Do automated digital health behaviour change interventions have a positive effect on self-efficacy? A systematic review and meta-analysis

Supplemental Materials

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Supplemental material 1: List of search terms

First filter; study design:

experiment OR randomi?ed OR controlled OR trial* OR manipulated OR evaluation OR follow-up stud* OR experiment OR program* OR intervention OR intervene*behaviour change OR health promotion OR preven*

Second filter; outcome measures:

Self-efficacy OR social cognitive theory OR vicarious learning OR vicarious experience OR mastery experience OR persuasion OR protection motivation theory

Third filter; intervention type

Digital OR mobile phone OR smartphone OR cell* phone OR email OR e-mail OR messaging service OR videogame OR video game OR website OR podcast OR social media OR app OR text* OR SMS OR computer OR television OR TV OR tablet OR DVD OR virtual reality OR VR OR wearable sensor OR internet OR web-based OR online OR blog OR vlog OR ehealth OR electronic health OR e-health OR mhealth OR m-health OR mobile health

Fourth filter; behaviour:

Condom* OR safe sex OR unsafe sex OR contracepti* OR safer sex OR smok* OR tobacco OR healthy eating OR nutrition OR food consumption OR healthy diet OR dietary behav* OR eating behav* OR physical activity OR physical exercise OR sport OR exercise OR alcohol OR heavy drinking OR binge drink* OR harmful drinking OR episodic drinking

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Supplemental material 2: List of reviews in the area

Bailey, J. V., Murray, E., Rait, G., Mercer, C. H., Morris, R. W., Peacock, R.…Nazareth, I. (2012). Computer-based interventions for sexual health promotion: Systematic review and meta-analyses. *Int.J.STD AIDS, 23*(6), 408-413. doi:10.1258/ijsa.2011.011221.

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Haug, S. & Schaub, M. (2011). Wirksamkeit internetbasierter programme zum tabakrauchen: Eine systematische literatur*ü*bersicht. = Efficacy of Internet programs for tobacco smoking: A systematic review. *Zeitschrift für Gesundheitspsychologie, 19*(4), 181-196. doi:10.1026/0943-8149/a000052.

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Supplemental material 3: Data extraction sheet

Paper Title:	
Author Surnames:	
Year of Publication:	
Journal:	
Volume & Pages:	

Study Design:	*RCT or Quasi-RCT*
Sample Size in Analysis:	
No. of Female Participants in Analysis:	
Income Level of Study Country:	*high, middle or low*

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Age range of Sample:	*8-24 years* *25-34 years* *35-64 years* *65+ years*

Behaviour Type:	*Alcohol use, healthy eating, sexual behaviour, smoking or physical activity*
Mode of Delivery:	*Classify according to the Mode of Delivery of Behaviour Change Interventions Taxonomy version 0 (MoDTv0); sub-levels 1 and 2 under top-level category 'digital'*[1]
How is SE measured:	*Single or composite*
Self-efficacy data	*Experimental condition 1:* *Pre-test: N= mean= SD=* *Post-test: N= mean= SD=*
	Experimental condition 2: *Pre-test: N= mean= SD=* *Post-test: N= mean= SD=*
	Control: *Pre-test: N= mean= SD=* *Post-test: N= mean= SD=*

Quality of Intervention Development:	*Co-design:* *Yes* *No/Not Reported* *Systematic:* *Yes* *No/Not Reported* *Theory:* *Yes* *No/Not Reported*

[1]The MoDTv0 has four major categories (human, printed material, digital and somatic) and within each of these, a further three sub-levels. For the major category 'digital' there are four level one categories (phone, computer/television, wearable and environmental sensor). Within each of these level one categories there are between zero and seven level two categories. Within the level one category 'phone' for example, there are the following level two categories: email, website, video game, podcast, social media, app, automated text message. In the present study, modes of delivery were categorised down to the sub-level two.

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Supplemental material 4: List of studies included in the review

Anderson, E., Winett, R., Wojcik, J., Winett, S., & Bowden, T. (2001). A computerized social cognitive intervention for nutrition behavior: Direct and mediated effects on fat, fiber, fruits, and vegetables, self-efficacy, and outcome expectations among food shoppers. *Annals of Behavioral Medicine, 23*(2), 88-100. doi:10.1207/S15324796ABM2302_3

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Brendryen, H., Drozd, F., & Kraft, P. (2008). A digital smoking cessation program delivered through internet and cell phone without nicotine replacement (happy ending): Randomized controlled trial. *Journal of Medical Internet Research, 10*(5), e51. doi:10.2196/jmir.1005

Brendryen, H., & Kraft, P. (2008). Happy ending: A randomized controlled trial of a digital multi-media smoking cessation intervention.(author abstract)(medical condition overview)(report). *Addiction, 103*(3), 478. doi:10.1111/j.1360-0443.2007.02119.x

Brown, T. C. (2016). Impact of a theory-guided encouragement intervention on an employee walking pilot program. *Journal of Applied Sport Psychology, 28*(4), 452-468. doi:10.1080/10413200.2016.1187687

Cook, R. F., Billings, D. W., Hersch, R. K., Back, A. S., & Hendrickson, A. (2007). A field test of a web-based workplace health promotion program to improve dietary practices,

reduce stress, and increase physical activity: Randomized controlled trial. *Journal of Medical Internet Research, 9*(2), e17. doi:10.2196/jmir.9.2.e17

Dadaczynski, K., Schiemann, S., & Backhaus, O. (2017). Promoting physical activity in worksite settings: Results of a german pilot study of the online intervention healingo fit.(report). *BMC Public Health, 17*(1) doi:10.1186/s12889-017-4697-6

Dunton, G. F., & Robertson, T. P. (2008). A tailored internet-plus-email intervention for increasing physical activity among ethnically-diverse women. *Preventive Medicine, 47*(6), 605-611. doi:10.1016/j.ypmed.2008.10.004

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Hager, R. L., Hardy, A., Aldana, S. G., & George, J. D. (2002). Evaluation of an internet, stage-based physical activity intervention. *Journal of Health Education, 33*(6), 329-337. doi:10.1080/19325037.2002.10604755

