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Game-Based Digital Interventions for Depression Therapy: A Systematic Review and Meta-Analysis

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Abstract

The aim of this study was to review the existing literature on game-based digital interventions for depression systematically and examine their effectiveness through a meta-analysis of randomized controlled trials (RCTs). Database searching was conducted using specific search terms and inclusion criteria. A standard meta-analysis was also conducted of available RCT studies with a random effects model. The standard mean difference (Cohen's *d*) was used to calculate the effect size of each study. Nineteen studies were included in the review, and 10 RCTs (eight studies) were included in the meta-analysis. Four types of game interventions—psycho-education and training, virtual reality exposure therapy, exercising, and entertainment—were identified, with various types of support delivered and populations targeted. The meta-analysis revealed a moderate effect size of the game interventions for depression therapy at posttreatment ($d = -0.47$ [95% CI -0.69 to -0.24]). A subgroup analysis showed that interventions based on psycho-education and training had a smaller effect than those based on the other forms, and that self-help interventions yielded better outcomes than supported interventions. A higher effect was achieved when a waiting list was used as the control. The review and meta-analysis support the effectiveness of game-based digital interventions for depression. More large-scale, high-quality RCT studies with sufficient long-term data for treatment evaluation are needed.

Introduction

DEPRESSION IS A HIGHLY PREVALENT mental disorder worldwide.[1] According to the World Health Organization,[2] more than 350 million people of all ages suffer from depression. Depression significantly decreases quality of life, and is reported to be a major risk factor for suicide.[3] However, many people are unable or reluctant to access and engage in effective treatment due to barriers such as personal stigma, high costs, waiting lists, and a shortage of trained professionals.[4] In recent years, the home computer boom has triggered a flood of research on the development of novel and cost-effective technologies for mental health therapy.[5] Among these innovative technologies, recent decades have witnessed the increasing use of digital interventions with game-like components to treat mental disorders. Initially developed for entertainment, a ''game'' is generally considered to be an activity with the key features of challenge, motivation, and reward. Game-based digital interventions have been found to have practical effects in addressing the main barriers of access and engagement in the healthcare domain, particularly for the young.[6] Evidence from neuropsychological research further suggests the therapeutic value of game-based digital interventions in depression therapy, finding that positive game-playing experiences trigger the release of hormones such as endorphins and striatal dopamine[7,8] that are responsible for feelings of pleasure and well-being.[9,10] Guided by reasoning, game-based interventions have specific potential for reducing depression through the natural benefits afforded by the game elements involved. Preliminary results from some early attempts to use this approach in the field have supported this claim by showing the effectiveness of individual games in reducing depression levels[11,12] and enhancing social support.[13]

As digital game interventions for mental health is a relatively new research area, systematic reviews and meta-analyses of their effectiveness in treating depression are scarce. A few recent reviews have focused on computer-based or Internet-delivered psychological interventions for depression disorders,[14–17] but they did not specifically focus on digital intervention with a game component. Previous reviews that have targeted the use of video games to encourage health improvement[18–20] have not covered the effects of such treatment on depression. Further research is thus required to determine the overall effects of digital game-based interventions compared with other treatments. We aimed to conduct a systematic review of trial studies that emphasized game-based digital interventions and depression improvements in a categorized fashion, thus identifying the

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current research trends and contributing to knowledge in this field. A meta-analysis of randomized controlled trials (RCTs) was also conducted to discover the true power of game applications as depression therapy, and to examine further the effects of different game types, support types, target users, and comparison conditions on treatment outcomes, which has not previously been undertaken.

Method

Identification and selection of studies

The scope of the systematic review was limited to studies that investigate the effect of game-based digital applications for depression. A qualifying intervention was defined as therapeutic technology that includes interactive game components. We excluded most of the current interventions in computerized cognitive behavioral therapy (CCBT) without game elements involved. A search of seven main health and technology databases[a] was conducted to identify studies published in English before May 2013. Studies were identified using key search terms selected following guidance from informatics experts, and included combinations of the terms ''digital games,'' ''computerized game intervention,'' ''video games,'' ''therapeutic games,'' ''game-based treatment,'' and ''depress*,'' ''stress,'' ''anxiety,'' ''mood,'' ''mental disorders,'' and ''mental health.'' We also searched for papers included in earlier reviews and the reference lists of the included studies.

Eligible studies had to contain an evaluation of the treatment's effects on participants' depression symptoms using a reliable and valid depression scale. There were no limitations on the participants' age or the significance of the depression symptoms. However, studies with different age groups were reviewed separately where appropriate.

Meta-analysis procedure

The meta-analysis only included RCTs that encompassed a controlled condition (such as waiting lists, treatment as usual, or other active treatments). Trials were excluded if they (a) did not involve an appropriate control group, or (b) lacked interpretable or complete data for the meta-analysis. We used the Review Manager 5.2 software[21] for the data analysis. To estimate the effects of game-based digital interventions on depression, we applied the standard mean difference (Cohen's d) to calculate the effect size for each study in the posttreatment period, weighted by sample size, using a random effects model. The effect size reflects the outcome difference between an intervention and the control treatment, with 0.8 indicating a large effect, 0.5 a moderate effect, and 0.2 a small effect.[22] Endpoint data on the trial completers were used for the effect size when intention-to-treat (ITT) data were not available. If studies did not report means and standard deviations, we used other statistics, such as the F value or p value, to calculate the effect sizes. For studies that used two instruments to measure depression, both trials were included in the meta-analysis due to the limited number of suitable studies found in the literature. Effect sizes in the follow-up period were not calculated because the number of eligible trials was too small, and the follow-up periods also differed greatly among the included trials.

