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Effect of exergaming on health-related quality of life in older adults: A systematic review

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Abstract

Introduction: Exercise through video or virtual reality games (i.e. exergames) has grown in popularity among older adults; however, there is limited evidence on efficacy of exergaming on well-being related to health in this population. This systematic review examined the effectiveness of exergaming on health-related quality of life in older adults.

Methods: PRISMA guidelines for this systematic review. Several databases were searched using keywords to identify peer-reviewed journal articles in English. Randomized control trials that evaluated the effect of exergaming on health-related quality of life in older adults when compared to a control group and published between January 2007 to May 2017 were included.

Results: Nine articles that in total included 614 older adults with varying levels of disability, mean age 73.6 + 7.9 years old, and 67% female were analyzed. Significant improvements in health-related quality of life of older adults engaged in exergaming were reported in three studies. Sample sizes were small in 7 of the studies (N < 60). The study participants, exergaming platforms, health-related quality of life instruments, study settings and length, duration and frequency of exergaming varied across studies.

Conclusion: Exergaming is a new emerging form of exercise that is popular among older adults. However, findings from this analysis were not strong enough to warrant recommendation due to the small sample sizes and heterogeneity in the study participants, exergaming platforms, health-related quality of life instruments, length, duration and frequency of the intervention and study settings. Further research is needed with larger sample sizes and less heterogeneity to adequately explore the true effects of exergaming on health-related quality of life of older adults.

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Declaration of conflicting interests
The authors declare that there is no conflict of interest.

Keywords

Aged; Exergaming; Exercise health; Quality of life; Virtual reality; Well-being

1. Introduction

Individuals age 65 years and older are rapidly growing in numbers, accounting for 15 percent of the total U.S. population in 2016. By 2050, the older adult population (≥65 years) is projected to grow to 88 million in the U.S. and 1.6 billion people worldwide (Erickson et al., 2011; Dang, 2010). Aging is associated with profound changes in body composition, structure and function that can negatively impact functional status, leading to limited mobility, frailty, isolation and other health problems (Murphy et al., 2014). Physiological changes (e.g., reduction in muscle mass and strength) impacts mobility, an important aspect in independent living among older adults which plays an important factor in their health-related quality of life (Pynoos et al., 2008).

Health-related quality of life is defined as the way people view and adapt to their symptom burden, functional limitations and prognosis, as well as perceptions of their overall health well-being (Rumsfeld et al., 2013). It has been linked to health status and symptoms reflecting the impact of health conditions (Ling et al., 2014). Measuring health-related quality of life is important for understanding the impact of health care interventions on daily life and well-being of older adults (Addington-Hall and Kalra, 2001; Kaplan and Ries, 2007). Furthermore, health-related quality of life can be used to determine cost effectiveness of the healthcare intervention(s) when compared to other forms of interventions (Vaapio et al., 2009).

Exercise has shown favorable outcomes among older adults including reduced risk of all-cause mortality, chronic disease, and premature death (Mora and Valencia, 2018). Participation in a regular exercise program is strongly recommended because it is an effective intervention in preventing a number of functional declines related to aging and it has been known to improve functional capacity and health-related quality of life (Bocalini et al., 2008). The recommendation for older adults should emphasize moderate-intensity aerobic activity, muscle-strengthening activity, reducing sedentary behavior and risk management to improve cardiovascular health and health-related quality of life (Nelson et al., 2007; Bize et al., 2007). However, older adults are less likely to engage in exercise due to several factors including discomfort, fatigue, access issues (i.e. fitness or rehabilitation center), unable to exercise outdoors due to unfavorable climate conditions, and other motivation and practical issues (Klompstra et al., 2014; Peng et al., 2011).

Recent studies have shown the potential benefit of technology as an effective strategy for improving physical activity among older adults (Peng et al., 2011; Smaerup et al., 2016). Exercise through video or virtual reality games (i.e. exergaming) has grown in popularity among older adults to increase physical activity, improve health and physical function including individuals with chronic illnesses (Skjaeret et al., 2016; Franklin, 2015; Peng et al., 2011; Verheijden Klompstra et al., 2014; Mazzoleni et al., 2014). Exergaming uses technology to monitor body movement and reaction and provides real time feedback on exercise performance, allowing participants to compete individually or with other players (Anderson-Hanley et al., 2011) resulting in fun and play.

Exergaming has the potential for increasing physical activity among persons 65 years and older due to easy accessibility, fun factor, increase social interaction when playing with peers or family members and may improve health-related quality of life. Systematic reviews have already been published elsewhere assessing the effect of exergaming or virtual reality exercise games in improving physical activity (Molina et al., 2014), health status (Primack et al., 2012) and depression (Li et al., 2016) among older adults. However, evidence to support the benefit of exergaming on health-related quality of life among older adults > 65 years old is limited. Likewise, there is a paucity of systematic reviews assessing the effect of exergaming on health-related quality of life among older adults that use a randomized control trial design. The objective of this systematic review was therefore to evaluate the effectiveness of exergaming on health-related quality of life among older adults in randomized control trials.

2. Methods

2.1. Data sources and search strategies

The PRISMA guidelines (Liberati et al., 2009) were adapted to establish the methodology of this review. The methodology included several stages varying from generating consensus on the definition of exergaming to analyzing articles. A systematic search of abstracts, trial data bases and peer reviewed articles published from January 2007 (the year after Nintendo Wii™ gaming system was released commercially) through May 2017 in PubMed, CINAHL, Web of Science, PsychInfo and Cochrane were conducted using the following keywords: *exergaming, exercise and game, active video, video games, virtual reality, elderly, geriatric, aged, older adults and health related quality of life*. In addition, hand search and checking reference lists were conducted to obtain additional articles. Only studies published in English language were included.

