Using digital devices to help people lose weight: a systematic review

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Introduction

Background

The negative consequences of the global obesity epidemic are now well known (WHO 2018). In 2015, being grossly overweight or obese contributed to 4 million deaths globally, which represented 7.1% of the deaths from any cause (GBD 2015 Obesity Collaborators, 2017). Obesity and overweight are risk factors for an expanding set of severe chronic diseases. Furthermore, they contribute to economic and social harms as well as the difficulties experienced by overweight and obese people in their lives, such as discrimination associated with overweight across many life domains, such as the workplace, interpersonal relationships or transportation (Puhl, et al 2015).

Nevertheless, overweight and obesity often are preventable and can be reversible, mainly by changing and maintaining diet and physical activity behaviours that support attainment of a healthy weight. Social marketing is widely recognised as a credible behaviour change discipline (Rundle-Thiele, 2015), which has been used successfully to alleviate many health issues. This includes efforts to increase preventive behaviours such as healthy eating and physical activity (Carins & Rundle-Thiele, 2014; Gordon, McDermott et al., 2006; Truong, 2014; Xia, Deshpande et al., 2016). Social marketing aims to change behaviour to bring about individual and societal benefit, and although this aim is shared with many other behaviour change approaches, the strength that social marketing brings to the space comes from the marketing lens—a focus on delivering solutions that are valued by people (French & Russell-Bennett, 2015).

Social marketing is a dynamic and evolving field (French & Russell-Bennett, 2015), which continues to pursue innovation to enhance the delivery and effectiveness of its programs[1] (Kubacki & Rundle-Thiele, 2017; Rundle-Thiele, David et al., 2019; Wymer, 2011). This involves consideration of new technologies that have the potential to be effective, and acknowledgement that programs need to be delivered through modes that are aligned with contemporary daily life. Today's society has been characterised as the digital era, with almost universal daily use of digital technology. Incorporating digital technologies into social

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[1] In this paper, we use the terms "program" and "intervention" interchangeably

marketing programs offer effective ways to increase reach and engagement, delivering similar outcomes more cost-effectively (Cugelman, Thelwall et al., 2011). The use of digital technologies to engage people in weight loss many have many advantages for social marketers, including increasing customisation to better meet citizen's needs (citizen orientation), ensuring efficient delivery of targeted strategies to different groups (segmentation), delivering solutions at the right time and place (value proposition delivery), and quantifying one's efforts and results (behavioural goals) (Mehmet et al., 2019; Dibb, 2017). These advantages assist social marketers to more effectively design and deliver programs that continue to be aligned to the principles of social marketing (Andreasen, 2002; ESMA, 2017).

Digital devices have been used for weight management, including weight loss, since the end of the 20th century. This includes use in both nutritional public health settings and a rapidly growing market of commercial applications[2] available on smartphones since 2010. However, prior to building digital social marketing programs, or social marketing programs containing digital elements, there is a need to assess the efficiency of any digital programs focused on weight loss that have already been developed. Systematic reviews are a useful tool to assess what has been done, what works and what does not, in order to strengthen the means of fighting the obesity epidemic for public authorities. Previous reviews have begun to examine the use of digital technologies in social marketing, or more generally health behaviour change. Kubacki *et al.,* (2015) investigated social marketing interventions using digital technologies, finding few implemented social marketing to its fullest extent. Their review included interventions for any behaviour, and found only one intervention focussed on healthy eating. Their review stopped short of examining the effectiveness of those interventions, remaining focussed on how comprehensively social marketing could be deployed through a digital medium. A systematic review of eHealth interventions for weight management for young adults discovered a limited evidence base, and mixed findings for effectiveness with fewer than half of the interventions producing a positive outcome (Willmott *et al.,* 2019). This review identified self-regulation, feedback, contact with an interventionist, social support, and behavioral prompts were more commonly present in effective interventions. A similar review of eHealth interventions for young adults across many health behaviours, found some effect in the short-term, but insufficient evidence in the longer-term (Oosterveen *et al.,* 2017). A meta-analysis of web-

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[2] In this paper, we use the terms application and the concise form "App" interchangeably

based weight loss interventions for adults, also found greater short-term but not long-term weight loss than offline interventions (Beleigoli *et al.,* 2019). Their review acknowledged diversity among the digital interventions, which may or may not contribute to successful outcomes.