The heterogeneity of the studies was assessed by the I^2 statistic and Q statistic. The I^2 value describes the percentage of total variation across trials attributable to their heterogeneity rather than by chance, while the p value in the Q statistic indicates whether the variability among effect sizes is greater than that which would result from subject-level sampling error alone.[23] An I^2 value of $>50\%$ or a p value of <0.1 was considered suggestive of heterogeneity.[24]

A priori subgroup analyses were conducted according to the types of games, types of support, target population, and comparison conditions. A mixed-effects model was applied in the subgroup analyses, whereby the studies within each subgroup were pooled in a randomized effects model and the significant differences between subgroups were calculated with a fixed-effects model.

Two reviewers were involved in the assessment of the methodological quality of each study, following Cochrane's method for assessing the risk of bias.[25] Six individual types of risk of bias were considered: (a) sequence generation, (b) allocation concealment, (c) blinding of participants and personnel, (d) blinding of outcome assessors, (e) incomplete outcome data, and (f) selection outcome reporting. The six domains were given one of three quality ratings: ''low risk of bias,'' ''unclear,'' or ''high risk of bias.''[25]

Results

The search yielded a total of 1,179 articles, with 19 studies meeting the criteria for inclusion in the final review. For the meta-analysis, 7 out of the 19 studies were excluded because they did not involve RCTs,[11,13,26–30] three were excluded due to uninterpretable or incomplete findings,[31–33] and one was excluded because its control conditions were also game-based digital applications.[34] Thus, eight studies involving a total of 636 participants in 10 RCTs were eligible for inclusion in the final meta-analysis. Figure 1 shows a flowchart of the selection of studies into the systematic review and meta-analysis.

Results of the review

Table 1 outlines the selected characteristics of the 19 studies included in the review. They were divided into four categories based on the game types they involved: (a) psycho-education and training, (b) virtual reality exposure therapy, (c) exercising, and (d) entertainment. Six studies introduced game applications with a psycho-education and training function to reduce depression. Fleming et al.[12] and Sally et al.[35] developed and evaluated the effectiveness of SPARX,[b] an interactive 3D fantasy game developed to deliver CBT to teenagers with clinical depression. Likewise, Reach Out Central (ROC),[c] a web-based interactive educational game with ''real-life'' scenarios and role-playing features, was shown to improve psychological distress among young adults.[29] Other studies used game-based computer programs that used interactive, multimedia techniques (video, audio, graphics) to enhance patients' engagement and to teach them to consolidate skills to address major depression disorders[36,37] or depressive symptoms caused by specific phobias.[26]

Virtual reality exposure therapy was the second type of game-based digital application for the treatment of depression. These therapeutic play interventions used virtual reality computer games to enable participants to be immersed in a virtual environment and create a sense of ''being there'' with

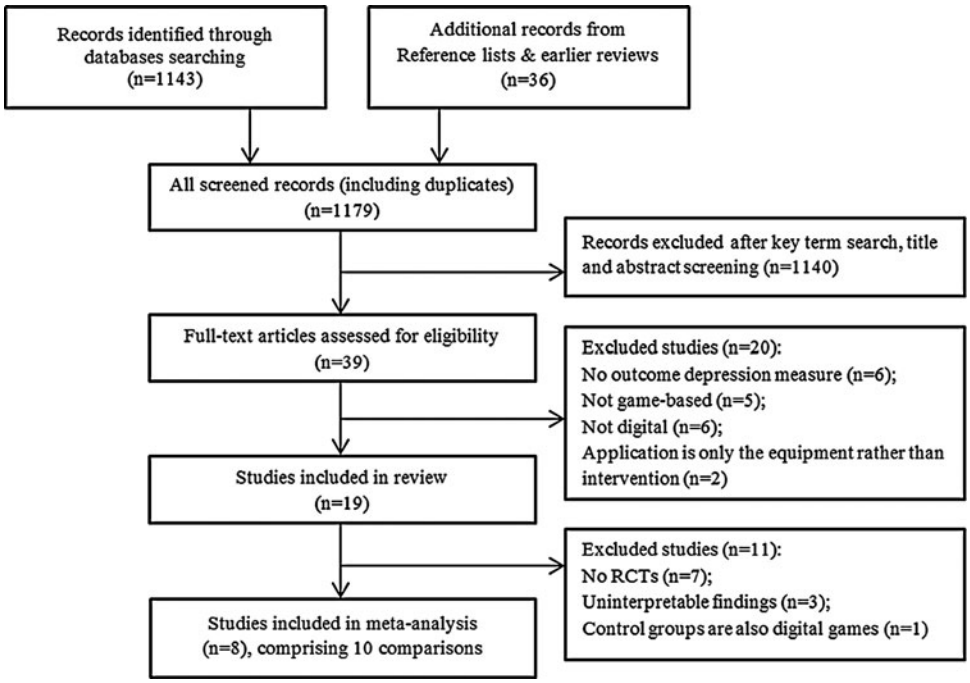

FIG. 1. Flowchart of the studies included in the systematic review and meta-analysis.

the help of visual, sound, olfactory, or tactile stimuli. Three studies[11,27,32] indicated that virtual reality exposure therapy was very effective for war posttraumatic stress disorder (PTSD). Significant reductions in depression were also found when interventions were used for specific driving phobia[30] and acrophobia.[38] In a clinical trial conducted among children hospitalized with cancer, Li et al.[39] also identified that virtual reality computer games had an effect on reducing children's depression symptoms in comparison with a control group in usual care.