2.2. Study selection

Studies were limited to randomized control trials that included a sample of older adults with a mean age of > 65 years old that participated in exergaming or virtual reality exercise games as an intervention. The main intervention was any type of exercise using video games or virtual reality following the criteria established by the American College of Sports Medicine that included: (a) involved technology-driven game playing; and (b) required participants to be sufficiently physically active to exercise or to play the game (Tavares et al., 2014). For comparison, the control group could be no intervention, conventional treatment (e.g., interventionist tailored exercise, cognitive program, walking, home-based exercise) and other interventions that are non-video or virtual reality based exercise activity.

The inclusion criteria were as follows: (1) randomized control trials only; (2) intervention was exergaming that clearly described the exercise program; (3) participants mean age > 65 years old; (4) health-related quality of life as primary or secondary outcome, and (5) English language. In addition, due to potential differences in the risk of bias such as selective reporting in abstracts, all identified studies that partially or fully met the inclusion criteria were fully assessed for eligibility.

2.3. Data extraction and quality assessment

Abstracts identified in the initial search were screened by two researchers excluding studies that did not meet the inclusion criteria. A data extraction sheet was developed based on the Cochrane Consumers and Communication Review Group to collect study characteristics and outcomes. With studies reported in more than one publication, the data were extracted from all publication directly into a single data collection form. The study characteristics extracted from each article included citation, country, design, sample size, participant's mobility, type of intervention, comparison, frequency and duration, adherence and attrition. Studies included in final review were analyzed using the sample composition, interventions/effects of interventions and outcomes descriptions.

The Cochrane risk of bias tool (Higgins and Green, 2011) was utilized to assess the quality of randomized control trials in this review. The instrument uses specific criteria for scoring as low, unclear or high risk across 7 categories: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessor, incomplete outcome data, selective outcome reporting and a category of "other bias".

3. Results

3.1. Search result

A flow diagram (Fig. 1) for study selection outlined the steps in choosing the articles. The search generated 213 citations, for which 61 articles were fully assessed for eligibility and 9 studies were selected for the final review and analysis. Because of the heterogeneity of the publications, exergaming devices and instruments used to measure outcomes, a meta-analysis is not feasible.

3.2. Study characteristics

The studies were conducted worldwide, with three from the U. S. (Franco et al., 2012; Padala et al., 2012, 2017), two from Australia (Haines et al., 2009; Laver et al., 2012), one each from the United Kingdom (Adie et al., 2017), Turkey (Karahan et al., 2015), Italy (Morone et al., 2016), and Denmark (Smaerup et al., 2016). The 9 studies provided a total of 614 participants, 309 in the intervention group and 305 in the control group. Varying health-status were noted among study participants including healthy and ambulatory (Franco et al., 2012; Padala et al., 2017; Karahan et al., 2015), Alzheimer's disease (Padala et al., 2012), and with functional impairments, such as stroke (Adie et al., 2017), gait instability (Haines et al., 2009), vestibular dysfunction (Smaerup et al., 2016), bone loss condition affecting balance (Morone et al., 2016) and semi-ambulatory post hospital discharges (Laver et al., 2012). Both genders were included, with a higher proportion of women in the majority of the studies (67%); one study was exclusively female (Morone et al., 2016). The participants' mean age was 73.6 + 7.9 years old years old. The comparison or control groups were allocated to no intervention (Franco et al., 2012; Haines et al., 2009), tailored arm exercise + usual rehabilitation therapy (Adie et al., 2017), home-based balance exercise (Karahan et al., 2015), walking (Padala et al., 2012), conventional therapy (Laver et al., 2012), standard of care (Morone et al., 2016), cognitive program (Padala et al., 2017) and printed instructions (Smaerup et al., 2016). All studies included in this review were reviewed and approved by the appropriate Institutional Review Board.

3.3. Quality assessment and bias

Overall, studies varied across bias domain (see Table 1 and Fig. 2). All studies were assessed as low risk for random sequence generation bias utilizing computerized random number generator, random permuted blocks and randomization through coin flipping for participant’s study selection. Likewise, all but three studies described allocation concealment (Franco et al., 2012; Padala et al., 2012; Karahan et al., 2015). Random sequence and allocation concealment prevent foreknowledge of the forthcoming allocation; these are important factors in study reliability and validity (Higgins and Green, 2011). Blinding of participants and personnel was somewhat challenging due to the nature of the intervention, however, outcome assessors were blinded in four studies (Smaerup et al., 2016; Haines et al., 2009; Laver et al., 2012; Adie et al., 2017).

Majority of the studies were assessed as low risk for attrition bias due to participants’ dropout rate of less than 20% (Smaerup et al., 2016; Padala et al., 2012; Haines et al., 2009; Laver et al., 2012; Adie et al., 2017; Karahan et al., 2015), or a sensitivity analysis was conducted to investigate bias due to missing data for subjects dropped out (Padala et al., 2017), and the use of intention to treat analysis (Padala et al., 2012, 2017; Laver et al., 2012). Common reasons for dropouts include illness, losing interest, lack of transportation, lack of time to complete sessions, patient deterioration and death. These reasons were similar across the studies. Furthermore, high risk for detection bias were assessed in four studies for not blinding the outcomes assessors (Smaerup et al., 2016; Franco et al., 2012; Padala et al., 2017) and two studies for use of participant self-reports (Haines et al., 2009; Adie et al., 2017). Two studies were assessed for other risk of bias: 1) one study lacked blinding after enrollment (Laver et al., 2012) that may resulted in prediction of future allocations, hence threatening patient assignment, and 2) a threat to validity related to a participant’s confusion in completing the quality of life survey questionnaire and following the Wii Fit instructions due to language barrier, thus, inaccurate data affected study outcomes (Franco et al., 2012).