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Klein, C. H., Kuhn, T., Altamirano, M., & Lomonaco, C. (2017). C-SAFE: A computer-delivered sexual health promotion program for latinas. *Health Promotion Practice, 18*(4), 516-525. doi:10.1177/1524839917707791

Mavrot, C., Stucki, I., Sager, F., & Etter, J. (2017). Efficacy of an internet-based, individually tailored smoking cessation program: A randomized-controlled trial. *Journal of Telemedicine and Telecare, 23*(5), 521-528. doi:10.1177/1357633X16655476

Muller, A. M., Khoo, S., & Morris, T. (2016). Text messaging for exercise promotion in older adults from an upper-middle-income country: Randomized controlled trial. *Journal of Medical Internet Research, 18*(1), e5. doi:10.2196/jmir.5235

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Swartz, L. H. G., Sherman, C. A., Harvey, S. M., Blanchard, J., Vawter, F., & Gau, J. (2011). Midlife women online: Evaluation of an internet-based program to prevent unintended pregnancy & STIs. *Journal of Women & Aging, 23*(4), 342-359. doi:10.1080/08952841.2011.613255

Supplemental material 5: Study characteristics

Lead author/ year	Total sample size	Study design	% female	Age group (where mean of sample resides)	Health behaviour	Study country (and high or medium / low income country)	Composite or single measure of self-efficacy?	Quality of intervention development

								Theory-based	Developed using a systematic approach	Co-designed with the target population
Anderson, Winnet & Wojcik (2001)	296	RCT	96.0%	Mean not reported	Healthy Eating	USA (High Income)	Composite	Yes	No/not reported	No/not reported
Bowen, Horvath and Williams (2007)	90	RCT	0%	25-34	Sexual Behaviour	USA (High Income)	Composite	Yes	No/not reported	No/not reported
Brendryen & Kraft (2008)	400	RCT	50.25%	35-64 years	Smoking	Norway (High income)	Composite	No	No/not reported	No/not reported

Brendyren et al (2008)	296	RCT	50.0%	35-64	Smoking	Norway (High Income)	Composite	Yes	No/not reported	No/not reported
Brown (2016)	106	RCT	84.9%	35-64	Physical Activity	USA (High Income)	Composite	Yes	No/not reported	No/not reported
Cook et al (2007)	419	RCT	72.0%	35-64	Healthy Eating	USA (High Income)	Composite	Yes	No/not reported	No/not reported
Dadacynski et al (2017)	176	RCT	35.4%	35-64	Physical Activity	Germany (High Income)	Composite	Yes	No/not reported	No/not reported
Dunton & Robertson (2008)	156	RCT	100%	35-64	Physical Activity	USA (High Income)	Composite	Yes	No/not reported	No/not reported

Gell & Wadsworth (2015)	87	RCT	100%	35-64	Physical Activity	USA (High Income)	Composite	Yes	No/not reported	No/not reported
Hagemman, Walker & Pullen (2005)	31	RCT	100%	35-64	Physical Activity	USA (High Income)	Composite	Yes	No/not reported	No/not reported
Hager et al (2002)	525	RCT	54.8%	35-64	Physical Activity	USA (High Income)	Composite	Yes	No/not reported	No/not reported
Irvine et al (2004)	517	RCT	73.0%	35-64	Healthy Eating	USA (High Income)	Single	Yes	No/not reported	No/not reported
Irvine et al (2011)	228	RCT	42.2%	35-64	Physical Activity	USA (High Income)	Composite	Yes	No/not reported	No/not reported

Keller et al (2018)	279	RCT	75.2%	25-34	Healthy Eating	USA (High Income)	Composite	Yes	No/not reported	No/not reported
Klein et al (2017)	321	RCT	100%	25-34	Sexual Behaviour	USA (High Income)	Composite	Yes	No/not reported	Yes
Mavrot (2016)	1160	RCT	65.7%	35-64	Smoking	Switzerland (High Income)	Composite	Yes	No/not reported	No/not reported
Muller, Khoo & Morris (2016)	43	RCT	74.4%	35-64	Physical Activity	Malaysia (Middle Income)	Composite	No	No/not reported	No/not reported
Powell (2016)	87	RCT	52.0%	35-64	Smoking	England (High Income)	Composite	Yes	No/not reported	No/not reported

Prestwich et al (2017)	281	RCT	75.7%	18-24	Physical Activity	England (High Income)	Composite	Yes	No/not reported	No/not reported
Swartz et al (2011)	422	RCT	100%	35-64	Sexual Behaviour	USA (High Income)	Composite	Yes	No/not reported	Yes

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Supplemental material 6: Incidence of BCTs across interventions along with associated dose

BCT		Incidence of BCT across interventions	Dose of BCT present across interventions		
			Low	Medium	High
1.1	Goal setting (behaviour)	11	3	1	7
1.2	Problem solving	9	3	3	3
1.4	Action planning	5	3	0	2
1.5	Review Behavioural Goal	2	1	0	1
1.6	Discrepancy between current behaviour and goal	2	0	0	2
1.9	Commitment	1	0	0	1
2.1	Monitoring of Behaviour by others Without Feedback	3	1	0	2
2.2	Feedback on	5	2	0	3

	Behaviour				
2.3	Self-monitoring of behaviour	9	3	1	5
2.4	Self-Monitoring of outcome of behaviour	1	1	0	0
2.7	Feedback on outcome(s) of Behaviour	2	2	0	0
3.1	Social Support (unspecified)	3	1	0	2
4.1	Instruction on How to Perform Behaviour	11	3	3	5
4.2	Information about antecedents	3	2	1	0
5.1	Information about Health Consequences	5	3	0	2
5.2	Salience of consequences	1	1	0	0
5.3	Information	4	4	0	0

	about Social and Environmental consequences				
5.5	Anticipated regret	2	2	0	0
6.1	Demonstration of Behaviour	4	1	0	3
6.2	Social Comparison	3	0	0	3
7.1	Prompts/Cues	1	0	0	1
8.1	Behavioural practice/ rehearsal	1	0	1	0
8.2	Behavioural Substitution	4	4	0	0
8.7	Graded Tasks	1	1	0	0
9.1	Credible source	1	1	0	0
10.1	Material incentive (behaviour)	1	0	0	1
10.4	Social Reward	4	0	0	4
11.1	Pharmacological Support	2	0	0	2

