

Digital interventions for depression and anxiety in older adults: a systematic review of randomised controlled trials

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One in five older adults experience symptoms of depression and anxiety. Digital mental health interventions are promising in their ability to provide researchers, mental health professionals, clinicians, and patients with personalised tools for assessing their behaviour and seeking consultation, treatment, and peer support. This systematic review looks at existing randomised controlled trial studies on digital mental health interventions for older adults. Four factors have been found that contributed to the success of digital mental health interventions: (1) ease of use; (2) opportunities for social interactions; (3) having human support; and (4) having the digital mental health interventions tailored to the participants' needs. The findings also resulted in methodological considerations for future randomised controlled trials on digital mental health interventions: (1) having a healthy control group and an intervention group with clinical diagnoses of mental illness; (2) collecting data on the support given throughout the duration of the interventions; (3) obtaining qualitative and quantitative data to measure the success of the interventions; and (4) conducting follow-up interviews and surveys up to 1 year post-intervention to determine the long-term outcomes. The factors that were identified in this systematic review can provide future digital mental health interventions researchers, health professionals, clinicians, and patients with the tools to design, develop, and use successful interventions for older users.

Introduction

More than 20% of older adults live with one or more psychological disorder, and this number will rise as the proportion of older adults in the world's population increases.¹ Older adults are particularly vulnerable to mental illnesses such as depression and anxiety due to the increasing frequency of negative life events (eg, death of a spouse, diagnosis of a chronic health condition, and moving into a nursing home).^{2,3} With the rapid technological boom transpiring in all parts of the world, the popularity and availability of mobile digital technologies to treat psychological disorders has grown in interest in the past decade.

Technology has increasingly been seen as a solution not only for younger people but also older adults' mental health needs.^{4,5} For example, technology has been highlighted during the COVID-19 pandemic as older people and family caregivers have struggled to cope with physical distancing and restrictions on face-to-face contact.⁶ The role of recent research from the past decade has shown increased usage of technology adoption among older people to manage social isolation and to access vital health and community services.^{7,8,9} There is evidence that suggest that digital mental health interventions (eg, computer-assisted therapy, smartphone apps, and wearable technologies) are effective for the treatment, diagnosis, and alleviation of depression and anxiety symptoms among the younger population.¹⁰⁻¹⁴ Previous systematic reviews have determined that digitally-delivered cognitive behavioural therapy (CBT) can be considered as a low-intensity psychological intervention that can aid older adults with mild-to-moderate mental health problems.^{15,16} Nevertheless, research and innovation within the digital mental health intervention field is still scarce for the older adult population in comparison to the younger population.¹⁷

This systematic review aims to investigate the evidence supporting the use of digital mental health interventions for treating and preventing symptoms of depression and anxiety in adults older than 50 years. This systematic review aims to gain insight into the various designs and aspects of digital mental health interventions for older adults, and to synthesise methodological findings from randomised controlled trials with older adult participants to extract important information to conduct future randomised controlled trials for this population.

Methods

Search strategy

This systematic review has been registered with PROSPERO (registration number: CRD42020192532). The protocol for this systematic review has been described and published in December, 2020.¹⁸ We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA; appendix p 2).

We searched academic databases Scopus, PsycINFO, AgeLine (EBSCO), and MEDLINE (PubMed) in Nov 1, 2021, for publications published from Jan 1, 2010, to Nov 30, 2021. Digital mental health interventions for treating depression and anxiety in older adults have existed before 2010.^{19,20} The reason behind this cutoff is that this systematic review is focused on a modern and fast-paced topic; studies using decades-old technologies are unlikely to maintain relevance with the current production rate of new technologies. The database searches were conducted using a combination of search terms (appendix p 4) relating to mental health problems (ie, depression and anxiety), the means of intervention delivery (ie, via the internet, smartphones, and tablets), population age (older adults), and the study design (randomised controlled trial). Reference lists of included articles were also screened for potentially relevant studies.

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See Online for appendix

Screening and selection process

All search results were downloaded into Clarivate EndNote, a reference management software, in which duplicates were identified and removed. First, two reviewers (IR and LK) independently reviewed all article titles and abstracts based on the inclusion and exclusion criteria. Then, full texts were examined by the same reviewers. Any disagreements between the two reviewers in the title and abstract stage or the full-text stage were resolved through consensus-based discussion with a third reviewer (TDC).

Eligibility criteria

This systematic review includes randomised controlled trials of digital mental health interventions for adults older than 50 years for their depressive or anxiety symptoms. The reason for this younger age cut-off for this population is because there are few studies that include the older population when looking at digital or technology-based health interventions. By lowering the age eligibility criteria, we hope to gather as much evidence as possible for the older population. We have included interventions using smartphones, enterprise digital assistants, personal digital assistants, portable media players, video game consoles (including virtual or augmented reality headsets), computers, laptops, tablets, and e-readers. Studies were included if the sample population completed pre-intervention and post-intervention anxiety or depression questionnaires. Only randomised controlled trial studies were included to minimise bias and confounding factors and provide statistical reliability.²¹ Peer-reviewed papers were not excluded based on language or country of origin. The exclusion criteria included non-peer-reviewed articles, conference proceedings, case reports, editorials, opinion papers, letters, and studies that focus on children or young adults. Additionally, we included studies in which depression and anxiety were measured as secondary outcomes to ensure that all evidence of digital mental health interventions for depression and anxiety for this population were included.

