Received:24 May 2024; Revised:2 September2024; Accepted:1 October 2024；Published：15 October 2024

Systematic Literature Review on User Experience Research of Somatosensory Games for the Elderly

Nan Jing[1,2], Noor Hidayah Azmi[3*]

[1]*Department of Creative Multimedia, Faculty of Art Sustainability and Creative Industry, Sultan Idris Education University, Perak, Malaysia.*
[2]*Department of Design, Faculty of Art, An Kang University, Shaanxi Province, China; jing19891561561@163.com*
[3]*Department of Computer Science And Digital Technology, Faculty Computer And Meta-Technology, Sultan Idris Education University, Perak, Malaysia; hidayah@meta.upsi.edu.my*

**corresponding author*

Abstract

This study aims to investigate the satisfaction levels of the elderly concerning their physical well-being and sociocultural entertainment needs, with a particular focus on engagement in sensor-based gaming. The objective is to systematically synthesise and evaluate empirical research findings regarding the factors influencing accessibility and enthusiasm for sensor-based gaming among older adults. Employing the PRISMA methodology, a comprehensive review was conducted, resulting in the identification of 43 English-language scholarly sources from the Web of Science, Scopus, and IEEE Xplore, covering the period from 2019 to 2024. The findings reveal that critical determinants affecting elderly engagement in sensor-based gaming include physical activity levels, cognitive capabilities, game incentive mechanisms, cooperative-competitive dynamics, personalised feature design, group participation, and gaming frequency. These insights contribute significantly to the discourse on utilizing exergames to enhance the physical and psychological well-being of the ageing population, providing valuable implications for researchers and policymakers aiming to address the challenges associated with an ageing demographic.

Keywords: somatosensory games, elderly people, user experience

INTRODUCTION

The global ageing population has emerged as a significant concern, with the United Nations projecting that approximately 918 million individuals aged 60 to 79 will constitute about 11.8% of the total population by 2020. Furthermore, the population aged 60 and above is expected to double, reaching 2.1 billion by 2050 (Bar-Tur, 2021; World Health Organization, 2022). This demographic shift is accompanied by various physical and mental health conditions, which pose significant challenges to families and societal progress. These conditions include physical decline, mental distress such as depression and autism, as well as sleep difficulties, among others (Bar-Tur, 2021; Corbo et al., 2023; World Health Organization, 2022; Zenebe et al., 2021).

In response to the challenges presented by global ageing, there is a growing interest in creative strategies to enhance physical activity, socialization, and overall well-being among older adults. Somatic games that incorporate motion sensors and interactive technologies have emerged as effective tools for promoting physical activity and social engagement among this demographic (Goumopoulos et al., 2023; Merilampi et al., 2019; Pirbabaei et al., 2023).

Somatic gaming utilizes hardware devices, camera-based motion capture technologies, and game algorithms to enable player interaction through bodily movements, gestures, and various forms of physical expression (Chang & Yen, 2023; Ringgenberg et al., 2022; Zhang et al., 2022). These physical games provide a heightened sense of immersion and tangible involvement compared to digital counterparts on mobile devices and computers, thereby stimulating bodily engagement and promoting physical movement and functionality (Chang & Yen, 2023; Chu et al., 2021; Da Silva Júnior et al., 2021; Ding et al., 2022).

Somatosensory technology has gained traction in medical applications, particularly in physical rehabilitation for older adults and individuals with disabilities. This technology has produced a range of positive outcomes, contributing to advancements in this field (Chang et al., 2021, 2022; Chen et al., 2019; Kappen et al., 2019). Additionally, research in computer science has focused on algorithms designed for somatosensory gaming, aiming to enhance the efficiency and effectiveness of interaction patterns within these systems (Gao, 2022. Despite this progress, there remains a paucity of scholarly studies addressing the user experience of older adults in the development and design of exergames (Chang et al., 2022; Ding et al., 2022). Most somatosensory games currently available primarily target younger demographics, including children and young adults. Some of these games feature high-intensity designs that demand quick reactions and optimal physical fitness (Chang et al., 2022). However, the design of user experiences in these games often overlooks the unique needs of older adults, including diminished physical abilities and learning capacities, as well as the need to mitigate fall risks (Wang et al., 2021).

Loneliness and despair are prevalent among elderly individuals worldwide due to the process of ageing and a multitude of societal factors (Yuan et al., 2022). Research indicates that engaging in physical play can effectively reduce feelings of loneliness while promoting physical activity and fostering social enjoyment (Chu et al., 2021; Ringgenberg et al., 2022; Rüth & Kaspar, 2021; Zhang et al., 2022). To enhance the overall well-being of older adults, a thorough assessment of the user experience related to physical games designed for this demographic is essential; this review will serve as a foundational basis for future scholarly investigations in this area (Mohamed Shaffril et al., 2021; Xiao & Watson, 2019).

The objective of this systematic literature review is to examine the existing knowledge base by evaluating various research processes, methods, and findings within authoritative empirical literature. Through critical analysis and synthesis of the available results and challenges, this review aims to identify reliable research findings and gaps for future scholars. The ultimate goal is to conduct a comprehensive investigation into the current state of user experience in somatic games for older adults. To effectively address the issue of population ageing and enhance the welfare of older.

