A Scoping Review of Digital Gaming Research Involving Older Adults Aged 85 and Older

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Original Article

A Scoping Review of Digital Gaming Research Involving Older Adults Aged 85 and Older

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Abstract

Background: Interest in the use of digital game technologies by older adults is growing across disciplines from health and gerontology to computer science and game studies. The objective of this scoping review was to examine research evidence involving the oldest old (persons 85 years of age or greater) and digital game technology.

Materials and Methods: PubMed, CINHAL, and Scopus were searched, and 46 articles were included in this review.

Results: Results highlighted that 60 percent of articles were published in gerontological journals, whereas only 8.7 percent were published in computer science journals. No studies focused directly on the oldest old population. Few studies included sample sizes greater than 100 participants. Seven primary and 34 secondary themes were identified, of which Hardware Technology and Assessment were the most common.

Conclusions: Existing evidence demonstrates the paucity of studies engaging older adults 85 years of age and above regarding the use of digital gaming and highlights a new understudied cohort for further research focus. Recommendations for future research include intentional recruitment and proportionate representation of participants $\geq$85 years of age, large sample sizes, and explicit mention of specific numbers of participants $\geq$85 years of age, which are necessary to advance knowledge in this area. Integrating a rigorous and robust mixed-methods approach including theoretical perspectives would lend itself to further in-depth understanding and knowledge generation in this field.

Introduction

Globally, the population of adults 65 years of age and over is growing exponentially with a particular increase among the "oldest old" (adults $\geq$85 years of age). With increased life expectancy, the population 80–89 years of age has increased 13 percent, with a 26 percent increase in those 90 years of age and above.[1] Simultaneously, there is also rising pressure to better meet and understand the healthcare and social care needs of older adults. Since the release of the Nintendo Wii™ console in 2006 (Kyoto, Japan), research interest exploring the health benefits of digital games (computer game or videogame) on the health and well-being of aging populations has increased.[2] However, with the growing prevalence of the oldest old, later life now encompasses several distinct generations (e.g., younger Baby Boomers, older Baby Boomers, the Silent Generation), most of which this study contends are underrepresented in research literature.

Previous studies related to videogaming have found a paucity of robust evidence showing physical-based interactive computer games as effective despite some indicators.[3] Research focusing on the application, feasibility, and effectiveness of virtual reality (VR) digital gaming systems to manage or improve the effects of physical and mental impairment and limitations in community settings found insufficient evidence to validate the feasibility and effectiveness of such an approach. Conversely, one of the limitations from these studies is the lack of physical recommendations as noted by these authors.[3] For example, Miller et al.[3] found that "evidence to date supporting the feasibility and effectiveness of VR/gaming systems undertaken for enabling physical activity in a home setting to address impairments, activity limitations and

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participation in people aged over 45 years old is relatively weak with a high risk of bias in this emerging area, and, therefore, insufficient to provide sound recommendations for clinical practice'' (p. 193).

Furthermore, Miller et al.[3] proposed that future studies should use a more rigorous study design and data collection methods. This recommendation is based on findings of their review identifying several ''feasibility issues and inconsistences relating to: recruitment, retention, target and recorded dosage of exercises, adherence, training, assistance, safety, cost, acceptability and take-up of technologies'' (p. 193) within the existing knowledge base.

The importance of identifying suitable game technologies to improve the health and well-being of older people has been highlighted in several reviews,[2–5] and several areas requiring further exploration have been identified. These areas include the need for a physical, cognitive, and social classification system specifically aimed at games for health while considering the implementation of longitudinal studies to ascertain the effects of videogames on participants,[2] and Bleakley et al.[4] provided 15 recommendations that related to the exploration of technologies across the selection/inclusion criteria, methodology, intervention, comparison group, outcomes, and follow-up, while also proposing the recommendation of tailoring the respective study to the participants and considering participant safety, engagement/motivation, and enjoyment. Conversely, Hall et al.[5] proposed future studies should consider ''more robust and rigorous research designs are needed to increase validity and reliability of results'' (p. 1). Although Miller et al.[3] echoed the recommendation of Hall et al.,[5] they also proposed three key points, including ''The current evidence for the effectiveness of home-based VR/gaming for improving health-related domains in older adults is relatively weak with a high risk of bias and therefore insufficient to provide sound recommendations for clinical practice, strong retention and adherence with exercise, and the need for assistance, training and monitoring to ensure safety was identified and future studies should not only address the effectiveness of VR/gaming exercise programs for particular older populations, but also the feasibility issues specific to the implementation in a home environment using more rigorous research designs'' (p. 194).[5]

As life expectancy continues to increase, new and innovative research is needed to explore digital game use by the oldest old. To date, the state of evidence surrounding the effects of digital gaming on the oldest old remains unclear, and to the authors' best knowledge, this review is the first attempt to investigate the breadth of research focusing on digital game use that included the oldest old as study participants. By highlighting the outcomes and themes of these research studies by exploring the breadth of evidence on this topic, this article highlights gaps in existing knowledge and provides recommendations for future research, including the integration of the oldest old into research involving digital game technology.

Materials and Methods

Because of the emerging nature of this area and for its ability to allow the authors to draw conclusions about the overall state of research activity and make recommendations for future research, a scoping review framework was selected to explore the breadth and depth of knowledge on the topic of the oldest old and digital gaming technology.[6] The five-stage Scoping Review framework by Arksey and O'Malley[6] was selected to ''map relevant literature in the field'' (p. 4) and to identify gaps and inconsistencies in the knowledge base. These stages included (1) identification of the research question, (2) identification of relevant studies, (3) study selection, (4) charting the data, and (5) collating, summarizing, and reporting the results. Finally, a qualitative content analysis of existing literature was completed to identify core thematic dimensions[7] through systematic coding and identification of patterns and themes.[8] This approach was selected for its value in synthesizing data when research on a particular topic is limited[8] and for how its purpose aligns nicely with the outcomes of a scoping review: to explore the breadth and depth of a of a topic while drawing conclusions about the overall state of research activity and identifying gaps and inconsistencies within the data.[6]

Search strategy (identification of relevant studies)

The electronic databases PubMed, SCOPUS, and CINAHL were searched for articles published before January 1, 2014. Search terminology prioritized two search criteria: the oldest old and digital gaming (videogames). Individual search strategies were designed for each database (Table 1), and articles were exported and managed in the referencing software program RefWorks.