11.2	Reduce Negative Emotions	3	1	2	0
12.1	Restructuring the physical environment	2	2	0	0
12.5	Adding objects to the environment	1	1	0	0
13.1	Identification of self as role model	1	1	0	0
13.2	Framing re-framing	2	0	0	2
15.1	Verbal Persuasion About Capability	4	4	0	0
15.2	Mental rehearsal of successful performance	1	1	0	0
15.3	Focus on past success	1	0	1	0
15.4	Self-talk	1	1	0	0
16.1	Imaginary	1	1	0	0

	punishment				
16.3	Vicarious consequences	1	1	0	0

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Supplemental material 7: Modes of delivery, BCTs and associated practical strategies coded for interventions included in the meta-analysis

Physical Activity Interventions

Brown (2016)

Intervention description: a workplace intervention designed to increase walking. Two intervention types were tested compared to a control (neutral emails with no encouragement): Task/care emails – encouragement stressed individual effort and improvement, and provided suggestions for how to encourage fellow co-workers to walk, and Ego emails: encouragement stressed competing with fellow co-workers to achieve the most steps in the group.

	Top level	Sub-level 1	Sub-level 2
Mode of delivery	Digital	Unspecified	Email

Task/care intervention

BCT number	BCT name	Practical strategy
3.1	Social support (unspecified)	Users were encouraged to provide social support to each other e.g. 'if you see a fellow walker today, why not give him or her a high five? Tell them that they are doing a great job'
10.4	Social	Users received updated step counts for the entire cohort via email

	reward	e.g. ‘congratulations, as a group, we’ve walked a daily average of 354,203 steps. That’s like walking from here to our states capital’
15.1	Verbal persuasion about capability	e.g. ‘Remember- the hardest step you’re going to take in this is just getting out the door. Every step you take today counts. Every single one. You can do this!’

Ego intervention

BCT number	BCT name	Practical strategy
6.2	Social comparison	Users received a running tally of everyone’s step count e.g. ‘this week Chris walked the most steps with 140,302 and Ann walked the least steps with only 2,103. Looks like everyone below Chris needs to step it up!’ and, ‘now’s the time to ask yourself- who’s the best here? Don’t you want it to be you? Take a look at the list of walkers this week. Where is your name? If you’re not at the top, remind yourself that you can do better. Don’t let someone out walk you!’
15.1	Verbal persuasion about capability	e.g. ‘Everyone has a million excuses for why they can’t do something. But if you want to be top of the walking group, you’ve got to keep pushing yourself no matter what. Just put one foot in front of the other. If you didn’t find yourself top of the walking group this week, remember you can always push yourself harder.

Don’t let yourself slack’

Dadaczynski et al (2017)

Intervention description: an intervention that aimed to increase low-level physical activity such as walking. The intervention included tracking of physical activity using a pedometer and also access to online content containing quizzes, goal setting/tracking features, and the facility to compare progress with others.

	Top level	Sub-level 1	Sub-level 2
Mode of delivery	Digital	Desktop computer	Website
		Mobile device	Website
		Wearable accessory	Digital accessory

BCT number	BCT name	Practical strategy
1.1	Goal setting (behaviour)	A daily step goal was implemented
1.5	Review behaviour goal(s)	Individual tailored step goals were calculated each day based on logged data of the pedometer for each user of the last four days
2.2	Feedback on behaviour	Users received daily emails with information about their current step goal as well as the results of the previous day
12.5	Adding	Users were given a Fitbit pedometer to measure their physical

	objects to the environment	activity
6.2	Social comparison	Users could join in team or individual challenges against each other. Additionally, game features were implemented to increase participation e.g. rankings (leader boards)

Dunton et al (2008)

Intervention description: this intervention aimed to increase physical activity amongst women. The website included an interactive computer programme that produced individualised physical activity feedback, images of women exercising (matched to age and type of activity), and tailored messages for overcoming barriers to exercising. Follow-up emails over 10 weeks provided encouragement and tips.

	Top level	Sub-level 1	Sub-level 2
Mode of delivery	Digital	Unspecified	Website
		Unspecified	Email

BCT number	BCT name	Practical strategy
1.1	Goal setting (behaviour)	Email newsletter: ‘addressed topics such as goal setting’
1.2	Problem	Webpage: provided suggestions for overcoming barriers to

	solving	physical activity
2.2	Feedback on behaviour	Webpage: after the information was entered, the computer programme generated a graph displaying each respondent's self-reported current level of activity compared to the 2005 USDA Dietary guidelines for physical activity
2.3	Self-monitoring of behaviour	Email newsletter: link to a downloadable log provided
4.1	Instruction on how to perform the behaviour	Email newsletter: information about appropriate portion sizes Email newsletter: number of recommended minutes of activity
5.3	Information about social and environmental consequences	Webpage: a tailored message provided either the consequences of inactivity, or reinforcement for meeting activity levels, based on self-reported number of minutes of physical activity

Gell et al (2015)

Intervention description: a text-message workplace-based intervention targeted at women aiming to increase physical activity. Text messages aimed to be informational and motivational. Three were sent per week for 24 weeks. All women received the same messages.

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	Top level	Sub-level 1	Sub-level 2
Mode of delivery	Digital	Phone	Automated text

BCT number	BCT name	Practical strategy
1.1	Goal setting (behaviour)	Text messages included 'goal setting' e.g. 'people who write down a goal are much more likely to achieve it than those who don't. What's your exercise goal for the next 3 months?'
1.2	Problem solving	Text messages included 'self-regulation strategies such as relapse prevention' and 'strategies to address the most common barriers to physical activity'
2.3	Self-monitoring of behaviour	Text messages included 'self-regulation strategies such as self-monitoring'
4.1	Instruction on how to perform behaviour	Text messages included 'specific suggestions for ways to meet physical activity guidelines' e.g. 'Add steps to your day: use the restroom on another floor and use they steps to get there' and 'try interval training while walking: spot something in the distance and walk fast, walk normal, pick another object and repeat'

Hageman et al (2005)

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Intervention description: this intervention consisted of a series of three tailored newsletters accessed via the internet that aimed to increase physical activity among older women. Tailored content was created automatically from a library of 350 messages selected according to individuals' responses to their baseline survey.