METHOD

This literature review followed the four phases of the PRISMA process: Identification, Screening, Eligibility, and Data Abstraction and Analysis. Additionally, it adhered to the seven key components of a systematic review: (1) developing a review protocol, (2) formulating research questions, (3) implementing a systematic search strategy, (4) assessing quality, (5) extracting data, (6) synthesizing data, and (7) presenting findings (Mohamed Shaffril et al., 2021; Mustafa et al., 2022). The primary focus of this review is the evaluation of the following research questions based on currently published empirical journals, which may serve as a foundation for future studies examining exergame experiences in various national and cultural contexts.

RQ1. How effective are somatic games in promoting physical activity levels and cognitive functioning in older adults?
RQ2. What is the level of user engagement and experience with somatic gaming among the older adult population?
RQ3. What are the usability and accessibility challenges for older adults using somatic games?
RQ4. What is the impact of somatic gaming on social interactions and group activities among older adults?

Identification

To establish the credibility and reliability of the data used for journal ranking, a comprehensive literature search was conducted over a specified timeframe from February 2019 to September 2024. This search was performed across three highly regarded and authoritative databases: Scopus, Web of Science, and IEEE (as indicated in Table 1). To ensure a thorough and precise search, the identification phase involved crafting and refining the search queries within these databases. This process included identifying precise synonyms for keywords and locating analogous terminology used in prior research. The search queries were employed to ascertain relevant academic articles by examining their metadata, including titles, abstracts, and keywords. The identified keywords derived from the research questions encompass user experience, somatic gaming, senior individuals, and related synonyms. Table 1 presents the search queries and corresponding results for each database. A total of 457 articles were generated through the application of the search formula, successfully meeting the predetermined parameters established by the search criteria.

Table 1: Retrieval formula

Scopus	TITLE-ABS-KEY ("user experience*" OR "UX" OR "user's experience*" OR "Usability*" OR "user feeling*") AND TITLE-ABS-KEY ("somatosensory game*" OR "exergame*" OR "Physical Interaction Game*" OR "Sensorimotor Game*" OR "Gesture-Controlled Game*" OR "Body-Motion Game*" OR "Interactive Motion Game*" OR "Physical Gaming" OR "Motion-Sensing Game*" OR "Sensory Gaming*" OR "Immersive Interaction Game*" OR "motion sensory game*") AND TITLE-ABS-KEY ("elderly*" OR "old people" OR "senior*" OR "Aged" OR "Older adult*" OR "Older generation*" OR "Elder population*" OR "Aging individual*")
WOS	Ts =（"user experience*" OR "UX"OR"user's experience*" OR "Usability*" OR "user feeling*"） AND（"somatosensory game*" OR "exergame*"OR"Physical Interaction Game*"OR"Sensorimotor Game*"OR"Gesture-Controlled Game*"OR"Body-Motion Game*"OR"Interactive Motion Game*"OR"Physical Gaming"OR"Motion-Sensing Game*"OR"Sensory Gaming*"OR"Immersive Interaction Game*"OR"motion sensory game*" ） AND （ "elderly*"OR"old people"OR"senior*"OR"Aged"OR"Older adult*"OR"Older generation*"OR"Elder population*"OR"Aging individual*"）
IEEE	("All Metadata":"user experience*"OR"UX"OR"user's experience*"OR"Usability" OR"user feeling") AND ("All Metadata":"somatosensory game*"OR"exergame*"OR "Physical Interaction Game*"OR"Sensorimotor Games"OR"Gesture-Controlled Games""Body-Motion Games"OR"Interactive Motion Games"OR"Physical Gaming"OR"Motion-Sensing Games"OR"Sensory Gaming"OR"Immersive Interaction Games"OR"motion sensory games") AND ("All Metadata":"elderly*"OR"old people"OR"senior*"OR"Aged"OR"Older adults"OR"Older generation*"OR"Elder population"OR"Aging individual*")

Screening

Utilizing the Boolean search formula, the range of journal sources was defined to conduct a precise literature search resulting from the initial screening. This search excluded journal articles published between 2019 and September 15, 2024, as well as non-English articles, conference papers, review articles, and articles that were in press, ensuring the reliability and relevance of the selected literature. The

exclusion of recent articles facilitates a focus on well-established findings while allowing for a comprehensive understanding of research progress in somatosensory games for the elderly. Non-English publications and conference papers were excluded to maintain consistency in language and research depth. Review articles were omitted to minimize potential bias and redundancy, while articles in press were excluded to ensure the completeness of peer review. The total number of articles meeting these criteria is 134. Additionally, 34 instances of duplicated journal publications were removed from the three databases (as indicated in Table 2).

Table 2: The selection criterion is searching

Criterion	**Inclusion**	**Exclusion**
Language	English	Non-English
Timeline	2019 –15/09/2024	< 2019
Literature type	Journal (Article)	Conference, Book, Review
Publication Stage	Final	In Press

Eligibility

A quality assessment was conducted on the 100 articles selected in the previous stage. Using the Critical Appraisal Skills Program (CASP) methodology, both authors independently carried out a critical appraisal of the included studies (Singh, 2013). The evaluation encompassed several key dimensions, including research objectives, methodology, participant recruitment, data collection procedures, bias evaluation, ethical issues, data analysis, precision of findings, evidence strength, and overall research value. Any discrepancies in the quality assessments were resolved through discussions between the authors until a consensus was achieved.

