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A Scoping Review of Health Game Research: Past, Present, and Future

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Abstract

Health game research has flourished over the last decade. The number of peer-reviewed scientific publications has surged as the clinical application of health games has diversified. In response to this growth, several past literature reviews have assessed the effectiveness of health games in specific clinical subdomains. The past literature reviews, however, have not provided a general scope of health games independent of clinical context. The present systematic review identified 149 publications. All sources were published before 2011 in a peer-reviewed venue. To be included in this review, publications were required (1) to be an original research, (2) to focus on health, (3) to utilize a sound research design, (4) to report quantitative health outcomes, and (5) to target healthcare receivers. Initial findings showed certain trends in health game publications: Focus on younger male demographics, relatively low number of study participants, increased number of controlled trials, short duration of intervention periods, short duration and frequency of user–game interaction, dominance of exercise and rehab games, lack of underlying theoretical frameworks, and concentration on clinical contexts such as physical activity and nutrition. The review concludes that future research should (1) widen the demographics to include females and elderly, (2) increase the number of participants in controlled trials, (3) lengthen both the intervention period and user–game interaction duration, and (4) expand the application of health games in new clinical contexts.

Introduction

A systematic review is a type of literature review that is inclusive of all publications meeting certain criteria while being exclusive of all others.[1] Previous reviews of health games have traditionally focused on specialized clinical applications,[2,3] have lacked rigorous systematic approaches,[4] or have ignored the larger picture of health games research.[5] This systematic review, however, is an attempt to systematically filter existing health game publications, independently from their clinical context, and provide a scope for the past, present, and future of health game research.

The ambiguity of the term "health game" has often created confusion in the research community. This ambiguity becomes salient when the term is interpreted against a large number of articles that cover different angles of health games. Multiple definitions have been proposed for health games in previous publications[3,6]; however, the boundaries of the definitions often change depending on the context. For the purpose of this review, the review team identified certain boundaries defined as a series of inclusion and exclusion criteria that were used to filter the publications.

The goal of this review is to provide a high-level overview on the current state of health game research specifically if contextualized within a clinical setting. To achieve this goal, scientific publications were systematically filtered, independently appraised, and thoroughly coded to identify publications that have used digital videogames as a direct method to improve health.

Methodology

Cochrane guidelines on systematic reviews[1] were adapted and modified to develop the methodology of this review. The methodology included multiple stages varying from generating consensus on the definition of health games to analyzing a complex matrix of coded articles. Because of the heterogeneity of the publications, a meta-analysis was not feasible.

The review included four independent reviewers with diverse academic backgrounds to ensure inter-rater reliability and fair coverage of variable research perspectives in health games. Consensus among the reviewers was reached in multiple stages of the review including the selection of search engines, keywords, and inclusion/exclusion criteria.

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The selected search engines were PubMed, EBSCO, IEEE/ACM, Google Scholar, and HG Database.[7] The following combinatory keyword was used across all selected search engines: ((Health OR Rehab*) OR (Exer* OR Acti*) OR Edu* OR Behav* OR Serious OR (Virtual AND Reality)) AND ((Interactive OR Computer OR Video OR Multimedia OR Internet OR Online) AND Gam*). The review included only articles published before 2011 in peer-reviewed journals and conferences. Articles published in or after 2011 will be considered for a separate review.

Using the given keyword, each reviewer generated an independent list of articles. An initial list of articles was generated after merging all individual lists and removing duplicates. The merged list included 396 articles on health games. To conform to the reviewers' initial definition on health games, however, a list of inclusion and exclusion criteria (Table 1) was applied to each article by individual reviewers. The responses were then compared, discussed, and merged for each article, resulting in the exclusion or inclusion of the articles for the final review. The final list of articles included 149 publications (see Appendix). Each publication was counted and included as a separate entity in the review (i.e., review per publication not clinical study). Cochrane quality measures[1] were not applied to the final list because of the limited number of full-featured randomized clinical trials.

The final list of articles was coded against a consensual hierarchical group of dimensions. The dimensions were specifically designed to elaborate on the similarities and differences of health game studies. The review team avoided dimensions that are specific to a certain subgroup of health game studies. After a preliminary training session with five selected publications, each member coded a quarter of the articles. The final coding sheet was cleaned twice, and ambiguous cases were resolved by consensus.

Findings

Publication statistics

The final list of reviewed articles included 149 publications (see Appendix). As depicted in Figure 1, the majority of health game publications meeting our criteria were published after 2005 (71.8 percent). The peak of the publications has occurred in 2008 (16.8 percent) and 2009 (20.1 percent), followed with a modest decline in 2010 (9.4 percent).

Considering the main author's affiliation, the majority of the publications originated from a center/institute in the United States (40.2 percent), followed by Canada (9.4 percent) and Israel (6.7 percent) (Fig. 2). If categorized based on geographical regions, North America (49.6 percent) and Europe (14.7 percent) generated most of the publications.