All studies lacked adequate information to assess for reporting bias using the criteria established by Higgins et al. (Higgins and Green, 2011) except for one study that was deemed high risk (Karahan et al., 2015) for excluding the attrition rate in the final analysis. Overall, these biases influenced generalizability and publication bias.

3.4. Description of exergaming

The Nintendo Wii Fit games comprised soccer heading, ski jumping, ski slalom, tightrope, table tilt, strength training, yoga, table tilt, tilt city, penguin slide, soccer heading, basic run, obstacle course, basic step and balance games. These games required participants to use their arms or body motions to simulate actions performed in real sports. The Nintendo Wii Balance requires a balance board where participants used certain body parts to simulate actions. The Nintendo Wii Sports included bowling, The non-commercial, video-based devices were the low technology "Kitchen Table Exercise Program," and "Move It to Improve It (Mitti). The "Kitchen Table Exercise Program" involved a video based Digital Video Device and workbook with six types of exercises each with different levels of difficulty that challenged both muscle strength and standing balance (Haines et al., 2009). In the Mitti program, participants watched and followed movements shown in the video. The program included drag-and-drop and follow- the- leader games where the participants manipulated the virtual object on the video screen by grabbing and dragging to different locations or to another virtual object (Smaerup et al., 2016).

3.5. Frequency, duration and adherence to exergaming

The prescribed exergaming regimen ranged from two to seven days a week and for 20–100 min per session. The shortest duration was three weeks and the longest 12 weeks. Data available for participants' adherence to the prescribed exergaming time ranged from 37% to 100%. Exergaming adherence was measured using a diary (self-report), interventionist/ clinician log and logs and playtime monitor recorded in the Wii and other exergaming devices. The exergaming sessions were conducted in different venus: three homebased (Smaerup et al., 2016; Haines et al., 2009; Adie et al., 2017), two in rehabilitation centers (Laver et al., 2012; Morone et al., 2016), senior housing (Franco et al., 2012) and assisted living facility (Padala et al., 2012), hospital outpatient clinic (Padala et al., 2017), and outpatient clinic (Karahan et al., 2015). Exergaming conducted at the rehabilitation centers, outpatient settings, senior and assisted living facilities and community settings employed physiotherapists, occupational therapists, nurses and research assistants to assist and supervise study participants however, individuals performing exergaming at home were given instructions but no close supervision. It is important to note that adherence to the prescribed exergaming was high in the rehabilitation centers and the outpatient settings and lowest in home-based setting.

3.6. Health-related quality of life findings

Studies characteristics and findings are shown in Table 2. Quality of life was measured using validated instruments. Four studies examined the impact of the Nintendo Wii Fit on health-related quality of life, and three studies (Franco et al., 2012; Padala et al., 2012; Laver et al., 2012) did not find exergaming to be statistically significant when compared to the control group. However, one study (Morone et al., 2016) showed Nintendo Wii Fit significant in improving the Quality of Life –SF 36 physical function scale at 4 weeks, but not significant at the 8-week follow-up; there were no changes in other subscales (Padala et al., 2017).

Conversely, the Wii Balance demonstrated a statistically significant difference in physical function subscale of the Quality of Life SF 36 post intervention at 8 weeks among older female with balance problems and bone loss condition, but this difference was not sustained at the 3-month follow up (Morone et al., 2016). The Wii Sports did not improve health-related quality of life (i.e. Stroke Impact Scale, Euroqol 5D) among stroke patients with arm weakness (Adie et al., 2017) however, the Microsoft Xbox 360Kinect demonstrated significant improvement among healthy ambulatory older adults in the Quality of Life SF 36 parameters of physical functioning, social role functioning, physical role restrictions, general health perceptions and physical component scores posttest at six weeks after playing the Xbox 360Kinect when compared to the control group using home-based balance exercise regime (Karahan et al., 2015). Non-commercial video-based device, Kitchen Table Exercise Program was not significant (Euroqol 5D) among older adults with gait instability at 6 months follow up when compared to the control group (i.e. no intervention) (Haines et al., 2009). Likewise, the Mitti program had no significant impact on the quality of life in older adults with vestibular dysfunction after 12 weeks of intervention versus the control group using printed instructions (Smaerup et al., 2016). Studies that showed statistical significance involved healthy participants with high adherence to exergaming and conducted in a center-based setting. Exergaming was less effective in improving health-related quality of life among participants with disabilities, low adherence and exergaming at home. Five studies reported no intervention related adverse events (Padala et al., 2012; Adie et al., 2017); four studies did not report adverse events (Smaerup et al., 2016; Franco et al., 2012; Karahan et al., 2015; Morone et al., 2016).

4. Discussion

Engaging in physical activity is important among older adults because it prevents or slows down functional and psychological deterioration related to aging and impacts health-related quality of life. However, engaging or adhering to physical activity or exercise among older adults is poor due to different factors that may include lack of enjoyment. Exergaming is a new emerging form of exercise that incorporates technology, play and fun. However, the relationship between exergaming and health-related quality of life among adults 65 years and older have not been well established in the literature. Establishing this relationship would provide knowledge and value of utilizing a home-based technology as a source of or adjunct modality in improving the physical activity in older adult population.

