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Title: The Social Effects of Exergames on Older Adults: A Systematic Review and Metric Analysis

Authors: Jinhui Li*, Ph.D., Kanokkorn Witedwittayanusat, BSc., Luxi Chen, Ph.D., Yuanyuan Cao, Ph.D., Shan Qi Lee, BA., Mojisola Erdt, Ph.D., and Yin-Leng Theng, Ph.D.

Affiliations (for all authors): Wee Kim Wee School of Communication and Information, Nanyang Technological University, 31 Nanyang Link, Singapore 637718

*Corresponding author: Jinhui Li

Email: jli020@e.ntu.edu.sg  |  Tel: (65) 67902030

Wee Kim Wee School Of Communication and Information,
Nanyang Technological University,
31 Nanyang Link, Singapore 637718
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Abstract

Background: Recently, many studies have been conducted to investigate the effects of exergames on the social well-being among older adults.

Objective: The aim of this paper is to synthesise existing studies and provide an overall picture on the social effects of exergames on older adults.

Methods: A comprehensive literature search with inclusive criteria was conducted among major bibliographic databases in social science. The review extracted their characteristics of exergames, participants, methodology, as well as outcome measurements. The bibliometric and altmetric outreach of the included studies were also investigated.

Results: A total of 10 studies were included, with 8 studies having applied Nintendo’s Wii platform. Most of the studies recruited healthy older adults from local communities or senior activity centers. Three groups of social-related outcomes have been identified, including emotion-related, behavior-related, and attitude-related outcomes. Metric analysis has shown that the emotion-related and behavior-related outcomes received high attention from both the academic community and social media platforms.

Conclusions: Overall, the majority of exergame studies demonstrated promising results for enhanced social well-being, such as reduction of loneliness, increased social connection and positive attitudes towards others. The paper also provided implications for healthcare researchers and exergame designers.
Keywords: active video games, psychosocial well-being, ageing, literature review, citation analysis
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Introduction

Our world has been experiencing significant ageing. A recent report from the United Nations [1] indicated the number of older adults aged 60 and above is 901 million in 2015, taking up 13% of the entire population. The report predicted that this number would have doubled by 2050, reaching nearly 2.1 billion. Population ageing has become a major global demographic trend, which raises many public concerns on the well-being of older adults [2, 3]. Older adults often suffer from several common negative events, such as lack of close family ties (e.g. living alone), loss of a loved one, or a decline in mobility or actively participating in social activities. The accumulation of these negative events has caused inadequate social support, or impaired social interaction. Studies indicated that lack of social interaction led to frequently experienced social problems and disorders, such as social isolation and loneliness [4-6]. Given the potential harmful effects of social isolation and loneliness, it is important to develop social interventions in order to reduce emotional damage to older adults and inappropriate health and social service usage.

With the advent of digital technology, exergames, which combine digital gaming and physical exercise, have become common daily exercise programmes [7]. Despite being originally designed for entertainment, exergames have been increasingly used in healthcare promotion. There is a rapid growth in the popularity and use of exergames as health programmes in public settings, such as communities [8], schools and work environments [9]. Many previous studies [10, 11] have assessed the potential benefits of exergames in physical, cognitive and
psychological well-being. For example, evidence from a 2-week pilot study demonstrated that exergames were able to significantly improve upper extremity function for post-stroke patients [12]. A pilot study from Chan et al. [13] has shown that older adults in virtual reality cognitive training programs have better improvements on repetition and memory than those in usual programmes. Albores et al. [14] reported that older patients with chronic obstructive pulmonary disease have significant improvements in emotion after a 12-week Wii Fit training.

The social effects of exergames have drawn considerable attention from researchers [15-17]. Exergaming is a social experience that allows an opportunity for players to interact with each other. This can in turn foster social networking and friendships among them. The results from Kooiman & Sheehan [15] showed that exergaming over the Internet increased students’ social relatedness in physical education. Social interaction was reported as the most important motivation for adolescents in a 20-week exergaming intervention [18]. Besides the young generation, recent exergaming research have also extended the investigation of the social effects to the older population [19, 20].