Whilst these reviews have provided some insights into the features and effectiveness of digital devices to support weight loss, they have either not examined effectiveness (Kubacki *et al.,* 2015), restricted their focus to you adults (Willmott *et al.,* 2019; Oosterveen *et al.,* 2017), or not attempted to determine which features of diverse digital interventions are likely to contribute to success. This review sought to address some of these gaps, by examining the effectiveness of digital weight loss interventions for adults, as well as the digital features that may contribute to successful behaviour change. This knowledge may help public authorities to develop social marketing interventions with and for adults to assist them to achieve and maintain a healthy weight.

Diet remains a key determinant of obesity although not the only factor involved (Hawkes et al, 2015). While numerous behavioural changes may be required to achieve and maintain a healthy weight, social marketing principles emphasise the setting of specific behavioural goals (ESMA, 2017), which may then necessitate development of different strategies for different behaviours, to be deployed concurrently or sequentially. According to some authors (Gill et al, 2005; Huong et al, 2009; Willmott et al, 2019) prevention is easier than cure when fighting the burden of overweight and obesity, and diet remains a preventive or protective factor. We therefore intend to focus on the assessment of publications mainly oriented towards a diet change.

Technology has become a cost-effective means of engaging people in losing weight (Krukowski et al., 2011) and an integral part of daily life. In this systematic literature review, we first sought to identify digital interventions that encourage weight loss, based on dietary change and sometimes accompanied by physical activity recommendations. To ensure we were reviewing robust evaluations of effectiveness, we sought evaluations that included a comparison group in the design. We sought to compare the effectiveness of the digital interventions, and then examined the different devices and features used, as well as the theoretical basis and behavioural change techniques incorporated in the weight loss programs. Our objective was to provide knowledge that will support the development of effective and efficient interventions by incorporating theoretical and operational inputs that have been used effectively in previously delivered digital programs.

Method

Search strategy

Using systematic review procedures, the literature was reviewed to examine healthy eating interventions coupled with digital devices over a fifteen-year period (2004 to 2018). Five databases (PubMed, Web of Science, Business Source Complete, Ebsco e-journals, and Science Direct) as well as Google Scholar were searched using a combination of terms (diet* or healthy eating or weight* AND connected devices or SMS or App* or web* AND intervention or campaign or program). Backward searching from reference lists and previous systematic literature reviews (SLR) and forward searching using author and study names were conducted to find other articles related to the studies discovered by the search.

Screening strategy

After duplicates were removed, the records were assessed for eligibility by two independent reviewers. When the same cohort had been used for multiple publications, the study presenting the results on the longest period was chosen. The full text of the remaining articles was then retrieved for further examination. At each stage, every disagreement was discussed and resolved between analysts.

Eligibility criteria

The eligibility criteria used in this review are as follows: (a) articles had to be peer-reviewed, (b) in English, (c) studies should be conducted among adult populations (not defined subpopulations, for example, mothers of young children), (d) include participants who were free from other acute illnesses or chronic disease[3], (e) be empirical studies and not theoretical research or literature reviews, (f) provide quantitative measures relating ***to weight loss or weight loss maintenance***.

In this systematic review, digital devices used to change behaviours included computers, tablets, mobile phones, portable and non-portable tracking devices. In order for studies to be

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[3] Treatment for some pathologies lead to medication-induced weight gain (Domecq, Prutsky et al., 2015), which may render dietary behavior change ineffective. As a result, we focused on overweight people who do not have any other medical problems.

selected in our review, digital devices needed to be the primary means of intervention delivery in at least one treatment group.