Study selection

The authors reviewed each article to determine eligibility based on inclusion and exclusion criteria. Inclusion criteria

Table 1. The Databases and Search Terms Used

Database	*MESH/search term*
PubMed	video games[mesh] OR games, experimental[mesh] OR video game*[tiab] OR (virtual reality[tiab] AND game*[tiab]) OR game console*[tiab] OR digital game*[tiab] OR Wii[tiab] OR Nintendo[tiab] OR Xbox[tiab] OR Kinect[tiab] OR computer game*[tiab] OR cywee[tiab] AND Aged[mesh] OR older people[tiab] OR older adult*[tiab] OR elder*[tiab]
CINAHL	''video game*'' OR (''virtual reality'' AND game*) OR ''game console*'' OR''digital game*'' OR Wii OR Nintendo OR xbox OR Kinect OR ''computer game*'' or cywee [in 'Select a Field (optional)']AND ''in old age'' OR aged OR aging OR ''older people'' OR ''older adult*'' OR elder* [in Select a Field (optional)]
SCOPUS	(TITLE-ABS-KEY((''video games'' OR ''games, experimental'' OR ''Wii'' OR ''Xbox'' OR ''Nintendo'' OR ''computer games'' OR ''digital games'' OR ''digital gaming'' OR ''game console'')) AND TITLE-ABS-KEY((''aged,80 and over'' OR ''oldest old'' OR ''centenarian'' OR ''nonagenarian'' OR ''octogenarian'' OR ''aged'' OR ''elderly'' OR ''older adult'')))

MESH, medical subject heading.

were as follows: (a) the study included one or more participants or reported a mean participant age of 85 years or older; (b) the article examined videogame technology; (c) the study examined participant physiological and/or psychological health; (d) the study was published in the English language; and (e) the article was available through PubMed, CINAHL, or Scopus. Studies that did not report original results (e.g., commentaries, study protocols, letters to the editor) were excluded. Abstracts and full texts were retrieved to determine if they met the inclusion/exclusion criteria. Database searching identified 933 articles (Fig. 1). After duplicates were removed, 697 articles were screened for inclusion. Forty-six articles met the inclusion/exclusion criteria and were included in this scoping review.

Analysis (charting, summarizing, and collating the data)

Microsoft Excel® (Redmond, WA) was used to extract, categorize, and organize the data and themes. Primary and secondary themes and descriptive information were recorded for each article. The thematic analysis, undertaken independently by two of the four authors, first examined, pinpointed, and recorded themes across the articles, resulting in a series of highlighted categories. The themes of all included articles ($n = 46$) were independently reviewed by two raters who are also authors, and any discrepancies were then explored through consultation and resolved through detailed discussion. Through a six-phase process involving data familiarization, code generation, themes code summary and discussions, review of themes, defining and naming of themes, and synthesis of the results,[9] the authors came to the consensus about themes. Seven primary themes emerged, and theme descriptions can be found in Table 2.

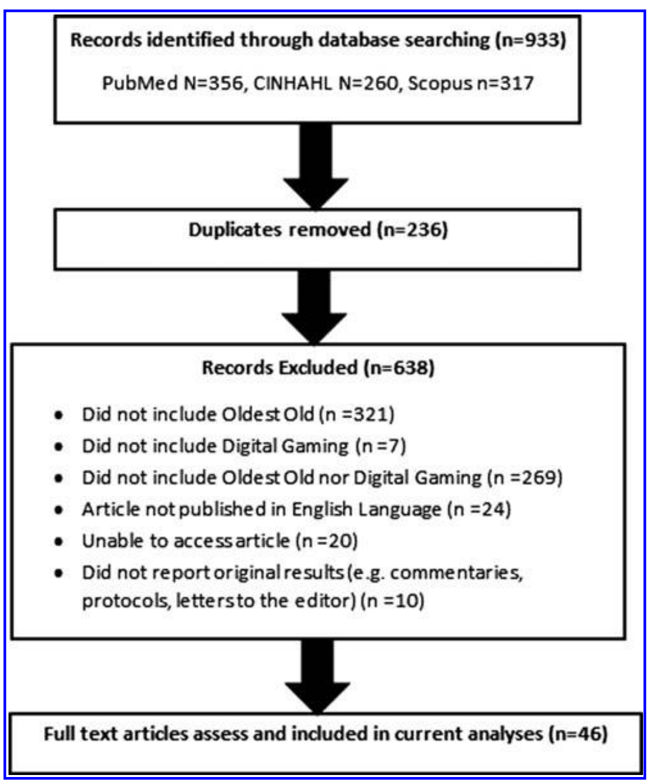

FIG. 1. Search process and eligible studies for inclusion based on exclusion/inclusion criteria.

Results

Table 3 provides a detailed overview of included articles ($n = 46$). With the exception of that by Weisman,[10] all studies were published between 2008 and 2013. The majority of studies (91.1 percent) were published in or after 2010, with 32.1 percent published in 2012 and 26.8 percent in 2013. Two-thirds of the articles (67.4 percent; $n = 28$) were published in 23 different aging- and health-focused journals, whereas 8.7 percent of articles were published in three different computer science–focused journals. Articles published in computer science–related journals were all published since 2012, of which 50.0 percent were published in 2013. The remaining 15 articles were published as conference proceedings (26.1 percent) and book chapters (4.4 percent). Multiple publications in the same journal including videogame use and the oldest old were rare. No journal was found to have published more than three articles including this demographic and subject area.

Sample sizes in these studies were often low (Table 3). The majority used sample sizes less than 50 (78.3 percent; $n = 36$),[11–17,20–40,42–46] three of which were case studies with a sample size of one.[18,19,41] In contrast, 6.5 percent of studies used a sample population greater than 100 ($n = 3$).[18,19,41] No articles explicitly articulated an intention to study the oldest old population in relation to digital gaming technology use.

There were 7 primary themes (Table 4) and 34 secondary themes. Articles addressed an average of 5.8 primary themes (range, 4–7). Eight articles (17.4 percent) addressed all primary themes. All articles made reference to the Assessment and Technology Hardware themes. The majority of articles referenced the Environment (89.1 percent), Technology Software (89.1 percent), and Game Technology (80.4 percent) themes. Less commonly mentioned themes were Physiological Health (71.4 percent) and Psychological Health (50.0 percent).

Great diversity was evident among the distribution of articles reporting secondary themes. Articles addressed on average 10.3 secondary themes. In the assessment theme, 52.2 percent of articles addressed three or more secondary themes. Clinical assessments, such as the Victoria Stroop Test or the Berg Balance Scale, and activities of daily living were most commonly reported (73.9 percent), followed by discussion of anthropometric characteristics (60.9 percent). Few studies included Technology Validation (13.0 percent).

More than two-thirds addressed one Hardware Technology secondary themes (69.6 percent), whereas only 28.3 percent addressed two, and 2.2 percent addressed three. No articles addressed four or more secondary Hardware Technology themes. Of specified videogame Hardware Technology secondary themes, more than half of the articles addressed the Nintendo console (58.7 percent), followed by the Xbox® Kinect® console (Microsoft) (13.0 percent) and Sony (Tokyo, Japan) console (4.4 percent). Hardware Technology utilization for mixed commercial purposes was addressed by 39.1 percent, whereas 17.4 percent addressed purpose-built devices.