Considering the major concern on older adults with social disorders, it is important to have an overview on whether exergames may serve as an effective intervention for the social well-beings of this group of people. In the literature of exergaming, many systematic reviews only focus on the physical and cognitive benefits on older adults [21-23]. For the papers which reviewed the psychosocial effects of exergames, they mainly referred to psychological changes, such as depression, mood, and enjoyment [24-27]. However, an overall picture is lacking in the social effects of exergames on older adults. With increasing research efforts in the field, the current systematic review was conducted to synthesise existing studies and provide implications for improving social well-being via exergaming. Additionally, the review also investigated the
bibliometric and altmetric outreach of the included studies in this systematic review, to understand their impacts in both academic and non-academic (social media) platforms.

**Method**

The current review adopted the definition of exergame from Oh and Yang [7] who defined it as ‘an experiential activity in which playing exergames or any videogames requires physical exertion or movements that are more than sedentary activities and also include strength, balance, and flexibility activities’. The included studies in the systematic review should involve primary intervention that used exergames fulfilling the above definition. Other inclusive criteria are: 1) incorporating measure of social outcomes such as social connection, social bonding, or loneliness; 2) targeting on participants aged 55 or above; 3) reporting original research in English. In order to achieve a complete picture of exergaming effects on social outcomes, there were no certain criteria related to study design. The review included studies using qualitative or quantitative methods.

A comprehensive literature search was conducted among major bibliographic databases in social science, including PsycINFO, PubMed, CINAHL, and ScienceDirect. Reference lists from included studies and relevant reviews were also inspected for additional studies. Potential studies were identified by the combination of exergame terms (exergame OR Wii OR Kinect OR active video game), social terms (socia* OR social support OR social interaction OR social bonding OR communicat*), and ageing terms (aging OR aged OR elderly OR older OR senior). We retrieved a total of 319 articles published before February 2017 for reviewing and analyzing. All articles were assessed by either title, abstract, or full text to determine their eligibility in the current systematic review. After identifying the final included studies, the review extracted their
characteristics of exergames, participants (country, sample size, age, and profile), methodology (study design and duration), as well as outcome measurements.

To investigate the bibliometric (in terms of citation count) and altmetric or social media presence of the articles included in the systematic review, we collected citation counts from Scopus [28], as well as usage and capture data from PlumX [29] in May 2017. We also collected Tweet counts, Mendeley readers, and the Altmetric Attention Score from Altmetric [30]. Altmetrics can be described as new or alternative measures of the impact of research objects, based mainly on social media data sources [31]. The Altmetric Attention Score is a weighted aggregate metric comprising diverse online sources from news outlets, policy documents, blogs, Wikipedia, Twitter, Facebook, YouTube, and other social media sources. Usage data from PlumX is a combined metric incorporating counts from downloads, views, library holdings, video plays, clicks, collaborators, and other usage metrics. Capturing data from PlumX comprises counts from bookmarks, favorites, followers, readers, subscribers, watchers, exports/saves and code forks. The 2015 QS world university rankings [32] were used to determine the prestigious universities. We used a logarithmic scale for a better visualization of the data. These metrics gave us an insight into the outreach and impact of the included studies in this systematic review.

Results

According to the inclusive criteria, a total of 10 studies were eligible to be included in the final review process. Figure 1 illustrates the flowchart for the selection of included studies. Table 1 outlines the key characteristics of these 10 studies.
Figure 1. Flowchart for the included studies in systematic review