Two studies introduced therapeutic interventions using exercising video games to treat depression.[28,40] Both were aimed at older adults, and used the Nintendo Wii device to encourage body motions during game playing. Lastly, five studies were identified that assessed the feasibility and efficacy of entertainment gaming technology for mental health improvement. Ferguson and Rueda[33] and Valadez and Ferguson[34] suggested that players' depression decreased when playing offline violent games, and Longman et al.[13] used World of Warcraft to show that massively multiplayer online games led to fewer negative psychological symptoms.[d] Casual games for relaxation, such as Bejeweled II,[e,31] FreezeFramer 2.0, and Journey to the Wild Divine,[41] were also found to be useful in depression therapy.

Following Glasgow and Rosen,[42] we categorized the studies based on their support types: eight studies were defined as examining self-administered therapy, with no support from a therapist or other health professional; four studies covered predominantly self-help, with limited therapist contact in teaching patients to use the interventions; three studies involved minimal contact therapy, in which a therapist was actively involved but less intensively than in traditional therapy; and four studies covered predominantly therapist-administered treatments, with a therapist keeping in regular contact with patients during the therapy. In terms of target groups, the majority of the studies (11) focused on general adults, four were aimed at adolescents younger than 18 years, and two targeted elderly people older than 65 years (two studies did not mention the participants' ages). However, it is important to note that 11 of the studies were aimed at ''young people'' younger than 30 years if we change the classification of the target population. Eleven out of the 19 studies recruited a small number of participants, with fewer than 50 people in each trial. Twelve out of the 19 studies involved between-group experiments with at least a control condition, whereas the other seven applied other methodologies such as a single-group study or case study. A wide range of different self-reported scales was used to measure depression in the trials, among which the Beck Depression Inventory was the most popular (used in 7 out of the 19 studies). Some scales were applied for particular age groups, such as the Children's Depression Inventory and Child Depression Rating Scale Revised (CDRS-R) for adolescents, and the Geriatric Depression Scale for elderly people.

Results of the meta-analysis

Across the 10 comparisons (eight studies) and a total of 387 game-based digital intervention groups and 388 control groups, there was a moderate effect size of $d = -0.47$ [95% CI -0.69 to -0.24]; Fig. 2) for self-reported depression posttest, which was statistically significant ($Z = -4.09$, $p < 0.0001$). Heterogeneity among the depression outcomes was moderate ($I^2 = 47\%$; Table 2). However, inspection of the forest plot suggested that one comparison was a possible outlier.[39] After removing the outlier, the effect size changed to -0.35 [95% CI -0.53 to -0.16] and the heterogeneity decreased significantly to a low level ($I^2 = 18\%$).

Several subgroup analyses were conducted to evaluate the effect size by type of game, type of support, target population, and control condition (Table 2). Games in the virtual reality exposure therapy group ($d = -0.67$ [95% CI -1.19 to -0.14])

Table 1. Characteristics of the Studies Included in the Review

	Intervention			Participants			Study design			
Study	*Type of game*	*Number of sessions*	*Type of support*	*Inclusive criteria*	*Age: mean (SD)**	*Total number*	*Type of experiment*	*Follow-up*	*Depression measure*	*Country*
Alvarez et al. (2008)	Psycho-education and training	—	MC	University students who presented a MDD diagnosis according to the DSM-IV criteria	21.0 (2.9)/23.8 (2.7)	31	RCT (analyses based on OC): CG 1 = antidepressant; CG 2 = cognitive treatment + antidepressant	—	BDI	Mexico
Emmelkamp et al. (2002)	Virtual reality exposure therapy	3	TA	Adults fulfil the DSM-IV criteria of acrophobia	43.97 (9.34)	33	RCT (analyses based on ITT): CG = exposure *in vivo*	6 months	Acrophobia questionnaire anxiety	Netherlands
Ferguson and Rueda (2010)	Entertainment	—	SA	Young students	23.6 (5.82)	103	RCT (analyses based on ITT): CG1 = NT; CG2 = a nonviolent game	—	BDI	United States
Fleming et al. (2012)	Psycho-education and training	7	SA	Adolescents (aged 13–16 years) with depressive disorder	14.9 (0.79)	32	RCT (analyses based on OC): CG = WL	5 weeks	CDRS-R; RADS-2	New Zealand
Gamito et al. (2010)	Virtual reality exposure therapy	12	TA	Older male war veteran patients with war posttraumatic stress disorder (PTSD)	63.5 (4.43)	10	RCT (analyses based on ITT): CG1 = exposure in imagination; CG2 = WL	—	BDI	United States
Gega, Marks, and Mataix-Cols (2004)	Psycho-education and training	5	TA	A woman reported severe general anxiety every morning and agitated depression. She was diagnosed with agoraphobia with panic disorder	28	1	Case study	—	Fear questionnaire anxiety/ depression	United Kingdom
Gerardi et al. (2008)	Virtual reality exposure therapy	16	MC	Adult, reported ongoing intrusive recollections of military trauma that interfered with functioning at home and work	29	1	Case study	—	BDI	United States
Knox et al. (2011)	Entertainment	8	SA	Adolescents (aged 9–17 years) reported symptoms of anxiety or carried a diagnosis of an anxiety disorder	12.88 (2.42)	24	RCT (analyses based on ITT): CG = WL	—	CDI	United States
Li, Chung, and Ho (2011)	Virtual reality exposure therapy	—	PSH	Hong Kong Chinese children (aged 8–16 years), admitted to a pediatric oncology ward during a 14-month period	11.6 (2.1)/12.1 (2.3)	122	RCT (analyses based on ITT): CG = TAU	—	CES-DC	Hong Kong
Longman, O'Connor, and Obst (2009)	Entertainment	—	SA	General adults (aged 14–65 years) from English-speaking Western nations	26.45 (7.99)	206	Survey study	—	DASS	United States
Proudfoot et al. (2003)	Psycho-education and training	9	TA	Adults (aged 18–75) suffering from depression, mixed anxiety/depression, or anxiety disorder	43.7 (14.7)/45.7 (14.1)	167	RCT (analyses based on ITT): CG = TAU	1 month; 3 months; 6 months	BDI	United Kingdom