	Top level	Sub-level 1	Sub-level 2
Mode of delivery	Digital	Unspecified	Website

BCT number	BCT name	Practical strategy
No unique BCTs were coded for this intervention		

Hager et al (2002)

Intervention description: This intervention aimed to increase physical activity and was offered within the workplace. The 'stage-based' version provided users with an initial exercise message tailored to their individual readiness to change. This was followed by email messages for five consecutive weeks.

	Top level	Sub-level 1	Sub-level 2
Mode of delivery	Digital	Unspecified	Website
		Unspecified	Email

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BCT number	BCT name	Practical strategy
1.1	Goal setting	The email 'be precise about what you plan to achieve, and when and how it will happen. Write down the details'
1.2	Problem solving	The email 'exercise is not for me, but I think about it' contained a 'barrier identification and solution exercise'
1.4	Action planning	Email: 'be precise about what you plan to achieve, and when and how it will happen. Write down the details'
2.3	Self-monitoring of behaviour	Email: Goals: Include a way to gauge your success- time spent exercising, number of workout sessions, or drop in cholesterol or blood pressure
2.4	Self-monitoring of outcome behaviour	Email: 'Goals: include a way to gauge your success - time spent exercising, number of workout sessions, or drop in cholesterol or blood pressure'
4.1	Instruction on how to perform behaviour	Email: 'a good fitness program includes three elements': Aerobic activity, exercises that increase your heart rate through nonstop activity. Fast walking, jogging, swimming, cycling, and roller skating Email: 'a good fitness program includes three elements': Stretching exercises that enable your joints to move through a full range of motion. Stretch after your body is warmed up and breathe naturally while you stretch. Hold each stretch comfortably for 30 seconds and never bounce

5.1	Information about health consequences	Email: 'Abdominal crunches, push ups, and weight lifting can strengthen and condition your muscles'
5.3	Information about social and environmental consequences	Email: 'Physical activity helps you feel better about yourself and makes you a role model for family and friends'
13.1	Identification as self as role model	Email: 'Physical activity helps you feel better about yourself and makes you a role model for family and friends'
15.2	Mental rehearsal of successful performance	Email: 'Picture yourself exercising- healthier and more energetic than you've ever been-looking forward to the day with enthusiasm and optimism for what lies ahead'

Irvine et al 2011

Intervention description: an automated internet-based work-place intervention (Get Moving) designed to improve the physical activity of sedentary workers. Content aimed to provide education, support and guidance using on-screen text, video, and animations. Employees were able to access the website using workstations located within their workplace computer lab.

	Top level	Sub-level 1	Sub-level 2

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Mode of delivery	Digital	Computer/television	Website

BCT number	BCT name	Practical strategies
1.1	Goal setting (behaviour)	The Web site helped users to set physical activity goals on a weekly basis. On each weekly return to the website, users were encouraged to set the same or an amended goal. Users were told that the goal was to make physical activity a habit over a period of months by building gradually to nationally recommended levels of 30 minutes of moderate intensity
1.2	Problem solving	Text and video messages were tailored to users' perceived personal barriers to PA. For example, they received encouragement to overcome self-perceived barriers to physical activity (e.g., too tired, no will power, self-conscious, not fun) and could view up to six different video testimonials offering tips in the form of personal stories about overcoming specified barriers Users could print tips for overcoming anticipated barriers; they were encouraged to review common barriers and address the previous week's obstacles on each return to website
1.4	Action planning	The website helped users to create an activity schedule, including day, time and type of activity they would perform
1.5	Review behavioural	When users returned to the website, they were queried about physical activity since previous visit. The programme

	goal(s)	compared the responses with their stored physical activity data from the previous visit and then provided tailored positive support even if their goals had not been met. Whether users chose the same or amended goal for the following week, a new physical activity schedule for the following week could be created
8.7	Graded tasks	The Web site helped users to set physical activity goals on a weekly basis. On each weekly return to the website, users were encouraged to set the same or an amended goal. Users were told that the ultimate goal was to make physical activity a habit over a period of months by building gradually to nationally recommended levels of 30 minutes of moderate intensity

Muller et al (2016)

Intervention description: this intervention aimed to increase exercise self-efficacy in inactive older adults using text messaging (60 messages over 12 weeks). Messages aimed to encourage, prompt and praise exercise behaviour.

	Top level	Sub-level 1	Sub-level 2
Mode of delivery	Digital	Phone	Automated text

BCT	BCT name	Practical strategies

number		
7.1	Prompts/ cues	Text message prompt: 'Please do the My Paths exercises regularly'
10.4	Social reward	Text messages praise efforts made towards the exercise behaviour e.g. 'all your efforts will impact your health'

Prestwich et al (2017)

Intervention description: an intervention that aimed to increase physical activity measured using step counts. Two different interventions were presented ('self-monitoring' and 'competition'). In both, users were asked to meet a daily step count goal and to track their physical activity using a pedometer. An online website allowed them to observe their step-count over time. In the competition intervention, users were additionally able to see how their step-count compared to other users.

Self-monitoring intervention

	Top level	Sub-level 1	Sub-level 2
Mode of delivery	Digital	Unspecified	Website
		Wearable accessory	Digital accessory

BCT number	BCT name	Practical strategy
1.1	Goal setting	Users were asked to perform a minimum of 10,000 steps per day

	(behaviour)	
1.6	Discrepancy between current behaviour and goal	Tailored message via website: You reported that you have achieved 11,000 steps so far. The daily target is to achieve at least 10,000, thus within the next 24 hours your pedometer should read at least 120,0000 steps
2.3	Self-monitoring of behaviour	Users were asked to log onto study website and record their number of pedometer steps (at least once every 7 days for 5 weeks). They were also asked to log any activity done whilst not wearing the pedometer
2.2	Feedback on behaviour	Users tracked changes in their pedometer steps over the course of the study via graphical and tabular feedback (at least once every 7 days for 5 weeks)

Competition intervention

BCT number	BCT name	Practical strategy
1.1	Goal setting (behaviour)	Users were asked to perform a minimum of 10,000 steps per day
1.6	Discrepancy between current behaviour	Tailored message via website: You reported that you have achieved 11,000 steps so far. The daily target is to achieve at least 10,000, thus within the next 24 hours your pedometer should read at least 120,0000 steps

	and goal	
2.3	Self-monitoring of behaviour	Users were asked to log onto study website and record their number of pedometer steps (at least once every 7 days for 5 weeks). They were also asked to log any activity done whilst not wearing the pedometer
2.2	Feedback on behaviour	Users tracked changes in their pedometer steps over the course of the study via graphical and tabular feedback (at least once every 7 days for 5 weeks)
6.2	Social comparison	Users received feedback relating to how their pedometer steps compared to others (at least once every 7 days for 5 weeks). This was presented in the form of a league table.