Retirement communities (47.8 percent) and community-based settings (37.0 percent) were more commonly discussed Environment secondary themes, in contrast to institutional settings (e.g., hospitals, long-term care facilities) (17.9 percent).

Table 2. Overview of Primary and Secondary Themes

Primary themes	*Associated secondary themes*
1. Physiological Health • Includes descriptions of physiology and changes in physiological health status	• Fall prevention • Balance • Physical activity • Rehabilitation
2. Psychological Health • Includes any reference made to mental health, cognitive functioning, and psychological well-being	• Cognition • Attention • Emotional well-being • Quality of life
3. Environment • Captures location of the study	• Residential/retirement home • Community-dwelling • Hospital facility • Long-term care facility • Public space (e.g., community center)
4. Technology Hardware • Refers to type of videogame technology or whether software was purposefully build to incorporate elements not commercially available	• Videogame console type: ○ Nintendo Wii ○ Sony PlayStation ○ Xbox Kinect
5. Technology Software • Examined type of software used • Differentiates between available, purposefully built, and adapted software	• Available software ○ For example, ''Wii Sports Resort''
6. Assessment • Includes descriptions of study measures	• Traditional assessment ○ For example, health profiles, demographic information • Clinical assessment ○ For example, Berg Balance Scale, Victoria Stroop Test • Self-report survey • Technology assisted: Used to aid primary purpose of the study to achieve the overall outcome ○ For example, a bicycle connected to a computer as integral component of an interactive game examining exercise • Qualitative assessment ○ For example, focus groups, participant interviews • Technology validation: Used to validate a prospective outcome ○ For example, use of the Wii Balance Board to measure participant's center of pressure
7. Game Technology • Includes descriptions of the tools, usability issues	• Usability and accessibility of game interface/hardware • Subject preferences • Feasibility/efficacy • Subjective perception • Diagnostic tool • Design

Of the Software Technology secondary themes, the commercial theme was reported double the rate of the purpose-built/modified (technology that has been adapted or modified to conduct a certain task for a pathology) theme (63.0 percent versus 26.1 percent). No articles simultaneously addressed both Software Technology secondary themes.

Among the nine Game Technology secondary themes, articles were more likely to report one or two secondary themes (21.7 percent and 37.0 percent, respectively). Few articles addressed four to seven (13.0 percent), and no articles addressed more than seven Game Technology secondary themes.

Nearly one-third of articles addressed psychological benefits (32.6 percent), feasibility/efficacy (30.4 percent), physiological benefits (26.9 percent), and usability (23.9 percent).

As specified in the inclusion criteria, all articles must have addressed either the Physiological Health or Psychological Health primary theme. It is interesting that these were the two least commonly reported themes, with less than three-quarters reporting a Physiological Health theme (71.3 percent; $n = 33$) and half reporting a Psychological Health theme (50.0 percent; $n = 23$). For Psychological Health, the subthemes of balance (47.8 percent), exercise (30.4 percent), and falls (28.3 percent) were much more common than articles that addressed rehabilitation (13.0 percent). For Psychological Health, cognition (29.3 percent) and quality of life (23.9 percent) were more common, in contrast to emotional well-being (19.6 percent) and mental health (13.0 percent).

Discussion

The majority of studies did not integrate the oldest old as a meaningful proportion of the sample, despite the increasing

Table 3. Summary of Articles (N=46) Included for This Scoping Review

			Sample description				
Reference (year)	*Journal*	*Study design*	*Study setting or context*	*Sample size(s)* (n)	*Age (years) description*	*Percentage female*	*Main findings*
Agmon et al.[11] (2011)	Journal of Geriatrics Physical Therapy	Pilot study, quasi-experimental single group pre–post	Continuing care retirement communities	7	Mean = 84 Range = 78–92	57.1 percent	"Use of Wii Fit for limited supervised balance training in the home was safe and feasible for a selected sample of older adults" (p. 161)
Allaire et al.[47] (2013)	Computers in Human Behavior	Pretest–posttest treatment control group design	Independently living older adults, senior centers, religious centers, and senior living apartments	140	Mean = 77.5 Range = 63–92	70.0 percent	"Differences among the groups were found for well-being, negative affect, social functioning, and depression with Regular and Occasional Gamers performing better, on average, than Non-gaming older adults. Findings suggest that playing may serve as a positive activity associated with successful aging" (p. 1302)
Anderson-Hanley et al.[12] (2011)	Clinical Interventions in Aging	Pilot	Retirement communities	14	Mean = 80.7 for Sample 1, 75.6 for Sample 2 Range = 60–99	92.8 percent	"Virtual social facilitation increased exercise effort among more competitive exercisers. Exercise programs that match competitiveness may maximize exercise effort" (p. 275)
Anderson-Hanley et al.[48] (2012)	American Journal of Preventive Medicine	Multisite cluster randomized clinical trial	Retirement communities	79	Mean = 75.7 for Sample 1 (cybercycle), 81.6 for Sample 2 (bike) Range = 58–99	Sample 1 (cybercycle) 70.7 percent Sample 2 (bike) 13.2 percent	"Cybercycling older adults achieved better cognitive function than traditional exercisers, for the same effort, suggesting that simultaneous cognitive and physical exercise has greater potential for preventing cognitive decline" (p. 109)
Bainbridge et al.[13] (2011)	Physical & Occupational Therapy in Geriatrics	Prospective, cross-sectional pilot	Community-dwelling older adults	8	Mean = 75.0 Range = 67–87 n 85+ = 2	87.5 percent	"[…] findings suggest that an intervention program including the Wii fit may be an effective rehabilitation option for older adults with perceived balance deficits" (p. 126)
Belchior et al.[49] (2013)	Computers in Human Behavior	Feasibility/pilot pretest–posttest	Community surrounding University of Florida	58	Mean = 74.5 Range = 65–91	51.7 percent	"There was a lack of difference between the two game conditions, differing from findings with younger adults" (p. 1318)
Bieryla and Dold[14] (2013)	Clinical Interventions in Aging	Pretest–posttest experimental.	Senior living community	12	Mean = 81.5 Range = 70–92	83.3 percent	"Balance training with Nintendo's Wii Fit may be a novel way for older adults to improve balance as measured by the BBS" (p. 775)
Boulay et al.[15] (2011)	Technology and Health Care	Pilot usability	Institutionalized patients at LUSAGE Living Lab in Paris	7	Mean = 88.5 Range = 77–94 n 85+ = 6	57.1 percent	"[…] overall very satisfied with the game and expressed a desire to repeat the experience: MINWii fosters positive interaction with the caregivers and elicits powerful reminiscence with even the most severely impaired patients" (p. 1)
Celinder and Peoples[16] (2012)	Scandinavian Journal of Occupational Therapy	Qualitative	Hospital	9	Mean = 68.2 Range = 51–95 n 85+ = 1	33.3 percent	"Stroke patients in hospital settings may experience Wii Sports as a beneficial and challenging occupation for both rehabilitation and leisure. Incorporation of Wii Sports into conventional occupational therapy services may benefit patient rehabilitation directly or provide motivation for alternative leisure activities" (p. 457)
Chao et al.[17] (2013)	Geriatric Nursing	Single-group, pre–post test	Assisted living residence	7	Mean = 86.0 Range = 80–94	71.4 percent	"The use of Wii exergames was an acceptable, safe, and potentially effective approach to promote physical activity in older adults. Findings provide support for the applications of integrating self-efficacy theory into exergames as a mechanism to encourage older adults to engage in exercise" (p. 377)