Risk of bias assessment

The risk of bias of each study was assessed using the revised Cochrane risk-of-bias tool for randomised trials (RoB 2, version 2).²⁰ Risk of bias was evaluated for each bias domain listed in the RoB 2 assessment tool, which covers bias arising from the randomisation process, deviations from intended interventions, due to missing outcome data, in the measurement of the outcome, and in the selection of the reported result.

Narrative synthesis

A systematic narrative framework was used to synthesise the data.²² Due to the high degree of heterogeneity in outcomes and measurement in the studies, a meta-analytic approach was not appropriate; therefore,

the results of included studies were narratively synthesised rather than meta-analysed.

The results were organised by types of digital mental health interventions that were commonly found in all the eligible articles (eg, digitally-delivered cognitive behavioural therapy [iCBT], online courses, and physical activity programmes delivered digitally, and computer programs). Within each type of digital mental health intervention, characteristics of the interventions and their effectiveness in alleviating depressive and anxiety symptoms were discussed.

Results

A total of 1202 article titles and abstracts were reviewed, and 58 full-text articles were reviewed for inclusion. All full-text studies were written in English. Among these full-text articles, 17 studies were included in the systematic review for data extraction (figure 1).

All 17 studies that were included are randomised controlled studies.^{23–39} Out of all the studies, seven studies were conducted in the USA,^{23–29} three in Sweden,^{30–32} two in Australia,^{33,34} and the remainder took place in Germany,³⁵ the Netherlands,³⁶ China,³⁷ Brazil,³⁸ and Russia.³⁹ Two of the studies were pilot studies.^{37,38} 12 studies had completed at least one follow-up study within 12 months after the completion of the initial study.^{23,26–28,30–32,35–37,39}

Three of the studies used iCBT,^{23,25,35} whereas others investigated online courses and computer lessons,^{33,34} digitally-delivered exercise courses to promote physical activity (exer-gaming),^{26,28,29,36,38,39} neuroplasticity-based computerised cognitive remediation,²¹ online speed of processing training,^{27,28} and technology-based rehabilitation programme (known as telerehabilitation).^{30–32} A few of the studies considered mental health measures as secondary outcomes, with the primary outcome being improvement of physical activity,^{26,28,29,36,38,39} sensory impairment rehabilitation,^{30–32} or cognitive functional performance.^{24,27,37} Study characteristics are summarised in table 1 and table 2.

12 studies determined that the digital mental health intervention used for that study was beneficial in their primary psychological outcome variables.^{23–25,28–33,37–39} Out of the 12 studies, one study investigated symptoms of anxiety,³³ seven studies investigated symptoms of depression,^{23–25,28,29,37,38} and four studies investigated symptoms of both anxiety and depression.^{30–32,39} The effectiveness of each study was not measured solely by the difference between intervention and control groups. Due to the novelty of the subject and the scarcity of randomised controlled trial research that has been conducted, the measurement of effectiveness varied by the specific depression and anxiety scales used and by each study's research questions or objectives (table 2).

iCBT

Three studies evaluated the use of iCBT among older adults. One study looked at the use of iCBT to treat older

adults with major depressive disorder and used a control group that underwent in-person CBT.²³ Egede and colleagues²³ found that the technology-based method resulted in outcomes similar to in-person delivery. Another study²⁵ used a treatment-as-usual control group and found that 84.6% of the intervention group participants no longer met the criteria for major depressive disorder versus only 50% in the control group. The third study focused on online writing assignments in their iCBT program for veterans with post-traumatic stress disorder.³⁵ The study compared the intervention group against a waiting list control group and found no significant improvement of Brief Symptom Inventory-18 (BSI-18) scores after the follow-up. However, the participants stated that the visual anonymity provided by iCBT allowed them to talk about their mental health concerns freely.³⁵ These results have determined that iCBT treatments can provide the same information and teach the same skills as traditional face-to-face CBT for participants without mental health multimorbidity (table 2).^{23,25}

Online courses and computer lessons

Two studies looked at or created online courses for older adults.^{33,34} One study provided a course that focused on managing stress and anxiety, and used an active control group (ie, a group who received the course in a self-guided format).³³ Their analysis indicated greater proportions of reliable improvement and recovery on the Generalised Anxiety Disorder Assessment (GAD-7) and the Patient Health Questionnaire-9 (PHQ-9) in the treatment group than in the control group.³³ Another study administered a customised computer platform with a simplified touch-screen interface and accompanying broadband infrastructures to older adults with sufficient cognitive ability to engage in computer training.³⁴ They found that participants in the intervention group (those who received training to use social media) experienced slightly better mental health than the care-as-usual control participants.³⁴ The intervention performed in this study yielded positive changes in depression and anxiety scales. However, the authors determined that the changes in depression and anxiety scales were contributed from other variables (such as the participants' competence with technology and previous social networking activity), and, therefore, hard to attribute to the training (table 2).³⁴

Physical activity interventions

Six studies looked at using physical activity interventions to alleviate depressive and anxiety symptoms. Two studies^{26,38} used video game consoles as means to deliver their physical activity interventions. Two physical activity interventions were delivered via robot assistance,^{29,39} and another two were digitally-delivered.^{28,36} The control groups included active control groups and waiting list control groups. Five of the six physical activity digital mental health intervention studies found that