Healthy Eating Interventions

Anderson et al (2001)

Intervention description: this intervention aimed to encourage users to decrease dietary fat and increase fruit, vegetables and fibre in their food purchases and consumption. Booths, containing computers hosting the intervention, were situated within supermarkets. The intervention consisted of 15 weekly segments containing pictures, graphics and audio, and the provision of food coupons to be used in the supermarket to buy healthy foods (nature/value of coupon was dependant on the focus of the weekly segment). Vouchers could be printed in the booth and redeemed within one week of printing.

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	Top level	Sub-level 1	Sub-level 2
Mode of delivery	Digital	Computer/television	DVD

BCT number	BCT name	Practical strategies
1.1	Goal setting (behaviour)	The intervention 'provided opportunities for personalised goal setting'
2.3	Self-monitoring of behaviour	Each segment 'provided prescriptive information, suggested strategies for monitoring and planning food purchases and meal preparation'
4.1	Instruction on how to perform behaviour	Strategies for monitoring and planning food purchases and meal preparation were provided
10.1	Material incentive	Targeted food coupons were provided; type, order, and value of these coupons was dependent on the programme segment's content, a products cost, and a weekly coupon allocation

Cook et al (2007)

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Intervention description: this was a workplace intervention ('Health Connection') delivered via a website. Graphics, audio and video were used to provide 'information and guidance' on three health topics: stress management, nutrition/weight management, and physical activity.

	Top level	Sub-level 1	Sub-level 2
Mode of delivery	Digital	Unspecified	Website

BCT number	BCT name	Practical strategies
1.1	Goal setting	Goals are set based on personal assessment information
1.2	Problem solving	Includes a printable 'tracker' for tracking obstacles and strategies that work
1.4	Action planning	Interactive daily meal planning exercises
2.1	Monitoring of behaviours by others without feedback	An interactive assessment of daily calorie and fat intake
2.3	Self-monitoring of behaviour	A printable smart goal planner and progress tracker
4.1	Instruction on	Tips for making healthy choices (protein, fats, beverages),

	how to perform the behaviour	information and training in reading nutritional facts labels and ingredients lists, food shopping strategies and tips, tips for cutting down on alcohol use
5.3	Information about social and environmental consequences	Video testimonials highlighting the benefits of good nutrition and weight management
6.1	Demonstration of behaviour	A demonstration of using the label to check fat content of foods is provided Video demonstrations of: planning ahead for healthy snacks, refusing unwanted drinks or food, using portion control with favourite rich foods, selecting the most healthful cooking method
8.2	Behaviour substitution	Advice on replacing alcohol with positive alternatives
11.2	Reduce negative emotions	'Education and training in the 5 steps of effective stress management'

Irvine et al (2004)

Intervention description: A computer programme which aimed to reduce dietary fat consumption and increase consumption of fruit and vegetables. Content (on-screen text and videos) was tailored according to users' gender, ethnicity, age and interest in content. It was

made available to employees of two large organisations via temporary computer workstations.

	Top level	Sub-level 1	Sub-level 2
Mode of delivery	Digital	Computer/television	DVD

BCT number	BCT name	Practical strategies
1.1	Goal setting (behaviour)	Users were asked to identify which of the recommended behaviours they were not currently doing and to commit to those which they would be willing to try in the next week
1.2	Problem solving	Users were asked to identify potential barriers to achieving these weekly goals from a total of 24 potential barriers. For chosen barriers, video models delivered short testimonial describing how they overcame the selected barriers
1.9	Commitment	Users were asked to 'commit' to the behaviours that they are willing to try in the next week
4.1	Instruction on how to perform the behaviour	On screen text was used to present practical steps for how to perform the behaviours e.g. 'add fruit & veggies when you pack your lunch' Video vignettes were used to model recommended eating behaviours e.g. the fork-dip method, ordering low-fat menu items

		The recipe section contained over 1500 low-fat recipes – users selected different criteria for recipes and the ones meeting these criteria were displayed and could be printed
5.1	Information about health consequences	The importance and health benefits of eating less dietary fat were stressed
6.1	Demonstration of the behaviour	Video vignettes were used to model recommended eating behaviours e.g. the fork-dip method, ordering low-fat menu items

Keller et al (2018)

Intervention description: an intervention that aimed to increase fruit and vegetable consumption. Via a website, users were presented with age and gender matched testimonials by others who had successfully increased their fruit and vegetable consumption and encouraged to focus on past success.

Self-monitoring intervention

	Top level	Sub-level 1	Sub-level 2
Mode of delivery	Digital	Unspecified	Website

BCT number	BCT name	Practical strategy
8.2	Behaviour	Testimonial: ‘Until recently I was a real sweet tooth! Chocolate

	substitution	and cookies in the evening in front of the TV were just a must. I then got the tip from a friend to simply replace sweets with fruit. I'm always nibbling on grapes and dry fruits. Never thought how delicious that is! If I can do that, you can do it!'
15.3	Focus on past success	Users were asked to recall their own experiences of success with fruit and veg by checking against some example statements or by documenting their own success stories
15.4	Self-talk	Users were encouraged to generate a self-motivating phrase that they could recall when being tempted to snack or otherwise being unmotivated to eat fruit and veg

Smoking Interventions

Brendryen & Kraft (2008) and Brendryen et al (2008)

Intervention description: The intervention ('Happy Ending') is a 1-year smoking cessation programme. The same intervention was examined in both studies. It has preparation, quitting and follow-up phases during which content, messages and support differ. Access to a website is prompted via email. Users are encouraged to call an Interactive Voice Response (IVR) helpline during the quitting phase whenever they experience an urge to smoke (just-in-time intervention). During this phase, users are additionally contacted by the IVR system daily and prompted to report whether they have smoked; reports of smoking trigger relapse prevention (a 'therapy regimen'). Text messages are used to remind users to contact the IVR helpline when needed.