(*continued*)

Table 3. (Continued)

			Sample description				
Reference (year)	*Journal*	*Study design*	*Study setting or context*	*Sample size(s)* (n)	*Age (years) description*	*Percentage female*	*Main findings*
Chen et al.[50] (2012)	IEEE	Quasi-experimental	Institutionalized older adults	61	Mean = 78.6 for Sample 1, 79.5 for Sample 2 Range = 65–92	70.5 percent	"[…] somatosensory video games had a great potential to be used as a health promotion tool for the elderly with disabilities" (p. 258)
Clark and Kraemer[18] (2009)	Journal of Geriatric Physical Therapy	Case report	Nursing home	1	89	100 percent	"Physical therapy intervention, using the Nintendo Wii bowling simulation, may have decreased fall risk for this individual" (p. 174)
Cornejo et al.[19] (2012)	Conference proceedings for International Conference on Pervasive Computing Technologies for Healthcare	Design	Family interaction, community dwelling	1	86	100 percent	"The system maintained the older adult engaged with her exercises while offering new opportunities for online and offline social encounters. […] the use of natural interfaces and family memorabilia facilitated the adoption of the game and catalyzed family social encounters" (p. 215)
Dougherty et al.[20] (2010)	Missouri Medicine	Within-subject experimental	Local senior community center	9	Mean = 74.9 Range = 65–90 *n* 85+ = 1	33.3 percent	"These improvement are postulated to be due to an increase in subjects' core and lower extremity muscle strength and improve proprioception; a result of balance board usage" (p. 128)
Fachko et al.[21] (2013)	Journal of Gerontological Nursing	Observational	Independently living	34	Mean = 81.0 Range = 69–91	70.6 percent	"[…] results suggest that Nintendo Wii Tennis EG technology represents an enjoyable, moderate intensity physical activity for healthy, older adults" (p. 43)
Franco et al.[22] (2012)	Technology and Health Care	Randomized pre–post intervention	Community-dwelling seniors, independent living senior housing facility	32	Mean = 78.3 Range = 63–90	78.1 percent	"[…] the interventions failed to significantly increase balance, with an increase in intervention duration of Wii Fit or Matter of Balance balance may be improved. Although results were not significant this study adds to the growing body of evidence regarding the use of Wii Fit as a rehabilitation tool" (p. 95).
Gerling et al.[23] (2013)	Proceedings of Graphics Interface	Evaluation	Not specified	33 (Sample 1, *n* = 16; Sample 2, *n* = 17)	Sample 1: mean = 23.9; range = 18–27 Sample 2: mean = 71.5; range = 62–86	60.6 percent	"[…] results show that older adults can apply motion-based game controls efficiently, and that they enjoy motion-based interaction" (abstract, paragraph 1)
Harley et al.[24] (2010)	HCI in Work and Learning, Life and Leisure	Longitudinal	Communal housing setting, sheltered housing settings	30	Range = 60–94	Not specified	"[…] older players create a 'sacred space' around the Wii where they can learn new technical literacies, make new social connections with peers and take ownership of the communal spaces in which they live" (p. 156)
Jung et al.[25] (2009)	Proceedings of the Sixth Australasian Conference on Interactive Entertainment	Longitudinal field experiment	Long-term care	45	Range = 56–92	Not specified	"Results showed that playing Wii games had a positive impact on the overall well-being of the elderly, compared to a control group that played traditional board games. Implications for future applications of Wii in interventions for the elderly are discussed" (p. 1)
Kahlbaugh et al.[26] (2011)	Activities, Adaptation & Aging	Randomized controlled trial	Independent living residential apartments	36	Mean = 82.0 Range = 50–94 *n* 85+ = 18	88.6 percent	"The elderly playing Wii had lower loneliness and a pattern of greater positive mood compared to the television group. No differences in life satisfaction or physical activity were found, but loneliness predicted positive mood, and positive mood predicted physical activity" (p. 331)

(*continued*)

Table 3. (Continued)

			Sample description				
Reference (year)	*Journal*	*Study design*	*Study setting or context*	*Sample size(s)* (n)	*Age (years) description*	*Percentage female*	*Main findings*
Keogh et al.[27] (2012)	Journal of Community Informatics	Quasi-experimental mixed-methods pilot	Nursing home	11	Mean = 81 n 85+ = 3	54.6 percent	"[…] the results of our study suggest that the use of the NWS is feasible in the nursing home context and that the residents may experience some psychosocial benefits after only five weeks of a self-selected amount of NWS game play. This suggests that even short-term unstructured use of this technology may be of some benefit to some nursing home residents." (p. 10).
Keogh et al.[28] (2014)	Journal of Aging and Physical Activity	Mixed-methods, quasi-experimental pilot	Residential aged care centers	34	Mean = 83 Range = 68–99	88.2 percent	"Analysis of the quotes underlying the three themes (Feeling Silly, Feeling Good; Having Fun; and Something to Look Forward to) suggested that intervention group participants developed a sense of empowerment and achievement after some initial reluctance and anxiousness. They felt that the games were fun and provided an avenue for greater socialization" (p. 235)
Koslucher et al.[29] (2012)	Gait & Posture	Experimental	University of Minnesota retirees volunteer list, community	10	Mean = 72.6 Range = 64–85	Not specified	"The WBB is an inexpensive, reliable technology that can be used to evaluate subtle characteristics of body sway in large or widely dispersed samples" (p. 605)
Laver et al.[30] (2011)	BMC Geriatrics	Discrete choice experiment	Geriatric rehabilitation hospital	21	Mean = 85.4	86.0 percent	"The usefulness of the Wii Fit as a therapy tool with hospitalised older people is limited not only by the small proportion of older people who are able to use it, but by older people's preferences for traditional approaches to therapy" (p. 1)
Liu et al.[51] (2012)	Fourth IEEE International Conference on Digital Game and Intelligent Toy Enhanced Learning	Cross-sectional	Community	111	Mean = 63.8 Range = 55–90	0.0 percent	"[…] using Wii video games to promote elderly's health is a potential valuable approach to understand their physical fitness, to motivate them to exercise and to understand their HRQOL" (p. 207)
Löckenhoff et al.[52] (2013)	The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences	Quasi-experimental	Community through print and online ads	80 (total) 40 (Sample 1) 40 (Sample 2)	Sample 1: mean = 28.0, range = 22–39 Sample 2: mean = 71.4, range = 58–89	73 percent	"Older adults were less likely than younger adults to respond to mild levels of social exclusion, but both age groups responded similarly to more pronounced exclusion. Within the older group, participants with lower cognitive functioning were less responsive to mild exclusion, but this effect did not reach significance in the younger group" (p. 13)
Olvera-Chávez et al.[31] (2013)	Gerontechnology	Cross-sectional	Community	20	Mean = 67.5 Range = 60–98	75.0 percent	"The Wii pressure board has a good concordance with usual clinical assessment of balance in the elderly" (p. 452)
Pichierri et al.[32] (2012)	BMC Geriatrics	Prospective randomized controlled trial	Swiss hostels for the aged	31	Mean = 86.2	58.1 percent	"These findings suggest that in older adults a cognitive-motor intervention may result in more improved gait under dual task conditions in comparison to a traditional strength and balance exercise program" (p. 1)