Table 1. Inclusion and Exclusion Criteria

Number	*Inclusion/exclusion criteria*
1	The primary purpose of the study is maintaining or improving health
2	The study has a sound research design which uses health game as the key intervention
3	The study measures a quantitative health outcome variable
4	The study is designed for the healthcare receiver population and not providers
5	The publication is an original study and not a review

Demographics

The average sample size of participants in reviewed publications is 109.5 users per study, but with a large standard deviation of 381.2. The majority of the articles (82.6 percent) included fewer than 100 participants, from which around one in four included fewer than 10 participants. Three articles skewed the results with more than 1,000 participants. Excluding these outliers, the average number of participants per publication is 61.4. Figure 3 depicts the distribution of participants in publications with less than 100 users.

Distribution of participants' age (Fig. 4) among the reviewed publications is skewed toward 10–20-year-old teenagers (39.8 percent). The average age of participants is 25.2 years (low average range of 18.5 years and high average range of 31.7 years). If adjusted based on number of participants, the average age of the participants is 13.0 years. Minimum age of participants was 3 years, and maximum age was 97 years.

The ratio of male participants to females is 1.43, indicating the focus of health game research on teenage boys.

Recruitment

The most common inclusion or exclusion criteria for recruitment were prior medical condition (66.9 percent), followed by demographics (39.6 percent) and current health indices (32.1 percent) (e.g., height and weight). Type of affiliation with certain healthcare centers (16.0 percent) and prior experience with gaming technology including possession of certain consoles (13.2 percent) were less reported as criteria for inclusion in the studies. Indeed, 28.9 percent of the publication did not have explicit inclusion or exclusion criteria for recruitment, and only 21.5 percent of them had a randomization process for recruitment. In addition, only 16.1 percent of the articles reported the race, and 5.4 percent reported the socioeconomic status of the participants.

Methodologies

Analyzing the methodology used in the experiments (Fig. 5) of the reviewed publications revealed that 43.6 percent of the studies used a controlled-treatment design, whereas 20.1 percent of them conducted only a focus group. The rest of the publications used other methodologies such as case study (12.1 percent), before-and-after (11.4 percent), unexplained pilot study (8.1 percent), and quasi-experimental (4.0 percent) designs. It should be remembered that all studies needed to have an explicit research design to be included in the review; thus publications with no user experiments were excluded early in the review.

The majority of the studies were conducted under lab settings (72.5 percent) compared with field settings (19.5 percent) or not being reported (9.4 percent). Note that some studies used both lab and field settings.

Study duration varied greatly among publications. Intervention period was recorded in 83.9 percent of the publications, while baseline and follow-up periods were collected in 36.9 percent and 30.2 percent, respectively, of the studies.