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	Top level	Sub-level 1	Sub-level 2
Mode of delivery	Digital	Unspecified	Website
		Unspecified	Email
		Phone	Automated text
		Phone	Interactive Voice Response (IVR)[1]

[1]IVR is not currently categorised within the Mode of Delivery of Behaviour Change Interventions Taxonomy Version 0 (MoDTv0) (Carey et al., 20016) as a mode of delivery

BCT number	BCT name	Practical strategies
1.2	Problem solving	Users were encouraged to make concrete 'coping plans' regarding how to stay smoke free in the immediate future Automated IVR based 'relapse prevention' system is incorporated in Happy Ending.
1.4	Action planning	Users are encouraged to make concrete 'implementation intentions' regarding how to stay smoke free in the immediate future Users who have a 'slip' are encouraged to prepare an 'implementation intention' regarding how and when to resume the quit attempt Repeatedly encouraged to make a plan to call the hotline every time they are tempted to have a cigarette
2.1	Monitoring of	Users' were contacted every night by the IVR system and asked

	behaviour by others without feedback	whether they had smoked during the day
2.3	Self-monitoring of behaviour	The preparation stage contains elements of behavioural skills training. These consist of techniques related to the acquisition of new skills, such as self-stopping, the use of substitutions, self-monitoring and foresight
2.7	Feedback on outcome(s) of behaviour	IVR message: today your blood pressure has been reduced to that of a non-smoker
3.1	Social support (unspecified)	The intervention contains an IVR based craving helpline. Users were instructed (repeatedly by text message) to call the helpline every time they are tempted to have a cigarette. Users were repeatedly encouraged via website messages to call the IVR helpline when experiencing cravings
4.1	Instruction on how to perform behaviour	The preparation stage contains elements of 'behavioural skills training'. These consist of techniques related to the acquisition of new skills, such as self-stopping, the use of substitutions, self-monitoring and foresight
4.2	Information about antecedents	Website message: 'what it is that distinguishes your smoking pattern? I often smoke… after a meal/ on the way to work/ when I have a coffee break ….?'
5.1	Information about health	Each morning during the quitting phase, users receive a pre-recorded message via the IVR system about one of the short

	consequences	term positive consequences of quitting e.g. 'today your blood pressure has been reduced to that of a non-smoker'
5.5	Anticipated regret	IVR relapse prevention message: 'How will you feel in a month's time if you decide to start smoking again now?'
8.2	Behaviour substitution	Website message: use some of the smoking breaks you used to have at work to go for a brisk walk instead
10.4	Social reward	Website message: 'you will see that you already have a much improved overall state of health – congratulations' Text message: 'congrats - smoke free for a whole work week' and, 'Bravo – it's now a full working week since you stopped'
11.1	Pharmacological support	Seven text messages are sent to users related to nicotine replacement therapy (NRT); reminders are sent about obtaining it, wearing it, and to use it regularly
11.2	Reduce negative emotions	Users are encouraged to attribute a 'slip' to situational factors, 'thereby preventing negative emotions and a full-blown relapse'
12.1	Restructuring the physical environment	Website message: 'clear away all ash tray and anything else that remind you of smoking- look through drawers and cupboards, throw away anything you find'
13.2	Framing/ re-framing	Website messages: 'even if you've had a few cigarettes it's not a disaster' and, 'a slip up is no great catastrophe, look on any slip up as a little step backwards before you continue ahead at full speed'
15.1	Verbal persuasion	Email message: 'your first weekend as a non-smoker is nearly here…. You won't destroy it now by being careless this

	about capability	weekend … you are over the worst cravings and you will have soon managed a whole week as a non-smoker'

Mavrot et al (2016)

Intervention description: this intervention ('Coach'), designed for both current and former smokers (both motivated and unmotivated to quit), aimed to increase smoking cessation and prevent relapse. Website content is tailored and provides 'counselling' through personalised messages (information, encouragement, advice, feedback).

	Top level	Sub-level 1	Sub-level 2
Mode of delivery	Digital	Unspecified	Website

BCT number	BCT name	Practical strategies
2.7	Feedback on behaviour	Users were able to view a personal web page with progress graphs that provided a visual representation of change over time in the levels of tobacco dependence, withdrawal symptoms motivation, and self-efficacy

Powell et al (2016)

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Intervention description: A website designed to increase smoking cessation, containing audio, video and on-screen text extracts of ex-smoker's experiences of quitting smoking, organised into topic groups. Users were able to navigate and browse content as they wished.

	Top level	Sub-level 1	Sub-level 2
Mode of delivery	Digital	Unspecified	Website

BCT number	BCT name	Practical strategies
No unique BCTs were coded for this intervention		

Sexual Behaviour Interventions

Bowen et al (2007)

Intervention description: A HIV risk-reduction intervention for men who have sex with men (MSM). HIV prevention messages were conveyed through video conversations between an HIV-positive man ('expert') and an HIV-negative man ('inexperienced'; engaging in high risk activities); dialogue was interspersed with interactive activities and graphics emphasising key points.

	Top level	Sub-level 1	Sub-level 2
Mode of delivery	Digital	Unspecified	Website

BCT number	BCT name	Practical strategies
4.1	Instruction on how to perform behaviour	The content focused on how the inexperienced man might maintain his HIV-negative status, including safe sex options, condom types, and correct condom application

Klein et al (2017)

Intervention description: a 2-hour long programme delivered within a sexual health setting. Users could stop at any point, resume where they left off, and if they wanted to, repeat already completed activities. Each session combines audio narration, visual presentations, interactive components, games, and a series of soap opera-style videos.