Studies were excluded on the basis of the following criteria: (a) not peer-reviewed, (b) not in English, (c) conducted on specific subpopulations, (d) included participants who were not healthy and free from acute illness or chronic disease, (e) not empirical, (f) did not provide quantitative measures relating to weight loss or weight loss maintenance. The number of excluded records, and reasons for exclusions, are reported in Figure 1.

Flowchart of the literature search process

Insert Figure 1. Around here

Figure 1: "PRISMA" flowchart of study selection process

Data extraction and management

A data extraction form based on the PRISMA[4] declaration was developed to extract the characteristics of the study (Liberati et al., 2009). The data extracted included the following: details of the study (author, year of publication and country), study design, participants (sample size, characteristics and retention rate), details of the intervention, and duration of the study, measurements, results and conclusions. Next, the authors thoroughly and independently reviewed the studies and resulting summary tables to determine their accuracy and relevance. All inconsistencies were resolved through discussion.

Sample of articles

As the primary objective of this review was to assess the efficiency of programs that used digital devices to help people lose weight, our review focused on studies that reported a quantitative assessment of the outcomes on weight loss. The selection of studies evaluating weight loss efficacy from 2004 to 2018 resulted in a sample of 15 articles, with all the selected articles reported in medical or health journals. To ensure our search had not missed digital social marketing interventions, were checked three other systematic reviews of similar scope. Carins and Rundle-Thiele (2014) examined 32 empirical interventions on eating behaviour

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[4] PRISMA: Preferred Reporting Items for Systematic reviews and Meta-Analyses

between 2000 and 2012 that were classified as social marketing by intervention authors (Carins and Rundle-Thiele, 2014). All 32 studies were outside the scope of this review: only 6 targeted adults, the remainder focussed on the elderly, children and college students. Of the 6 studies, only one referred to an online information intervention, with the only measure of that intervention being response rate to the campaign (Tettey, 2011). The review covered the period 2000-2012 which could explain the scarcity of studies using digital devices. Indeed, apart from experimental devices developed and tested in the medical field, the main digital devices used by consumers and observed by marketing researchers are smartphones, which have been in widespread use since 2010, which overlaps with the latter end of the Carins and Rundle-Thiele review (2014). We also examined the studies captured in the Kubacki (2015) review of social marketing interventions using digital technologies finding no nutrition or weight loss interventions. More recently, in their systematic review, Shawky et al. (2019) found four social marketing programs that aimed to change dietary behaviour using social media (Shawky et al, 2019). However, their review focused on social media, and did not meet our inclusion criteria regarding what was measured or who was targeted.

Data synthesis

The empirical studies were analysed to determine whether the authors presented evidence of weight loss or sustained weight loss for any program that included digital devices. It was soon evident that the studies varied greatly in the design employed, and the quantitative measures used, so a narrative approach to data analysis was used in this review. For systematic reviews to include quantitative meta-analyses to assess the extent of change in outcomes across primary studies, and to analyse the sources of variation between study results, summary studies must be accompanied by appropriate quantitative data (Gurevitch et al., 2018). With only 15 studies extracted from our systematic research, a meta-regression would not have the power to reliably detect modest associations (Hempel et al., 2013). In addition, a large degree of heterogeneity was apparent within the 15 studies (in terms of number of participants, experimental conditions, duration of the experiment and so on), making it impossible to calculate an effect size for a particular outcome. In such cases, it is considered more appropriate to undertake a systematic narrative review rather than a meta-analysis (Liberati et al., 2009). Systematic narrative reviews are useful for exploring the development of specific ideas to advance our knowledge of a particular field of research (Gurevitch et al., 2018).