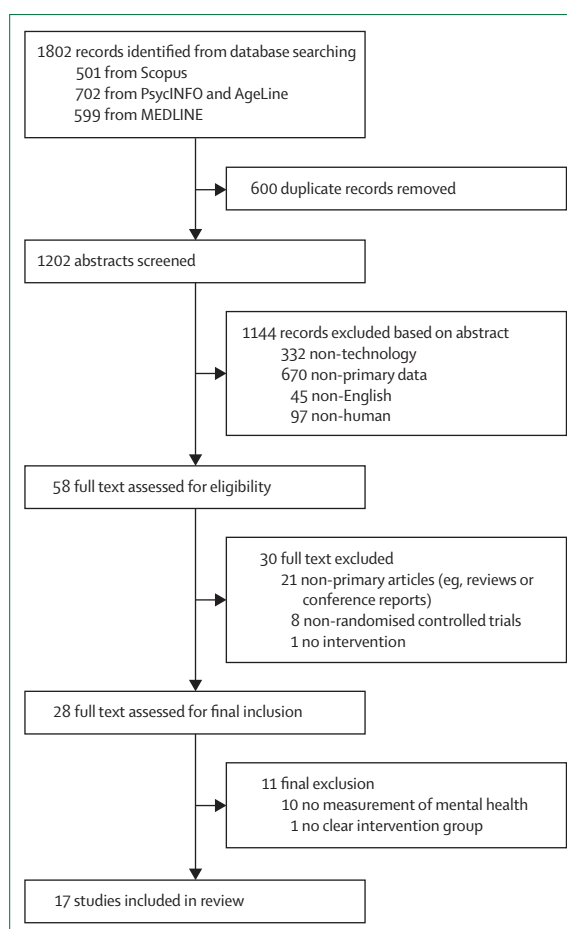


Figure 1: PRISMA flowchart

intervention groups showed improvement in depressive symptoms and only slight differences were found between treatment and active control groups.^{28,29,36,38,39} These results indicate that physical activity can alleviate depressive and anxiety symptoms; however, delivering these programs via gaming consoles, robots, and computers does not yield better psychological outcomes than face-to-face or in-person physical activities.^{29,38,39} One unsuccessful digital mental health intervention used virtual reality hardware to deliver a physical activity intervention to their participants.²⁶ They found that their participants expressed safety concerns due to the novelty of the device and no supervision during the intervention (table 2).

Online cognitive training

Three studies looked at alleviating depressive and anxiety symptoms as outcomes of digitally-delivered cognitive training activities.^{24,27,37} Two studies used an online speed of processing training program on two different populations of older adults.^{27,37} Lee and colleagues³⁷ examined the effects of online speed of processing training on patients with early Alzheimer's disease.³⁷

	Mean age, years		Participants		Female, %		Male, %		Inclusion criteria
	Control	Treatment	Control	Treatment	Control	Treatment	Control	Treatment	
Dear et al (2015) ³³	65.39	65.51	35	37	67%	54%	33%	46%	Aged over 60 years and assessed by a general practitioner or specialist to rule out any physical cause for anxiety
Egede et al (2015) ³³	63.5	64.2	120	121	3%	2%	97%	98%	Aged over 60 years, male and female veterans who meet DSM-IV criteria for major depressive disorder
Ferraz et al (2018) ³⁸	..	..	22	25	50%	27%	50%	73%	Aged over 60 years, diagnosed with Parkinson's disease, and using medication for Parkinson's disease; modified Hoehn and Yahr stages 2, 2.5, or 3
Knaevelsrud et al (2017) ³⁵	70.91	71.91	47	47	75%	55%	26%	45%	Experienced a traumatic event as a child or adolescent during World War 2 that met the criterion A for post-traumatic stress disorder as specified in DSM-IV; must report at least a subsyndromal level of post-traumatic stress disorder symptoms
Kotov et al (2020) ³⁹	65.02	64.8	50	50	40%	38%	60%	62%	Individuals with ischaemic stroke of hemispheric location that has been confirmed by computer tomography
Lee et al (2013) ³⁷	78	78	7	6	86%	67%	14%	33%	Aged over 60 years and experiencing early dementia (score of 1 on screening with the Chinese Dementia Rating Scale); participants must be mentally stable, capable of following instructions, and have an attention span of 30–45 min
Linder et al (2015) ³⁹	55.5	59.4	48	51	31%	39%	69%	61%	Individual who experienced unilateral ischaemic or haemorrhagic stroke within the previous 6 months with some voluntary movement as indicated by a score of 11–55 on the Fugl-Meyer assessment; must have limited access to an organised stroke rehabilitation programme; must have preserved cognitive function
Malmberg et al (2017) ³⁹	71.1	69.6	20	21	53%*	46%*	47%*	54%*	Individuals who had conductive or sensorineural binaural hearing loss of 20–60 decibel hearing level; must have completed a hearing aid fitting 3 months before the study began; must have a Hearing Handicap Inventory score for the elderly ≥ 20 , indicative of some residual hearing problems
Morimoto et al (2020) ³⁴	74.7	72.2	18	18	64%*	64%*	33%*	33%*	Older adults aged 60–89 years with major depression who failed to achieve remission (Montgomery-Asberg depression rating scale >15) after treatment with therapeutic dosages of an SSRI or SNRI antidepressant for at least 8 weeks
Morton et al (2018) ³⁴	80.71*	80.71*	53	44	65%*	65%*	36%*	36%*	Must have the space and infrastructure for internet use (ie, a phone connection and a table that could accommodate the computer package); sufficient cognitive ability to engage with the training
O'Moore et al (2018) ³⁵	63.16	59.68	44	25	86%	68%	14%	32%	Older than 50 years and had a self-reported diagnosis of symptomatic knee based on radiographic criteria and knee pain on most days; must have major depressive disorder and have access to a computer with internet
Rendon et al (2012) ³⁸	85.7	83.3	20	20	100%	100%	0	0	Community-dwelling adults aged between 60 and 95 years
Smith et al (2019) ³⁷	80.6*	80.6*	173	178	73%†	73%†	27%†	27%†	Older than 55 years and living in a supported living facility; must have sufficient vision and dexterity to use a monitor, keyboard, and mouse
Sparrow et al (2011) ³⁸	70.3	71.7	52	51	..	..	..	..	Community-dwelling men in the Boston area of USA
Thorén et al (2011) ³¹	63.5*	63.5*	29	30	49%†	49%†	51%†	51%†	Have a hearing impairment with subjective, significant communication difficulties; have been using hearing aids for at least 1 year
Thorén et al (2014) ³⁷	69.4	69.2	38	38	42%	42%	58%	58%	Have a hearing impairment with subjective, significant communication difficulties; have been using hearing aids for at least 1 year
Vloothuis et al (2019) ³⁸	Patient: 60.53; caregiver: 53.91	Patient: 59.26; caregiver: 54	Patient: 32; caregiver: 9	Patient: 34; caregiver: 13	Patient: 34%; caregiver: 23%	Patient: 41%; caregiver: 21%	Patient: 66%; caregiver: 77%	Patient: 59%; caregiver: 79%	Have a score of <11 on the domain depression on the Hospital Anxiety and Depression Scale

