

Role of Video Games in Improving Health-Related Outcomes

A Systematic Review

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Context: Video games represent a multibillion-dollar industry in the U.S. Although video gaming has been associated with many negative health consequences, it also may be useful for therapeutic purposes. The goal of this study was to determine whether video games may be useful in improving health outcomes.

Evidence acquisition: Literature searches were performed in February 2010 in six databases: the Center on Media and Child Health Database of Research, MEDLINE, CINAHL, PsycINFO, EMBASE, and the Cochrane Central Register of Controlled Trials. Reference lists were hand-searched to identify additional studies. Only RCTs that tested the effect of video games on a positive, clinically relevant health consequence were included. Study selection criteria were strictly defined and applied by two researchers working independently. Study background information (e.g., location, funding source); sample data (e.g., number of study participants, demographics); intervention and control details; outcomes data; and quality measures were abstracted independently by two researchers.

Evidence synthesis: Of 1452 articles retrieved using the current search strategy, 38 met all criteria for inclusion. Eligible studies used video games to provide physical therapy, psychological therapy, improved disease self-management, health education, distraction from discomfort, increased physical activity, and skills training for clinicians. Among the 38 studies, a total of 195 health outcomes were examined. Video games improved 69% of psychological therapy outcomes, 59% of physical therapy outcomes, 50% of physical activity outcomes, 46% of clinician skills outcomes, 42% of health education outcomes, 42% of pain distraction outcomes, and 37% of disease self-management outcomes. Study quality was generally poor; for example, two thirds (66%) of studies had follow-up periods of <12 weeks, and only 11% of studies blinded researchers.

Conclusions: There is potential promise for video games to improve health outcomes, particularly in the areas of psychological therapy and physical therapy. RCTs with appropriate rigor will help build evidence in this emerging area.

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Man is most nearly himself when he achieves the seriousness of a child at play.
—Heraclitus, c. 500 BCE

You can discover more about a person in an hour of play than in a year of conversation.
—Plato, c. 400 BCE

Context

In 2009, U.S. retail sales of video games—including portable and console hardware, software and accessories—totaled more than \$19.5 billion,¹ which is greater than the gross national product for each of more than 90 world nations.² In the U.S. and UK, the best-selling video game title of 2010, “Call of

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Duty: Black Ops,” amassed more revenue in its first day of sales than the biggest-ever first-day sales of any book, record album, or movie, including all *Harry Potter* and *Star Wars* titles.³

Today’s video game players defy traditional stereotypes. The average game player is 34 years old; 40% of players are female, and 26% are aged >50 years.⁴ In 2009, 67% of U.S. households owned either a console or a personal computer (PC) used to run entertainment software or both.⁴ Thus, video game playing is now a phenomenon woven into the fabric of American life.

Most research related to video games and health has focused on their potential for harm. Ample violence is portrayed in video games, even when they are not labeled as such,^{5,6} and exposure to violent video games has been linked to aggressive cognitions, aggressive behaviors, desensitization to violence, and decreases in pro-social behavior.⁷ Research further suggests that active participation with violent video games may increase aggression more than equivalent time passively exposed to movie violence.⁸

Video games also provide substantial screen time that has been associated with inactivity and the development of obesity.⁹ The playing of video games also has been linked to adolescent risk-taking in traffic,¹⁰ poor school performance,¹¹ video game addiction,¹² unfavorable changes in hemodynamic parameters,¹³ seizures,¹⁴ motion sickness,¹⁵ and physical injuries related to repetitive strain.¹⁶

However, a growing set of console and PC-based video games aim to increase physical activity and reduce obesity.^{17–19} Youth playing these so-called “active” video games expend more energy than those interacting with inactive video games.^{9,20–22} In some cases, policymakers have made substantial investments in video games to increase physical activity, despite a lack of effectiveness data. For example, the state of West Virginia recently committed to installing the active video game “Dance Dance Revolution” in all 765 of its public schools.²⁰

Video games also have been used to distract people from acute or chronic pain.^{23,24} They also may represent an effective vehicle to provide health education¹⁹: they have been developed to educate individuals about fire and street safety,²⁵ knowledge and self-management of diabetes,^{26,27} and self-management of asthma.^{28–30} Video games also have potential value in other health-related areas as varied as supporting psychotherapeutic treatment,³¹ improving self-esteem,³² conflict resolution,³³ and improving spirometric measurement.³⁴ Video games additionally have been used in an effort to enhance the cognitive or physical skills of healthcare providers, such as training surgeons in endoscopic skills.^{35,36}

