# Gaming for health: an updated systematic review and meta-analysis of the physical, cognitive and psychosocial effects of active computer gaming in older adults

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## ABSTRACT

Active computer gaming (ACG) is method of enabling physical activity in older adults. This review aimed to determine the effect of ACG on health outcomes in older adults. Four electronic databases were searched to identify 24 eligible randomised controlled studies: 1049 participants; 72.2% female; mean age 78±5 years. Data were pooled for six outcomes, with small to moderate effects observed in favour of ACG for functional mobility and balance outcomes. A large effect was observed in favour of ACG for cognitive function. This review presents evidence that ACG is effective in improving physical and cognitive function in older adults.

## 1. INTRODUCTION

The fastest growing portion of the population is older adults. Physical activity in older adults is associated with higher levels of physical function and independence, as well as reduced cognitive decline and falls prevention. The American College of Sports Medicine (Nelson et al. 2007) recommend at least 150 minutes of moderate exercise per week, or 30minutes on most days, while a systematic review by Sherrington et al. (2011) recommends interventions of at least 120 minutes per week for falls prevention. Many older adults do not meet these recommendations, reporting various barriers including poor health, lack of social support, and fear.

The use of active computer gaming (ACG) is becoming a recognised method of enabling physical activity in older adults. ACG interventions have been used in trials to investigate their safety, feasibility and effectiveness. Studies have indicated that ACG may contribute to slowing the deterioration of health and function associated with ageing, with favourable results in outcomes such as balance, confidence, functional mobility, and quality of life. The current review updates a previous review of the literature for ACG (Bleakley et al. 2015). This review showed preliminary evidence to support ACG as a safe and effective intervention for promoting physical activity in older adults which may have physical and cognitive benefits; however, it was not possible to pool data for health outcomes due to heterogeneity and insufficient data available.

## 2. AIMS AND OBJECTIVES

To update and extend a systematic review of the evidence for the physical, psychosocial and cognitive effects of ACG in older adults, and to explore ACG design and intervention delivery. The objectives are:

1. Determine the effect of ACG on physical health outcomes, particularly those related to balance and mobility
2. Determine the effect of ACG on cognitive function and psychosocial outcomes
3. Explore adherence with, and delivery of interventions (ie. dose, setting, supervision)

## 3. METHODS

### *3.1 Criteria for selecting studies for this review*

A protocol was developed a priori and registered on Prospero (CRD42015017227). This review included randomised or quasi-randomised controlled trials (RCTs) of interventions that used ACG as all or part of the delivery, aimed at improving physical and cognitive function in older adults (>65 years), and published in English. ACG was defined as a digital game that requires players to interact with objects within a virtual context

using some part of their body as, or to manipulate, a controller, and requiring some physical exertion. Primary outcomes of interest were related to physical and cognitive function. Secondary outcomes of interest included psychosocial outcomes, such as fear of falling and health-related quality of life.

### *3.2 Search methods for identification and selection of studies*

Four electronic databases (MEDLINE, EMBASE, Cochrane Register of Controlled Trials, and PsycInfo) were searched on 1st February 2015 to identify trials published since the previous systematic review (Week 2 July 2011) using predefined search strategies including a range of subject headings and key words, based on those used in the systematic review being updated. One review author (SH) screened all titles and abstracts, and then retrieved full text reports for the papers that met the inclusion criteria for full eligibility screening, using standardised criteria. Queries were resolved by discussion with a second reviewer (SMcD). A record was kept of all excluded trials along with the reason for their exclusion. Additionally, full texts of RCTs included in the previous systematic review were screened for eligibility for inclusion in the current review.

### *3.3 Data extraction and management*

Data was extracted independently by two authors (100%SH, 50%AM, 50%PD) using a customised form, piloted prior to use. Two authors (SH, KP) independently assessed the included studies for risk of bias using the Cochrane risk of bias tool, grading on each criterion as having low, high, or unclear risk of bias. The kappa statistic was calculated individually for each criterion then averaged to formally assess the level of agreement of the two authors in assessing risk of bias.