(*continued*)

Table 3. (Continued)

Reference (year)	Journal	Study design	Sample description: Study setting or context	Sample size(s) (n)	Age (years) description	Percentage female	Main findings
Pichierri et al.[33] (2012)	Clinical Interventions in Aging	Prospective randomized controlled trial, pilot study	Care homes	25	Sample 1 (Intervention): mean = 83.6 Sample 2 (Control): mean = 86.2	60.0 percent	"A cognitive-motor intervention based on strength and balance exercises with additional dance video gaming is able to improve voluntary step execution under both single and dual task conditions in older adults" (p. 175).
Pompeu et al.[34] (2012)	Physiotherapy	Parallel, prospective, single-blind, randomized clinical trial	Parkinson's Association	32	Mean = 67.4 Range = 60–85	46.8 percent	"Patients with Parkinson's disease showed improved performance in activities of daily living after 14 sessions of balance training, with no additional advantages associated with the Wii-based motor and cognitive training" (p. 196)
Reichlin et al.[35] (2011)	Journal of Medical Internet Research	Mixed-methods	Hospital	13	Range = 45–85	0.0 percent	"Serious games are a promising approach to health education and decision support for older men. Participants were receptive to the idea of a serious game as a decision aid in localized prostate cancer. However, usability issues are a major concern for this demographic, as is clarity and transparency of data sources" (paragraph 4)
Schoene et al.[53] (2014)	Age and Ageing	Cross-sectional study	Independently living cognitively intact older adults, retirement residences	103	Mean = 79.5 Range = 70–93	Not specified	"[…] the SST a low-cost video game device is feasible for older people to undertake. The SST was able to distinguish fallers from non-fallers, providing a novel way to explore cognitive mechanisms for fall-risk in older people" (p. 1)
Schoene et al.[36] (2011)	Archives of Physical Medicine and Rehabilitation	Randomized order, crossover comparison	Balance laboratory, medical research institute, and retirement village	47	Mean = 78.9 Range = 65–90	55.0 percent	"The new dance mat device is a valid and reliable tool for assessing stepping ability and fall risk in older community-dwelling people. Because it is highly portable, it can be used in clinic settings and the homes of older people as both an assessment and training device" (p. 947)
Sirkka et al.[37] (2011)	Europe PubMed Central	Preliminary experiment	Assisted living environments	34	Mean = 85.9 Range = 70–98	50.0 percent	"The overall experiences of mobile controlled game described in this paper appeared to be a successful experiment also proving that the elderly are not as reluctant to use technical devices or playing virtual games as often thought. The game was reckoned very motivating, interesting, and entertaining both by the aged and the staff" (p. 289)
Smeddinck et al.[38] (2013)	ACM SIGACCESS	Comparative study within-subjects design	Weekly community groups of older adults	15	Mean = 73.6 Range = 61–85	86.7 percent	"[…] while older adults do have preferences in terms of visual complexity of video games, notable effects were only measurable following drastic variations. […] perceived exertion shifts depending on the degree of visual complexity" (p. 1)
Stone and Skubic[39] (2012)	Conference Proceedings for 2012 6th International Conference on Pervasive Computing Technologies for Healthcare	Quasi-experimental	Independent living facility	7	Range = 75–95	42.9 percent	"[…] a single Kinect sensor and computer have been deployed in five apartments, two of which contain multiple residents, in an independent living facility for older adults" (p. 183)

(*continued*)

Table 3. (Continued)

			Sample description				
Reference (year)	*Journal*	*Study design*	*Study setting or context*	*Sample size(s)* (n)	*Age (years) description*	*Percentage female*	*Main findings*
Stone and Skubic[40] (2013)	IEEE Transactions on Biomedical Engineering	Probabilistic methodology for generating gait estimates	Independent living facility	15	Range = 67–97	60.0 percent	"A probabilistic methodology for generating automated gait estimates over time for the residents of the apartments from the Kinect data is described, along with results from the apartments as compared to two of the traditionally measured fall risk assessment tools" (p. 2925)
Sugarman et al.[41] (2009)	IEEE	Feasibility pilot study	Hospital	1	Age = 86	100 percent	"[…] the Wii Fit gaming system has the potential to be used in clinical settings in order to improve balance" (p. 111)
Torres[42] (2008)	ZON Digital Games 2008	Pre–post assessment	Senior homes	43	Mean = 78.3 Range = 65–93	76.7 percent	"[…] results show that the use of videogames leads to the improvement of cognitive functioning and to the maintenance of the self-concept and the quality of life of elderly people" (p. 21).
Tsai et al.[55] (2012)	Computer Aided Design & Applications	Quasi-experimental	Elderly community	52	Mean = 79.0 Range = 64–91 *n* 85+ = 10	67.3 percent	"Our findings indicated that all proposed hypotheses had a positive and significant impact on the intention of older people to interact with Sharetouch. Unlike the computer- based system, Sharetouch is created as a user-friendly interface system. Sharetouch can enrich the users' social network experiences through its hardware and software architectures" (p. 1364)
Weisman[10] (1983)	The Gerontologist	Quasi-experimental	Institutionalized elderly	50	Mean = 85.0	Not specified	"Moderate mental and physical impairments did not prevent 50 nursing home residents from participating in four computer games which were especially adapted for this population" (p. 361)
Weybright et al.[43] (2010)	Therapeutic Recreation Journal	Single-subject, multiple baseline ABAB design	Assisted living facility	2	Mean = 89.5 Range = 86–93	100 percent	"The low-impact activity of the Nintendo Wii™ bowling program may provide the appropriate amount of physical and mental challenge and stimulation for older adults with mild cognitive impairments" (p. 271)
Whitlock et al.[54] (2011)	Proceedings of the Human Factors and Ergonomics Society Annual Meeting	Cognitive Intervention study	Independent living facilities, assisted living facilities, and the community	56	Mean = 79.8 Range = 65–93	Not specified	"We examined video recordings and open-ended questionnaire responses of 56 older adults taking part in a video game-based cognitive intervention study. Usability findings and recommendations for inclusive video game design for older adults are discussed" (p. 187)
Williams et al.[44] (2011)	Occupational Therapy in Health Care	Pilot study, quasi-experimental, single group, pretest–posttest	Independent retirement communities or skilled nursing facilities	22	Mean = 83.9 Range = 74–94	81.8 percent	"[…] results of this study suggest the potential effectiveness of utilizing the Nintendo Wii as a therapeutic agent in occupational therapy practice" (p. 131)
Yamada et al.[45] (2011)	Geriatric Nursing	Quasi-experimental	Community-dwelling	45	Mean = 81.3	100 percent	"[…] results suggest that game-based fall risk assessment using the Basic Step has a high generality and is useful in community-dwelling older adults" (p. 188)
Zavala-Ibarra and Favela[46] (2012)	2012 Eighth International Conference on Intelligent Environments, IEEE	Evaluation study	Community center	11	Range = 65–85	Not specified	"[…] a formative evaluation of the games with 5 older adults to assess ease of use and their interest in playing them. We compare the results of traditional measures of muscle strength using a clinical dynamometer with those obtained using the videogame" (p. 27)