Table 1. Characteristics of Included Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Exergames</th>
<th>Participants</th>
<th>Methodology</th>
<th>Outcome measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chao, Musanti [19]</td>
<td>Wii Fit U (balance games, yoga poses, strength training, aerobics, and dance games)</td>
<td>US 12 64.17 (6.74)</td>
<td>Within-group, post-study interview</td>
<td>Social connection: Semi-structured interviews</td>
</tr>
<tr>
<td>Jung, Li [34]</td>
<td>Wii Sports (tennis, bowling, baseball and boxing) and Cooking Mama</td>
<td>Singapore 45 56-92</td>
<td>Between-group, 2 conditions: Play exergame, Play traditional board games (memory games)</td>
<td>Loneliness: UCLA Loneliness Scale</td>
</tr>
<tr>
<td>Kahlbaugh, Sperandio</td>
<td>Wii game (Wii bowling)</td>
<td>US 35 82 (9.8)</td>
<td>Between-group, 3 conditions:</td>
<td>Loneliness: UCLA</td>
</tr>
<tr>
<td>Study</td>
<td>Platform</td>
<td>Country</td>
<td>Sample Size</td>
<td>Age Range</td>
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<td>-------</td>
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<tr>
<td>Keogh, Power [36]</td>
<td>Nintendo Wii Sports</td>
<td>Australia</td>
<td>34</td>
<td>83 (8)</td>
</tr>
<tr>
<td>Millington [37]</td>
<td>Exergame such as Wii Bowling</td>
<td>Canada</td>
<td>8</td>
<td>N/A</td>
</tr>
<tr>
<td>Theng, Chua [38]</td>
<td>Wii games such as “Wii Sports”, “Cooking Mama” and “Wii Party”</td>
<td>Singapore</td>
<td>28</td>
<td>&gt; 60</td>
</tr>
<tr>
<td>Wollersheim, Merkes [39]</td>
<td>Wii games</td>
<td>Australia</td>
<td>11</td>
<td>73.5 (9)</td>
</tr>
<tr>
<td>Wu, Li [40]</td>
<td>Kinect Sport Bowling with a partner</td>
<td>Singapore</td>
<td>113</td>
<td>&gt; 55</td>
</tr>
<tr>
<td>Xu, Li [20]</td>
<td>Three Kinect exergames</td>
<td>Singapore</td>
<td>89</td>
<td>75</td>
</tr>
</tbody>
</table>
Characteristics of the studies included

**Exergame types.** Eight out of the 10 studies investigated the social effects of exergames on the platform of Nintendo’s Wii, while 2 studies investigated those on the platform of Microsoft Xbox Kinect. Both platforms are the most popular exergaming platforms in the current market, which offer console-based devices and games that make exergaming possible in home settings. In terms of game topics, it is interesting to find that half of the studies (n=5) applied games from Nintendo’s Wii Sports package [34-38]. The Wii Sports game package allows participants to play virtual sport games (such as tennis, bowling, baseball, golf, or boxing) by performing body motions that they do in actual sports. Another study from Wu, Li, and Theng [40] also used virtual bowling game among older adults, but from the Microsoft Kinect Sports game package. Two studies were reported to use exercise games from Nintendo’s Wii Fit, or its successor Nintendo’s Wii Fit U [19, 33]. Different from Wii Sports games, Wii Fit exergames aim to improve players’ physical fitness through exercise activities such as strength training, aerobics, yoga and balance games. Besides those simulating actual exercise, exergames with topics from daily life activities were also found in two studies [34, 38], such as cookery simulation-styled *Cooking Mama* and party simulation-styled *Wii Party*.

**Participants.** Most of the studies recruited healthy older adults from local communities or senior activity centers. Two studies [33, 39] are the exceptions that investigated the social effects of exergames on older adults with physical or social problems, such as those with impaired balance, with a disability or who are socially isolated. Six studies included participants with anxiousness scale - Sociability: Sociability scale
Western cultural backgrounds, including United States, Australia, and Canada. Among these Western studies, one was found to be particularly focused on African Americans [19]. Four studies were conducted in the context of Asia, but all of them came from Singapore. Majority of the studies involved a small sample size that was less than 50 participants.

Methodology. Half of the studies applied post-study qualitative methods to assess the social effects of exergames, such as semi-structured interview, semi-structured group interview, or focus group discussion. Among those applying quantitative methods, four studies tested the effects between exergames and other control conditions. For example, Wu et al. [40], Jung et al. [34], and Kahlbaugh et al. [35] compared exergames with traditional activities like playing board games, watching television programs, or performing normal exercise. Xu et al.’s [20] study is an exception which compared the effects among three exergame conditions (play alone vs. play with elderly vs. play with youths). One study [38] applied within-group experiment to compare the effects before and after the exergame intervention. The duration of the intervention period ranged from 1 to 12 weeks, while most of the studies involved 8 sessions and more.

Social Outcomes

The findings of the included studies have identified several social-related outcomes. Based on the various natures, these outcomes were categorized into three groups: emotion-related; behavior-related; and attitude-related.