### *3.4 Strategy for Synthesis*

Outcomes of interest were analysed as continuous data, and standardised mean differences (SMDs) and 95% confidence intervals (CI) were calculated to pool outcomes. Meta-analyses were carried out using RevMan v.5.3 to compare physical, cognitive and psychosocial outcomes between ACG intervention and control groups. In the case of low heterogeneity ($I^2$ <50%), studies were pooled using a fixed effects model. Where substantial heterogeneity was identified ($I^2$ >50%), the random effects model was used to pool results. Effect sizes were summarised as follows: SMD <0.40 = small; 0.40 to 0.70 = moderate; >0.70 = large (Cohen 1988). Sub-group analyses were performed according to: control group, inactive or active; and, studies delivering an intervention dose above or below the recommendation of 120minutes/week, to assess the impact of intervention dose on outcome. Sensitivity analyses were carried out to assess the impact of excluding trials with higher risk of bias in the meta-analysis.

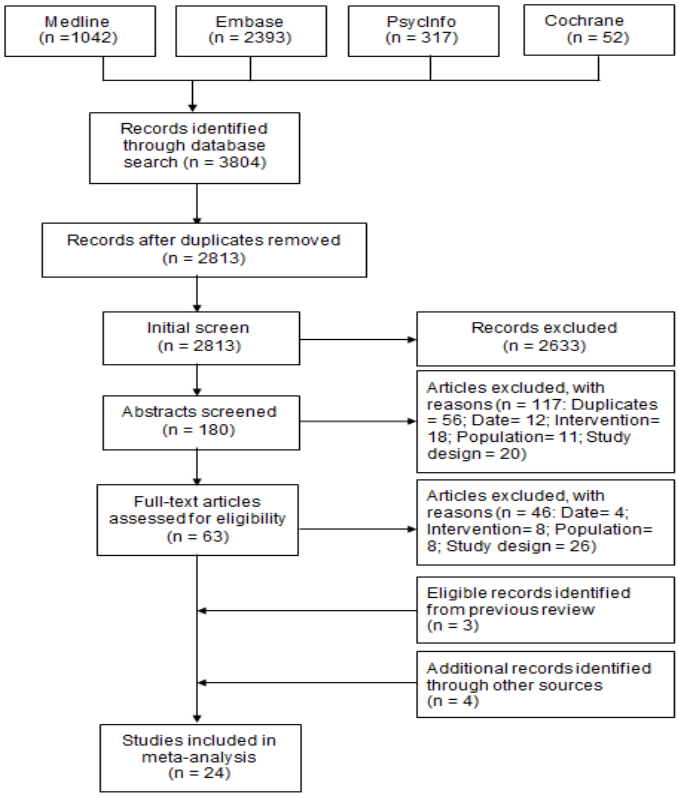



**Figure 1.** *PRISMA Flowchart.*

# 4. RESULTS

## *4.1 Description of studies*

The search strategies identified 3804 references (Figure 1); of these, 63 full text reports were retrieved and screened for eligibility. 24 studies (22 RCTs and 2 quasi-RCTs) have been included in this review, with 1049 participants. The mean sample size was 44 participants. 72.2% of participants were female. The mean age of included participants was 78±5 years. The majority of studies included healthy older adults (n=13). Eight studies recruited participants at high risk of falls. ACG interventions included Nintendo Wii Fit (n=15), Xbox Kinect (n=1), dance mat video game (n=2), and bespoke ACG (n=6). The majority of studies investigated the effect of ACG on physical function (n= 23). Cognitive outcomes were investigated as primary outcomes in two studies, and as secondary outcomes of interest in three studies. Psychosocial outcomes were investigated in terms of quality of life, mental health, and social participation. Details related to intervention delivery are summarised in Table 1. Mean adherence rate reported for the ACG group in n=11 studies was 78.1%. Mean adherence for the control group was 78.2% (n=7 studies).