EG, exergame; HRQOL, health-related quality of life; NWS, Nintendo "Wii Sports"; SST, Stroop Stepping Test; WBB, Wii Balance Board.

Table 4. The Themes from the Selected Articles (N=46)

Reference (year)	*Physiological Health*	*Psychological Health*	*Environment*	*Technology Hardware*	*Technology Software*	*Assessment*	*Game Technology*
Agmon et al.[11] (2011)	Balance		Residential/ retirement communities	Nintendo Wii	Commercial	Anthropometric, clinical, self-reporting, technology-assisted, qualitative	Usability, accessibility, subject preferences, feasibility/efficacy, psychological benefits, physiological benefits
Allaire et al.[47] (2013)		Mental health, emotional well-being	Public space, community-dwelling, residential/ retirement communities	Nintendo Wii	Commercial	Anthropometric, clinical	Psychological benefits
Anderson-Hanley et al.[12] (2011)	Exercise		Residential/ retirement communities	Purpose-built, computer/mixed commercial	Purpose-built	Anthropometric, clinical, self-reporting, technology-assisted	
Anderson-Hanley et al.[48] (2012)	Exercise	Cognition, attention	Residential/ retirement communities	Purpose-built, computer/mixed commercial	Purpose-built	Anthropometric, clinical, self-reporting, technology-assisted	Psychological benefits, physiological benefits
Bainbridge et al.[13] (2011)	Balance		Community-dwelling	Nintendo Wii	Commercial	Anthropometric, clinical, technology-assisted	
Belchior et al.[49] (2013)		Cognition, attention	Community-dwelling	Sony PlayStation, computer/mixed commercial	Commercial	Anthropometric, clinical	
Bieryla and Dold[14] (2013)	Balance		Residential/ retirement communities	Nintendo Wii	Commercial	Anthropometric, clinical	Feasibility/efficacy
Boulay et al.[15] (2011)		Cognition	Hospital/long-term care	Nintendo Wii, computer/mixed commercial		Self-reporting, technology-assisted, qualitative	Usability, accessibility, feasibility/efficacy
Celinder and Peoples[16] (2012)	Rehabilitation		Hospital/long-term care	Nintendo Wii	Commercial	Qualitative	Usability, psychological benefits, subject perception, game technology other
Chao et al.[17] (2013)	Balance, falls		Residential/ retirement communities	Nintendo Wii	Commercial	Clinical, self-reporting	Feasibility/efficacy, game technology other

(*continued*)

Table 4. (Continued)

Reference (year)	Physiological Health	Psychological Health	Environment	Technology Hardware	Technology Software	Assessment	Game Technology
Chen et al.[50] (2012)		Quality of life, emotional well-being	Hospital/long-term care	Kinect	Commercial	Clinical, self-reporting, qualitative	
Clark and Kraemer[18] (2009)	Balance, falls		Hospital/long-term care	Nintendo Wii	Commercial	Clinical	
Cornejo et al.[19] (2012)	Exercise			Purpose-built, Kinect	Purpose-built	Self-reporting, qualitative	Design
Dougherty et al.[20] (2010)	Balance, falls, exercise		Public space	Nintendo Wii	Commercial	Anthropometric, clinical, self-reporting, technology-assisted, technology validation	Physiological benefits, diagnostic tool
Fachko et al.[21] (2013)	Exercise		Community-dwelling, residential/retirement communities	Nintendo Wii	Commercial	Anthropometric, clinical, self-reporting, technology-assisted	
Franco et al.[22] (2012)	Balance, falls, exercise	Quality of life, emotional well-being	Community-dwelling, residential/retirement communities	Nintendo Wii	Commercial	Anthropometric, clinical, self-reporting	Feasibility/efficacy
Gerling et al.[23] (2013)	Exercise	Cognition, emotional well-being		Kinect, Sony PlayStation, Computer/mixed commercial	Commercial	Anthropometric, self-reporting	Usability, feasibility/efficacy, design
Harley et al.[24] (2010)		Quality of life, emotional well-being	Residential/retirement communities	Nintendo Wii	Commercial	Qualitative	Accessibility, psychological benefits
Jung et al.[25] (2009)		Quality of life, emotional well-being	Hospital/long-term care	Nintendo Wii	Commercial	Clinical, self-reporting	Psychological benefits, physiological benefits
Kahlbaugh et al.[26] (2011)		Mental health, quality of life, emotional well-being	Community-dwelling, residential/retirement communities	Nintendo Wii	Commercial	Clinical	Psychological benefits, physiological benefits

(*continued*)

Table 4. (Continued)