(*continued*)

Table 1. (Continued)

	Intervention			Participants			Study design			
Study	Type of game	Number of sessions	Type of support	Inclusive criteria	Age: mean (SD)*	Total number	Type of experiment	Follow-up	Depression measure	Country
Rendon et al. (2012)	Exercising	18	PSH	Community-dwelling older adults (aged 60–95 yeas)	85.7 (4.3)/83.3 (6.2)	40	RCT (analyses based on ITT): CG = TAU	—	GDS	United States
Rothbaum et al. (1999)	Virtual reality exposure therapy	14	MC	Older adult, met DSM-IV criteria for current PTSD, current major depressive disorder (recurrent, with melancholic features), and past alcohol abuse	50	1	Case study	3 months; 6 months	BDI	United States
Rosenberg et al. (2010)	Exercising	36	PSH	Community-dwelling older adults (aged 63–94 years) with subsyndromal depression	78.7 (8.7)	19	Single group with pre- and posttest	20–24 weeks	QIDS	United States
Russoniello, O'Brien, and Parks (2009)	Entertainment	—	SA	—	—	69	RCT (analyses based on ITT): CG = control Internet activity	—	Profile of Mood States (POMS) assessment depression scale	United States
Sally et al. (2012)	Psycho-education and training	7	SA	Adolescents (aged 12–19 years) seeking help for depressive symptoms	15.55 (1.54)/ 15.58 (1.66)	187	RCT (analyses based on ITT): CG = TAU	3 months	CDRS-R; RADS-2	New Zealand
Shandley et al. (2010)	Psycho-education and training	—	SA	Young adults (aged 18–25 years) and an Australian resident	18–25	154	Single group with pre- and posttest	2 months	K10	Australia
Valadez and Ferguson (2012)	Entertainment	—	SA	Young adult students (aged 18–45 years)	19.9 (3.92)	100	RCT (analyses based on ITT): CG1 = nonviolent game; CG2 = nonviolence within a violent game	—	BDI	United States
Proudfoot et al. (2003)	Psycho-education and training	9	TA	Adults (aged 18– to75) suffering from depression, mixed anxiety/depression, or anxiety disorder	43.7 (14.7)/45.7 (14.1)	167	RCT (analyses based on ITT): CG = TAU	1 month; 3 months; 6 months	BDI	United Kingdom
Walshe et al. (2003)	Virtual reality exposure therapy	12	PSH	Adults meet current DSM-IV criteria for specific phobia, situational type-driving, or posttraumatic stress disorder with the clinical criteria for specific phobia, situational type driving	—	7	Single group with pre- and posttest	—	HAM-D	Ireland

*If any, data from the intervention and the control arms are presented respectively.

Note: BDI, Beck Depression Inventory; CDI, Children's Depression Inventory; CDRS-R, Child Depression Rating Scale Revised scores; CES-DC, Center for Epidemiologic Studies Depression Scale for Children; CG, control group; DASS, Depression Anxiety Stress Scales; GDS, Geriatric Depression Scale; DSM-IV, Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition; HAM-D, Hamilton Depression Scale; ITT, intention-to-treat; K10, Kessler Psychological Distress Scale; MC, minimal-contact therapy; OC, only completer; PSH, predominantly self-help; QIDS, Quick Inventory of Depressive Symptoms; RADS-2, Reynolds Adolescent Depression Scale; RCT, randomized control trial; SA, self-administered; SD, standard deviation; TA, therapist-administered; TAU, treatment as usual; WL, waiting list;

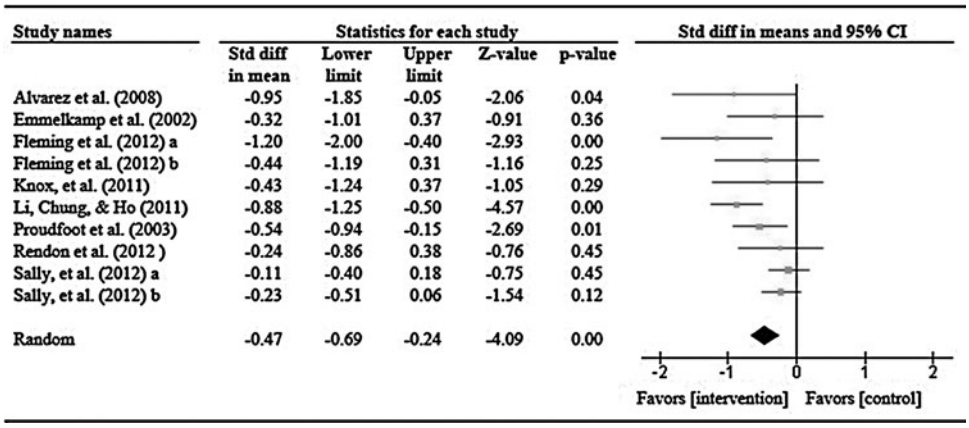

FIG. 2. Meta-analyses of studies examining the effect of game-based digital applications for depression at posttreatment. *Note*: For studies with two depression measures, both comparisons were included in the analysis.