Two recent literature reviews^{37,38} were conducted to assess the potential value of video games in promoting health. In one,³⁷ researchers searched MEDLINE and their personal files for relevant studies. Their³⁷ emphasis was on the use of video games with “fantasy,” and the included articles were not limited by design. Although another set of researchers³⁸ published a review of both facilitating and debilitating effects of video games, this review focused on the potential benefit of improved visuospatial cognition only, which has questionable clinical benefit. Additionally, most of the studies discovered in these analyses were observational in nature.^{37,38} Because the gold standard for medical evidence is the RCT, stronger evidence will be necessary if video games are to be accepted as valuable interventions.¹⁹ Thus, the aim of the current study was to assess the usefulness of video games in improving health-related outcomes as evidenced by studies with rigorous designs.

Evidence Acquisition

Research Question

The research question was defined as: Do results from RCTs indicate that video games can be effective interventions in promoting health and/or improving health outcomes associated with established ICD-9 codes? The scope of the question was not limited based on patient characteristics such as age.

Selection Criteria

A comprehensive research protocol was created (Appendix A, available online at www.ajpmonline.org). For inclusion in this systematic review, studies had to (1) be an RCT; (2) use a video game as the intervention; and (3) test the effect of the video game intervention on a health-promoting, clinically relevant health outcome. For a study to be considered an RCT, participants must have been assigned randomly to intervention and control groups. Studies were excluded if they used nonrandom group assignment (e.g., via an alternation procedure) or if they did not specify whether there was random group assignment. Studies also were excluded if they assessed outcomes only at follow-up, and not at baseline. All studies that met the inclusion criteria published prior to February 2010 were included. Study inclusion was not limited by language, sample size, publication date, age, gender, race, or ethnicity.

A “video game” was defined as described by the *American Heritage Dictionary*: “An electronic or computerized game played by manipulating images on a video display or television screen.” In order to be a “game,” the intervention was required to: (1) have a system of reward, incentive, and/or objective; (2) be interactive and/or competitive; and (3) be designed for recreational use (i.e., be designed to be “fun”). Studies were excluded if the intervention described did not meet this definition of a video game.

For example, Cohen and colleagues³⁹ described an RCT to test the effectiveness of a computer-based system to improve expressive language impairment; however, this did not qualify as a game because it was not designed for recreational use. Similarly, computer-based multimedia systems were not considered video

games based on these criteria. Studies involving video game interventions of any dose, intensity, and/or length were accepted.

With regard to allowable controls, studies that compared the intervention to nothing, another treatment that did not involve video games, or to a different (control-type) video game were included. For example, studies were included if they assessed the difference between an intervention and a control video game^{26,40} or if they compared similar material in either a control or a video game format.^{34,41} If the intervention was multimodal, at least 50% of it was required to involve a video game for the study to be included. The video game itself had to be the intervention; studies that assessed the efficacy of some other intervention with computer games as the control were not included.

A “health-promoting, clinically relevant health outcome” was defined as the alleviation of a condition classified as a disorder by the ICD-9 system, or with a known association with an ICD-9 code. Therefore, studies testing the effect of video games on knowledge or management of asthma exacerbations fulfilled this criterion,^{29,30,42} because such knowledge and/or management skills have been associated with improvements in asthma outcomes.⁴³ Similarly, outcomes related to patient-provider communication, patient satisfaction, and treatment adherence were included, because these constructs have been associated with health outcomes.⁴⁴ However, a study testing the effect of a video game on improving hand-eye coordination in normal participants did not fulfill this criterion.

Further, studies were considered to meet the criterion of testing a “health-promoting, clinically relevant health consequence” if they had an effect on healthcare providers that was likely to improve outcomes in patients. Thus, studies testing the effect of a video game on improving a nurse’s decision-making ability^{45,46} or a surgeon’s skills^{35,36} satisfied this criterion.