Reference (year)	*Physiological Health*	*Psychological Health*	*Environment*	*Technology Hardware*	*Technology Software*	*Assessment*	*Game Technology*
Keogh et al.[27] (2012)	Balance, falls	Quality of life	Hospital/long-term care	Nintendo Wii	Commercial	Anthropometric, clinical, self-reporting, qualitative	Psychological benefits
Keogh et al.[28] (2014)	Exercise	Quality of life	Community-dwelling, residential/retirement communities	Nintendo Wii	Commercial	Anthropometric, clinical, self-reporting, qualitative	Psychological benefits, physiological benefits
Koslucher et al.[29] (2012)	Balance		Public space	Nintendo Wii, computer/mixed commercial	Commercial	Clinical, technology validation	Diagnostic tool
Laver et al.[30] (2011)	Rehabilitation		Hospital/long-term care	Nintendo Wii	Commercial	Clinical, self-reporting, qualitative	Usability, subject preferences, feasibility/efficacy
Liu et al.[51] (2012)	Exercise	Quality of life		Nintendo Wii	Commercial	Anthropometric, clinical, self-reporting	Physiological benefits
Löckenhoff et al.[52] (2013)		Mental health, cognition, quality of life, attention, emotional well-being	Public space, community-dwelling	Computer/mixed commercial		Anthropometric, clinical, self-reporting	
Olvera-Chávez et al.[31] (2013)	Balance		Community-dwelling	Nintendo Wii, computer/mixed commercial	Commercial	Clinical, technology-assisted, technology validation	Feasibility/efficacy, diagnostic tool
Pichierri et al.[32] (2012)	Balance, falls, exercise	Mental health, cognition, attention	Residential/retirement communities	Purpose-built, computer/mixed commercial	Purpose-built	Anthropometric, clinical, technology-assisted	Psychological benefits, physiological benefits
Pichierri et al.[33] (2012)	Balance, falls, exercise	Mental health, cognition, attention	Residential/retirement communities	Purpose-built, computer/mixed commercial	Purpose-built	Anthropometric, clinical, technology-assisted	Psychological benefits, physiological benefits
Pompeu et al.[34] (2012)	Balance, exercise	Cognition, attention	Public space	Nintendo Wii	Commercial	Anthropometric, clinical	Psychological benefits, physiological benefits
Reichlin et al.[35] (2011)		Quality of life	Public space, community-dwelling	Computer/mixed commercial	Purpose-built	Clinical, self-reporting	Usability, accessibility, design

(*continued*)

Table 4. (Continued)

Reference (year)	*Physiological Health*	*Psychological Health*	*Environment*	*Technology Hardware*	*Technology Software*	*Assessment*	*Game Technology*
Schoene et al.[53] (2014)	Balance, falls		Community-dwelling, residential/ retirement communities	Purpose-built	Purpose-built	Anthropometric, clinical, technology-assisted, technology validation	Feasibility/efficacy, diagnostic tool
Schoene et al.[36] (2011)	Balance, falls		Community-dwelling, residential/ retirement communities	Purpose-built	Purpose-built	Anthropometric, clinical, technology-assisted, self-reporting, technology validation	Feasibility/efficacy, diagnostic tool
Sirkka et al.[37] (2011)	Balance, rehabilitation		Residential/ retirement communities	Computer/mixed commercial	Purpose-built	Anthropometric, self-reporting, qualitative	Usability, accessibility, subject preferences, feasibility/efficacy, subject perception, physiological benefits, design
Smeddinck et al.[38] (2013)	Rehabilitation	Exercise	Public space	Purpose-built, computer/mixed commercial	Purpose-built	Anthropometric, self-reporting, technology-assisted, qualitative	Accessibility, subject preferences, subject perception, design
Stone and Skubic[39] (2012)	Balance, falls		Community-dwelling, residential/ retirement communities	Kinect, computer/ mixed commercial		Technology-assisted	
Stone and Skubic[40] (2013)	Balance, falls		Community-dwelling, residential/ retirement communities	Kinect, computer/ mixed commercial		Clinical, technology-assisted	Diagnostic tool
Sugarman et al.[41] (2009)	Balance, rehabilitation		Hospital/long-term care	Nintendo Wii	Commercial	Clinical, self-reporting	Feasibility/efficacy
Torres[42] (2008)		Mental health, cognition, quality of life, attention, emotional well-being	Residential/ retirement communities		Commercial	Anthropometric, clinical, self-reporting, qualitative	Usability, subject preferences

(*continued*)

Table 4. (Continued)

Reference (year)	*Physiological Health*	*Psychological Health*	*Environment*	*Technology Hardware*	*Technology Software*	*Assessment*	*Game Technology*
Tsai et al.[55] (2012)	Rehabilitation, exercise			Computer/mixed commercial	Purpose-built	Anthropometric, qualitative	Usability, accessibility, subject preferences, feasibility/efficacy
Weisman[10] (1983)		Cognition, attention	Hospital/long-term care	Computer/mixed Commercial	Purpose-built	Self-reporting	Usability, psychological benefits, diagnostic tool
Weybright et al.[43] (2010)		Cognition, attention	Residential/ retirement communities	Nintendo Wii	Commercial	Clinical, self-reporting, qualitative	Game technology other
Whitlock et al.[54] (2011)		Cognition, attention	Community-dwelling, residential/ retirement communities	Nintendo Wii	Commercial	Self-reporting, qualitative	Usability, accessibility, design
Williams et al.[44] (2011)	Balance		Community-dwelling, residential/ retirement communities	Nintendo Wii	Commercial	Anthropometric, clinical	Psychological benefits, physiological benefits
Yamada et al.[45] (2011)	Balance, falls	Cognition	Community-dwelling	Nintendo Wii	Commercial	Anthropometric, clinical, technology-assisted, technology validation	Feasibility/efficacy, diagnostic tool
Zavala-Ibarra and Favela[46] (2012)	Balance, falls		Public space	Nintendo Wii, Kinect	Commercial	Anthropometric, self-reporting	Usability, subject preferences, psychological benefits, subject perception, physiological benefits, design

global attention surrounding this rapidly growing population cohort. Most articles ($n = 35$) clearly identified the proportion of the sample size made up of the oldest old.[10–12,14,17,21–25,28–40,42,44–54] To clarify sample proportions and enable our analysis, two authors contacted the respective authors seeking further clarification of the actual number of participants ≥ 85 years of age when necessary. Consistent with previous reviews,[2–5] this study highlights a substantial gap in the knowledge base and encourage further exploration into digital gaming use in those 85 years of age and greater. Future research is warranted using a representative sample of the oldest old cohort to facilitate greater understanding of cohort-specific needs and challenges to using and implementing videogaming technology.

For this scoping review, the decision not to limit articles based on a particular number of individuals ≥ 85 years of age was made in order to demonstrate the meager way this population is integrated in this knowledge base. Our findings demonstrate that individuals in the oldest old age group are either minimally included or are excluded all together and rarely receive the primary focus as a sample group within the virtual gaming technology literature. Further research is needed that focuses primarily on the videogaming experience of adults in this age cohort in order to fully understand their specific rehabilitation and health needs.