seem to achieve the biggest effect size, followed by the entertainment ($d = -0.42$ [95% CI −1.23 to 0.39]) and psycho-education and training groups ($d = -0.41$ [95% CI −0.67 to −0.14]). However, the results should be interpreted with caution, as both the entertainment and exercising groups have only one trial for comparison. In terms of type of support, interventions with therapist involvement were shown to have a weaker effect size than those without therapist involvement ($d = -0.44$ vs. $d = -0.54$), despite there being no heterogeneity between the two subgroups. Studies aimed at adults were recorded as having the strongest effect size ($d = -0.54$ [95% CI −0.86 to −0.21]) in the subgroup analyses of target population, with no heterogeneity in the three trials included in the subgroup. Although the effect size was quite low for the elderly population ($d = -0.24$ [95% CI −0.86 to 0.39]), the estimate is probably not meaningful, as it was only based on one study. Lastly, the findings also demonstrate that studies that used a waiting list control condition yielded a greater effect ($d = -0.66$ [95% CI −1.14 to −0.18]) than those using treatment as usual ($d = -0.39$ [95% CI −0.68 to −0.11]) or active treatments ($d = -0.53$ [95% CI −1.10 to 0.03]) as controls.

In many cases, due to incomplete reporting, several domains of the included studies were rated as unclear when their methodological quality was assessed. For example, many of the studies used only a simple statement such as ''we randomly allocated'' or ''using a randomized design'' without indicting clearly the process of randomization, indicating that selection bias may have been a problem. One study had a high risk of bias in random sequence generation,[41] and two had a high risk of bias due to incomplete outcome data.[39,41] Figure 3 shows the methodological quality of the studies included in the meta-analysis.

Discussion

The aim of this study was to conduct a systematic review of the existing literature on game-based digital applications

TABLE 2. SUBGROUP ANALYSES AT POSTTREATMENT

Type of subgroup[a]	N_{comp}	d	*95% CI*	Z	I^2	*Subgroup differences*
Overall studies	10	−0.47	[−0.69, −0.24]	4.09****	47%	
One possible outlier removed[b]	9	−0.35	[−0.53, −0.16]	3.68****	18%	
Type of game						$\chi^2 = 1.19$, $p = 0.75$, $I^2 = 0\%$
Psycho-education and training	6	−0.41	[−0.67, −0.14]	3.00****	48%	
Virtual reality exposure therapy	2	−0.67	[−1.19, −0.14]	2.49****	49%	
Exercising	1	−0.24	[−0.86, 0.39]	0.74	—	
Entertainment	1	−0.42	[−1.23, 0.39]	1.02	—	
Type of support						$\chi^2 = 0.91$, $p = 0.34$, $I^2 = 0\%$
Nontherapist involved (SA + PSH)	3	−0.54	[−0.86, −0.21]	3.27****	0%	
Therapist involved (MC + TA)	7	−0.44	[−0.73, −0.15]	3.00***	60%	
Target population						$\chi^2 = 1.08$, $p = 0.58$, $I^2 = 0\%$
Adolescents ($M < 18$)	6	−0.47	[−0.80, −0.15]	2.85***	66%	
Adult ($18 < M < 65$)	3	−0.54	[−0.86, −0.21]	3.27****	0%	
Elderly ($M > 65$)	1	−0.24	[−0.86, 0.39]	0.74	—	
Control condition						$\chi^2 = 1.80$, $p = 0.41$, $I^2 = 0\%$
TAU	5	−0.39	[−0.68, −0.11]	2.70***	66%	
WL	3	−0.66	[−1.14, −0.18]	2.72***	9%	
Active treatment	2	−0.53	[−1.10, 0.03]	1.85***	6%	

[a]All subgroup analyses were conducted in mixed effects analyses. [b]Li, Chung, and Ho (2011). ***$p < 0.01$; ****$p < 0.001$.

CI, confidence interval; *M*, mean of age; N_{comp}, number of comparisons; MC, minimal-contact therapy; PSH, predominantly self-help; SA, self-administered; TA, therapist-administered; TAU, treatment as usual; WL, waiting list.

