-blind, controlled	Adults ≥ 65 years of age, able to walk 10 meters unaided and mild cognitive	12 weeks. 3 sessions of 60 minutes per	VR headsets and controls (No brand	Job Simulator: simulated instrumental

clinical trial Quality of evidence: High	impairment. No neurological and/or orthopedic disease, schooling < 6 years. n= 18 intervention /16 control	week.	specified).	activities of daily living.
Liao et al., 2020 [22] Location: Taiwan Design: Randomized single-blinded clinical trial Quality of evidence: High	Adults ≥ 65 years of age, able to walk 10 meters unaided and mild cognitive impairment. No neurological and/or orthopedic disease, schooling < 6 years. n= 18 intervention /16 control	12 weeks. 3 sessions of 20 minutes per week.	HTC Vive headsets and hand controllers.	Instrumental activities: purchasing, food preparation, financial management and transportatio n.
Liu et al., 2019 [23] Location: China Design: Mixed methods Quality of evidence: Medium	Adults ≥ 60 years old who attended a community center. n= 58	1 session of 8 minutes.	Pico 4K G2 headsets.	National Geographic 360° Video (VR China)
Liu et al., 2020 [24] Location: China Design: Mixed methods Quality of evidence: Medium	Adults ≥ 60 years old who attended a community center. n= 58	1 session of 8 minutes.	Pico 4K G2 headsets.	National Geographic 360° Video (VR China)
Syed-Abdul et al., 2019 [25] Location: China Design: Pilot study Quality of evidence: High	Adults ≥ 60 years of age from an elderly center. n= 30	6 weeks. 2 sessions of 15 minutes per week	HTC Vive headset.	The Lb2, Everest VR3, The Body VR, Journey Inside a Cell4, To the Top 5, Waltz of the Wizard, Google Earth, Found 8, Sparc 9, Final Soccer VR
Thapa et al., 2020 [26] Site: South Korea Design: Randomized clinical trial Quality of evidence: High	Adults aged 55-85 years, with mild cognitive impairment. Without dementia and/or vertigo. n = 34 intervention /34 control	8 weeks. 3 sessions of 100 minutes per week.	Oculus Rift headset, Oculus Quest earphones, 2 wireless hand controllers.	4 games: juice making, shooting crows, fireworks and house of love.

Zajac-Lamparska et al., 2019 [27] Location: Poland Design: Pretest and posttest Quality of evidence: Medium	Adults without mental disorders or serious illness, visual, hearing and/or motor impairment. n= 99	8 sessions. 2 sessions of 45 minutes per week.	Oculus Rift DK2 headsets.	GRADYS game: with 4 modules: attention, memory, language and visual-spatial processing.

Use, acceptance and tolerance of IVR systems

Six of the studies used IVR to promote functional physical fitness [16, 19-22, 26] and five to stimulate cognitive functions of memory, reasoning, executive function, immediate and delayed recall, visual-spatial ability and language [21, 22, 26, 27]. Only two studies analyzed its effect on quality of life, happiness, pain and depression [16, 17].

Appel et al. [14] reported with regard to tolerance that 88% of participants did not feel heavy the virtual reality headset, 82% found them easy to get used to, and 25% reported problems focusing. On average the tolerated exposure was 8 minutes. 76% showed a desire to use virtual reality again and 71% indicated that they would recommend it to a friend.

Baker et al. [15] reported that after the virtual reality sessions four of the participants felt happy, excited, and surprised; only one participant reported feeling sick and sad, due to making many mistakes while using the systems.

Benham Kang and Grampurohit [17] found that 100% of the participants showed positive attitudes. Users perceived that the controls and instructions were easy to follow, plus the level of presence served as a distraction to decrease pain. Users expressed that they would like to continue using it and would certainly recommend it to a friend.

Chan et al. [18] observed that following virtual reality exposure, positive feelings of interest and enthusiasm increased; and negative feelings of distress, dissatisfaction, guilt, fear, irritability, embarrassment, nervousness, and fear decreased. Regarding adverse events, only three participants (1.4%) reported having severe symptoms of cyber-dizziness (visual fatigue, blurred vision, dizziness with eyes open and eyes closed).

Li et al. [20] found that most participants were satisfied with the IVR game, and expressed that combining the brain and body was a good stimulus. The only drawback mentioned was that the headsets were very heavy.

Liu et al. [23] found no significant changes in emotions (positive and negative) after using virtual reality. Positive experiences were associated with the high sense of presence, ease of use, and wide field of view offered by these systems. Negative experiences were: physical discomfort, blurred vision, preference for other digital media and resistance to new technologies.

Liu et al. [24] reported that older adults expressed that watching virtual reality videos promoted positive emotions.

Syed-Abdul et al. [25] reported that the majority of older adults (77.8%) reported that virtual reality amused them, improved their mood, and motivated them to perform their daily activities; furthermore, more than half (65%) of the participants perceived that virtual reality were easy to use.

Effect on physical and cognitive health

Barsasella et al. [16] saw significant ($p< .05$) improvements with time in functional capacity (arm flexion, exercise capacity, dynamic agility, and balance) of the virtual reality group.