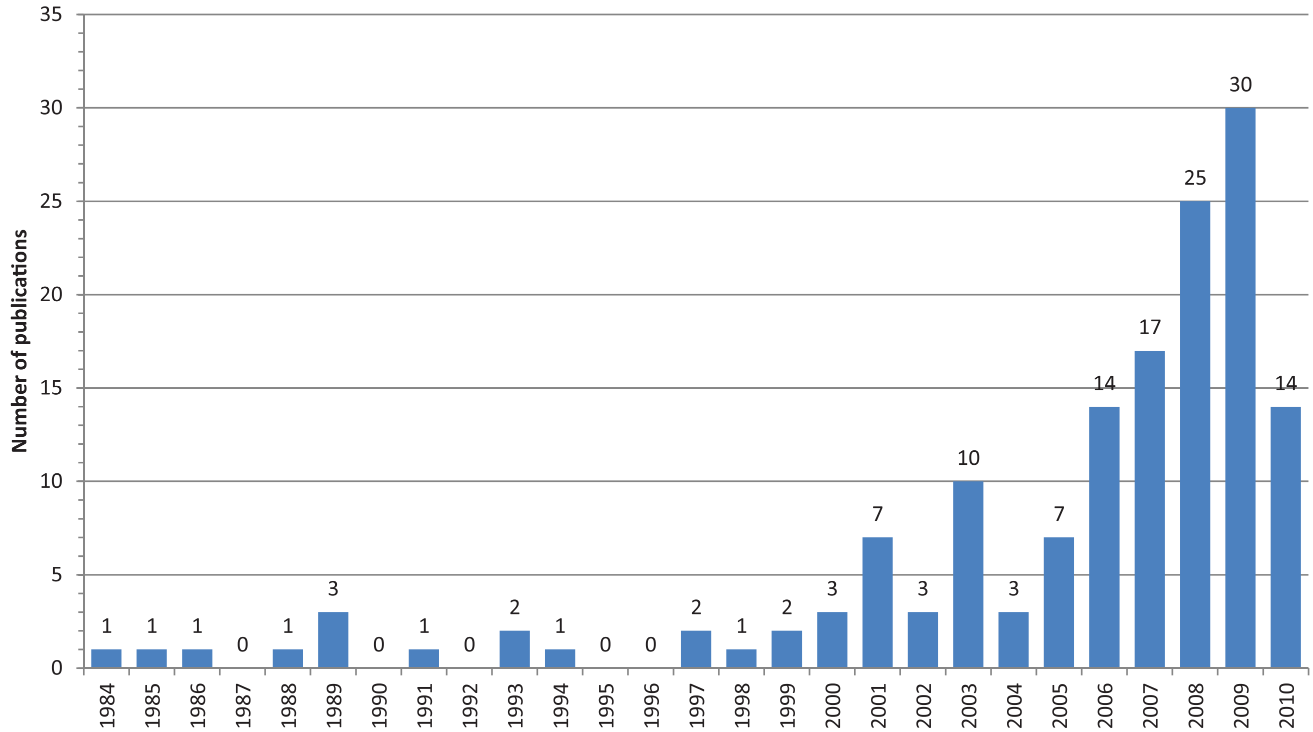

FIG. 1. Number of health game publications per year. Color images available online at www.liebertonline.com/g4h

Average intervention period was 5.4 weeks. When reported, average time spent interacting with the solution (e.g., playing the game) in the intervention period was 396 minutes (approximately 6.6 hours). As depicted in Figure 6 most of the publications (45.8 percent) included less than 100 minutes of user–game interaction.

Type of health game

Publications were coded into six custom categories of health games: (1) educational games (e.g., informing users about a disease); (2) behavioral games (e.g., improving adherence to medication); (3) cognitive games (e.g., memory

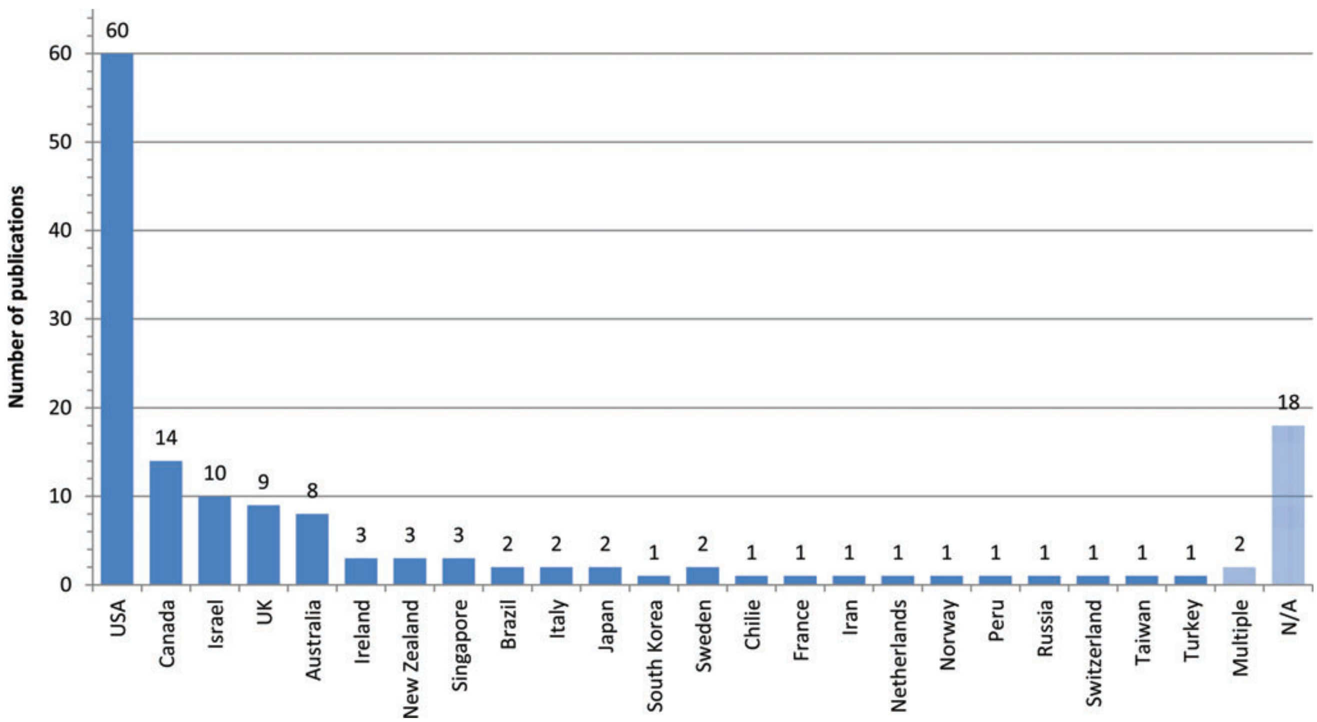

FIG. 2. Number of health game publications per country of origin (by first author). Color images available online at www.liebertonline.com/g4h