Our narrative synthesis includes two aspects (a) intervention results in terms of weight loss and (b) digital components/features used, theoretical support, and behavioural change techniques embedded within the interventions. To facilitate the second aspect, we examined each intervention for the presence of theory and behaviour change techniques. Beyond noting if the authors referenced a theoretical framework, we analysed the level of use of theory they had based on the work of Michie and Prestwich (2010). The latter suggest calculating a theoretical score (TCS) by checking if reference is made to (a) underpinning theory, (b) targeting of relevant theoretical constructs, (c) use of theory to select recipients or tailor interventions, (d) measurement of theoretical constructs, (e) testing of mediation effects and (f) refining theory. This calculation has previously been used to identify the theoretical support within studies included in a systematic review (e.g. Webb et al., 2010, Garnett et al., 2018, Wilmott et al, 2019a). Using the Michie and Prestwich coding scheme (2010), two independent researchers calculated the theoretical score for each study to ensure the reliability of coding; with discrepancies solved through discussion. We also examined the studies to look for evidence of the 40 behaviour change techniques specified by Michie, Ashford et al. (2011). Study descriptions were not detailed enough to determine if some techniques were included in the intervention—but those that were described were recorded against each study.

Results

Description of the included studies

The 15 studies included in our review report statistically reliable results of digitally delivered or digitally supported weight loss programs. All studies were published in medical and health journals. The participants were overweight adults (mean size of the sample: 142 participants (SD=110.4) participating in studies for a mean duration of 32 weeks (SD=25.6)). Most studies were conducted in the USA, with one in Australia, one in Korea, one in Belgium and one in Finland.

Due to the rapid evolution of information technologies, the studies used various devices and various interaction software. Over the years the interventions moved from prompt messages (SMS, or Short Message Service) on mobile phones or development of specific websites for interventions, to the use of mobile applications (Apps), which corresponds to recent consumer practices. Devices used include personal computers (PC) (in six studies published between

2004 and 2012), mobile phones or smartphones (eleven studies) and a Personal Digital Assistant (PDA) (one study); two studies used both PCs and mobile phones. Interactions with the participants were managed through websites (six studies between 2004 and 2012), specific software for the PDA study (Burke et al., 2011), SMS (five studies between 2009 and 2013), social networks (Turner-McGrievy and Tate, 2011; Napolitano et al., 2013), or mobile applications (Apps) (six studies between 2010 and 2018). Earlier studies analysed both the acceptability of the connected programs and their efficacy (e.g. Campbell et al., 1994), whereas the most recent studies no longer determined the acceptability of technologies and just focussed on evaluating the effect on weight loss.

Each study was intrinsically interesting, but the specificities of each study did not allow a direct comparison between them. As presented in Table 1, the profiles of participants were variable, as were the technologies tested in the various studies and the duration of the studies. In order to provide useful information to improve the design of future interventions, the authors sought to provide two narratives, one relating to the lessons of the studies derived from examination of the effectiveness of the digital interventions, and the second analysing the delivery features, theoretical support, and behavioural techniques embedded within the interventions. These narratives underpinned some recommendations for future research.

Insert Table 1. around here

Table 1: Description of the studies included in the SLR

Overall effectiveness of interventions using digital devices for weight loss

The effectiveness of digital interventions aimed at weight loss was evaluated, and then consideration given to the use of theory, behaviour change techniques and other elements of the intervention (e.g. monitoring, feedback or social support) within the intervention. In general, the studies indicate that digital interventions can support weight loss for adults, with nine studies showing a significant difference between treatments, in favour of one (or more) intervention arm (Tate et al., 2006; Haapala et al., 2009; Shaw et al., 2013; Harvey-Berino et al., 2010; Patrick et al., 2009; Lee et al., 2010; Brindal et al., 2018; Napolitano et al., 2013; Hurkmans et al., 2018). The remaining six studies failed to find a significance difference

between treatments, but had used an active intervention as a comparison (for example an in-person or paper-based intervention) meaning it was possible that the digital intervention was as successful as the intervention used as the comparison (Brindal et al., 2018; Shapiro et al., 2012; Burke et al., 2011; Turner-McGrievy & Tate, 2011; Womble et al., 2004; Svetkey et al, 2015).