Chen et al. [19] reported improvements for gait speed ($F = 8.65$, $d = 1.00$, $p = .006$), shoulder flexion ($F = 29.26$, $d = 1.65$, $p = .001$), shoulder external rotation ($F = 6.90$, $d = 0.83$, $p = .013$), elbow pronation ($F = 5.40$, $d = 0.46$, $p = . 015$) and supination ($F = 5.00$, $d = 0.39$, $p = .026$), flexion ($F = 11.96$, $d = 0.95$, $p = .001$) and wrist extension ($F = 18.26$, $d = 1.24$, $p = .006$), biceps strength ($F = 19.63$, $d = 1.19$, $p = .001$) and triceps brachii of the dominant hand ($F = 6.87$, $d = 0.79$, $p = .001$).

Li et al. [20] obtained significant changes for working memory ($F(1, 18) = 6.89$, $p < .05$). For reasoning ability ($F(1, 18) = 8.56$, $p < .01$) and balance ($F(1, 18) = 4.81$, $p < .05$) pretest-posttest changes were obtained in the virtual reality group.

Liao et al. [21] saw significant changes by group and time for executive function ($p = .032$) and cadence in the dual-task gait test ($p = .018$). For the intervention group there were pretest-posttest changes for step length ($\bar{X} = 98.5$ vs $\bar{X} = 98.6$, $p = .018$; $\bar{X} = 68.1$ vs $\bar{X} = 82.5$, $p = .003$) and gait speed ($\bar{X} = 82.3$ vs $\bar{X} = 92.9$, $p = .016$; $\bar{X} = 84.2$ vs $\bar{X} = 96.2$, $p = .001$).

Liao et al. [22] saw significant effects according to time for global cognition ($\bar{X} = 23.00$ vs $\bar{X} = 25.20$, $p = .001$), executive function ($\bar{X} = 6.61$ vs $\bar{X} = 5.11$, $p = .013$), immediate recall ($\bar{X} = 18.33$ vs $\bar{X} = 23.27$, $p = .001$), delayed recall ($\bar{X} = 4.27$ vs $\bar{X} = 5.72$, $p = .002$) and instrumental activities of daily living ($\bar{X} = 18.16$ vs $\bar{X} =19.77$, $p = .001$). Only for instrumental activities ($p = .006$) there were significant changes by group and time.

Thapa et al. [26] reported significant changes regarding time for the virtual reality group in grip strength ($\bar{X} = 22.2$ vs $\bar{X} = 24.4$, $p = .03$), gait speed ($\bar{X} = 1.15$ vs $\bar{X} = 1.19$, $p = .04$), and executive function ($\bar{X} = 26.3$ vs $\bar{X} = 24.2$, $p = .04$). In addition, a positive effect by group and time was obtained for gait speed ($p = .02$) and executive function ($p = .03$).

Zajac-Lamparska et al. [27] found significant changes on memory ($Z = -03.04$, $p = .02$), visual-spatial ability ($Z = 3.50$, $p < .001$) and language ($Z = 2.74$, $p = .006$) in healthy adults. Older adults with mild dementia showed no significant changes ($p = 2.42$) in cognitive function compared to the healthy ones ($p < .001$).

DISCUSSION

The use of IVR systems focused mainly on the stimulation and improvement of cognitive and walking functions, finding positive effects on executive function and spatiotemporal parameters of gait such as speed, cadence and stride length. The results were similar to those found in the review by Jahn et al. (28) who found improvements in some cognitive domains mainly in executive function and attention in adults with neurological diseases. It is also consistent with findings reported in non-immersive virtual reality interventions in patients with Parkinson's disease, where increased gait length and faster gait speed are reported after using these systems (29).

Half of the studies included in the analysis evaluated the acceptance and tolerance of older adults to virtual reality headsets. This finding is consistent with the review by Campo-Prieto, Cancela and Rodriguez-Fuentes (11) who found that most studies implementing fully immersive systems in older adult users are in the early stages of clinical development.

Regarding acceptance and tolerance, it was found that more than half of the groups evidenced positive attitudes and/or emotions and showed a good tolerance of the IVR systems. Positive attitudes were associated with ease of use and ease of getting used to the virtual reality headsets. Likewise, Sayma et al. (30) in their review found that adults with dementia and mild cognitive impairment were very satisfied with IVR systems and reported no adverse effects.

One third of the studies reported adverse effects associated with cyber-dizziness, which refers to symptoms of dizziness experienced due to the visual conflict caused by these systems; the symptoms experienced by older adults were blurred vision, physical discomfort, visual fatigue, dizziness with eyes open, and also dizziness with eyes closed. This finding differs with clay et al. (10) who, in their review, found that none of the groups of patients with Alzheimer's disease presented adverse effects and/or symptoms associated with cyber-dizziness.

CONCLUSION

Based on the results, it was concluded that IVR is well accepted and tolerated, in addition to being a promising tool for improving physical and cognitive health in older adults. However, a great diversity was identified among the systems and content used, and studies with small samples and uncontrolled designs; therefore, studies with greater methodological rigour are required to design appropriate interventions and confirm the positive effect of IVR in older adults.

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ISSN 1695-6141
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