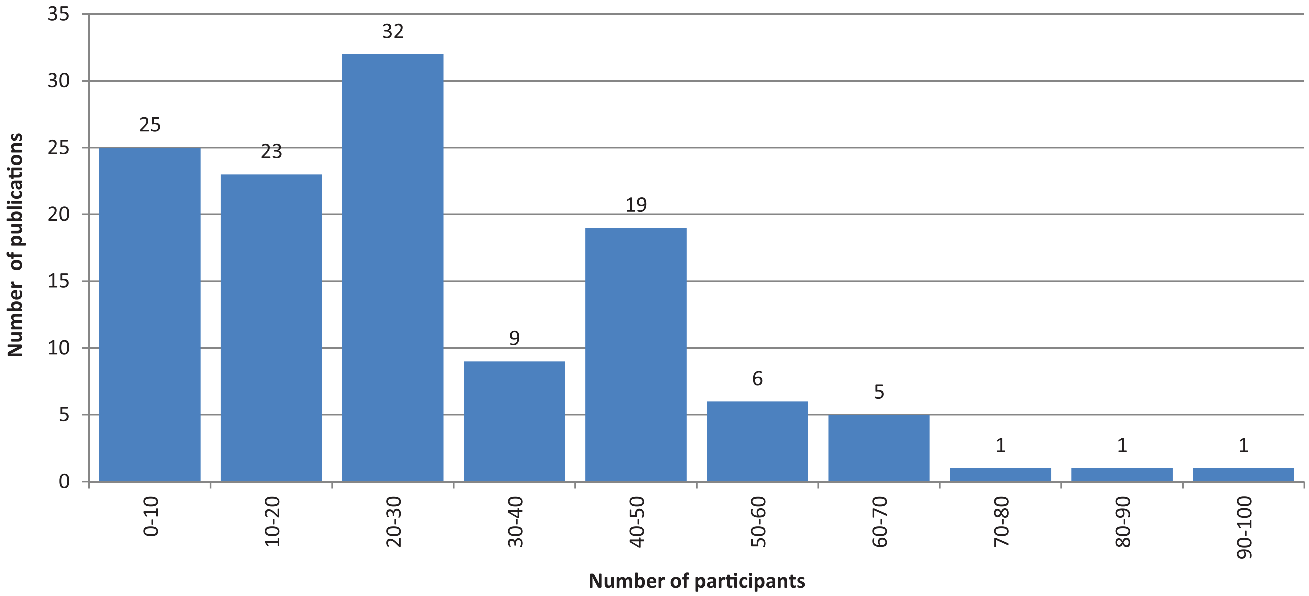

FIG. 3. Distribution of participants across studies (if less than 100). Color images available online at www.liebertonline.com/g4h

training); (4) exercise games (e.g., improving physical exercise); (5) rehab games (e.g., rehabilitation of upper extremity); and (6) hybrid games (i.e., a mix of others). As shown in Figure 7, rehab (29.5 percent), exercise (27.5 percent), behavioral (27.5 percent), and educational (24.1 percent) categories were significantly more present in the publications than hybrid (12.0 percent) and cognitive (3.3 percent) types. Figure 8 shows the increasing trend of exercise and rehab health games in recent years.

Behavioral change theories

Only 18.8 percent of the publications applied an established behavioral change theory to ensure the long-term effect of the health game. Although 36.6 percent of the behavioral games and 39.0 percent of the educational games integrated a theory, less than 5 percent of the exercise or rehab games utilized such methods. The most common used theory has been "Social Cognitive Theory" (42.9 percent) followed by "Theory of Planned Behavior" (10.7 percent).

Clinical/health domains

Notable clinical/health domains attracting most of the health game studies included physical activity (27.1 percent), nutrition (10.3 percent), stroke (9.7 percent), balance (5.8 percent), cerebral palsy rehabilitation (5.2 percent), and pain distraction (5.2 percent) (Fig. 9). The domains were custom-developed by the review team.