As a result, 57 reports were removed from the analysis for the following reasons: 21 reports were excluded for being outside the scope of the research, 17 reports had titles that did not significantly contribute to the study, and 14 reports had abstracts that were not aligned with the study's purpose. Five articles were excluded based on CASP criteria. These exclusions were supported by empirical evidence. The total number of papers available for examination was 43 (as indicated in Figure 1).

Data Extraction and Analysis

This study employed an integrative analytic assessment approach to examine and combine multiple research designs, including quantitative, qualitative, and mixed methods. This approach involved systematically extracting and analyzing data from each study to identify key themes and sub-themes. The themes were derived through a combination of thematic analysis and content analysis, ensuring that insights from both the data-gathering methods used in the systematic literature review and the systematic analysis methodology were incorporated. The review aims to comprehensively analyze the research problem, research questions, research objectives, hypotheses, methodologies, theories, instruments, sample sizes, and methods employed in the final included literature based on the review questions. The primary objective is to compare the content of research topics across various journal articles and critically evaluate the reliability of the data and themes presented in the literature.

Received:24 May 2024; Revised:2 September2024; Accepted:1 October 2024；Published：15 October 2024

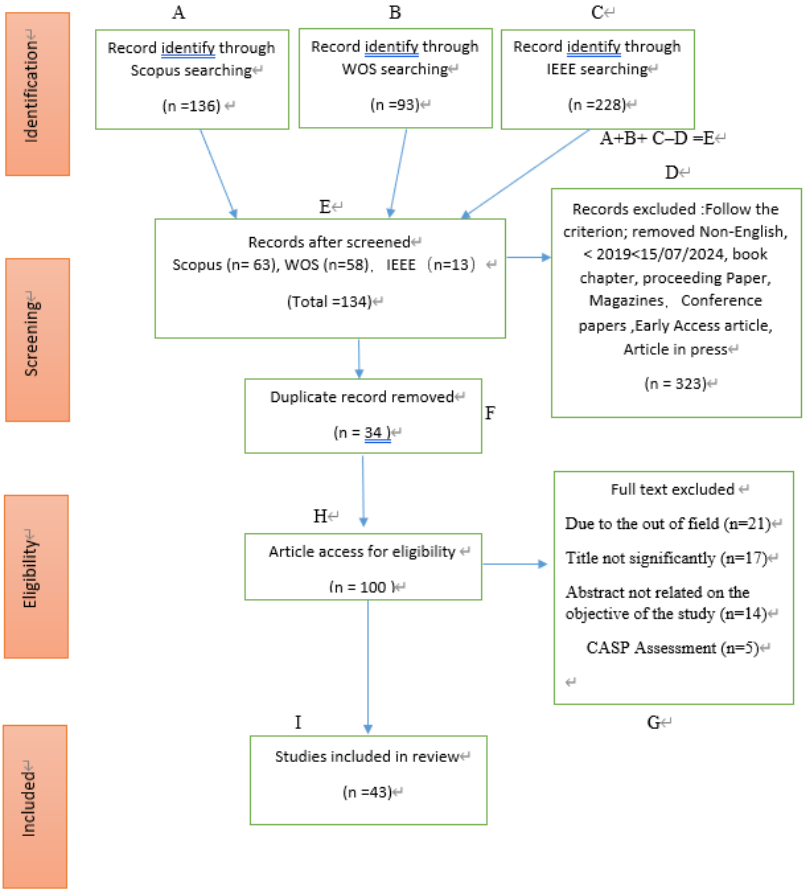

Figure 1: Flow diagram of the proposed searching study

RESULTS AND FINDINGS

The synthesized findings are organized by research questions (RQ) and reveal several key themes regarding the user experience of group sensory games for older adults. The studies included in this review were examined in terms of the user experience of group sensory games among older individuals. The findings were categorized into various topics, including user engagement and experience, promotion of physical activity levels and cognitive benefits, accessibility, and challenges, among other factors. The majority of research documented favourable results related to user involvement and enjoyment. Furthermore, a considerable number of users reported perceiving cognitive advantages and experiencing heightened levels of physical activity. However, the study also revealed concerns about the uptake of technology, the complexity of games, and potential challenges that older individuals may encounter.

RQ1：Intervention Efficacy on Physical Activity and Cognition

Numerous studies have demonstrated favourable results regarding enhancements in physical activity levels and cognitive functioning among older adults engaged in somatic games. These games commonly incorporate components such as balance training, motor-cognitive interventions, and fall prevention exercises, and users frequently report improvements in memory, attention, and problem-solving abilities (Campo-Prieto, Cancela-Carral, Alsina-Rey & Rodríguez-Fuentes, 2022; Manser et al., 2023; Wang,

2024). However, many studies indicate a lack of extensive large-sample and long-term longitudinal research on this topic (Chang et al., 2022; Fan et al., 2022; Ramsayer et al., 2023). Consequently, future investigations should explore the potential impact of increasing sample sizes and extending the duration of somatic gaming research on the physical activity levels and cognitive function of older individuals (Chang et al., 2022; Sápi et al., 2021; Wan et al., 2024). Presently, scholarly investigations concerning the impact of interventions aimed at enhancing physical activity levels and cognitive functioning primarily focus on the utilization of sensors, motor feedback, and diverse gaming mechanics as means to improve physical activity levels among older individuals (Svanæs et al., 2021; Tuena et al., 2020; Wan et al., 2024). Longitudinal studies can explore optimal game design elements (e.g., intensity, duration, type of game) Long-term studies are needed to compare exercise game interventions with traditional exercise programs to determine relative effectiveness (Manser & de Bruin, 2021). Simultaneously, scholars advocate for further investigations into the influence of intelligent agent games on elderly individuals with varying levels of cognitive impairments, as well as examining whether the long-term effects of such games can consistently enhance cognitive functions in older adults (Chang et al., 2022; Manser et al., 2023).