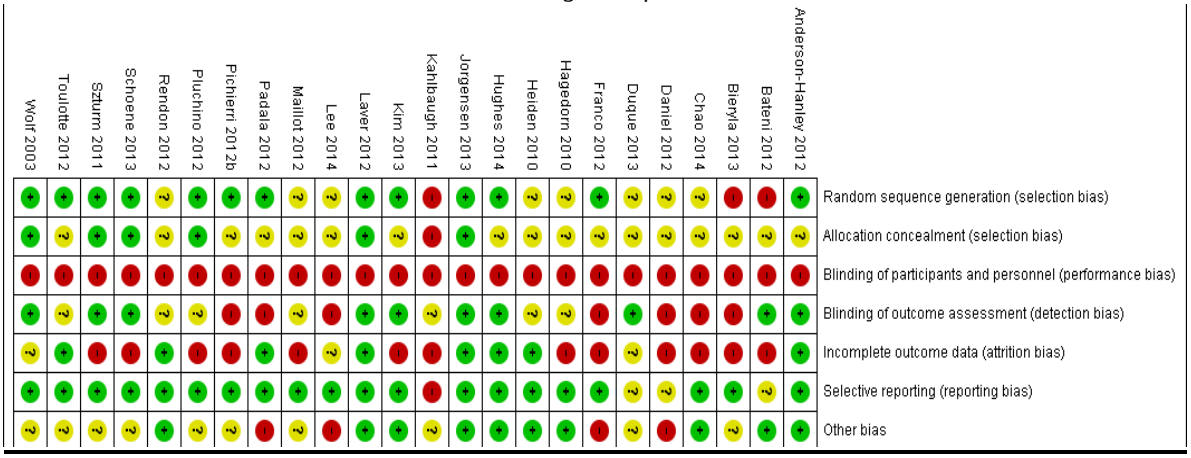
**Table 1.** *Table summarising intervention delivery.*

| Study ID | *Intervention* | *Supervision* | *Setting* | *Dose (minutes/ week)* | *Adverse events intervention group* | *Adverse events control group* | *Adherence intervention group* | *Adherence control group* |
|---|---|---|---|---|---|---|---|---|
| **Anderson-Hanley 2012** | Cybercycle | NR | Living facility | 225 | 7 (4 study-related) | 6 (4 study-related) | NR | NR |
| **Bateni 2012** | Wii | SV | Clinic/ research | 90 | NR | NR | NR | NR |
| **Bieryla 2013** | Wii | SV | NR | 90 | NR | NR | 67.5% | n/a |
| **Chao 2014** | Wii + behavioural | SV | Living facility | 60 | 0 | 0 | NR | NR |
| **Daniel 2012** | Wii | SV | Clinic/ research | 135 | NR | NR | 86% | 86% |
| **Duque2013** | Balance rehabilitation unit | SV | Falls clinic | 60 | NR | NR | 91% | NR |
| **Franco2012** | Wii + HEP | SV | Clinic/research | 25 | NR | NR | 79% | 84% |
| **Hagedorn 2010** | Computer feedback balance | SV | Falls clinic | 180 | NR | NR | NR | NR |
| **Heiden 2010** | Computer feedback balance | SV | Community | 180 | NR | NR | NR | NR |
| **Hughes 2014** | Wii | NR | Community | 90 | NR | NR | NR | NR |
| **Jorgensen 2013** | Wii | SV | NR | 70 | 0 | 0 | 63% | n/a |
| **Kahlbaugh 2011** | Wii | NR | Living facility | 60 | NR | NR | NR | NR |
| **Kim 2013** | Kinect | No SV | Clinic/ research | 180 | NR | NR | NR | NR |
| **Laver 2012** | Wii | SV | Living facility | 125 | 13 (10 study-related) | 10 (9 study-related) | 90% | 91% |
| **Lee 2014** | Wii | NR | NR | 135 | NR | NR | NR | NR |
| **Maillot 2012** | Wii | SV | NR | 120 | NR | NR | 91% | n/a |
| **Padala 2012** | Wii | SV | Living facility | 150 | 1 (0 study-related) | 1 (0 study-related) | 56% | 66% |
| **Pichierri 2012** | Dance mat | NR | Clinic/ research | 120 | NR | NR | 70% | 60% |
| **Pluchino 2012** | Wii | NR | Clinic/ research | 120 | NR | NR | NR | NR |
| **Rendon 2012** | Wii | NR | NR | 120 | 2 (2 study-related) | 0 | NR | NR |
| **Schoene 2013** | Dance mat | No SV | Living facility | 45 | 0 | 0 | 86% | n/a |
| **Szturm 2011** | Computer feedback balance | SV | Clinic/ research | 90 | NR | NR | 87% | 93% |
| **Toulotte 2012** | Wii | NR | NR | 60 | NR | NR | NR | NR |
| **Wolf 2003** | Computer feedback balance | SV | NR | 45 | NR | NR | NR | NR |