SNRI=Serotonin-norepinephrine reuptake inhibitors. SSRI= Selective serotonin reuptake inhibitor. *Based on both older and younger groups combined. †Overall.

Table 1: Participant demographics for the 17 included studies

Psychological outcome measured	Depression or anxiety scale used	Intervention	Control	Presence of support	Mode of delivery	Duration of the intervention	Follow-up	Psychological outcomes	Percentage participant completion rate (treatment; control), %
Dear et al (2015) ³³	Anxiety PHQ-9, GAD-7	Online course—the Managing Stress and Anxiety course allows participants to learn and practise psychological skills. The course is comprised of the following components: five online lessons, five lesson summaries and homework assignments, regular automatic reminder and notification emails, secure email-type messaging with the therapist, and several detailed case stories, which participants can follow throughout the course	Performed the course in self-guided format without the contact of therapists	Weekly contact with therapist	Digitally-delivered	8 weeks	3 and 12 months	Reliable improvement and reliable recovery on the GAD-7 and the PHQ-9 in the treatment group compared with the waiting list control group. At 3-month and 12-month follow-up, over 75% of the treatment group reported reliable improvement on the GAD-7 and the PHQ-9	87%; 86%
Egede et al (2015) ³²	Depression GDS, BDS	iCBT—behavioural activation for depression via video conferencing technology with a therapist. Behavioural activation is based on the idea that what a patient does plays a part in how they feel. Behavioural activation is a CBT skill	Same-room treatment	CBT performed with a therapist	Video conferencing technology	8 weeks	4-week, 8-week, 3-month, 12-month	Teleconference method is feasible and produces outcomes that are no worse than in-person delivery 12 months after treatment. Participants in both groups tolerated and clinically benefited from behavioural activation for depression	83%; 86%
Ferraz et al (2018) ³⁸	Depression GDS	Physical activity program—Xbox 360 video game with Kinect. These games use full body motion to allow the player to engage in various mini-games, all of which feature jump-in, jump-out multiplayer play	Physical exercises without the use of a gaming console	Under the supervision of a physiotherapist	Gaming console	8 weeks	..	All groups showed significant improvement in depressive symptoms. No significant differences were found between treatment and control groups	91%; 88%
Knaevelsrud et al (2017) ³⁵	Depression and anxiety BSI-18	iCBT—the intervention comprises structured writing assignments that are facilitated through a secured web-based platform. Study participants write and upload their texts within a secure web portal and study therapists provide feedback subsequently within 24 h. Therapy delivery instructions are based on a disorder-specific CBT manual that was developed for the purpose of the study	Waiting list control group	Therapist feedback	Digitally-delivered	6 weeks	3, 6, and 12-month	No statistically significant improvement.	87.2%; 95.6%