RQ2：User Engagement and Experience

Numerous scholarly investigations have demonstrated that a majority of old participants exhibit favourable dispositions towards somatic games (Chang & Yen, 2023; Ding et al., 2022; Kappen et al., 2019; Liu et al., 2020). The interactive design of these games, which incorporates somatic elements, along with the provision of positive feedback, effectively captivates players' attention and engenders their interest. Moreover, the social interactions facilitated by these games, particularly among family members or friends, coupled with the interactive nature of the gameplay itself, contribute to a profound sense of enjoyment and fulfilment experienced by players (Shah, Karlsen, et al., 2022). Incentives serve as a catalyst for fostering player engagement, while the incorporation of gamification components, feedback mechanisms, and realistic actions contributes to the preservation of sustained interest (Seinsche et al., 2023). Additionally, the inclusion of cooperative or competitive gaming modes has the potential to enhance social interaction, a crucial factor in addressing social isolation (Chan et al., 2019; Høeg et al., 2023; Rüth & Kaspar, 2021; Shah, Karlsen, et al., 2022).

Several studies indicate that older individuals prefer game element designs specifically customized to their distinct cognitive functions (Koivisto & Malik, 2021; Lau & Agius, 2021; W. Li & Chen, 2023). However, there remains a dearth of research investigating the effects of somatic games on various cognitive domains in this population (Ingold et al., 2020; Merilampi et al., 2019; Quigley et al., 2020; Shah, Karlsen, et al., 2022). The level of user engagement is influenced by age and frequency of game playing, whereby younger users exhibit higher levels of engagement, while older users have more pronounced decreases (Kojić et al., 2023). Future research should explore strategies aimed at enhancing the engagement and overall experience of older individuals who do not frequently participate in gaming activities and exhibit diminished interest in such pursuits (Koivisto & Malik, 2021). The examination of variables such as personalized feedback, game incentive techniques, and game goal setting in the context of somatic games has the potential to enhance the sustained involvement of game players over an extended period (Shah, Karlsen, et al., 2022). However, it is important to acknowledge that older individuals lacking familiarity with somatic games may encounter certain constraints or restrictions in this regard (Sayago et al., 2019; Wang, 2024).

Some studies have investigated themes associated with the exploration of the latent benefits of sensory gaming in enhancing engagement and overall well-being among the elderly. These inquiries have conducted in-depth examinations of the psychological and emotional advantages of such games,

Received:24 May 2024; Revised:2 September2024; Accepted:1 October 2024； Published： 15 October 2024

emphasizing their capacity to enhance cognitive stimulation, alleviate feelings of social isolation, and improve the emotional well-being of older individuals. However, it is noteworthy that existing research predominantly focuses on specific game genres from a medical perspective, often overlooking a broader spectrum of gaming types and design elements, thereby limiting a comprehensive understanding of user preferences and motivational factors (Anders et al., 2020; Pirbabaei et al., 2023; Ringgenberg et al., 2022).

RQ3：Usability and Accessibility Challenges

Although somatic games are generally well-regarded, concerns related to usability have been identified, particularly regarding interaction difficulties and learning curves experienced by older adults when engaging with these games (Ramsayer et al., 2023; Seinsche et al., 2023). Preferences among older individuals who engage in somatic gaming include a strong emphasis on user-friendly interfaces, easily understood instructions, consistent and frequent feedback, and designs tailored to the needs of the older population. There is also a desire for game duration to be suitable for older adults, as well as the incorporation of fall prevention measures into game actions to enhance accessibility (Chang et al., 2022; Chu et al., 2021; Shah, Karlsen, et al., 2022; Ramsayer et al., 2023). Furthermore, the complexity of game operations and actions, along with familiarity with the technology, can impact the long-term engagement of older users with somatic games (Shah, Hameed, et al., 2022; Svanæs et al., 2021; Wang, 2024).

Regarding the accessibility of somatic games, it is observed that older adults prefer games with design elements specifically catered to their individual needs and preferences (Manser & de Bruin, 2021). This inclination towards customized features has been found to contribute to more enjoyable experiences among older adults. Potential areas for future investigation may involve examining the usability obstacles faced by older adults with varying levels of technology proficiency when engaging with somatosensory games (Wang, 2024; Chang et al., 2021, 2022; Havukainen et al., 2020; Liu et al., 2020).