Exergaming has been used as a healthcare intervention among older adults to increase physical activity in the recent decade. A three-step approach was utilized to determine eligibility for inclusion; the search generated 213 articles and only nine were eligible for analysis. Findings demonstrated that in six out of the nine randomized control trials, exergaming did not show statistically significant results in improving the health-related quality of life in older adults. It is worthwhile to note that the studies used different exergaming devices and technologies to administer the therapies with the interactive games. Likewise, the variation in intervention methods, outcome measures, and control groups made it challenging to translate these preliminary findings into a general recommendation on the effect of exergaming on health-related quality of life. For example, the interventions in two of the nine randomized control trials compared exergaming with conventional therapy or standard of care omitting details making it difficult to conclude whether the beneficial effect or lack thereof was due to exergaming or the comparative therapy. In addition, the study population composed of older adults that were healthy and with disabilities (e.g., stroke, Alzheimer’s disease, gait and vestibular problems). Next, the majority of the study participants were female, with one study being inclusive of females only (Morone et al., 2016). This may influence gender-based efficacy and efficiency in improving health outcomes. Li et al. reported that gender is a predictor of exergaming motivation and performance; males are more physically active in exergaming and they find it more enjoyable than females (Li et al., 2016). This finding may be due to the physicality and competitiveness nature involved in exergaming that is traditionally more favored and enjoyed by the male gender. The differences in the level of enjoyment between genders may have affected the participants' perceived health-related quality of life.

The majority of the randomized control trials were pilot or feasibility studies. Therefore, generalizability was compromised and at least in one study, it was not a priori powered to address all outcomes (Padala et al., 2017). Another factor that may have contributed to inconsistent findings in health-related quality of life outcome was the variability in the length, frequency and duration of the interventions. The shortest intervention was three weeks and the longest was 12 weeks. The prescribed frequency ranged from two to seven days a week and for 20–100 min per session. The Global Recommendations directive on Physical Activity for Health (WHO, 2010) recommended that older adults engage in moderate aerobics physical activity for at least 150 min or at least 75 min of vigorous aerobic exercise over a course of a week. However, with exergaming or video based interactive exercise games, there have been no established guidelines with intervention times needed for functional or physical improvement (Molina et al., 2014). Increased functional and physical capacities have been associated with improved health-related quality of life in older adults (Tavares et al., 2014; Ostman et al., 2017).

Most importantly, findings from the studies demonstrated varying degrees of adherence to exergaming in the interventions group. The variability in adherence may result in inconsistent or non-significant findings. Adherence to exergaming is important as it affects study outcomes. The three studies that showed statistical significance in health-related quality of life reported high to 100% adherence rate even though the dose and frequency of exergaming differed. However, exergaming sessions were conducted at rehabilitation centers and outpatient clinic. Indeed, study settings or exercise venues may be an important factor in determining exercise adherence. In this review, exergaming sessions were held in different settings: rehabilitation centers, outpatient clinics, senior housing and assisted living facilities, and at participants home. Findings from these studies demonstrated that adherence to the prescribed time, length and duration of exergaming were high in the rehabilitation centers and the outpatient clinic and lowest in home-based setting. One can ascertain that the high adherence rate in the rehabilitation centers and clinics can be attributed to the interventionist or clinicians on site where assistance and support were readily available. These findings also suggest that exergaming is more efficient in group activities such as those occurring at rehabilitation centers where individuals exercise with other people. This may result in social interaction and connectedness, a motivating factor to engage in exercise (Klompstra et al., 2014). In contrast, home-based exercise had the lowest adherence rate. This may be due to participants' lack of motivation to engage in exercise regimen or lack of support from family members. Exergaming provide opportunities for social interactions and connectedness with family members and peers (Agmon et al., 2011), however, for those individuals with no family members, social support, or lacking motivation, adherence to home-based exergaming program may not be attainable.

All studies used validated instruments to assess health-related quality of life, but the instruments vary. These variations may pose a challenge to compare studies and draw relevant conclusions. Also, health-related quality of life is a complex concept that involves several distinctions between measures and different dimensions (Kaplan and Ries, 2007). As mentioned earlier, health-related quality of life was measured using both generic and disease specific instruments. One can argue that it is justified to include studies with different assessment procedure for health-related quality of life, however, it should be noted that the heterogeneity may restrict the degree to which studies can be compared. In addition, multiple distinctions between instruments and the evaluation of different health dimensions to produce a single expression of health status makes health-related quality of life difficult to measure because different health problems are not of equal concern for different people (Kaplan and Ries, 2007).

The three studies that showed statistical significance in health-related quality of life reported high to 100% adherence rate with interventions conducted at rehabilitation clinics and outpatient clinics (Padala et al., 2017; Karahan et al., 2015; Morone et al., 2016). These findings suggest that adherence is an important factor in improving exercise regimen and may result in increased physical function and health-related quality of life. Notably, study settings may have influence on exercise adherence. Settings such as rehabilitation centers and outpatient clinics have clinicians and other staff available to provide support and guidance. Also, exercising with other individuals provide social support, interaction and connectedness (Agmon et al., 2011), that may result in an increased motivation to exercise, thus improving adherence.