It is possible that the number of studies including the oldest old is underrepresented as it was found many studies did not explicitly state the exact number of participants ≥ 85 years of age. Although an age range was described, it is possible there is a publication bias or a failure of studies to report actual age range. Some studies[24,25,35,39,40,46] only reported the age range with no mean or standard deviation; conversely, five studies[10,27,30,32,33] reported the mean age but no age range or standard deviation. Albeit the authors were able to substantiate some aspect of the participants' ages, the authors believe future studies should use clear measures to depict the exact number of participants ≥ 85 years of age and aim to have a proportionate representation of older adults in studies. Recruitment of larger sample sizes is crucial to gain additional and in-depth knowledge of one's experience in addition to measuring the attrition and adherence of training programs.

Seven[10,24,25,29,46,53,54] of the 46 articles did not report the percentage of female participants included in the study, and two articles[35,51] did not have any female participants in their sample. The remaining 37 articles all reported high percentages of female participants, thus being the majority of the gender split. The study setting/context varied widely across the 46 articles and was composed of retirement/independent communities[11,12,14,21,24,26,29,32,39,40,42,44,47,48,53] ($n = 15$), community-dwelling[13,16,19,45,46,49] ($n = 6$), community center[20,31,38,51,52] ($n = 5$), hospital/assisted living/residential/nursing home/long-term care/institutionalized[10,15–18,25,27,28,30,33,35,37,41,43,50,54] ($n = 16$), not specified[23] ($n = 1$), or other[34,36,55] ($n = 3$). The majority of the studies were primarily conducted across two different living environments (hospital/assisted living/residential/nursing home/long-term care/institutionalized) or retirement/independent living communities. Due to the nature of the age cohort, it is possible that many future studies will be required to recruit from hospital/assisted living/residential/nursing home/long-term care/institutionalized environments. However, if it is the aim of the academic community to utilize technology with the means of maintaining independence into old age, then recruitment from community dwelling/centers should be a primary focal point in future studies.

Various study designs have been conducted to explore this topic, including experimental, quasi-experimental, and non-experimental designs (Table 3). It is noticeable that experimental and quasi-experimental study designs were most prominent. Yet, there were also limited studies focusing on evaluation and using a qualitative or mixed-methods focus. Future studies should consider taking an observation, evaluation, and/or longitudinal/field experiment approach, which in turn would provide researchers and the community greater depth surrounding the feelings and experiences of the oldest old to support expanding current understanding of the utilization and deployment of the technology in a real-life setting. Additionally, taking into account the studies of Bleakley et al.[4] and Miller et al.[3] noted in the Introduction, by tailoring specific studies with robust methods and theory, it is possible that future studies will be able to provide a more substantial and robust validity and reliability of results for academics and clinicians wishing to use videogames for health and rehabilitation.

Based on the findings of this review, all articles referred to the Assessment and Technology Hardware themes, whereas a substantial number of articles covered the Environment, Technology Software, and Games Technology themes. Conversely, the primary themes of Physiological and Psychological Health were less common, which implies the primary aim of the studies may not have been physiological or psychologically related but more attuned to the technology, software, or environment itself, with a secondary focus of physiological and psychological health integrated. However, the physiological theme is prevalent across both gerontology and computer science journals, albeit gerontology is more prominent.

Based on the results of this study, research to date involving the oldest old and videogames has predominantly been published in gerontological journals and not in computer science journals. Since 2011, studies published in the computer science field were predominantly found in conference proceedings, resulting in limited access or knowledge for those accessing the gerontological knowledge base. The same can be noted when trying to access published work in gerontology journals from a computer science department. What this means is that these two fields have continued to emerge independently; however, a more pluralistic approach to videogaming technology in the oldest old may be a way forward to advance knowledge on the intersection of these two topics and a way to bridge the knowledge gap for both sides.

Opportunity exists for further research to conduct more extensive studies related to the impact of results and outcomes from studies included in this review with a representative study population of the oldest old and a direct focus on their use of videogame technology in regard to psychological impact on aging cohorts while still aiming to ascertain suitable solutions for physiological age-related impairments. This may enable study design and execution to better target this population and identify age-related characteristics and issues for consideration.

This article shows a positive incline toward understanding the use of videogame technology for health and aging populations. The 2006 release of the Nintendo Wii console has promoted the use of digital game consoles for health benefits resulting in innovative research projects. The 2010 release of the Microsoft Kinect has also raised interest based on speech recognition and gesture interaction with the environment.

Four key points have been identified from the results of this scoping review. The increasing attention to videogame research including the older adult population in the past 5 years may coincide with recent advancements experienced in the videogaming industry and the positive public/health interest in interactive videogame technology such as the Nintendo Wii and Kinect consoles. The majority of articles used the Nintendo console ($n = 27$), supporting previous findings showing positive benefits to well-being, quality of life, and cognitive performance and it being a low-cost, effective piece of technology for utilization of physical activity and balance.[19–21] Furthermore, over one-third of articles used a mixed variation of purpose-built and commercial hardware. Researchers have also been quick to integrate newer videogame technology into studies; 10.7 percent of articles used the Kinect console despite the fact that the hardware was only released in 2010.

Based on user engagement within the environment, as well as expansion of gesture and speech recognition and in particular with the Xbox One, Kinect version 2.0, the software may be of increased benefit to the oldest old. Measuring heart rate and blood pressure through such platforms offers the possibility to hypothesize the presence of stress, depression, and mental and other physical conditions,[56,57] which may be of great use to the older adults, including the oldest old, thus warranting their inclusion in research studies.

Themes relating to balance, falls, cognition, emotional well-being, and quality of life were prevalent; however, validation and reliability were lacking.[13,48]

We propose a series of recommendations to further enhance the work in this area and in regard to the recruitment and reporting of participants $\geq$85 years of age: Integrating and executing a mixed-methods approach to data collection may be advantageous to gain an in-depth understanding of the role technology can play within the lives of oldest old from multiple perspectives. Using videorecording to analyze observations, interviews, focus groups, and specific game data may produce greater knowledge. Further analyses could examine attitudes to technology, methods of learning technology, technology preferences, and usage. Furthermore, in-game experiences, performance, the effects of flow and immersion, player satisfaction and personality traits, usability, and accessibility experiences of study participants should also be considered. Future studies using the Nintendo or the Kinect consoles should consider executing validation and reliability testing of the technology. Prospective research is warranted to better understand cohort differences among the older adult population to form an initial baseline data for longitudinal research.

Conclusions

Although this review is timely in summarizing the breadth of studies that have recruited adults $\geq$85 years of age for participation with videogames, several points have been highlighted based on the results and in conjunction with the proposed recommendations. This article highlights the necessity for primary research to be undertaken with individuals $\geq$85 years of age based on the presence of low sample sizes, poor representation of study proportions, and the absence of studies that have included a meaningful proportion in their sample size and the sole focus is on the oldest old. The authors anticipate the proposed recommendations will improve the quality of data collection and to encourage interdisciplinary collaboration between the computer science and gerontology fields in order to encourage future studies focused on this cohort and provide greater understanding of technology use for an aging society.

Author Disclosure Statement

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