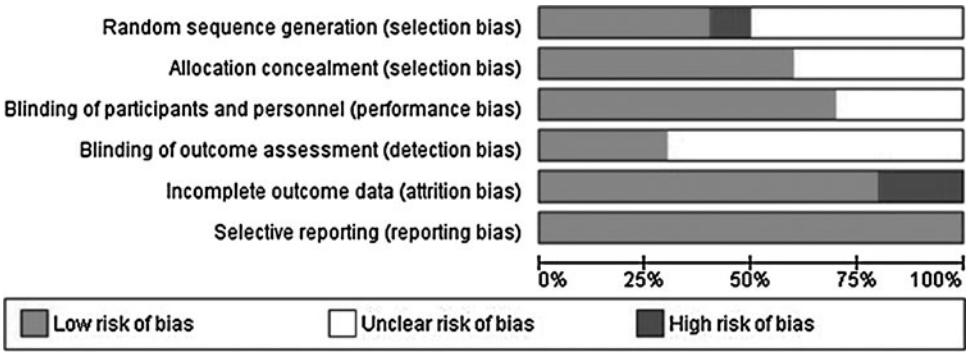

FIG. 3. Risk of bias graph.

for depression therapy, and to examine their effectiveness through a meta-analysis of available RCTs. In the 19 studies included in the review, four categories of game types were identified and described, of which psycho-education and training and virtual reality exposure therapy were identified as the most popular types of game application for depression. The psycho-education and training interventions were developed mainly from traditional CBT, which is a widely used and effective form of depression therapy with a particular focus on problem-solving skills.[43] With the interactive platform and game elements involved, psycho-education and training interventions may have further advantages in activating patients' motivation in the learning process and increasing the efficacy of teaching instrumental actions to deal with stressful situations.[15] In addition, the self-help features of this type of digital intervention reduce therapist time and effort during the education and training process.[44] According to Caillois' well-known taxonomy of games, virtual reality exposure therapy is a typical ''mimicry'' game type.[45] By simulating a real environment and contexts, this type of intervention can lead to a sense of illusion and the delimitation of space and time.[45] The unique experience of virtual reality exposure therapy was reported to be particularly effective for reducing depression caused by fear.[27,32] Compared with exposure *in vivo*, which requires going outside, virtual reality exposure therapy is more cost effective, and allows therapists to control the appropriate exposure stimuli for patients. The other two types of digital game therapies, exercising and entertainment, share the same purpose of relaxation. These games provoke sensations of pleasure,[45] further resulting in behavioral or cognitive distraction in individuals toward external stressors. As distraction is a significant way of managing negative emotions,[46] exercising and entertainment interventions have the potential to reduce depression by suspending reality.

The majority of the studies were aimed at young people aged younger than 30 years. This is in line with Ceranoglu's study,[47] which demonstrated that game-based applications have found their way into the mental healthcare for young people in clinical treatment. Given that digital games are popular among young people,[48,49] they have a high potential to become valuable tools for mental therapy for teenagers and young adults. Two studies were identified that presented interventions specifically for older adults older than 65 years. Increasing evidence shows that a high percentage of such adults actively play digital video games in daily life.[50,51] The health benefits of digital videogames for older adults have been supported by a recent review,[52] and Wilkinson et al.[20] further suggested that the elderly population is an important group that merits attention from therapeutic game developers. As only 2 out of the 19 studies focused on the elderly, there is clearly a research demand for future studies on the development and evaluation of digital game-based interventions tailored specifically to address elderly depression.

The findings of the meta-analysis suggest that game-based digital applications in general have a moderate effect size ($d=0.47$) as depression therapy. It is important to note that after the removal of a possible outlier,[39] the effect size of the other nine trials did not change significantly, but the heterogeneity decreased significantly to a low level. This finding indicates that the majority of the included studies had a moderate effect on depression. This is similar to findings in other recent meta-analyses of computerized interventions for depression, such as $d=0.41$ in Andersson and Cuijpers' study,[17] $d=0.51$ in Spek et al.'s study,[15] and $d=0.56$ in Richards and Richardson's study.[16] The results reveal that game-based applications do not differ much from other forms of computerized interventions in terms of effectiveness in depression treatment. However, in this study, the nontherapist supported interventions were reported to have a greater effect size than those with therapist support ($d=0.54$ vs. $d=0.44$), which is inconsistent with the results presented in these three previous reviews. This is probably attributable to the fundamental characteristic of game-based applications, and thus the effect may be superior if the game intervention was in a self-administered condition. In line with previous research,[16,17] our review also shows the influence of the control condition on the final effect size of the interventions, with higher effects when a waiting list was used as the control condition. The effects of the trials with a waiting list control were superior to those with active treatment controls (such as antidepressants). This may be because no treatment is worse than some treatment. Andersson and Cuijpers[17] compared the effects of computerized interventions based on CBT and those based on other psychological treatments, but found no significant difference. In the study, it is interesting to note that there was a big variance between two trials from Fleming et al.'s[12] and Sally et al.'s[35] studies ($d=-1.20$ vs. $d=-0.11$; see Fig. 2), which in fact applied the same intervention (SPARX) under the same depression measurement (CDRS-R). The variance might reflect that game-based psycho-education intervention has higher effect on treating depression among adolescents excluded from mainstream education (Fleming et al.'s trial), rather than typical young people (Sally et al.'s trial). Sample size is another possible explanation, with Sally et al.'s trial involving nearly six times as many participants than Fleming et al.'s trial (187 vs. 32 participants).

It is important to note that most of the studies were conducted with a small number of participants, and thus suffer from the risk of bias. As RCTs are considered to be standard for evidence-based study, more large-scale and high-quality RCT studies are needed in future to discover the true power of game-based digital interventions as depression therapy. There is also a significant lack of data on the long-term effects of such interventions. In our meta-analysis, only the RCT studies by Emmelkamp et al.[38] and Proudfoot et al.[37] reported some remaining benefits at the 6 month follow-up. As research on game-based digital interventions in depression therapy is still in its infancy, more studies with longer follow-up evaluations are particularly needed.