To ensure a favourable experience for older adults, it is imperative that games incorporate content in the local language. Future research might investigate the effects of different assistive features on the usability and accessibility of physical games for older adults, particularly in relation to their engagement with motor games (Goumopoulos et al., 2022). A user-centered design approach enhances usability and accommodates physical constraints. Conducting usability studies to identify specific interaction challenges and areas for improvement is essential. Implementing user-centered design principles can help create intuitive interfaces that adapt to age-related physical and cognitive changes. Exploring adaptive and customization options based on individual needs and abilities is also crucial. However, insufficient scholarly investigation has been conducted regarding the effects of social movement game environments on adherence, motivation, and general engagement of older adults in physical games. Investigating the feasibility of motor gaming interventions for enhancing social connectivity and alleviating loneliness among older adults is warranted (Pirbabaei et al., 2023).

RQ4：Social Interaction and Group Settings

Numerous scholarly investigations have examined the capacity of physical games to facilitate social contact and foster group participation. These studies have revealed that the inclusion of multiplayer capabilities and collaborative activities positively affects user engagement (Merilampi et al., 2019; Shah, Hameed, et al., 2022; Svanæs et al., 2021; Tuena et al., 2020). However, the current body of research has yet to investigate the influence of social contacts on the engagement of older adults in exergames. Previous literature indicates that scholarly investigations have predominantly concentrated on individual experiences, neglecting to study the potential advantages associated with group training. Therefore, it is recommended that future studies explore the impact of collective somatic game training on individual

motivation, adherence, and outcomes. Additionally, it would be beneficial to assess the consequences of individual versus group training on physical activity levels, cognitive functioning, and user engagement (Merilampi et al., 2019). Future research may also examine the influence of social connections on the engagement of older adults in physical gaming activities.

DISCUSSION & CONCLUSION

The findings of this study highlight the significant potential of somatic games in enhancing the physical activity, cognitive function, and social engagement of older adults (Campo-Prieto, Cancela-Carral, & Rodríguez-Fuentes, 2022; Pirbabaei et al., 2023b; Zhang et al., 2021； Wang, 2024). The review reveals several key themes related to user experiences, including the efficacy of these games in promoting health benefits and the importance of engaging design elements. Notably, participants expressed enjoyment and perceived cognitive advantages, underscoring the positive impact of somatic games on their overall well-being.

Despite these positive outcomes, challenges persist that may hinder the widespread adoption and long-term effectiveness of somatic games in this population. Issues such as usability, interaction difficulties, and the learning curve associated with technology present barriers to effective engagement. The complexity of game mechanics and the need for user-friendly interfaces are essential considerations for developers aiming to enhance accessibility and ensure that older adults can fully benefit from these interventions (Campo-Prieto, Cancela-Carral, Alsina-Rey, et al., 2022. Cognitive and physical impairments may also limit interaction with these technologies (Chang et al., 2022; Manser & de Bruin, 2021). Additionally, many studies have limitations such as small sample sizes and short durations, which reduce the generalizability and long-term applicability of the results (Rebsamen et al., 2019; Wan et al., 2024). Finally, most of the current research is based on medical rehabilitation, focusing on diseases of the elderly or preventing falls in the elderly. Fewer studies are conducted from the perspective of user experience and interactive design of commercial games based on different cultural backgrounds.

Future research should address these challenges by conducting large-scale, long-term longitudinal studies to better understand the sustained impact of somatic games on physical and cognitive health in older adults. Investigations into optimal game design elements—such as intensity, duration, and type of game—are necessary to achieve desired outcomes. Incorporating personalized feedback and adaptive difficulty levels may enhance effectiveness, especially for individuals with varying levels of cognitive impairments (Campo-Prieto, Cancela-Carral, & Rodríguez-Fuentes, 2022; Pirbabaei et al., 2023). Furthermore, while the current body of research emphasizes individual experiences, it often overlooks the social dimensions of gaming. The potential benefits of group dynamics, such as enhanced motivation and adherence to physical activity, warrant further exploration. Future studies should investigate the effects of social interactions facilitated by somatic games and examine how cooperative and competitive elements can foster community and reduce feelings of isolation (Shah, Hameed et al., 2022).

In conclusion, while current evidence supports the efficacy of somatic games in promoting physical activity and cognitive functioning among older adults, more comprehensive and long-term research is essential. By overcoming existing challenges and tailoring interventions to meet the specific needs of older populations, somatic games have the potential to become a valuable tool in promoting healthy ageing.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

AUTHOR CONTRIBUTIONS

Nan Jing：Original draft preparation and revision. **Noor Hidayah**: Supervision and reviewing

DATA AVAILABILITY STATEMENT

Data available within the article or its supplementary materials.