Therefore, these findings call for the question of why other forms of exercise have positive impact on older adults health-related quality of life but not exergaming? A systematic review that reported on other types of exercise with positive impact on health-related quality of life included strength training, tai chi, combined exercise (strength, aerobic, balance and flexibility) but in individuals with depression (Tavares et al., 2014). Likewise, a systematic review on aerobic exercise and resistance training with varying intensities in patients with heart failure also showed positive effect on health-related quality of life (Ostman et al., 2017). Another study that reported a positive effect of exercise on health-related quality of life among patients with heart failure involved exercise intensity; greater improvement in exercise capacity and intensity is strongly associated with increased health-related quality of life (Evangelista et al., 2017). Both systematic reviews and the study conducted by Evangelista and colleagues (Evangelista et al., 2017) reported that moderate to high intensity exercise is associated with improved health-related quality of life in older adults. In this systematic review, exergaming intensity was not evaluated suggesting the need to explore and evaluate exergaming intensity in order to determine the impact of this intervention on health-related quality of life.

4.1. Strength and limitations

The major strength of this systematic review is the use of PRISMA guidelines (i.e., comprehensive search strategy including hand searching and checking reference lists, duplicate and independent screening, methodological data extraction and quality assessment). Next, only randomized control trials were included in the analysis using validated instruments to measure outcomes. Although this review chose only randomized control trials, the studies included in the analysis presented methodological limitations; these limitations pose biases in generating evidence regarding the efficacy of intervention with exergaming. One of the limitations is the relatively small sample size in most studies. Most studies were pilot or feasibilities studies that tested the efficacy of the interventions. Studies with a small sample size are at risk of being underpowered resulting in less reliable findings. Since health-related quality of life was the secondary outcomes, if a sample size calculation was performed prior to the study it was for the primary end-point. Finding statistically significant differences using a generic health-related quality of life instrument often required larger sample sizes than most studies provided in this review. Also, health-related quality of life was measured using different instruments and the heterogeneity in measurement tools would make it challenging to do a meta-analysis. Due to the nature of the healthcare intervention, blinding participants and interventionist were not feasible leading to performance bias. However, blinding of assessors was used in six studies. Most significantly, the clinical heterogeneity of the studies included in this analysis revealed diversity in study population, exergaming devices, outcomes measure, outcomes instruments, study settings, and dose, frequency and duration of the interventions. Such limitations pose challenges in drawing relevant conclusion for exergaming as an effective intervention to improve health-related quality of life in older adult. Finally, the review was limited to studies in the past 10 years. A search was conducted prior to 2007 for randomized control trial studies on exergaming and health-related quality of life among older adults but unable to find articles that met criteria for this systematic review. Studies not referenced in PubMed, CINAHL, Web of Science, PsychInfo or Cochrane and unpublished studies were not identified; thus, this study is subject to publication bias.

5. Conclusions

This systematic review appraised randomized control trials that evaluate the effect of exergaming on health-related quality of life in older adults. Of the 219 articles retrieved, 9 articles were reviewed in the final analysis after meeting the inclusion criteria. At present, participants with high adherence to exergaming and those in a center-based setting appear to have the most promising effect. Overall, the evidence was not sufficiently strong to determine if exergaming is an effective health care intervention to improve health-related quality of life in older adults. Furthermore, interventions were conducted in heterogeneous patient population, exergaming devices, frequency, duration and length of the intervention, and study settings. Such factors do not allow for definitive conclusions to be made on the use of exergaming for improving health-related quality of life in this patient population. Further research is needed with larger sample size and less heterogeneity in design and measurements to explore the true effects of exergaming on the health-related quality of life in this patient population.

Appendix A

Search Strategies

PubMed Clinical Queries

"exercise game" OR "exercise games" OR "exercise gaming" (exergam* OR (exercise AND (game* OR gaming)) OR (digital exercis*) OR ("virtual reality" AND (game* OR gaming)) OR Kinect OR Wii OR (activevideo AND (game* OR gaming)) OR ("active video" AND (game* OR gaming)) OR (interactive AND (game* OR gaming)) OR ("Video Games"[mesh] AND "Exercise Therapy"[mesh]))

AND

"Quality of Life"[Mesh] OR "quality of life" OR "Health-related Quality of Life"

AND

(aged OR elderly OR elder OR geriatric)

WEB of Science

(exergam* OR (exercise NEAR/3 gam*) OR (digital NEAR/3 exercis*) OR ("virtual reality" NEAR/3 gam*) OR Kinect OR Wii OR (activevideo NEAR/3 gam*) OR ("active video" NEAR/3 gam*) OR (interactive NEAR/2 gam*)) AND (exercise* OR physical activity* OR physical function*) AND (quality of life) OR health-related quality of life)

exergam* OR (exercise AND (game* OR gaming)) OR (digital exercis*) OR ("virtual reality" AND (game* OR gaming)) OR Kinect OR Wii OR (activevideo AND (game* OR gaming)) OR ("active video" AND (game* OR gaming)) OR (interactive AND (game* OR gaming))

AND

(quality of life) OR health-related quality of life)

AND

(aged OR elderly OR elder OR geriatric)

CINAHL

((MH "Exergames") OR exergame* OR (exercise N3 gam*) OR (digital N3 exercis*) OR ("virtual reality" N3 gam*) OR Kinect OR Wii OR (activevideo N3 gam*) OR ("active video" N3 gam*) OR (interactive NEAR/2 gam*))

AND

(MH "Quality of Life") OR (MH "Comfort")

AND

(aged OR elderly OR elder OR geriatric)

PsycInfo

(exercise NEAR/3 (game* OR gaming)) OR (digital NEAR/3 exercis*) OR (“virtual reality” NEAR/3 (game* OR gaming)) OR Kinect OR Wii OR (activevideo NEAR/3 (game* OR gaming)) OR (“active video” NEAR/3 (game* OR gaming)) OR (interactive NEAR/2 (game* OR gaming))

AND

SU.EXACT(“Lifestyle”) OR SU.EXACT(“Life Satisfaction”) OR SU.EXACT(“Lifestyle Changes”) OR SU.EXACT(“Life Changes”) OR SU.EXACT(“Well Being”)

AND

elderly OR geriatric

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What is already known about the topic?