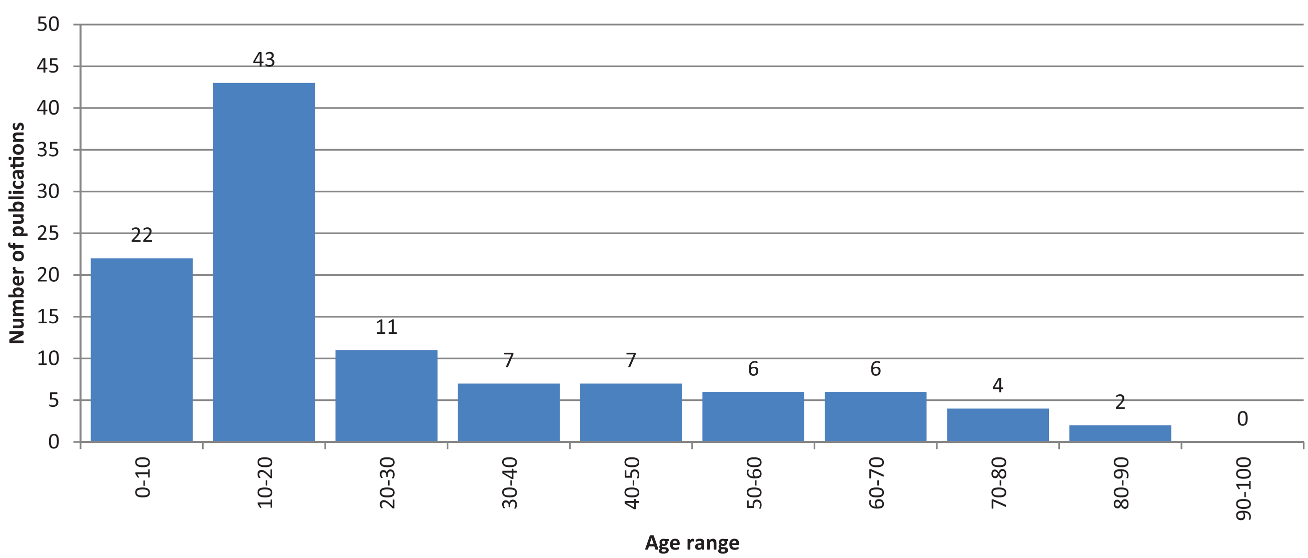

FIG. 4. Distribution of participants' age (excluding outliers and unreported cases). Color images available online at www.liebertonline.com/g4h

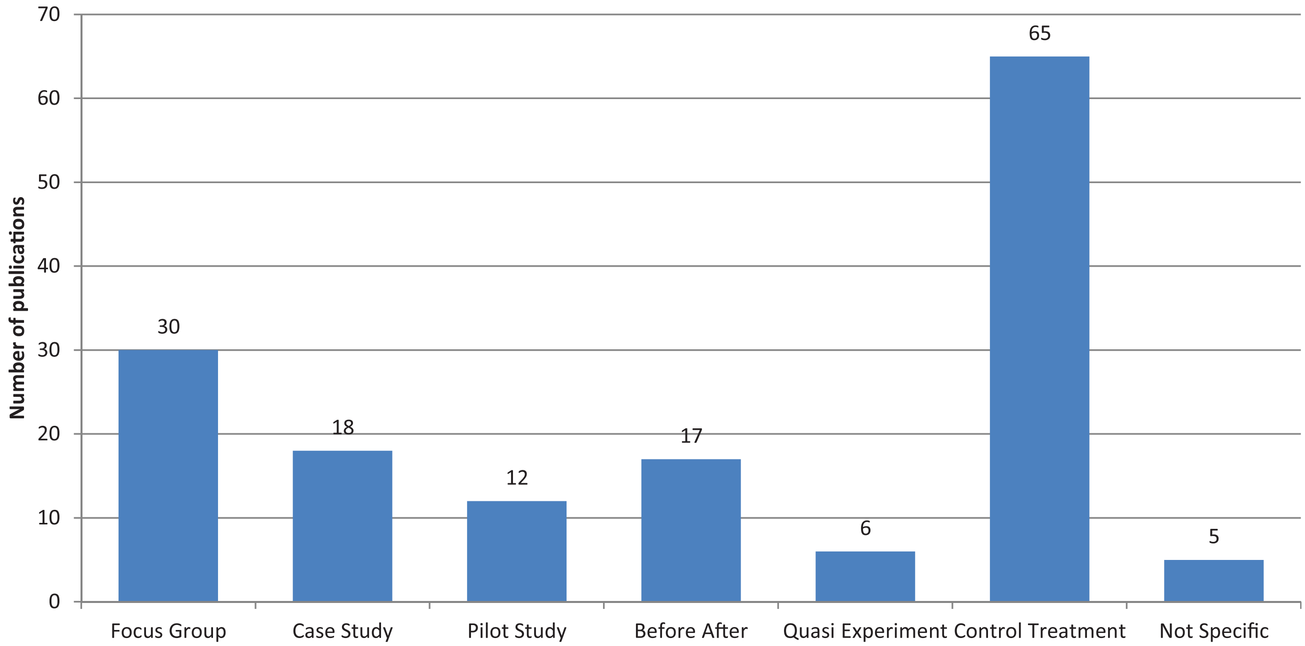

FIG. 5. Study designs of the reviewed publications (some studies had multiple designs). Color images available online at www.liebertonline.com/g4h

Technology

Computer-based videogames composed 67.8 percent of the health games, whereas console-based games made up 31.5 percent of them. Around 5 percent of the health games were developed on mobile devices. Among the consoles, Sony (Tokyo, Japan) PlayStation® (53.2 percent) and Nintendo® (Kyoto, Japan) Wii™ (38.3 percent) were the most common consoles, followed by Microsoft® (Redmond, WA) Xbox (8.5 percent). Of all health game studies reviewed, 59.7 percent used a commercial game, whereas 42.3 percent developed a non-commercial game. Keyboard and mouse were the main haptic interfaces for 45.6 percent of cases, whereas the rest of the publications (54.4 percent) used health games with other means of user interaction (e.g., motion detection).

Outcomes and results

Because of word limitations, a separate systematic review is planned for the outcomes and results.