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Psychological outcome measured	Depression or anxiety scale used	Intervention	Control	Presence of support	Mode of delivery	Duration of the intervention	Follow-up	Psychological outcomes	Percentage participant completion rate (treatment; control), %	
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Kotov et al (2020) ³⁹	Depression and anxiety	BDS, BAS	Physical activity program—daily robot mechanotherapy using a MOTomed, a motorised bedside trainer, which performs passive and active training mode for legs with reversal of the forward and backward directions every 5 min	Standard face-to-face therapy	First sessions were run by a doctor in-person and the patients worked independently afterwards	Robot-assisted and computer-delivered	14 days	5-day, 21-day, 3-month, and 6-month	There was a decrease in the mean depression and anxiety level in the intervention group. Follow-ups showed a continuous decrease in depression and anxiety compared to the control group	..
Lee et al (2013) ³⁷	Depression	GDS	Cognitive training—training with a computer-assisted errorless learning program (CELP). The training programs are implemented on an individual basis, approximately twice a week with a total of 12 30-min training sessions, which are completed in around 6 weeks. The CELP is run using a touch-screen notebook computer with a touch-pen input device. Therapists provide guidance if the subjects have difficulty using the computer input device or have literacy problems	Waiting list control group	Guidance by a therapist	Digitally-delivered	6 weeks	3-month	GDS showed a statistically significant difference improvement in the intervention group	100%; 100%
Linder et al (2015) ³⁹	Depression	CES-D	Physical activity programme that is a robot-assisted intervention coupled with a home exercise program, and a home exercise program done alone. A physical or occupational therapist completes a home visit to educate participants and their caregivers if indicated in their assigned intervention. To facilitate compliance, participants sign a behaviour contract and are instructed to complete a daily exercise log. Each participant is asked to complete 3 h of study-related interventions 5 days per week for 8 weeks total within a 12-week period, thus allowing for life events such as illness or vacation that could have prevented study completion	Physical activity program without technology	A physical or occupational therapist completed a home visit to educate participants and their caregivers	Robot-assisted and computer-delivered	8 weeks	..	Both treatment and control group showed improvements in depression scores, but treatment showed more improvements. 95% CIs were observed indicating a significant change for both treatments of control groups. Treatment group showed slightly more improvements than control group (no statistically significant changes between groups)	88.2%; 83.3%

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Psychological outcome measured	Depression or anxiety scale used	Intervention	Control	Presence of support	Mode of delivery	Duration of the intervention	Follow-up	Psychological outcomes	Percentage participant completion rate (treatment; control), %
(Continued from previous page)									
Malmberg et al (2017) ³⁸	HADS	Aural rehabilitation—the internet-based intervention programme is based on four elements: reading, home training, interaction with an audiologist, and interaction with peers in an internet-based discussion forum. The reading element is divided into five modules, one module for each of the 5 weeks. The participants are instructed to read specific content each week based on the various chapters of the book. The weekly home assignments are accessible to facilitate an understanding of the contents of the book and the compendium. The weekly home assignments are handed in via the internet by the participants (weeks 1–5), and direct responses are provided online by an audiologist. Weeks 1–4 end with quiz questions on the content of the past weeks' readings	Reading activity with no assignment and no supervision	Direct responses were provided online by an audiologist	Digitally-delivered	4 weeks	6 months	Intervention group and the control group improved their total scores over time (ie, there was no significant difference between the groups). No significant changes in follow up	89%; 81%
Morimoto et al (2020) ²⁴	MADRS	Cognitive training—neuroplasticity-based computerised cognitive remediation for 4 weeks. Three so-called bottom-up training exercises are used: one low-level auditory tone sweep, one phonemic discrimination task, and one low-level visual discrimination training exercise. Two so-called top-down training exercises are used: catch the ball (individually titrated training in visual attention, inhibition of pre-potent responses, working memory, cognitive flexibility, and dual task performance) and semantic strategy (rearranging multiple, increasingly complex word lists into categories with individually titrated decreases in allotted processing time)	Same audio-visual presentation, length, contact with study staff, engagement of participants' attention and learning, but not to target cognitive control functions specifically	Access to the supervising psychologist and research assistants for questions. After the initial computerised programme was set up, participants worked on their own without intervention	Digitally-delivered	4 weeks	..	Intervention improved both depressive symptoms and cognitive control deficits more than an active control condition	83%; 83%

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Morton et al (2018) ²⁴	CES-D, GAI-5F Depression and anxiety	Social networking—the training group receives a customised computer platform with a simplified touch-screen interface (known as EasyPC) and any necessary broadband infrastructure (ie, modem and cables) for social networking activities. Three qualified carers administer the training. The training schedule is manualised, and participants are also provided with a user manual to support their training, including homework tasks to consolidate learning in between sessions. Training is stepped down across 3 months	Care-as-usual	Administration of computer training by technologists	Digitally-delivered	3 months	..	Trainees experienced slightly statistically significantly better mental health than control participants; however, these effects were independent of time of measurement and therefore hard to attribute to the training	83%; 72%
O'Moore et al (2018) ²⁵	PHQ-9, K-10, SF-12 MCS Depression	iCBT—the iCBT Sadness internet-delivered programme consists of 6 online lessons representing best practice CBT, regular homework assignments, and access to supplementary resources. Each lesson comprises a cartoon narrative in which a character gains mastery over major depressive disorder symptoms by learning and implementing CBT skills. Patient queries throughout the programme are primarily addressed by email contact	Treatment as usual	Email contact with researchers and therapists	Digitally-delivered	10 weeks	1 week, 3 months	The proportion of recovered patients in the iCBT group was significantly higher than in the control group	..
Rendon et al (2012) ²⁶	GDS Depression	Physical activity program—the program consists of an 8-min cardiovascular warm up on a stationary bicycle and an 8-min cool down. Each participant uses three different balance games from the Wii Fit software package. Participants are instructed to follow the onscreen visual displays	Care-as-usual	The intervention group was under supervision of a physical therapist and was pre-post tested by two additional physical therapists	Virtual Reality Gaming	6 weeks	..	Both groups scored in the normal classification of depression scoring by the GDS	80%; 90%
Smith et al (2019) ²⁷	PHQ-9 Depression	Cognitive training—the participants are tasked to complete a traditional puzzle format on the monitor. Unlike a paper and pencil puzzle, the participants use the mouse and keyboard to enter their answers to the row and column clues	Computerised crossword puzzles	Research assistants available on site	Digitally-delivered	6 weeks	5–8 weeks, 6-month, 12-month	Intervention significantly increased, rather than decreased, the burden of depressive symptoms among participants residing in assisted living	82%; 75%