- Engaging in physical activity is important among older adults since it prevents or slows down functional and psychological deterioration related to aging.
- Exergaming is a new emerging form of exercise that incorporates technology, play and fun with potential to improve physical activity and psychosocial well-being.
- There are currently no systematic reviews evaluating the effect of exergaming in improving the health-related quality of life among older adults.

What this paper adds

- Engaging or adhering to exercise using exergaming among older adults is moderately high and may be related to the enjoyment and convenience of this form of physical activity.
- The heterogeneity in study sample, exergaming devices, study settings, and instruments used to measure health-related quality of life is not sufficiently strong to determine if exergaming is an effective health care intervention to improve the health-related quality of life in older adults.

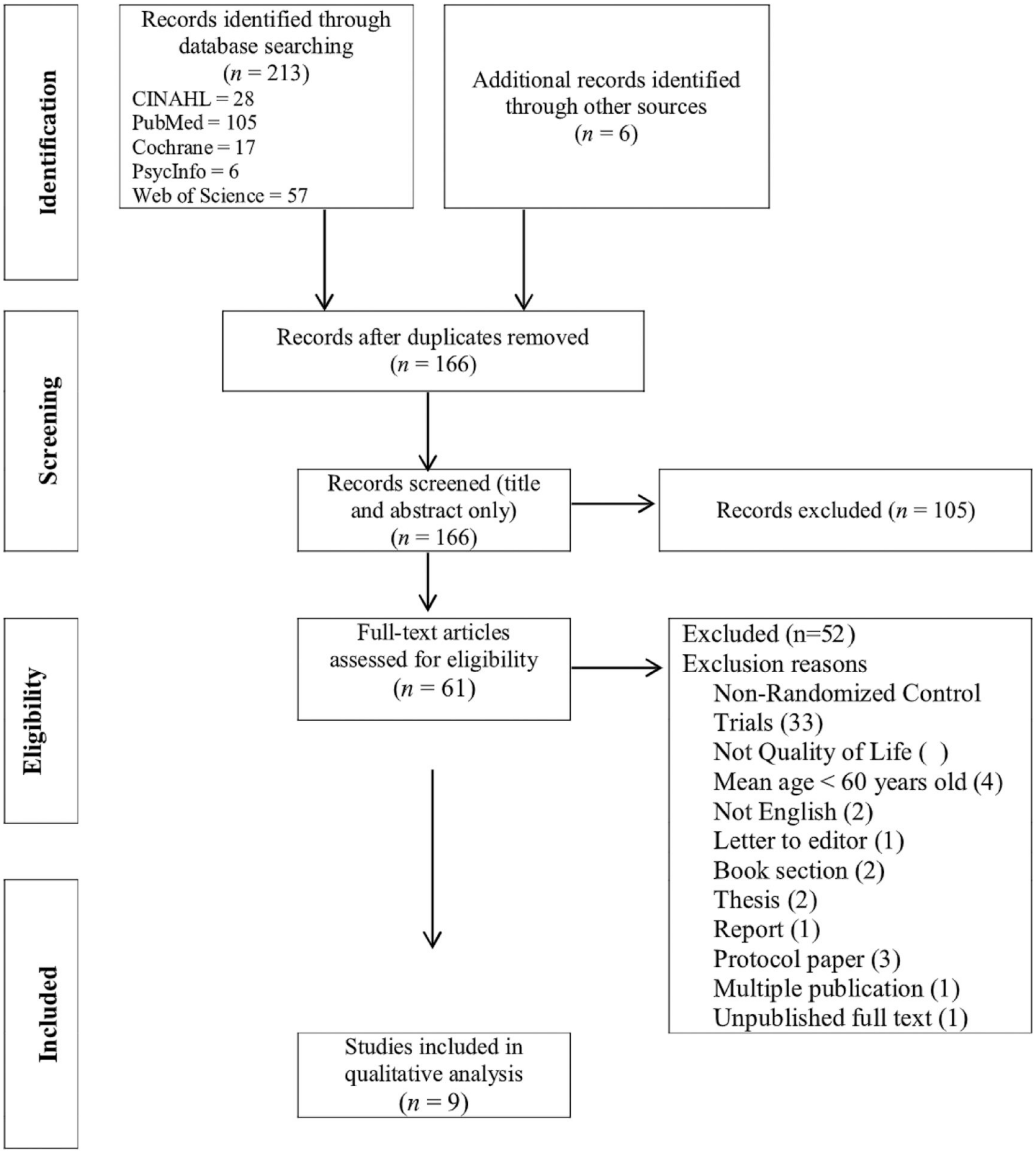

Fig. 1.

Flow diagram for study selection.

Study selection according to PRISMA (Liberati et al., 2009).