REFERENCES

Anders, P., Bengtson, E. I., Grønvik, K. B., Skjæret-Maroni, N., & Vereijken, B. (2020). Balance training in older adults using exergames: Game speed and cognitive elements affect how seniors play. *Frontiers in Sports and Active Living*, *2*. https://doi.org/10.3389/fspor.2020.00054

Bar-Tur, L. (2021). Fostering Well-Being in the Elderly: Translating Theories on Positive Aging to Practical Approaches. *Frontiers in Medicine*, *8*. https://doi.org/10.3389/fmed.2021.517226

Campo-Prieto, P., Cancela-Carral, J. M., Alsina-Rey, B., & Rodríguez-Fuentes, G. (2022). Immersive virtual reality as a novel physical therapy approach for nonagenarians: Usability and effects on balance outcomes of a game-based exercise program. *Journal of Clinical Medicine*, *11*(13), 3911. https://doi.org/10.3390/jcm11133911

Campo-Prieto, P., Cancela-Carral, J. M., & Rodríguez-Fuentes, G. (2022). Feasibility and effects of an immersive virtual reality exergame program on physical functions in institutionalized older adults: A randomized clinical trial. *Sensors*, *22*(18), 6742. https://doi.org/10.3390/s22186742

Chan, G., Arya, A., Orji, R., & Zhao, Z. (2019). Motivational strategies and approaches for single and multi-player exergames: A social perspective. *PeerJ Computer Science*, *5*, e230. https://doi.org/10.7717/peerj-cs.230

Chang, C.-H., Liu, K.-H., Kajihara, H., Lien, W.-C., Chen, P.-T., Hiyama, A., Lin, Y.-C., Chen, C.-H., & Inami, M. (2021). Designing a somatosensory interactive game of lower extremity muscle rehabilitation for the elderly. In Q. Gao & J. Zhou (Eds.), *Human aspects of IT for the aged population. Supporting everyday life activities. HCII 2021. Lecture Notes in Computer Science* (Vol. 12787). Springer, Cham. https://doi.org/10.1007/978-3-030-78111-8_2

Chang, C.-H., Yeh, C.-H., Chang, C.-C., & Lin, Y.-C. (2022). Interactive somatosensory games in rehabilitation training for older adults with mild cognitive impairment: Usability study. *JMIR Serious Games*, *10*(3), e38465. https://doi.org/10.2196/38465

Chang, I.-C., & Yen, C.-E. (2023). Application of somatosensory computer game for nutrition education in preschool children. *Computers*, *12*(1), 20. https://doi.org/10.3390/computers12010020

Chen, D.-R., Chen, Y.-M., & Tseng, W. T. (2019). Using somatosensory games to improve health and social engagement of Taiwanese older adults in a community. *Innovation in Aging*, *3*(Supplement_1), S921–S922. https://doi.org/10.1093/geroni/igz038.3357

Chu, C. H., Biss, R. K., Cooper, L., Quan, A. M. L., & Matulis, H. (2021). Exergaming platform for older adults residing in long-term care homes: User-centered design, development, and usability study. *JMIR Serious Games*, *9*(1), e22370. https://doi.org/10.2196/22370

Corbo, I., Forte, G., Favieri, F., & Casagrande, M. (2023). Poor sleep quality in aging: The association with mental health. *International Journal of Environmental Research and Public Health*, *20*(3), 1661. https://doi.org/10.3390/ijerph20031661

Da Silva Júnior, J. L. A., Biduski, D., Bellei, E. A., Becker, O. H. C., Daroit, L., Pasqualotti, A., Tourinho Filho, H., & De Marchi, A. C. B. (2021). A bowling exergame to improve functional capacity in older adults: Co-design, development, and testing to compare the progress of playing alone versus playing with peers. *JMIR Serious Games*, *9*(1), e23423. https://doi.org/10.2196/23423

Ding, Y., Han, T., Liu, C., Zhang, Y., & Zhao, S. (2022). Analysis of the influencing factors of the elderly user's somatosensory game themes preferences – Based on the DEMATEL method. In Q. Gao & J. Zhou (Eds.), *Human aspects of IT for the aged population. Technology in everyday living. HCII 2022. Lecture Notes in Computer Science* (Vol. 13331). Springer, Cham. https://doi.org/10.1007/978-3-031-05654-3_15

Fan, M., Tibdewal, V., Zhao, Q., Cao, L., Peng, C., Shu, R., & Shan, Y. (2022). Older adults' concurrent and retrospective think-aloud verbalizations for identifying user experience problems of VR games. *Interacting with Computers*, *34*(4), 99–115. https://doi.org/10.1093/iwc/iwac039

Gao, P. (2022). Key technologies of human-computer interaction for immersive somatosensory interactive games using VR technology. *Soft Computing*, *26*(20), 10947–10956. https://doi.org/10.1007/s00500-022-07240-3

Goumopoulos, C., Drakakis, E., & Gklavakis, D. (2022). Augmented and virtual reality-based exergames in GAME2AWE for elderly fall prevention. *International Conference on Wireless and Mobile Computing, Networking and Communications*, 2022-October, 100–105. https://doi.org/10.1109/WiMob55322.2022.9941651

Goumopoulos, C., Drakakis, E., & Gklavakis, D. (2023). Feasibility and acceptance of augmented and virtual reality exergames to train motor and cognitive skills of elderly. *Computers*, *12*(3). https://doi.org/10.3390/computers12030052

Havukainen, M., Laine, T. H., Martikainen, T., & Sutinen, E. (2020). A case study on co-designing digital games with older adults and children: Game elements, assets, and challenges. *The Computer Games Journal*, *9*(2), 163–188. https://doi.org/10.1007/s40869-020-00100-w

Høeg, E. R., Bruun-Pedersen, J. R., Cheary, S., Andersen, L. K., Paisa, R., Serafin, S., & Lange, B. (2023). Buddy biking: A user study on social collaboration in a virtual reality exergame for rehabilitation. *Virtual Reality*, *27*(1), 245–262. https://doi.org/10.1007/s10055-021-00544-z