Emotion-related. Loneliness was identified to be the main emotion-related social outcome affected by exergames. Jung et al. [34] conducted a study to assess the potential of Nintendo Wii in improving the quality of life among older adults in a long-term care facility. Their results indicated that elderly in the Wii condition had a significantly lower level of
loneliness than those who played traditional board games. Similarly, another between-group study in US also reported that playing *Wii* rather than watching television led to lower loneliness [35]. Xu et al. [20] also found a significant decrease in loneliness among older adults after exergaming, although little differences were found across different play types or age groups (young-old vs. old-old). In the same study, social anxiousness was also found to have significantly declined only in the young-old participants who played exergame with youths [20].

*Behavior-related.* Exergames were found to have several behavior-related outcomes on older adults, such as changes in social connection, bonding, and engagement. After completing an exergaming program over 14 weeks, some older adults felt that they were more connected with others [19]. Three studies [33, 36, 39] also indicated that exergames provided an avenue for greater socialization and stronger bonding with peers or even grandchildren. Millington [37] further found that exergames were able to increase social engagement by bringing the seniors together in retirement centres and also by getting them to be more active. In Xu et al.’s study [20], sociability was increased significantly among the young-old participants playing exergames with youths, and old-old participants playing with their peers.

*Attitude-related.* Wu et al. [40] presented a study which examined the exergame effects on social presence, which was defined as the sense of connecting or being with others in a media-mediated environment. Nevertheless, their results found that older adults in the exergame setting had a significant lower social presence than those in traditional exercise. Another Singapore study from Theng et al. [38] showed that playing exergames with youths led to improvement on older adults’ positive attitude towards the other age group.

**Metric Analysis**
Currently, the study from Agmon et al. [33] has received the most attention from the scholarly community with a total of 105 citations, 27 of which came from prestigious universities. Wollersheim et al. [39] also received a good amount of attention with a total of 63 citations, of which 8 were from prestigious universities. Most of the citations of these two studies came from articles published between 2014 and 2016, and mainly from the fields of Medicine and Computer Science. Since the studies from Xu et al. [20] and Chao et al. [19] were only recently published in December 2016 and January 2017 respectively, no citations could yet be found for these articles. Figure 2 shows the bibliometric outreach of the exergame studies.

**Figure 2.** Overview of the bibliometric outreach of included studies
Figure 3 gives an overview of the altmetric outreach of the exergame studies. The study with the highest Altmetric Attention Score was Theng et al. [38] with a score of 29. This high score was attributed to three mentions on news outlets in March 2017, naming this study as an example of how Nintendo’s motion control system has helped to make gaming accessible to new groups of users. Kahlbaugh et al. [35] had a very high PlumX usage count of 5,300, and a high PlumX capture count of 498. These were mainly due to abstract views, clicks on outbound links, and exports/ saves on EBSCO [41]. Agmon et al. [33] had a high count of 180 Mendeley readers, but since Altmetric.com does not include Mendeley readers in its score, this is not reflected as this study had a score of 3. Again, two recent studies [19, 20] did not yet have any altmetrics, however one tweet could already be found for the article from Chao et al. [19], giving this article an Altmetric Attention Score of 0.5. Tweet counts were however low across all studies, with Milington [37] and Agmon et al. [33] having the highest count of 5 tweets each.
Discussion

While previous reviews have synthesized the psychosocial effects of exergames [24, 26, 27], the current review focused specifically on social benefits and extended to the ageing population. The systematic review shows an increasing interest in using exergames to improve the social well-being among older adults, with 9 out of 10 included studies published after the year 2010. Overall, the majority of exergame studies demonstrated promising results for enhanced social well-being, such as reduction of loneliness, increased social connection and positive attitudes towards others.

Figure 3. Overview of the altmetric outreach of included studies
Social Benefits of Exeragmes

Although the social benefits of exergames were often discussed in exergame literature, there was no particular review found on this topic. By summarizing the existing original studies, the findings from the current review showed exergames to be an effective intervention for social improvements among older adults. It supported that exergames were able to reduce the loneliness level among older adults. The decrease in loneliness was perhaps not due to playing the exergames itself, but due to the interactions between older participants and other players. In a large sample survey study, Lee and Ishii-Kuntz [42] indicated that doing something together with other people reduced loneliness among older adults. Many included studies also suggested that exergames provide opportunities for social interaction and connectedness with peers and family members [33, 36, 39]. Older adults often lack the motivation to engage in exercise. Chao et al. [25] indicated that these behavior-related social outcomes of exergames may increase exercise motivation and adherence among older adults. Metric analysis has shown that the emotion-related and behavior-related outcomes of exergames received high attention from both the academic community and social media.