Location and Selection of Studies

Systematic literature searches in six databases were performed: the Center on Media and Child Health Database of Research (1956–2010); MEDLINE (1950–2010); Ovid CINAHL (1981–2010); Ovid PsycINFO (1967–2010); EMBASE (1974–2010); and the Cochrane Central Register of Controlled Trials (CENTRAL; via Wiley Inter-science; 1948–2010). Search strategies were developed with the assistance of two professional research librarians. When available, search precision was enhanced by the addition of search filters designed to identify RCTs or controlled clinical trials.^{47,48}

Initial searches were conducted in these databases between July and November of 2006, and final updated searches were conducted in February of 2010. All specific search terms are included in Appendix B (available online at www.ajpmonline.org). These searches were designed to be very broad so as not to miss any relevant articles. Reference lists of articles found through the database searches were hand-searched to identify additional relevant articles. Two researchers independently reviewed all retrieved articles to identify articles that met inclusion criteria. When they disagreed, the reviewers met to discuss and achieve consensus.

Data Extraction

Data were extracted independently by two researchers who were different from those who retrieved studies. Extracted data included (1) study background information such as study location and source of funding; (2) sample-related information such as sample size and participant demographics; (3) intervention- and control-related infor-

mation, such as descriptions of the intervention and control and the duration and intensity of the intervention; (4) outcomes-related information such as the primary and secondary outcomes of interest; and (5) quality-related information including drop-out rate, intention-to-treat analysis, and blinding. Because of the volume and complexity of abstraction information, extracted data from the two different reviewers were not compared statistically. However, a series of meetings were held to compare responses, and the few discrepancies noted were adjudicated by a third reviewer.

For each study, one primary outcome was assigned. When the primary outcome was not stated explicitly by the authors, the most frequently mentioned outcome, or the first outcome within a composite score, was selected. When no single outcome was mentioned most frequently, the first outcome described in the “results” section was selected as the primary outcome. All other outcomes were considered secondary outcomes. Coders based their findings of outcome measures presented in the included studies only.

Data Analysis

Because of the wide variety of outcomes assessed and the lack of standard measurements for the few outcomes that different studies had in common, meta-analyses to quantitatively combine the data were not performed. Instead, data were qualitatively described using standard methods of systematic review described by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.⁴⁹ Appendix C (available online at www.ajpmonline.org) presents the PRISMA checklist for this analysis.

A funnel plot was used to assess for evidence of publication bias for studies reporting sufficient primary outcomes data.⁵⁰ In the absence of publication bias, a funnel plot should demonstrate greater variation in outcomes for smaller (less-precise) studies than larger studies, and be relatively symmetric. Funnel plot visual inspection was not suggestive of publication bias.

Finally, a sensitivity analysis was conducted to assess the robustness of the results to categorization of outcomes. Specifically, outcomes were summarized across types of studies while stratifying for the type of outcome (primary versus secondary versus all outcomes). This was done to ensure that overall results were not driven by primary or secondary outcomes alone.

Evidence Synthesis

Study Identification and Selection

The search strategy yielded 1452 unique articles. Of the 1452 articles, 38 (2.6%) met inclusion criteria (Figure 1). The two researchers who reviewed articles for inclusion had substantial agreement after their first independent assessments (% agreement=98.4%; $\kappa=0.70$, $p<0.0001$) according to the Landis and Koch framework.⁵¹ After adjudication, consensus was achieved easily in 100% of cases. Each article was assigned a single primary reason for exclusion. The most common reason for study exclusion was lack of a health-promoting, clinically relevant health outcome ($n=668$, 46%). However, more than one third of articles ($n=545$, 38%) were excluded for not involving video games that meet the current definition, and 14% ($n=201$) were excluded for not being RCTs.

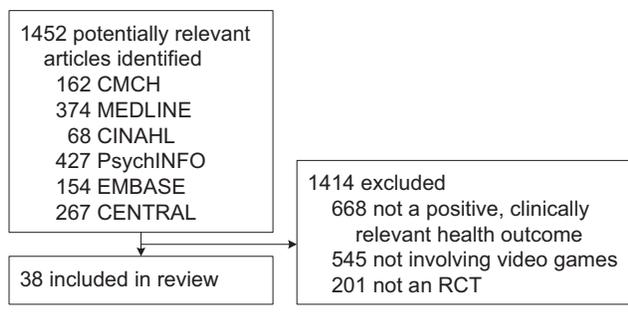


Figure 1. Study selection flowchart

Note: Numbers indicated for each database represent unique contributions from that database after elimination of duplicates. Although many articles did not meet inclusion criteria for more than one reason, each article was assigned a primary reason for exclusion.