This review has several limitations. As game-based digital applications for depression therapy is a rather new research area, only a small number of studies met the inclusion criteria, which also led to relatively few RCTs being identified for the meta-analysis. In addition, as the review involved studies with a broad range of target groups, support types, and significance of depression symptoms, there was considerable heterogeneity across the studies. This heterogeneity can be seen as an advantage because it allowed us to investigate the differences among the studies, but it does mean that the results are of limited generalizability and should be interpreted with caution. Finally, we did not present data on attrition rates in the meta-analysis, which is a common concern for interventions that offer no support.[53]

Conclusion

This study presents a systematic review of existing research on game-based digital interventions for depression. Four categories of game interventions were identified that had an overall medium effect size, as supported by a meta-analysis of available RCTs. Subgroup analyses were conducted to compare the effectiveness of different types of games, levels of therapist support interventions, populations, and comparison conditions. Due to the limited number of studies in this new and important area of game-based digital interventions, further research is needed, in particular to confirm the effectiveness of larger scale and longer term RCTs, and the use of this treatment in an aging population.

Notes

a. PubMed (www.ncbi.nlm.nih.gov/pubmed/), PsycINFO (www.apa.org/psycinfo/), EMBASE (www.elsevier.com/online-tools/embase/), Cinahl (www.ebscohost.com/cinahl/), Web of Science (http://portal.isiknowledge.com/), Cochrane Central Register of Controlled Trials (CENTRAL) on the Cochrane Library (www.thecochranelibrary.com/), and ACM Digital Library (http://dl.acm.org/).
b. http://sparx.org.nz/
c. www.reachoutcentral.com.au/
d. http://us.battle.net/wow/
e. www.popcap.com/games/bejeweled2/online/

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Author Disclosure Statement

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References

1. Richards D. Prevalence and clinical course of depression: a review. Clinical Psychology Review 2011; 31:1117–1125.
2. World Health Organization. *Depression*. 2012.
3. Mann JJ. A current perspective of suicide and attempted suicide. Annals of Internal Medicine 2002; 136:302–311.
4. Cuijpers P. Bibliotherapy in unipolar depression: a meta-analysis. Journal of Behavior Therapy & Experimental Psychiatry 1997; 28:139–147.
5. Fernández-Aranda F, Jiménez-Murcia S, Santamaría JJ, et al. Video games as a complementary therapy tool in mental disorders: PlayMancer, a European multicentre study. Journal of Mental Health 2012; 21:364–374.
6. Coyle D, Matthews M, Sharry J, et al. Personal Investigator: a therapeutic 3D game for adolescent psychotherapy. International Journal of Interactive Technology & Smart Education 2005; 2:73–88.
7. Koepp MJ, Gunn RN, Lawrence AD, et al. Evidence for striatal dopamine release during a video game. Nature 1998; 393:266–268.
8. Craig AB, Asher DE, Oros N, et al. Social contracts and human–computer interaction with simulated adapting agents. Adaptive Behavior 2013; 21:371–387.
9. Amir S, Brown ZW, Amit Z. The role of endorphins in stress: evidence and speculations. Neuroscience & Biobehavioral Reviews 1980; 4:77–86.
10. Salamone JD. Dopamine, effort, and decision making: theoretical comment on Bardgett et al. (2009). Behavioral Neuroscience 2009; 123:463.
11. Gerardi M, Rothbaum BO, Ressler K, et al. Virtual reality exposure therapy using a virtual Iraq: case report. Journal of Traumatic Stress 2008; 21:209–213.
12. Fleming T, Dixon R, Frampton C, et al. A pragmatic randomized controlled trial of computerized CBT (SPARX) for symptoms of depression among adolescents excluded from mainstream education. Behavioural & Cognitive Psychotherapy 2012; 40:529–541.
13. Longman H, O'Connor E, Obst P. The effect of social support derived from World of Warcraft on negative psychological symptoms. CyberPsychology & Behavior 2009; 12:563–566.
14. Richardson T, Stallard P, Velleman S. Computerised cognitive behavioural therapy for the prevention and treatment of depression and anxiety in children and adolescents: a systematic review. Clinical Child & Family Psychology Review 2010; 13:275–290.
15. Spek V, Cuijpers P, Nyklícek I, et al. Internet-based cognitive behaviour therapy for symptoms of depression and anxiety: a meta-analysis. Psychological Medicine 2007; 37:319–328.
16. Richards D, Richardson T. Computer-based psychological treatments for depression: a systematic review and meta-analysis. Clinical Psychology Review 2012; 32:329–342.
17. Andersson G, Cuijpers P. Internet-based and other computerized psychological treatments for adult depression: a meta-analysis. Cognitive Behaviour Therapy 2009; 38: 196–205.