Self-monitoring intervention

	Top level	Sub-level 1	Sub-level 2
Mode of delivery	Digital	Unspecified	Website

BCT number	BCT name	Practical strategy
1.1	Goal setting (behaviour)	'Think about it' activity – for which goal setting is outcome
1.2	Problem solving	Presentation on ways of getting past barriers to condom use, communication strategies video, 'excuses and comebacks

		game'
4.1	Instruction on how to perform behaviour	Interactive review of correct condom use steps; 'Andrea demonstrates correct condom use'; 'salsa dancing game: user negotiates each step of the encounter (sexual communication) until the dance is complete'
4.2	Information about antecedents	Unsafe sex triggers – video of workshop women discussing their own unsafe sex triggers and then 'what are your triggers' exercise
5.1	Information about social and environmental consequences	Consequences of risky sex = STIs; Interactive activity 'you and Ramon'- animated chart depicting how Ramon's sexual experiences translate into a larger sexual history than spans nearly 100 people
5.2	Salience of consequences	Interactive activity 'you and Ramon' - animated chart depicting how Ramon's sexual experiences translate into a larger sexual history than spans nearly 100 people
6.1	Demonstration of behaviour	Video demonstration of communication role play and of condom use: 'Andrea demonstrates correct condom use'; video of workshop women practicing putting on condoms on penis proxies; video demo of communication role-play
8.1	Behaviour practice/rehearsal	Activity- Users negotiates each step of sexual encounter until dance is complete; if he says/ you can say' activity- communication role-play activity
9.1	Credible source	Video of health educator Andrea demonstrating correct

		condom use
16.1	Imaginary punishment	Exercise- visualise the impact of contracting HIV on family, friends and their quality of life
16.3	Vicarious consequences	Video of women's experiences of contracting an STI multiple times from their partners

Swartz et al (2011)

Intervention description: this intervention aimed to reduce unwanted pregnancy and sexually transmitted infections (STIs) amongst middle-aged women. The website had five modules and included on-screen text, animations, quizzes, and videos (including those presented by midwife and testimonials from other women).

	Top level	Sub-level 1	Sub-level 2
Mode of delivery	Digital	Unspecified	Website

BCT number	BCT name	Practical strategies
4.1	Instruction on how to perform the behaviour	The 'talking to your partner' module presents information and skill-building techniques for talking with sexual partners about how best to initiate and conduct discussions regarding risk-reduction behaviours (e.g. changing contraceptive methods, using condoms, or being tested for STI's) Tip sheets and video modelling are presented to help build communication skills, and include a) effective communication

		with your health care provider b) helpful information to bring to an appointment and c) sample questions to ask your health care provider
5.1	Information about health consequences	Information is presented on the benefits and limits of commonly used prevention strategies (e.g. condoms) in preventing specific STI's
6.1	Demonstration of behaviour	Tip sheets and video modelling are presented to help build communication skills, and include a) effective communication with your health care provider b) helpful information to bring to an appointment and c) sample questions to ask your health care provider

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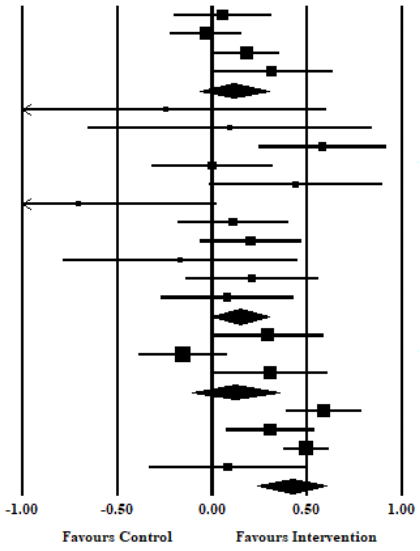
Supplemental material 8: Forest plot for self-efficacy of automated digital interventions versus no/usual treatment by behavioural domain

Group by Behaviour Type	Study name	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Healthy Eating	Anderson et al 2001	0.053	0.133	0.018	-0.207	0.314	0.402	0.688
Healthy Eating	Cook et al 2007 (diet)	-0.035	0.098	0.010	-0.226	0.157	-0.354	0.723
Healthy Eating	Irvine et al 2004	0.184	0.088	0.008	0.012	0.357	2.093	0.036
Healthy Eating	Keller et al 2018	0.311	0.165	0.027	-0.012	0.634	1.890	0.059
Healthy Eating		0.115	0.093	0.009	-0.068	0.298	1.230	0.219
Physical Activity	Brown 2016 (ego)	-0.245	0.433	0.188	-1.094	0.604	-0.566	0.571
Physical Activity	Brown 2016 (task/care)	0.092	0.383	0.147	-0.659	0.844	0.240	0.810
Physical Activity	Dadaczynski et al 2017	0.581	0.170	0.029	0.247	0.915	3.411	0.001
Physical Activity	Dunton & Robertson 2008	0.000	0.163	0.027	-0.319	0.319	0.000	1.000
Physical Activity	Gell & Wadsworth 2015	0.441	0.233	0.054	-0.016	0.897	1.891	0.059
Physical Activity	Hageman et al 2005	-0.705	0.373	0.139	-1.435	0.026	-1.890	0.059
Physical Activity	Hager et al 2002 (staged)	0.108	0.149	0.022	-0.185	0.400	0.720	0.472
Physical Activity	Irvine et al 2011	0.202	0.138	0.019	-0.069	0.473	1.463	0.143
Physical Activity	Muller et al 2016	-0.169	0.315	0.099	-0.787	0.448	-0.537	0.591
Physical Activity	Prestwich et al 2017 (competition)	0.210	0.179	0.032	-0.141	0.561	1.173	0.241
Physical Activity	Prestwich et al 2017 (self-monitoring)	0.078	0.180	0.033	-0.276	0.432	0.432	0.666
Physical Activity		0.145	0.078	0.006	-0.007	0.298	1.868	0.062
Sexual Behaviour	Bowen et al 2007	0.293	0.149	0.022	0.000	0.585	1.962	0.050
Sexual Behaviour	Klein et al 2017	-0.155	0.120	0.014	-0.390	0.080	-1.295	0.195
Sexual Behaviour	Swartz et al 2011	0.303	0.156	0.024	-0.003	0.610	1.940	0.052
Sexual Behaviour		0.123	0.117	0.014	-0.105	0.352	1.058	0.290
Smoking	Brendryen & Kraft 2008	0.587	0.102	0.010	0.386	0.788	5.731	0.000
Smoking	Brendryen et al 2008	0.306	0.118	0.014	0.075	0.536	2.593	0.010
Smoking	Mavrot et al 2016	0.495	0.061	0.004	0.376	0.613	8.157	0.000
Smoking	Powell et al 2016	0.082	0.213	0.045	-0.335	0.499	0.386	0.699
Smoking		0.420	0.093	0.009	0.238	0.601	4.528	0.000