CMCH, Center for Media and Child Health (Harvard University database); CENTRAL, Cochrane Central Register of Controlled Trials; CINAHL, Ovid CINAHL

Study Characteristics

Each study was assigned to one of six primary categories based on the general purpose of the video game intervention (Appendix D, available online at www.ajpmonline.org). Of the 38 eligible studies, nine (24%) involved video games for physical therapy (e.g., for rehabilitation after a stroke)^{41,52–59} and six (16%) used video games for psychological therapy (e.g., to reduce post-traumatic flashbacks).^{32,60–64} Additionally, seven studies (18%) used video games for health education^{29,30,65–69} and four (11%) to assist with disease self-management.^{27,28,42,70} Five (13%) used video games to distract from discomfort and/or procedures^{24,71–74} and four (11%) used video games to increase physical activity.^{18,75–77} Finally, three (8%) used video games to improve clinician knowledge or skill.^{35,78,79}

Health topics commonly addressed included asthma ($n=5$); age-related morbidity such as postural instability or cognitive decline ($n=4$); physical activity ($n=4$); stroke ($n=3$); and cancer ($n=3$). Other less commonly addressed health topics ranged widely and included dyslexia, cerebral palsy, type I diabetes, burns, and self-esteem. The studies included a total of 2662 participants, for a mean of 70 (SD=73) participants per study. Mean study age demonstrated a distribution with three peaks: although 50% of studies involved those of average age ≤ 19 years, 28% focused on those aged 20–49 years, and 22% involved those aged 50–80 years (Appendix D, available online at www.ajpmonline.org). Results did not differ across age groups for the primary outcomes; however, there were more-positive secondary and overall outcomes for the group aged 20–49 years (Table 1).

Intervention and control conditions are described in Appendix D (available online at www.ajpmonline.org). Seventeen (45%) studies utilized intervention games that are already commercially available for entertainment, such as the active game *Dance Dance Revolution™* which

requires weight-bearing activity on floor pads to interact with the game^{53,75,76}; *Rise of Nations®* in which participants build new cities and improve country infrastructure⁶⁰; or *Tetris®* in which a player manipulates falling shapes, fitting them together efficiently.^{56,61} However, other studies utilized games that were developed for specific therapeutic purposes, such as *Packy & Marlon*, an interactive video game in which two adolescent elephant friends must save a summer diabetes camp from rats and mice who have disrupted the camp's food and diabetes supplies,²⁶ or *Re-Mission®*, an action game in which players carry out missions inside three-dimensional models of 19 young patients being treated for cancer.^{65,70}

Study Outcomes and Quality

Because each study was assigned a single primary outcome, there were 38 primary outcomes (Appendix D, available online at www.ajpmonline.org). An outcome was considered “positive” if the video game intervention was superior to the control based on significance criteria for that study. Otherwise, the outcome was “negative.” Study outcomes differed by game purpose category (Table 1). For example, only 50% of studies that aimed to improve disease self-management had positive primary outcomes, compared with 67%–100% for all other game types (e.g., physical therapy, psychological therapy, distraction from pain).

Among the 38 studies, a total of 157 secondary health outcomes were examined, for a total of 195 primary and secondary outcomes (Table 1). Although results were similar overall, secondary outcomes were somewhat less frequently positive (44%) than primary outcomes. Secondary outcomes were least often positive for studies of health education (33%) and distraction from discomfort (29%). Including both primary and secondary outcomes, the intervention games that most commonly resulted in positive outcomes were those related to psychological therapy (69%) and physical therapy (59%).

In general, outcomes were more frequently positive among the studies that were of shorter duration (Table 1); 70% of studies that were less than 12 weeks in duration reported positive primary outcomes, compared to 55% of studies 12 weeks or longer in duration. Outcomes were positive for all of the eight studies that involved only a one-time intervention. Of the four studies with durations of 24 weeks or longer, only one reported a positive primary outcome. Of the 33 studies reporting follow-up rate, the average retention rate was 93%.