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Sparrow et al (2011) ²⁸	BDI-II	Physical activity program—this intervention is a telephone-linked computer-based long-term interactive fitness trainer (TLC-LIFT) system and it provides real-time guidance, meaning that the system provides instructions on what exercises to do and how to do them, guiding the participants through the exercises as they perform them in their homes. It is fully automated and administered by telephone in the participant's own home	Received general health education	Researchers conducted periodic home visits in the first 3 months. The rest was fully automated	Telephone-linked computer-delivered	6 months	3, 6, and 12-month	Lower levels of depressive symptoms were observed in the intervention group than in the control group	81%; 92%
Thorén et al (2011) ³¹	HADS	Rehabilitation programme—online education programme and forum for adult hearing aid users. The programme includes professional guidance by an audiologist	Referred to an online discussion forum without any audiologist contact	Contact with audiologist	Digitally-delivered	5 weeks	6-month	The results showed that the participants in the intervention group showed significantly reduced symptoms of depression and anxiety immediately and at 6 months after the intervention	83%; 80%
Thorén et al (2014) ³²	HADS	Rehabilitation digitally-delivered programme—a five-week online intervention programme that includes weekly assessments and interaction with an audiologist and with peers. The intervention programme includes self-studies, training, and professional coaching in hearing physiology, hearing aids, and communication strategies	Asked to read materials related to the history of hearing aids	Weekly assessments and interaction with an audiologist and with peers	Digitally-delivered	5 weeks	3-month	Significant improvements in the domain of psychosocial wellbeing in the intervention group compared with the control group were found at the follow-up	100%; 100%

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(Continued from previous page)									
Vloothuis et al (2019) ³⁸	HADS	Physical activity programme—an 8-week caregiver-mediated exercise programme with e-health support after stroke in addition to usual care. Exercises are combined into a patient-tailored, progressive training regimen related to the patient goals. Patient-caregiver couples were encouraged to contact the coordinating therapist using telerehabilitation services (eg, telephone, video conferencing, or email) when appropriate in between the weekly exercise sessions. The patients and their care-givers are instructed to perform the selected set of exercises at least five times a week for 30 min. This approach means that patients received 20 h of caregiver-mediated exercises in addition to usual care during the 8-week intervention period	Care-as-usual	Caregiver-mediated, contact with researcher every week	Video conferencing technology, digitally-delivered	8 weeks	8-week, 12-week	No significant improvements	100%; 100%

CBT=cognitive behavioural therapy, iCBT=Internet-delivered cognitive behavioural therapy, BAS=Behavioural Activation System questionnaire, BDS=Bodily Distress Syndrome checklist, BDI-II=Beck Depression Inventory (brief version), BSI-18=18-item Brief Symptom Inventory, CES-D=Center for Epidemiological Studies Depression Scale, GAD-7=7-item General Anxiety Disorder Scale, GAI-SF=Geriatric Anxiety Inventory (short form), GDS=Geriatric Depression Scale, HADS=Hospital Anxiety and Depression Scale, K-10=10-item Kessler Psychological Distress Scale, HADS=Hospital Anxiety and Depression Scale, MADRS=The Montgomery-Asberg Depression Rating Scale, PHQ-9: 9-item Patient Health Questionnaire, SF-12 MCS: Mental Component Summary (short form).

Table 2: Digital mental health intervention characteristics and outcomes of the 17 included studies

Their findings indicated that Geriatric Depression Scale showed significant improvements in participants who received computer-delivered and therapist-delivered cognitive training compared with those in the waiting list group.³⁷ Smith and colleagues²⁷ investigated the effects of online speed of processing training in depressive symptoms among older adults who lived in supported senior living settings.²⁷ Their results differ from the study by Lee and colleagues finding that the program significantly increased, rather than decreased, the burden of depressive symptoms among participants residing in assisted living.²⁷

A study conducted by Morimoto and colleagues²⁴ looked at a different cognitive training digital mental health intervention, recognised as a neuroplasticity-based computerised cognitive remediation, designed to target the cognitive control functions of older adults with late-life depression.²⁴ The authors used an active control group matched for the duration, engagement, reward, computer presentation, and contact with study staff. Morimoto and colleagues' results showed that neuroplasticity-based computerised cognitive remediation induced remission in an additional 58% of participants versus 8% in the control condition (table 2).²⁴