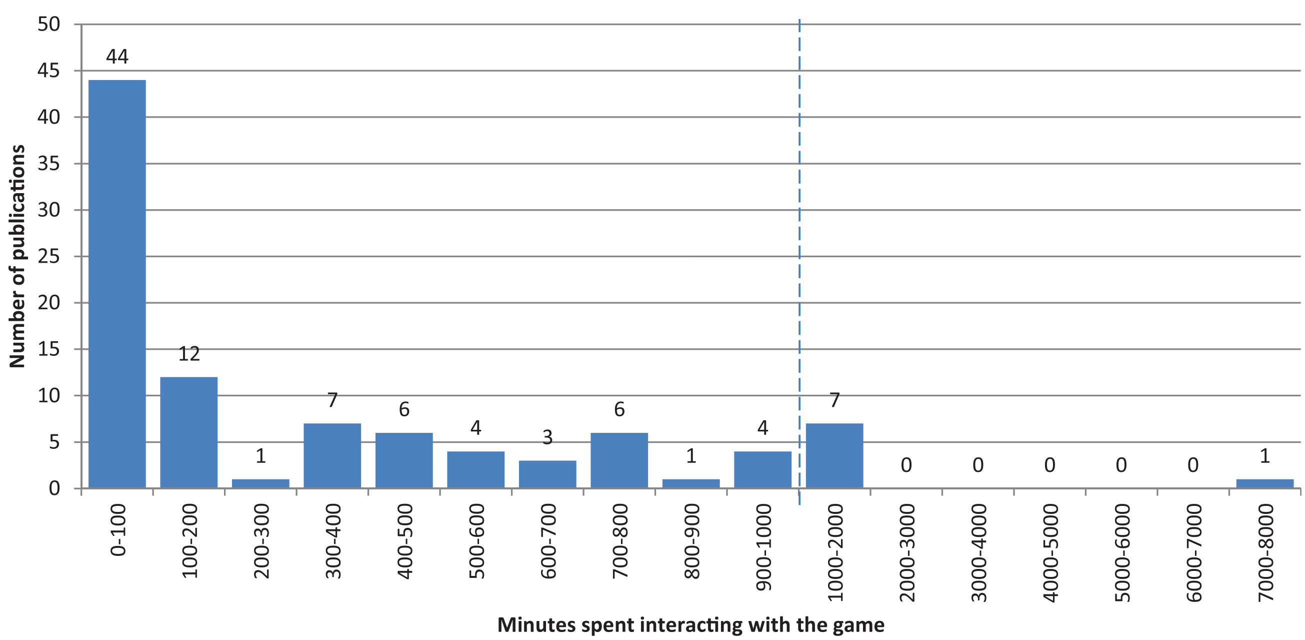

FIG. 6. User–game interaction time (in minutes). Color images available online at www.liebertonline.com/g4h

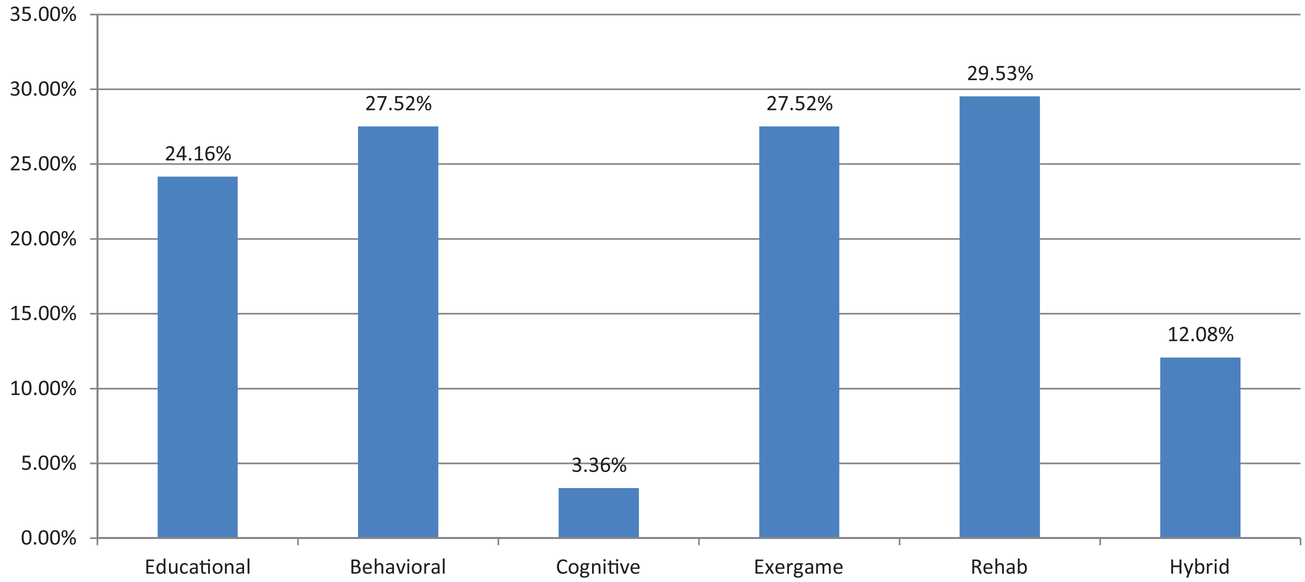

FIG. 7. Distribution of health game categories (some publications had multiple categories). Color images available online at www.liebertonline.com/g4h

Discussion

The sudden surge of health game publications in 2008 and 2009 can be attributed to the availability of specific funding for health games research (i.e., Robert Wood Johnson Foundation[8] funding), advancements in commercialized gaming technology (e.g., Nintendo Wii), and the establishment of health game research networks through various scientific venues (e.g., Games for Health Conferences[9]).