Several representative study quality measures were selected, including those specified in the PRISMA statement (blinding, method of randomization, and intention-to-treat analyses).⁴⁹ Blinding was reported in only five of 38 studies (13%). In three of these studies, researchers were blinded to group assignment,^{29,59,70} while in the fourth and fifth re-

Table 1. Outcomes of video game trials presented by health goal and outcome type, *n* (%)

	Studies ^a	Outcomes ^a	Primary <i>n</i> =38		Secondary <i>n</i> =157		All <i>n</i> =195	
			–	+	–	+	–	+
Category								
Physical therapy	9 (24)	32 (16)	3 (33)	6 (67)	10 (43)	13 (57)	13 (41)	19 (59)
Psychological therapy	6 (16)	26 (13)	1 (17)	5 (83)	7 (35)	13 (65)	8 (31)	18 (69)
Health education	7 (18)	31 (16)	2 (29)	5 (71)	16 (67)	8 (33)	18 (58)	13 (42)
Disease self-management	4 (11)	35 (18)	2 (50)	2 (50)	20 (65)	11(35)	22 (63)	13 (37)
Distraction from discomfort	5 (13)	26 (13)	0 (0)	5 (100)	15 (71)	6 (29)	15 (58)	11 (42)
Physical activity	4 (11)	32 (16)	1 (25)	3 (75)	15 (54)	13 (46)	16 (50)	16 (50)
Clinician skills	3 (8)	13 (7)	2 (33)	1(67)	5 (50)	5 (50)	7 (54)	6 (46)
Age (years)^b								
1–19	19 (53)	99 (52)	6 (32)	13 (68)	52 (65)	28 (35)	58 (59)	41 (41)
20–49	9 (25)	47 (25)	3 (33)	6 (67)	13 (34)	25 (66)	16 (34)	31 (66)
50–80	8 (22)	43 (23)	2 (25)	6 (75)	21 (60)	14 (40)	23 (53)	20 (47)
All	38 (100)	195 (100)	11 (29)	27 (71)	88 (56)	69 (44)	99 (51)	96 (49)

^aBecause of rounding, total percentages do not equal 100.

^bFor two studies, age range was not reported.

searchers were blinded to outcome assessment.^{65,76} Method of randomization was explicitly described in only eight of the 38 studies (21%), with only four of 38 (11%) specifying allocation concealment using opaque envelopes. Finally, only four of 29 studies (14%) specified the use of intention-to-treat analyses (for nine of the 38 studies, intention-to-treat analyses were not necessary because there were no participants lost to follow-up).

Study duration and intensity of intervention varied widely and are reported in Appendix E (available online at www.ajpmonline.org). Mean study duration was 9 weeks (SD=11); the longest study duration was 1 year. Mean weekly intervention frequency was 2.6 (SD=1.9).

Discussion

The present study synthesizes the results of 38 RCTs, each of which tested the ability of a video game intervention to promote health and/or ameliorate disease. It finds that video games have been evaluated for a wide variety of health-related purposes among participants of all ages, most commonly for their ability to train patients and clinicians physically or psychologically. However, they also have been studied with respect to health education, disease self-management, distraction from pain, and promotion of increased physical activity. Of these areas, studies of video games involving physical or psychological therapy most frequently were successful at achieving

their purpose, whereas those that aimed to improve disease management were least successful. Finally, studies conducted to date in this area generally have been of low quality with relatively brief follow-up periods.

These findings are consistent with prior scholarly works related to positive uses of video games,^{17,37,38} having described some of the same studies. However, the current study was unique from these other reviews in three ways. First, it cast a wide net with regard to topic, aiming to discover the various health-related purposes to which video games have been applied, instead of focusing on particular health topics. Second, it was more selective in terms of quality, accepting only studies that met the rigorous criteria of an RCT. Finally, this systematic review is unique in its rigor, having adhered closely to current guidelines related to search criteria, study selection, data extraction, and data synthesis.⁴⁹

It is an important finding that there are potential health-related benefits from using video games to address a variety of health conditions and sociodemographic groups. Video gaming represents a multibillion-dollar industry in the U.S., and entertainment-related use is increasing among participants of all ages.⁴ Thus far, the entertainment and educational power of this medium for pro-social purposes has centered on younger participants, focusing on education, disease management for

youth with particular common conditions (e.g., asthma, juvenile diabetes), and promotion of physical activity.