Rehabilitation programs

Three studies included in this systematic review explored digitally-delivered rehabilitation programs^{30,32} and support through online forums.³¹ The studies suggest that a combination of online professionals, supervised education, and informal online discussions could be a promising rehabilitation tool.³⁰⁻³² Additionally, Thorén and colleagues³¹ established that telerehabilitation and online support groups could yield positive results in alleviating symptoms of anxiety and depression, and psychosocial wellbeing (table 2).³¹

Risk of bias

The risk-of-bias assessment of the included studies is summarised in figure 2. Although the majority of studies were not characterised by missing data, masking for most of the studies was not possible or reported. In addition, many of the studies had substantial drop-out rates, which contributed to much of the missing data. Three (17·6%) of 17 included studies were deemed to be at high risk of bias, and seven (41·2%) of 17 included studies were deemed to be at some risk of bias.

Discussion

This systematic review aimed to collate all existing literature on digital mental health interventions for the older adult population. Many digital mental health interventions are neglectful of the mental health needs of the older adult population in the digital age.⁴⁰ It is essential to understand the types of technology-based interventions that have been introduced and their effectiveness in the older population to design future

interventions that are user-friendly, practical, effective, and meet their mental health needs.

Successful digital mental health interventions

We found that interventions involving learning or attending a course have done well with the older adult population who do not have severe mental health diagnoses.^{33,34} In existing literature, learning activities have been identified as successful because the participants do not have to rely on their existing knowledge of technology to participate in the intervention. This finding might have lessened the burden or the expectation to perform well in these studies.⁴¹ Additionally, successful interventions have utilised simpler technologies as a means of delivery, such as a computer or tablet,^{23,33,37} instead of using more advanced hardware such as virtual reality headsets.²⁶ This important aspect of digital mental health interventions can be said to be unique to the older adult population as this population has been known to have generally lower digital literacy and higher computer anxiety than the younger population.⁴² A previous systematic review⁴³ that discussed barriers and facilitators of digital mental health interventions has stated that a participant's digital health literacy influences the extent to which they are able to adapt and engage with digital mental health interventions. A population with low levels of digital literacy therefore requires novice-friendly interventions.

A crucial question was whether a digital mental health intervention facilitated social connectedness and enabled the user to interact with other people. Social support through social networks not only increases engagement but could also have a positive effect on depressive symptoms and anxiety symptoms.⁴⁴ However, in the studies included in this systematic review, social interaction was not included as a part of the interventions, and its effect on depressive symptoms and anxiety symptoms were not discussed. Nevertheless, from the results, we have found that digital mental health interventions with social components tend to show clear improvements in mental health outcomes. For example, one study³⁹ assessed participants who were a part of a physical activity programme in which they were given the option to complete some of the activities in a group setting. Individuals who were part of the group activity fostered greater social interaction, resulting in clear improvements in mental health. However, it must be noted that the mental health outcomes were not exclusively the results of the social components of the intervention. It has been known that the effect that an intervention had on participants' sense of social connectedness (eg, being able to connect to peers and having regular contact with a personal therapist) was found to facilitate user engagement.⁴³ This aspect of successful digital mental health interventions is not unique to older adult users.

All successful digital mental health interventions have provided their participants with in-person support, and, at the very least, in the initial moments of digital mental

	Randomisation process	Deviations from intended intervention	Missing outcome data	Measurement of the outcome	Selection of reported result	Overall
Dear et al (2015) ³³						
Egede et al (2015) ²³						
Ferraz et al (2018) ³⁸						
Knaevelsrud et al (2017) ³⁵						
Kotov et al (2020) ³⁹						
Lee et al (2013) ³⁷						
Linder et al (2015) ²⁹						
Malmberg et al (2017) ³⁰						
Morimoto et al (2020) ²⁴						
Morton et al (2018) ³⁴						
O'Moore et al (2018) ²⁵						
Rendon et al (2012) ²⁶						
Smith et al (2019) ²⁷						
Sparrow et al (2011) ²⁸						
Thorén et al (2011) ³¹						
Thorén et al (2014) ³²						
Vloothuis et al (2019) ³⁶						

■ Low risk of bias
 ■ Some risk of bias
 ■ High risk of bias

Figure 2: Risk of bias of included studies

health interventions administration. There were five types of support provided to the participants during interventions: the presence of a therapist, a health professional (including physicians and nurses), researchers or research assistants, a physical activity coach, or a combination of supports. We could not determine the difference between each type of support provided to the participants and whether it influences the mental health outcomes of the digital mental health interventions. One iCBT study included in this systematic review claimed iCBT can only be effective for alleviating depressive symptoms and anxiety symptoms solely when therapists are present (and not delivered in a self-guided format).²³ Another study that looked at an online rehabilitation programme has found that the intervention was only successful in the treatment group that had direct support from a medical professional. The group who had to do it in a self-guided format showed no psychological improvements.³¹ Previous studies of completely self-guided digital mental health interventions found that users of any age had difficulty engaging with the digital

mental health interventions, and, at times, neglected to use the intervention completely.^{45,46} Additionally, a systematic review of unguided digital mental health interventions found that trial settings have a large effect on user engagement with unguided interventions, and, consequently, on the generalisability of the findings to the real world.⁴⁷

Many of the successful digital mental health interventions included in this systematic review have targeted populations or groups of older adults who share a specific condition. Therefore, the interventions themselves have been designed to alleviate a common problem that their target population shares. For example, some studies looked at using technologies to deliver rehabilitation programmes for older adults with hearing impairments, including programmes to improve hearing and hearing-related issues.^{30–32} Other studies examined digital mental health interventions for stroke survivors,^{29,39} older adults with Parkinson's disease,³⁸ and individuals with major depressive disorder.²³ Ultimately, each intervention was tailored to a specific problem that participants shared due to their disability or disease. Creating specific and tailored interventions with clear objectives and outcomes is key to its success.