NR – not reported; SV - supervision; n/a – not applicable

Risk of bias in included studies was assessed using the Cochrane Risk of Bias tool, as of low (n=9), high (n=9), or unclear (n=6) risk of bias (Table 2). There was substantial agreement between the two independent reviewers, with a kappa of 0.67. No conflicts of interest were declared or identified in any of the included studies.

**Table 2.** *Table summarising risk of bias in included studies.*



### *4.2 Effects of interventions*

Main results are presented taking into account a sensitivity analysis removing the studies assessed as having a high risk of bias. Twelve studies (n=326 participants) evaluated the effect of ACG on balance and found a moderate significant effect in favour of ACG [SMD 0.52, 95% CI 0.14, 0.91]. Seven studies (n= 234 participants) evaluated the effect of ACG on functional mobility and found a small effect in favour of ACG [SMD -0.31, 95% CI -0.57, -0.05]. A non-significant effect was observed for functional exercise capacity [SMD -0.34, 95% CI -0.79, 0.10]. For cognitive function, data were pooled for a tracking task (4 studies, n=160). A large effect was observed in favour of ACG [SMD -0.82, 95% CI -1.15, -0.50]. Eleven studies (n=470) evaluating the effect of ACG on fear of falling were pooled, with no significant effect [SMD 0.15, 95% CI -0.14, 0.45]. Six studies (n=161) evaluating the effect of ACG on quality of life were pooled, with no significant effect [SMD 0.25, 95% CI -0.07, 0.56].

Sub-group analysis according to intervention dose suggested a dose response for functional exercise capacity, with a moderate significant effect in favour of ACG interventions of >120minutes/week [SMD 0.63, 95% CI 0.19, 1.07; four studies; n=86 participants] compared with a small effect that did not reach significance in interventions of <120 minutes/week. Sub-group analysis did not indicate a potential dose response for any other outcome.

## 5. DISCUSSION & CONCLUSION

This review identified, graded and synthesised the available literature for ACG in older adults. Overall findings suggest that ACG has a small to moderate effect on physical outcomes, such as balance and functional mobility, and a large effect on cognitive outcomes, in older people. The findings indicate that a higher dose of ACG participation may be associated with a larger positive effect on outcomes related to functional exercise capacity. Most trials included healthy older adults, and were conducted in a clinical setting with supervision. Incidence of AEs was low, their rate and type were comparable to those reported for the control group. Adherence rates, as well as number of and reason for drop-outs, were comparable in intervention and control groups. This supports evidence that ACG is feasible for older people.

This review highlights that ACG is a growing area of research, with the number of eligible randomised controlled studies increasing from 3 to 24 in the four years since the last search. Despite the advances in this research area, trials with small sample size and limited methodological may overestimate the effect of the intervention. Sensitivity analysis, removing studies of lower methodological quality, continued to support the positive effect of ACG; however, the total number of observations remains small, limiting the generalizability of the findings.

Findings of this review suggest that ACG may provide positive physical and cognitive health benefits greater than those observed following traditional exercise or rehabilitation interventions, with a potential dose response for some outcomes. Adherence and adverse events were comparable to those for the control intervention indicating that ACG is feasible for older people.

## 6. REFERENCES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Reference list of included studies (n=24): http://bit.ly/29oWZ8l