The higher number of publications in the United States and Canada may be partly due to the non-English publications of other countries/regions that were not included in this review. This may have contributed to the lower number of publications in health games from Japan despite their considerable role in the videogame industry.

The reviewed studies often included trials with small to moderate sample sizes. Despite the promising fact that more health game trials have started to have satisfactory sample sizes, only a few of them included large-scale trials. In addition, there is a lack of explicit inclusion and exclusion criteria for user recruitment. Conducting trials with larger number of participants recruited through carefully

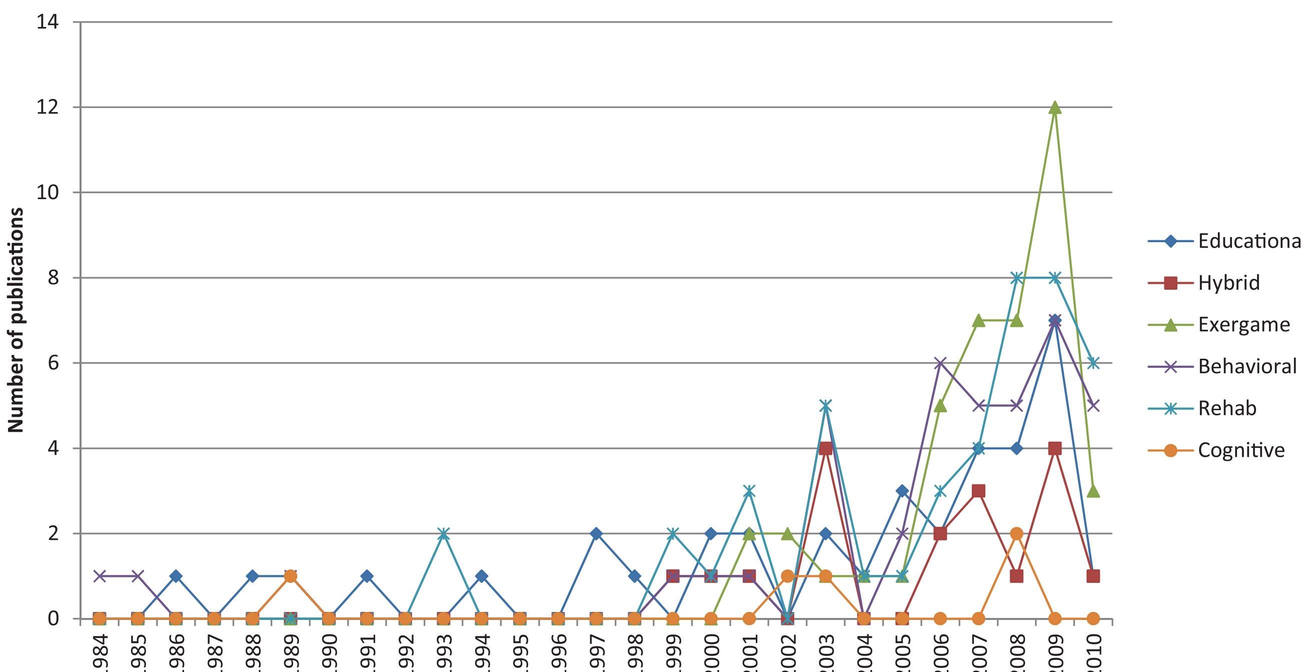

FIG. 8. Number of publications per health game type over multiple years. Color images available online at www.liebertonline.com/g4h