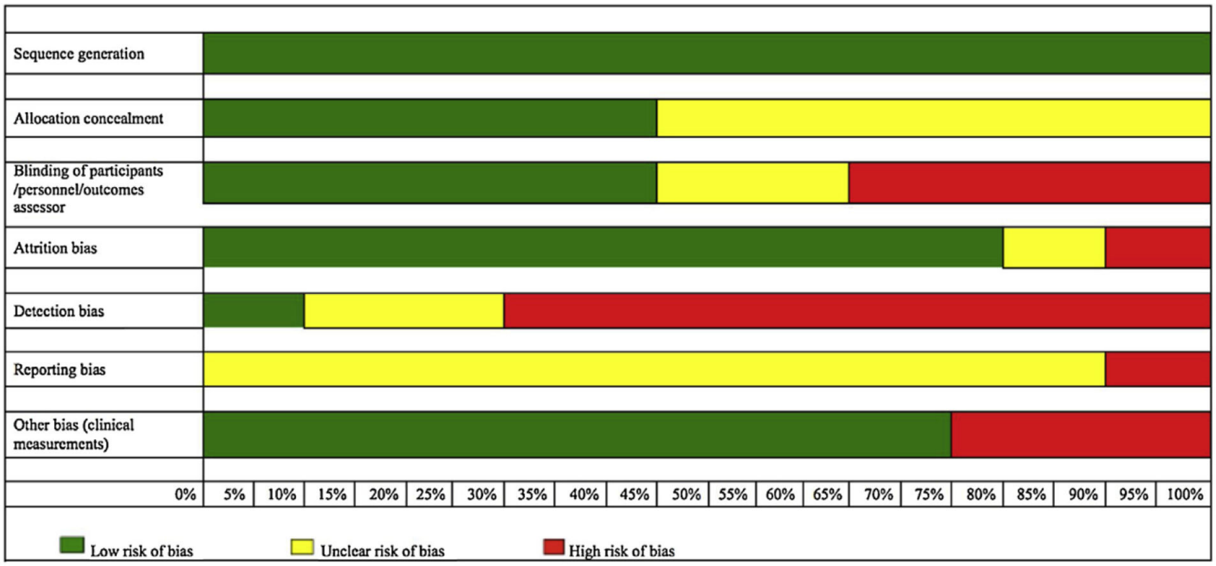

Fig. 2.
Risk of bias summary.

Table 1

Bias Risk Assessment within Studies following the Cochrane Handbook methodology.

Citation	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants, personnel and outcomes assessor (performance bias)	Incomplete Outcome Data (attrition bias)	Blinding of participant, personnel and outcome assessors (detection bias)	Selective Reporting (reporting bias)	Other potential threats to validity
(Adie et al., 2017)	❍	❍	❍	❍	✣	?	❍
(Franco et al., 2012)	❍	?	✣	✣	✣	?	✣
(Haines et al., 2009)	❍	❍	❍	❍	✣	?	❍
(Karahan et al., 2015)	❍	?	?	❍	?	✣	❍
(Laver et al., 2012)	❍	❍	❍	❍	❍	?	✣
(Morone et al., 2016)	❍	❍	?	?	?	?	❍
(Padala et al., 2012)	❍	?	✣	❍	✣	?	❍
(Padala et al., 2017)	❍	?	✣	❍	✣	?	❍
(Smaerup et al., 2016)	❍	?	❍	❍	✣	?	❍

✣ = high risk of bias ❍ = low risk of bias? = unclear risk of bias.

Table 2

Characteristics of Studies and Result.

Citation, Country	Design/Setting	Sample size; % Female; age (years) (SD)	Participants Physical Mobility	Type of Intervention and Format	Comparative	Frequency and Duration	Adherence	Dropouts	Quality of Life Measures	Findings
(Adie et al., 2017)	Randomized Control Trial	N = 235	Stroke patients with arm weakness	Arm exercise	Tailored arm exercise	Every day for 45 minutes	Exercise adherence	I = 6 (5%)	SIS,	No significant improvement in I group when compared to C group at 6 weeks and 6 months follow up
United Kingdom	Multicenter	I = 117; C = 118				6 weeks	I = 82%	C = 9 (7%)	EQ-5D 3L	
	Two groups	Female		Wii Sports			C = 71%	Lost to follow up = 6 (3%)		
	Home-based	I = 51%; C = 53%		Games: bowling, tennis, golf, baseball		6 months follow up				
		Mean age		Sitting position		post intervention				
		I = 66.8 (+ 14.6) C = 68 (+ 11.9)								
(Franco et al., 2012)	Randomized Control Trial	N = 32	Senior housing residents;	Balance exercise	No intervention	2 days/week	Exercise adherence	I1 = 3 (27%)	SF 36	No significant improvement in I groups when compared to C group post intervention
United States	Three groups	I1 = 11; I2 = 11;	healthy, ambulatory			10–15 min/ session	I1 = 87%	I2 = 2 (18%)		
	Community	C = 10		I1 = Wii fit		3 weeks	I2 & C = data not clear	C = 0		
		Female		Games: soccer heading, ski jumping, ski slalom, Wii tightrope, table tilt, balance bubble						
		I1 = 82%; I2 = 73%				No follow up post intervention				
		C = 80% Mean Age I1 = 79.8 (+ 4.7) I2 = 77.9 (+		I2 = Matter of Balance						