Attitude-related social outcomes are one new finding that has not been mentioned in previous exergame reviews such as Chao et al. [25] or Matallaoui et al. [27]. Exergames were found to affect a sense of being with others [40] and positive attitudes towards others [38]. The findings were similar to recent research in persuasive video gaming [43, 44]. An experiment from Alhabash & Wise [43] found that video game role-play led to a change in students’ explicit and implicit attitudes toward Palestinians and Israelis. In another study, students who played the persuasive social impact game had an increased positive attitude towards the homeless [44]. Results from the current review further supported that active video games, such as exergames,
have the potential to affect older adults’ attitudes towards other groups of people. Although attitude-related social outcomes currently have low academic impacts on the exergaming research area, they have begun to receive a certain amount of discussion on the social media platforms.

Implications for Future Study

The findings also suggested that Nintendo’s Wii was the most frequently used exergaming platform in the included studies. It was supported by another review [25], which also reported Nintendo Wii to be one of the most accessible and popular exergames for seniors. Chao et al. [25] further indicated the high attendance rates among older players in Wii exergames programs. Although the evidences may suggest Wii to be a suitable platform for older adults to perform exergames, there are no previous studies conducted to investigate the different effects between Wii and other platforms, such as Microsoft Kinect consoles. More studies are needed to compare the effects of different exergaming platforms. Sport games were identified to be the favored type of games used in the included studies, while bowling was a particular sport exergame tested in three studies [35, 37, 40]. According to the American College of Sports Medicine [45], older adults were encouraged to perform physical activities that maintain or increase balance and flexibility through slow movements. The bowling games allow slow movements that match these typical physical activities recommended for older adults. Meanwhile, bowling was a self-paced exercise in which older adults could take the time they need to perform the moves [25]. However, all the studies applied commercial exergames in the existing market; none of the interventions were integrated with social theories. It highlighted the needs to combine the social-related theories with exergame programmes to optimize the effectiveness for social improvements.
Although most of studies targeted healthy older adults, two studies examined the social effects on older adults with physical disability [33, 39]. Physical disability, particularly low mobility, was often identified to be the risk factor for social isolation among older adults [46]. Low mobility prevents seniors from active social engagement and connection, leading to common social disorders such as loneliness. Two included studies have shown that playing exergames was able to improve their social well-being by increasing social bonding with their peers and grandchildren. However, the physical limitation of this group of older adults may lead to difficulty in interacting with exergames. They may have frustrating experiences or even safety accidents without proper human or technical assistance. As a result, healthcare providers and exergame designers should take this into consideration when implementing future social exergame programs for older adults with disability. In terms of cultural background, the studies were conducted in both Western and Asian contexts. It appeared that exergames might have social effects on older adults with various cultural backgrounds, but knowledge is lacking on whether the social outcomes would be affected by cultural factors. Future studies are recommended to compare the social effects between different cultural contexts.

Study designs varied in rigor, with 6 studies applying within-group design, and 4 studies applying between-group design comparing exergames with a control condition. Although the majority of studies showed promising results for the use of exergames for social enhancement, the conclusions needs to be interpreted with caution due to the limited number of randomized controlled trials. The included studies were either predominantly small pilot trials or feasibility studies; they lacked the adequate sample size needed for a powered efficacy trial. Meanwhile, half of the studies used qualitative methods for data collection. Without validated quantitative
instruments, their findings did not have the capacity to detect significant changes in social outcomes.

**Limitations**

There are some limitations in the review. Because of the limited number of identified studies, the systematic review included articles with both qualitative and quantitative analyses. The quality assessment of the included studies was difficult to conduct, and it was not possible to produce mean effect sizes via a meta-analysis. However, the review was broad in scope and included a diversity of study conditions and social outcome measures. Another limitation is that relevant studies may have been unintentionally excluded because of the specific keywords used and the databases selected.

**Conflict of Interest**

None.

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