Ingold, M., Tulliani, N., Chan, C. C. H., & Liu, K. P. Y. (2020). Cognitive function of older adults engaging in physical activity. *BMC Geriatrics*, *20*(1), 229. https://doi.org/10.1186/s12877-020-01620-w

Kappen, D. L., Mirza-Babaei, P., & Nacke, L. E. (2019). Older adults' physical activity and exergames: A systematic review. *International Journal of Human–Computer Interaction*, *35*(2), 140–167. https://doi.org/10.1080/10447318.2018.1441253

Koivisto, J., & Malik, A. (2021). Gamification for older adults: A systematic literature review. *The Gerontologist*, *61*(7), e360–e372. https://doi.org/10.1093/geront/gnaa047

Kojić, T., Spang, R., Vergari, M., Meier, L., Möller, S., & Voigt-Antons, J.-N. (2023). Effects of user factors on user experience in virtual reality: age, gender, and VR experience as influencing factors for VR exergames. *Quality and User Experience*, *8*(1), 3. https://doi.org/10.1007/s41233-023-00056-5

Lau, S.-Y. J., & Agius, H. (2021). A framework and immersive serious game for mild cognitive impairment. *Multimedia Tools and Applications*, *80*(20), 31183–31237. https://doi.org/10.1007/s11042-021-11042-4

Li, W., & Chen, Y. (2023). Research on the design of serious games for the elderly cognitive training based on augmented reality. In Q. Gao & J. Zhou (Eds.), *Human aspects of IT for the aged population. HCII 2023. Lecture Notes in Computer Science* (Vol. 14042). Springer, Cham. https://doi.org/10.1007/978-3-031-34866-2_32

Liu, Y.-H., Liu, J. C., Lin, M.-T., & Chen, W.-C. (2020). Participation of senior citizens in somatosensory games: a correlation between the willingness to exercise and happiness. *Journal of Ambient Intelligence and Humanized Computing*. https://doi.org/10.1007/s12652-020-01918-y

Manser, P., & de Bruin, E. D. (2021). Making the best out of IT: Design and development of exergames for older adults with mild neurocognitive disorder – A methodological paper. *Frontiers in Aging Neuroscience*, *13*. https://doi.org/10.3389/fnagi.2021.734012

Manser, P., Poikonen, H., & de Bruin, E. D. (2023). Feasibility, usability, and acceptance of "Brain-IT"—A newly developed exergame-based training concept for the secondary prevention of mild neurocognitive disorder: a pilot randomized controlled trial. *Frontiers in Aging Neuroscience*, *15*. https://doi.org/10.3389/fnagi.2023.1163388

Merilampi, S., Mulholland, K., Ihanakangas, V., Ojala, J., Valo, P., & Virkki, J. (2019). A smart chair physiotherapy exergame for fall prevention – User experience study. *2019 IEEE 7th International Conference on Serious Games and Applications for Health (SeGAH)*, 1–5. https://doi.org/10.1109/SeGAH.2019.8882482

Mohamed Shaffril, H. A., Samsuddin, S. F., & Abu Samah, A. (2021). The ABC of systematic literature review: The basic methodological guidance for beginners. *Quality and Quantity*, *55*(4), 1319–1346. https://doi.org/10.1007/s11135-020-01059-6

Mustafa, W. A., Alias, N. A., Jamlos, M. A., Ismail, S., & Alquran, H. (2022). A recent systematic review of cervical cancer diagnosis: Detection and classification. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, *28*(1), 81–96. https://doi.org/10.37934/araset.28.1.8196

Pirbabaei, E., Amiri, Z., Sekhavat, Y. A., & Goljaryan, S. (2023). Exergames for hand rehabilitation in elders using Leap Motion Controller: A feasibility pilot study. *International Journal of Human-Computer Studies*, 103099. https://doi.org/10.1016/j.ijhcs.2023.103099

Quigley, A., MacKay-Lyons, M., & Eskes, G. (2020). Effects of exercise on cognitive performance in older adults: A narrative review of the evidence, possible biological mechanisms, and recommendations for exercise prescription. *Journal of Aging Research*, *2020*, 1–15. https://doi.org/10.1155/2020/1407896

Ramsayer, N., Philippe, M., Marco De Nunzio, A., & Johannsson, J. (2023). Acceptation et perception de satisfaction des jeux d'exercice pour prévenir les risques de chute chez les personnes âgées. *Kinésithérapie, La Revue*, *23*(258), 11–19. https://doi.org/10.1016/j.kine.2022.10.003

Rebsamen, S., Knols, R. H., Pfister, P. B., & de Bruin, E. D. (2019). Exergame-driven high-intensity interval training in untrained community-dwelling older adults: A formative one-group quasi-experimental feasibility trial. *Frontiers in Physiology*, *10*. https://doi.org/10.3389/fphys.2019.01019

Ringgenberg, N., Mildner, S., Hapig, M., Hermann, S., Kruszewski, K., Martin-Niedecken, A. L., Rogers, K., Schättin, A., Behrendt, F., Böckler, S., Schmidlin, S., Jurt, R., Niedecken, S., Brenneis, C., Bonati, L. H., Schuster-Amft, C., & Seebacher, B. (2022). ExerG: Adapting an exergame training solution to the needs of older adults using focus group and expert interviews. *Journal of NeuroEngineering and Rehabilitation*, *19*(1). https://doi.org/10.1186/s12984-022-01063-x