Citation, Country	Design/Setting	Sample size; % Female; age (years) (SD)	Participants Physical Mobility	Type of Intervention and Format	Comparative	Frequency and Duration	Adherence	Dropouts	Quality of Life Measures	Findings
		6.9) C = 76.9 (+ 6.3)								
(Haines et al., 2009)	Randomized Control Trial	N = 53	Older adults with gait instability	Lower limb strength and balance exercise	No intervention	100 minutes duration of video	Adherence unclear	I = 0	EQ-5D	No significant improvement in I group when compared to C group post intervention and at 6 months follow up
Australia	Pilot	I = 19; C = 34		Video based = “Kitchen Table Exercise Program”		frequency not specified		C = 3 (8%)		
	Two groups	Female					Participants weekly participation declined starting at week 3 until week 8	at 6 months follow up		
	Home-based	I = 74%; C = 63%				6 months follow up post intervention				
		I = 80.9 (+ 8.9) C = 80.5 (+ 6.5)								
(Karahan et al., 2015)	Randomized Control Trial Two groups	N = 100	Older adults attending physical and rehabilitation medicine outpatient clinic; ambulate independently	Balance exercise	Home based balance exercises	30 min, 5 days/ week	100% adherence	Lost to follow up	SF - 36	Significant (p = <.005) improvement in the parameters of physical functioning, social role functioning, physical role restrictions, general health perceptions and physical component scores post-test in the I group when compared to the C group.
Turkey	Outpatient clinic	I = 54; C = 46				6 weeks		I = 6 (11%)		
		Female I = 44%; C = 43%		Xbox 360Kinect Games: Kinect		No follow up post intervention		C = 4 (8%)		

Citation, Country	Design/Setting	Sample size; % Female; age (years) (SD)	Participants Physical Mobility	Type of Intervention and Format	Comparative	Frequency and Duration	Adherence	Dropouts	Quality of Life Measures	Findings
				adventures, sports, (football, tennis, table tennis, skiing, golf, volleyball, bowling)						
		Mean Age I = 71.3 (+ 6.1) C = 71.5 (+ 4.7)								
(Laver et al., 2012)	Randomized Control Trial	N = 44	Older patients from a geriatric rehabilitation unit in the hospital	Balance exercise	Conventional therapy	25 min/day; 5 days/wk.	90% adherence with mean length of stay 12.3 (+ 5.6) days	I = 2 (9%)	EQ-5D 3L	No significant improvement in I groups when compared to C group post intervention
Australia	Pilot	I = 22; C = 22	Able to perform sit to stand transfers without physical assistance			duration of stay on the unit		C = 0		
	Two groups Hospital Geriatric rehabilitation unit	Female I = 86%; C = 74%		Nintendo Wii Fit Games:		No follow up post intervention				
		Mean age I = 85.2 (+ 4.5) C = 84.6 (+ 4.4)		Balance board						
(Morone et al., 2016)	Randomized Control Trial	N = 38	Older females with bone loss condition with balance problems	Balance exercise	Standard of care	1 hour training; 2 days/wk.	100% adherence	Not discussed	SF - 36	Significant (p = .031) difference for physical activity score post intervention
Italy	Two groups Rehabilitation Center	I = 19; C = 19 Female		Wii balance	No description	8 weeks				No significant difference at 3 month follow up
		100%				Follow up at 3 months				
		Mean Age I = 67.8 (+ 2.9) C = 70.05 (+ 4.9)								
(Padala et al., 2012)	Randomized Control Trial Pilot	N = 22	Older adults with mild Alzheimer	Balance and gait exercise	Walking	30 min/day, 5 days/week	Exercise time 11.5 (+ 3.5) hours - 37%	I = 1 (9%)	QOL-AD	No significant difference in the I group but significant

Citation, Country	Design/Setting	Sample size; % Female; age (years) (SD)	Participants Physical Mobility	Type of Intervention and Format	Comparative	Frequency and Duration	Adherence	Dropouts	Quality of Life Measures	Findings
										difference in the C group ($p = .03$)
United States	Two groups	I = 11; C = 11				8 weeks		C = 1 (9%)		
	Assisted living facility	Female	Uses cane or walkers for ambulation	Wii Fit						
		I = 73%; C = 73%		Games: strength training, yoga and balance games		No follow up post intervention				
		Mean age I = 79.3 (+ 9.8) C = 81.6 (+ 5.2)								
(Padala et al., 2017)	Randomized Control Trial	N = 30	Healthy older veterans	Balance exercise	Computer based cognitive program (Brain Fitness) games: memory, language, attention, executive function, visual and spatial domain	45 min/3 days week for both groups	High adherence to the program	I = 3 (20%)	SF-36	Significant within group improvement in physical function scale at 4 weeks in I group ($p = .03$) but not at 8 weeks in all scales
United States	Two groups	I = 15; C = 15	Ambulate independently with mild to moderate balance problems			8 weeks		C = 0		
	Community	Female I = 13%; C = 13%		Wii Fit and Training Plus		No follow up post intervention				
		Mean Age I = 67.5 (+ 8.1) C = 69 (+ 3.8)								
(Smaerup et al., 2016)	Randomized Control Trial Two groups	N = 60	Older adults with vestibular dysfunction	Exercise to reduce dizziness and improve physical function	Home exercise using printed instructions	20 to 30 min daily for 12 weeks (84 recommended sessions)	39% adherence	I = 2 (7%)	SF-12	No significant difference between two groups post intervention
Denmark	Home-based	I = 30; C = 30 Female		Computer program "Move		No follow up post intervention		C = 1 (3%)		

Citation, Country	Design/Setting	Sample size; % Female; age (years) (SD)	Participants Physical Mobility	Type of Intervention and Format	Comparative	Frequency and Duration	Adherence	Dropouts	Quality of Life Measures	Findings
		I = 57%; C = 63% Mean Age I = 76.4 (+ 7.6) C = 78.9 (+ 6.6)		It To Improve It" (Mitii)						

I = Intervention; C = Control (PPT); SIS = Stroke Impact Scale; EQ5D = EuroQol 5 Dimensions; SF = Short Form; QOL-AD = Quality of Life - Alzheimer's Disease.