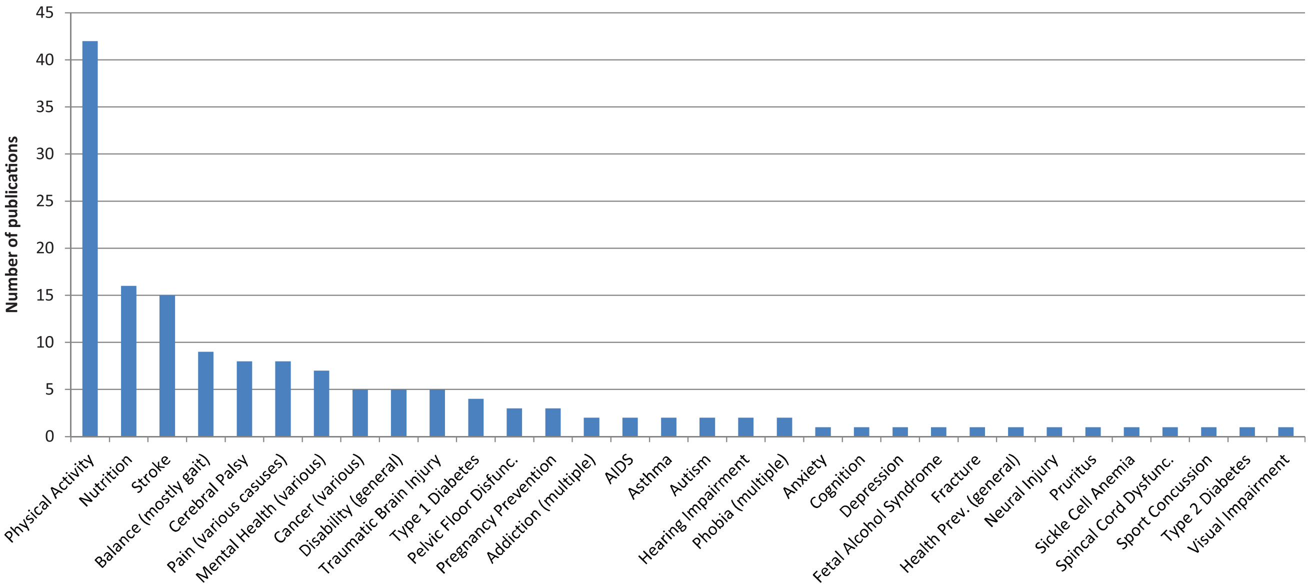

FIG. 9. Number of publications per clinical context. Color images available online at www.liebertonline.com/g4h

designed inclusion and exclusion criteria is crucial for the health game research community to provide opportunities for conducting future meta-analysis across studies. In addition, most of the reviewed studies included young participants. Considering the penetration of gaming across all demographics, the aging population, and the advancements in gaming rehabilitation, the age distribution of health game studies may change soon.

Controlled experiments offer valid statistical approaches to measure the net effect of health games on users. The fact that the majority of the publications used a controlled experiment is encouraging; however, most of them are missing preparatory experiments such as focus groups. On the other hand, focus groups, case studies, and before-and-after studies, if not followed with a controlled experiment (around 50 percent of the publications), do not provide the necessary evidence to show the statistical significance of health games in changing the health outcome. It is recommended that health game studies use pilot studies (e.g., focus group, case study) to prepare the grounds for larger controlled studies. In addition, the majority of the studies were conducted in lab environments (>70 percent), reducing the practicality and generalizability of the outcomes in the field. The latter fact increases the need for more controlled studies to be conducted in field settings.

The relative short intervention period of the studies (around 1¼ months) and the short user–game interaction time (less than 100 minutes) have substantially limited these studies to generate significant effect sizes. Health games studies require longer intervention periods along with lengthier and more frequent user–game interaction when dealing with chronic conditions. The lack of either baseline or follow-up period has made the low effect size problem more severe by eliminating the possibilities to show the long-term effect of health games for chronic conditions.

The surge of exercise and rehab games compared with behavioral games in the recent years may be due to (1) new advancements in haptic technology that has enabled users to interact with games by moving certain body parts (e.g., Nintendo Wii, Microsoft Kinect), (2) accurate methods to measure objective outcomes of exercise and rehab games (e.g., energy expenditure), and (3) the growth of the underlying condition in the targeted demographic (e.g., sedentary lifestyle in children). However, compared with behavioral games, exercise/rehab games have often lacked theoretical frameworks of behavioral change to ensure the long-term effect of such interventions. The latter necessitates more collaborative research between exercise/rehab health game researchers and behavioral/educational researchers in the near future.

The change is the technological platform of health games is partly due to the natural trend in the gaming industry. Although custom-made computer games offer great flexibility to be tailored based on a given clinical setting (e.g., tracking specific physical movements or certain behavioral factors), the advancements in gaming technology and the lower cost to acquire them have led the health game research community to adopt more of-the-shelf commercial games over time. The adaptation of commercial games, however, may inversely impact the significance of such interventions because of limited customizability.

Limitations

Common limitations of this review include the following: (1) the possibility of overlooking publications that meet the inclusion and exclusion criteria; (2) skewing the review toward conditions more common in certain countries by excluding non-English publications; (3) raised recall rate of search results because of the use of a general definition for "digital/videogames"; and (4) inflated outcome measures because of the publication bias (i.e., insignificant results are less publishable).

Conclusions

Health game research has grown constantly over the past years. Despite the occasional setbacks due to limited research funding, the general trend shows positive progress toward adapting new gaming technology in specialized health contexts. Discussed recommendations of this review can be effective in propelling health game research in the near future. Furthermore, exploring new funding mechanisms, establishing communities of researchers, developing theoretical basis for health games, and introducing new publishing venues will empower health games to become a sustainable research field in the long term.

Author Disclosure Statement

No competing financial interests exist.

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(*Appendix follows* →)

Appendix

List of articles included in the review

Akhutina T, Foreman N, Krichevets A, et al. Improving spatial functioning in children with cerebral palsy using computerized and traditional game tasks. Disabil Rehabil 2003; 25:1361–1371.

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