Interventions with limited mental health outcomes

We have found four studies in which the digital mental health intervention was not associated with reductions in depressive symptoms and anxiety symptoms,^{26,27,35,36} and one study that was inconclusive.³⁴ The unsuccessful digital mental health interventions share a common feature in that they include components that are difficult to understand or to use. Unsuccessful digital mental health interventions can involve tasks that are overly challenging to complete, whether it be physically or cognitively. One study that examined a physical activity intervention stated that the participants could not complete the entire exercise routine without the use of assistive devices,²⁶ which caused some concerns about potential injuries that could occur due to no supervision for the digital mental health intervention.²⁶ Another study found that their intervention exacerbated the depressive symptoms and anxiety symptoms of their participants due to the excessive mental difficulty of the task that was introduced.²⁷ Some studies have also found that their sample populations require more advanced mental health care due to their existing mental illnesses.^{34,35} This finding could mean that digital mental health interventions can be successful only to alleviate minor depressive symptoms and anxiety symptoms, or those in the lower end of major disorders. Severe mental health concerns might need to involve direct contact and care from mental health professionals, a service that digital mental health interventions cannot yet provide.

Additionally, from the included studies on cognitive training, we can determine that the effects of online speed of processing training differ for various populations

of older adults.^{27,37} Neuroplasticity-based computerised cognitive remediation has been associated with inducing remission in older adults who have late-life depression,²⁴ but there is no evidence on populations without a diagnosis of depression or individuals with psychological multimorbidity. These results therefore indicate that there are too many variables to consider in cognitive training digital mental health interventions to conclude its effectiveness.

Limitations

Due to the novelty of the topic of digital mental health interventions in the older adult population, we were only able to include 17 studies in this systematic review, two of which were pilot studies. We were not able to conduct a meta-analysis due to the heterogeneity of the population, measures, and results of the papers included. All studies included did not have qualitative components, which prevents the ability to analyse the fundamental aspects that has made each intervention successful or unsuccessful from the perspectives of the end users. Scholars have critiqued that randomised controlled trial research has ignored the full advantage of the insights that might be gained through the inclusion of interpretive qualitative approaches because they tend to undervalue and underuse interpretive approaches in practice.⁴⁸

Future randomised controlled trial studies looking at digital mental health interventions with the older populations should consider the following methodological recommendations: (1) having a healthy control group and an intervention group with clinical diagnoses of mental illness; (2) collecting data on the support given throughout the duration of the interventions; (3) obtaining qualitative and quantitative data to measure the success of the interventions (ie, mental health questionnaires and post-intervention interviews); and (4) conducting follow-up interviews and surveys up to 1 year post-intervention to determine the long-term outcomes of the digital mental health interventions.

Bias primarily emerged due to unreported blinding during the randomised controlled trial and the selection of reported results. Digital mental health interventions research on older adults is especially difficult to interpret because of the number of variables that need to be considered during data analysis. Furthermore, a meta-analysis was not possible due to the heterogeneity of existing research on digital mental health interventions, including the types of interventions, data analysis methods, variations in control groups, and different measurements of depressive and anxiety symptoms. Our results further confirm that a substantial amount of research needs to be done on this topic to make digital mental health interventions a reality for the older population.

Conclusions

Digital mental health research is still in its infancy. There is yet to be a regulated gold standard design of successful

digital mental health interventions for the older adult population. Despite the apparent potential of digital technology supporting mental health, insufficient evidence suggests that this potential is not being fully realised, with uptake being scarce and outcomes being largely anecdotal and unpublished. The results of digital mental health interventions literature from the past decade suggest that: (1) end-users and the population of interest should be at the center of digital mental health interventions creation and design; (2) digital mental health interventions need to be malleable and able to adapt to different life circumstances, education level, and physical and psychological abilities of the population; and (3) creation of digital mental health interventions must be accompanied by (human) support available for all users.

Contributors

IR, LK, SD, and TDC contributed to the conception and design of the study. IR, LK, and TDC contributed to the literature search and data extraction. IR, LK, SD, KT, RC, and TDC contributed to writing the manuscript. KGC, SM, AS, KLF, and JT contributed to the critical revisions of the manuscript. IR, LK, and SD accessed and verified the data reported in this systematic review. All authors have approved the final manuscript.

Declaration of interests

IR is supported by Mental Health Research Canada (MHRC), Mitacs Accelerate, and AGE-WELL. The views expressed are those of authors and not necessarily those of MHRC, Mitacs Accelerate, or AGE-WELL. All other authors declare no competing interests.

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