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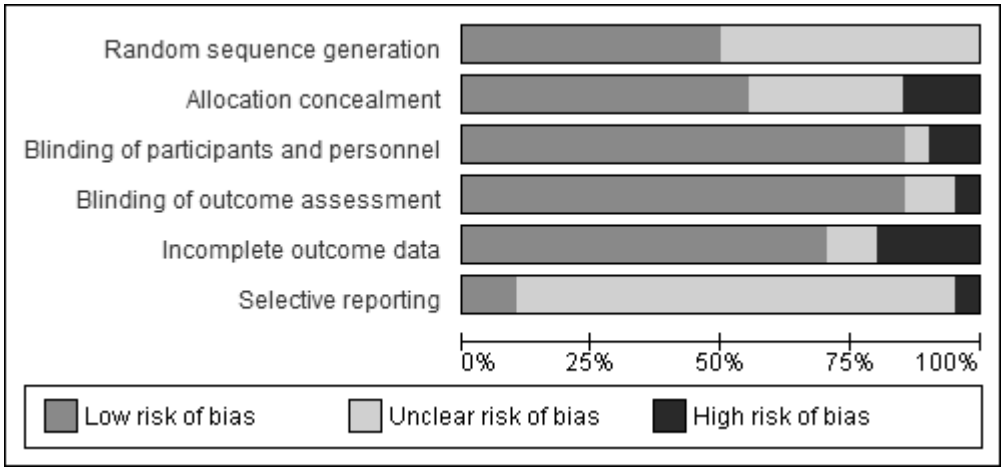
Supplemental material 9: Risk of bias plots of ratings by domain and by study

Risk of bias ratings by domain



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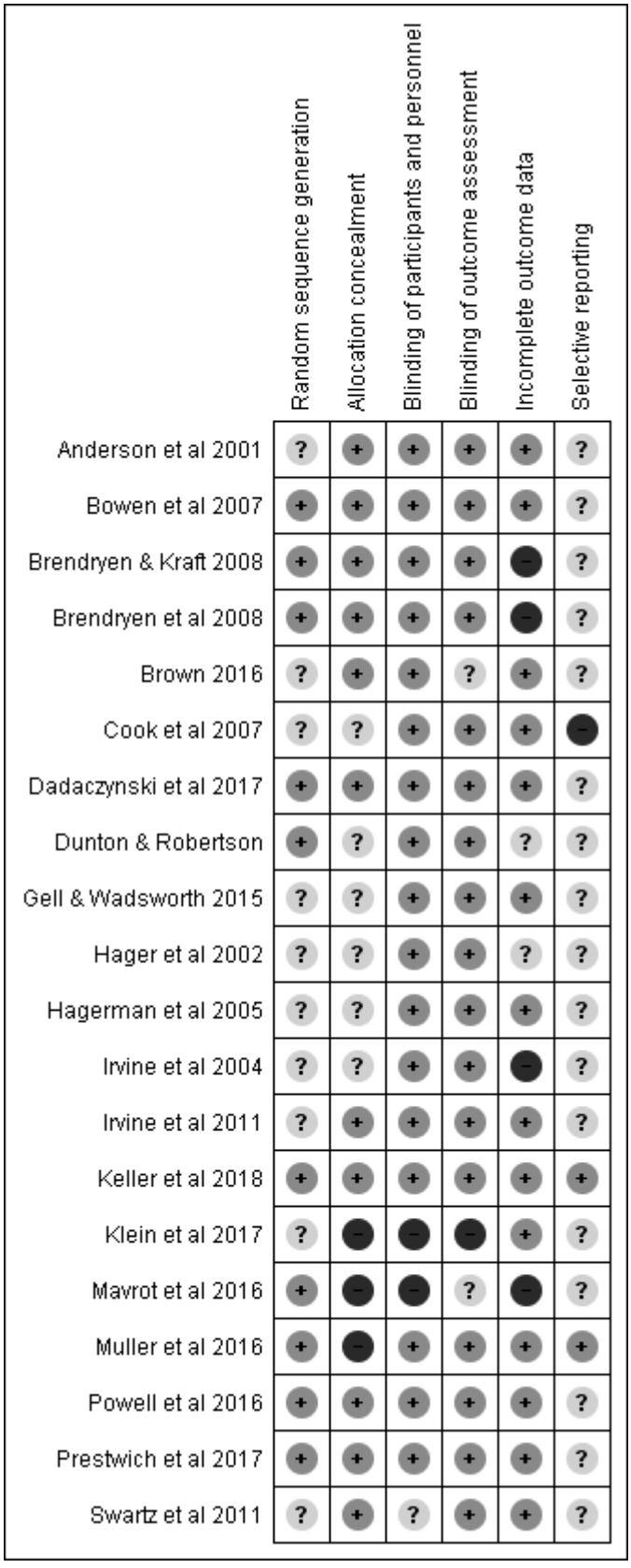
Risk of bias ratings by study



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 High risk of bias

 Low risk of bias

 Unclear risk of bias

Do automated digital health behaviour change interventions have a positive effect on self-efficacy? A systematic review and meta-analysis

Supplemental material 10: PRISMA Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4-7
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	7
METHODS			

Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	7
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	7-8
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	8
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Supplemental material 2
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	9-10
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	10-13
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	10-13

Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	13
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	13-14
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	13-14
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	14
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	14-15
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	10 (figure 1), 15-16
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	16-17, Supplemental

			material 4-7
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	18, supplemental material 9
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	17 (Figure 2)
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	17
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	18, supplemental material 9
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	17-18
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	18-19

Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	24-25
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	25-26
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	2

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