18. Rahmani E, Boren SA. Videogames and health improvement: a literature review of randomized controlled trials. Games for Health Journal 2012; 1:331–341.
19. Baranowski T, Buday R, Thompson D, et al. Playing for real. Video games and stories for health-related behavior change. American Journal of Preventive Medicine 2008; 34:74–82.
20. Wilkinson N, Ang RP, Goh DH. Online video game therapy for mental health concerns: a review. International Journal of Social Psychiatry 2008; 54:370–382.
21. The Cochrane Collaboration. Review Manager (RevMan). 5.2 ed. Copenhagen: Nordic Cochrane Centre, 2012.
22. Cohen J. (1988) *Statistical power analysis for the behavioral sciences*. Hillsdale, NJ: Lawrence Erlbaum.
23. Lipsey MW, Wilson DB. Practical meta-analysis. Applied Social Research Methods Series 2001; 49.
24. Higgins JPT, Thompson SG, Deeks JJ, et al. Measuring inconsistency in meta-analyses. British Medical Journal 2003; 327:557–560.
25. Higgins JPT, Green S. (2009) *Cochrane handbook for systematic reviews of interventions*. Chichester, United Kingdom: John Wiley.
26. Gega L, Marks I, Mataix-Cols D. Computer-aided CBT self-help for anxiety and depressive disorders: experience of a London clinic and future directions. Journal of Clinical Psychology 2004; 60:147–157.
27. Rothbaum B, Hodges L, Alarcon R, et al. Virtual reality exposure therapy for PTSD Vietnam veterans: a case study. Journal of Traumatic Stress 1999; 12:263–271.
28. Rosenberg D, Depp CA, Vahia IV, et al. Exergames for subsyndromal depression in older adults: a pilot study of a novel intervention. American Journal of Geriatric Psychiatry 2010; 18:221–226.
29. Shandley K, Austin D, Klein B, et al. An evaluation of ''Reach Out Central'': an online gaming program for supporting the mental health of young people. Health Education Research 2010; 25:563–574.
30. Walshe DG, Lewis EJ, Kim SI, et al. Exploring the use of computer games and virtual reality in exposure therapy for fear of driving following a motor vehicle accident. CyberPsychology & Behavior 2003; 6:329–334.
31. Russoniello CV, O'Brien K, Parks JM. EEG, HRV and psychological correlates while playing Bejeweled II: a randomized controlled study. Studies in Health Technology & Informatics 2009; 144:189–192.
32. Gamito P, Oliveira J, Rosa P, et al. PTSD elderly war veterans: a clinical controlled pilot study. Cyberpsychology, Behavior, and Social Networking 2010; 13:43–48.
33. Ferguson CJ, Rueda SM. The Hitman Study: violent video game exposure effects on aggressive behavior, hostile feelings, and depression. European Psychologist 2010; 15:99–108.
34. Valadez JJ, Ferguson CJ. Just a game after all: violent video game exposure and time spent playing effects on hostile feelings, depression, and visuospatial cognition. Computers in Human Behavior 2012; 28:608–616.
35. Sally NM, Karolina S, Matthew S, et al. The effectiveness of SPARX, a computerised self-help intervention for adolescents seeking help for depression: randomised controlled non-inferiority trial. British Medical Journal 2012; 344.
36. Alvarez LMA, Sotres JFC, León SO, et al. Computer program in the treatment for major depression and cognitive impairment in university students. Computers in Human Behavior 2008; 24:816–826.
37. Proudfoot J, Goldberg D, Mann A, et al. Computerized, interactive, multimedia cognitive-behavioural program for anxiety and depression in general practice. Psychological Medicine 2003; 33:217–227.
38. Emmelkamp PM, Krijn M, Hulsbosch AM, et al. Virtual reality treatment versus exposure in vivo: a comparative evaluation in acrophobia. Behaviour Research & Therapy 2002; 40:509–516.
39. Li WH, Chung JO, Ho EK. The effectiveness of therapeutic play, using virtual reality computer games, in promoting the psychological well-being of children hospitalised with cancer. Journal of Clinical Nursing 2011; 20:2135–2143.
40. Rendon AA, Lohman EB, Thorpe D, et al. The effect of virtual reality gaming on dynamic balance in older adults. Age Ageing 2012; 41:549–552.
41. Knox M, Lentini J, Cummings TS, et al. Game-based biofeedback for paediatric anxiety and depression. Mental Health in Family Medicine 2011; 8:195–203.
42. Glasgow RE, Rosen GM. Behavioral bibliotherapy: a review of self-help behavior therapy manuals. Psychological Bulletin 1978; 85:1–23.
43. Hollon SD, Stewart MO, Strunk D. Enduring effects for cognitive behavior therapy in the treatment of depression and anxiety. Annual Review of Psychology 2006; 57:285–315.
44. Wright JH, Wright AS, Albano AM, et al. Computer-assisted cognitive therapy for depression: maintaining efficacy while reducing therapist time. American Journal of Psychiatry 2005; 162:1158–1164.
45. Caillois R. (2006) The definition of play and the classification of games. In Salen K, Zimmerman E, eds. *The game design reader: a rules of play anthology* Cambridge, MA: MIT Press; pp. 122–155.
46. Skinner EA, Zimmer-Gembeck MJ. The development of coping. Annual Review of Psychology 2007; 58:119–144.
47. Ceranoglu TA. Video games in psychotherapy. Review of General Psychology 2010; 14:141–146.
48. Olson CK, Kutner LA, Warner DE, et al. Factors correlated with violent video game use by adolescent boys and girls. Journal of Adolescent Health 2007; 41:77–83.
49. Lenhart A, Kahne J, Middaugh E, et al. Teens, video games, and civics. Pew Internet and American Life Project, 2008.
50. Lenhart A, Jones S, Macgill AR. Adults and video games. Pew Internet and American Life Project, 2008.
51. McGonigal J. (2011) *Reality is broken: why games make us better and how they can change the world*. New York: Penguin Press.
52. Hall AK, Chavarria E, Maneeratana V, et al. Health benefits of digital videogames for older adults: a systematic review of the literature. Games for Health Journal 2012; 1:402–410.
53. Eysenbach G. The law of attrition. Journal of Medical Internet Research 2005; 7:e11.

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