Rüth, M., & Kaspar, K. (2021). Educational and social exergaming: A perspective on physical, social, and educational benefits and pitfalls of exergaming at home during the COVID-19 pandemic and afterwards. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.644036

Sápi, M., Fehér-Kiss, A., Csernák, K., Domján, A., & Pintér, S. (2021). The effects of exergaming on sensory reweighting and mediolateral stability of women aged over 60: Usability study. *JMIR Serious Games*, *9*(3), e27884. https://doi.org/10.2196/27884

Sayago, S., Rosales, A., Righi, V., Ferreira, S. M., Coleman, G. W., & Blat, J. (2019). Digital games and older people from a theoretical and conceptual perspective: A critical literature review. In B. Neves & F. Vetere (Eds.), *Ageing and digital technology*. Springer, Singapore. https://doi.org/10.1007/978-981-13-3693-5_6

Seinsche, J., de Bruin, E. D., Carpinella, I., Ferrarin, M., Moza, S., Rizzo, F., Salatino, C., & Giannouli, E. (2023). Older adults' needs and requirements for a comprehensive exergame-based telerehabilitation system: A focus group study. *Frontiers in Public Health*, *10*. https://doi.org/10.3389/fpubh.2022.1076149

Shah, S. H. H., Hameed, I. A., Karlsen, A. S. T., & Solberg, M. (2022). Towards a social VR-based exergame for elderly users: An exploratory study of acceptance, experiences, and design principles. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *13317 LNCS*, 495–504. https://doi.org/10.1007/978-3-031-05939-1_34

Shah, S. H. H., Karlsen, A. S. T., Solberg, M., & Hameed, I. A. (2022). A social VR-based collaborative exergame for rehabilitation: Co-design, development, and user study. *Virtual Reality*, *27*, 3403–3420. https://doi.org/10.1007/s10055-022-00721-8

Singh, J. (2013). Critical appraisal skills programme. *Journal of Pharmacology and Pharmacotherapeutics*, *4*(1), 76–77. https://doi.org/10.4103/0976-500X.107697

Svanæs, D., Scharvet Lyngby, A., Bärnhold, M., Røsand, T., & Subramanian, S. (2021). UNITY-Things: An internet-of-things software framework integrating Arduino-enabled remote devices with the UNITY game engine. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *12789 LNCS*, 378–388. https://doi.org/10.1007/978-3-030-77277-2_29

Tuena, C., Pedroli, E., Trimarchi, P. D., Gallucci, A., Chiappini, M., Goulene, K., Gaggioli, A., Riva, G., Lattanzio, F., Giunco, F., & Stramba-Badiale, M. (2020). Usability issues of clinical and research applications of virtual reality in older people: A systematic review. *Frontiers in Human Neuroscience*, *14*. https://doi.org/10.3389/fnhum.2020.00093

Wan, F. K. W., Mak, A. T. H., Chung, C. W. Y., & Yip, J. Y. W. (2024). Development of a motion-based video game for postural training: A feasibility study on older adults with adult degenerative scoliosis. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, *32*, 2106–2113. https://doi.org/10.1109/TNSRE.2024.3398029

Wang, Y., Huang, Y., Xu, J., & Bao, D. (2021). Interaction preference differences between elderly and younger exergame users. *International Journal of Environmental Research and Public Health*, *18*(23). https://doi.org/10.3390/ijerph182312583

Wang, Y.-H. (2024). Understanding senior adults' needs, preferences, and experiences of commercial exergames for health: Usability study. *JMIR Serious Games*, *12*, e36154. https://doi.org/10.2196/36154

World Health Organization. (2022, October 1). *Ageing and health*. https://www.who.int/news-room/fact-sheets/detail/ageing-and-health

Xiao, Y., & Watson, M. (2019). Guidance on conducting a systematic literature review. *Journal of Planning Education and Research*, *39*(1), 93–112. https://doi.org/10.1177/0739456X17723971

Yuan, J., Wang, Y., & Liu, Z. (2022). Chronic disease and depression among the elderly in China: The mediating role of instrumental activities of daily living and the moderating role of area of residence. *Current Psychology*, *42*, 27186–27193. https://doi.org/10.1007/s12144-022-03782-9

Zenebe, Y., Akele, B., W/Selassie, M., & Necho, M. (2021). Prevalence and determinants of depression among old age: A systematic review and meta-analysis. *Annals of General Psychiatry*, *20*(1), 55. https://doi.org/10.1186/s12991-021-00375-x

Zhang, H., Shen, Z., Liu, S., Yuan, D., & Miao, C. (2021). Ping Pong: An exergame for cognitive inhibition training. *International Journal of Human–Computer Interaction*, *37*(12), 1104–1115. https://doi.org/10.1080/10447318.2020.1870826

Zhang, Y., Han, T., Ding, Y., & Zhao, S. (2022). Design of somatosensory interactive balance training exergame for the elderly based on Tai Chi. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *13331 LNCS*, 305–319. https://doi.org/10.1007/978-3-031-05654-3_21