Interestingly, many studies included in this review also targeted individuals aged 50–80 years, often focusing on reduction of age-related changes such as postural instability or cognitive decline. However, the greatest opportunity with respect to age group for further studies of video games to improve health may be for individuals aged 30–50 years. Although individuals in this age group, like others, wrestle with multiple concerns related to health promotion and disease prevention (e.g., diet, exercise, mental health, and substance use), no studies in this review were designed for individuals of these ages.

Although many people associate video gaming with the male gender, 40% of players are now female.⁴ All studies included in this review included both men/boys and women/girls, and most studies included about half women/girls. It may be valuable for future RCTs of video games to evaluate whether gender is associated with the efficacy of various video games to improve health outcomes.

In this qualitative analysis of 195 reported primary and secondary outcomes in all 38 studies included in this systematic review, positive results were reported most frequently by studies using video games for physical therapy, psychological therapy, or physical activity. Video games particularly may be suited to these applications because they can make potentially monotonous, repetitive tasks more compelling. Thus, as evidence accumulates, it may be valuable to assess the extent to which adherence mediates any association found between video game use and training-related outcomes; and whether adherence to these video games persists over time.

Simultaneously, it will be important to assess the tradeoffs inherent in the use of video games instead of other modalities. For example, estimated calorie expenditure per hour when using a simulator for skiing is likely to be substantially lower than calorie expenditure during actual skiing. Thus, it will be important to assess carefully the balance of benefits and drawbacks of video games compared to other modalities.

Compared with secondary outcomes, primary outcomes somewhat more commonly were found to be positive. This may be because authors select primary outcomes they feel are likely to be achieved, whereas secondary outcomes may be more exploratory in nature. Although outcomes were positive for each of the eight studies that involved only a one-time intervention and only one of the four longer studies, the shorter studies were generally of lower quality and less ambitious. Therefore, it should not be concluded that it is preferable to have shorter duration of intervention, and future studies should compare interventions of various lengths.

The results suggest not only that few RCTs have been conducted in this area but also that the RCTs conducted have been of relatively low quality. Almost all of the studies with higher-quality design features reported positive results; this provides reassurance that the current findings of potential health benefits of video games are not simply a consequence of low-quality studies. However, higher-quality studies remain relatively uncommon in this area.

Some measures of quality may be more difficult to achieve when studying a video game as opposed to other types of interventions. For example, only 11% of eligible studies blinded researchers, because researchers were often heavily involved in helping operate and/or facilitate the video games (e.g., when stroke or fracture victims were assisted with rehabilitation).^{52,54,58} This also may reflect challenges to obtaining funding for most costly studies in this area. Despite challenges such as these, other quality measures should be achieved easily; for example, all research teams should be able to adhere closely to CONSORT guidelines related to appropriate randomization procedures and concealment of allocation.⁸⁰

Limitations

The present study included only RCTs. It is possible that other video game interventions are highly successful but only have been reported using observational trials. However, this important inclusion criterion was maintained to evaluate a higher level of evidence for the usefulness of video games to improve health outcomes than prior reviews on this topic. Another limitation of this systematic review was that some of the study selection criteria used are inherently subjective, such as the definition of what constitutes a “game.” Despite this inherent limitation, bias was minimized by carefully defining the current selection criteria with specific protocols and examples, and by comparing the assessment of each study completed by two researchers working independently using established measures of inter-rater reliability.

Another limitation is that coders relied on authors’ selection of appropriate measures to operationalize their outcomes. It may be valuable for future assessments to more rigorously examine reliability and validity of these measures. Additionally, because each of the included studies was relatively small, the total number of study participants assessed in all 38 studies was only 2662. Finally, it was not possible to employ formal techniques of meta-analysis because of the wide diversity in study interventions and outcome measures.

Conclusion

Despite these limitations, this comprehensive systematic review demonstrates that video games may have potential

for improving health in a wide variety of areas, for a variety of sociodemographic groups. This is a valuable finding, particularly given the growing popularity and ubiquity of video games worldwide. To most effectively assess the potential benefits of video games for health, it will be important for further research to utilize (1) RCT methodology when appropriate; (2) longer follow-up duration; (3) improved measures of quality, such as randomization and blinding; and (4) standardized measurement tools and careful attention to the quality of outcome measures.

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Appendix

Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.amepre.2012.02.023.

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