Digital devices were shown to support weight loss for overweight adults through automated counselling (Tate et al., 2006), web programs including personalised interactions (Haapala et al., 2009; Shaw et al., 2013), Internet chats (Harvey-Berino et al., 2010), personalised text messages (Patrick et al., 2009), mobile Apps (Hurkmans et al., 2018; Lee et al., 2010; Brindal et al., 2018), or Podcast interventions (Turner-McGrievy and Tate, 2011). Napolitano et al. (2013) failed to demonstrate the efficacy of a weight-loss intervention on Facebook targeting young adults (college students), however, another treatment arm using the same Facebook intervention combined with SMS prompts, feedback and social support was found to be effective.

When comparing the efficacy of digital intervention to traditional face-to-face / human counselling interventions the results were found to be mixed. Whereas most technological devices were shown to be relatively effective at helping with weight loss, some programs using a digital device were ineffective, or comparably effective to traditional interventions. Hurkmans et al. (2018) found a hybrid (digital and human) intervention to be more effective than digital-only or human-only interventions; whereas Svetkey et al. (2015) found no difference between an App, human coaching and information provision (control). Harvey-Berino et al. (2010) found in-person delivery more effective than internet and hybrid delivery; and Tate et al. (2006) found that automated counselling was similar to human counselling in the short term, but human counselling was more effective in the longer term. This finding is consistent with Mohr et al. (2011) who proposed that adherence and effectiveness of e-Health interventions based on digital devices are greatly increased when human intervention is integrated into the intervention.

Devices have evolved over time, however no study in this review attempted to compare the same program in different technological settings (App versus website, etc.). It appeared that one technology replaced another technology, and that over time the studies were trying to validate a new digital technology, interface or protocol. Some studies attempted to measure the additional effectiveness of a multi-technology device. However, neither the adding of text

messages to a website (Shapiro et al., 2012), nor using Twitter in combination with a podcast program (Turner-McGrievy and Tate, 2011), were found to increase the efficiency of the original digital intervention.

The mixed results above may be related to different theoretical approaches or underpinning, as suggested by Webb et al. (2010). Theoretical insights remain paramount to understand the complexity of consumer behavioural changes (Hekler et al., 2016, Willmott et al., 2019). Furthermore, Angus et al. (2013) suggest that interventions should be based on solid theories, and theory should also form the basis for evaluation. In the following paragraphs, we analyse the theoretical support of the studies, identifying the theory(s) mentioned and the level of use of the theoretical framework.

Behaviour change theories supporting digital interventions

In eight of the fifteen studies, the published article mentioned that a theoretical framework was used to develop the weight loss program (see Table 2, below). This represents around half of the studies; however, it does not necessarily indicate an absence of theory in any of the other studies—it may be that the authors did not explicitly report it in the article.

Table 2 below presents the theories reported in the articles in the review, the level of use of the theoretical framework (as reported), as well as a simplified statement of the results of each research project on the effectiveness of the weight loss devices tested. The last two columns present, respectively, the result of each treatment intervention ("WL observed": weight loss for one specific treatment) and the possible difference between the interventions ("Treatment differences). "No treatment difference" means that no statistically significant difference appears between the two (or three) treatments. When a difference appears between some of the treatments, this is described in detail.

Insert Table 2. around here

Table 2: Behaviour change theories and techniques, technical device and efficacy on weight loss

Of those weight loss interventions that clearly mentioned a theoretical reference, five were based on Bandura's Social Cognitive Theory or self-efficacy theory (Bandura, 1976; Bandura 1986; Bandura 1998). Other theoretical frameworks include a self-regulation model and

systems contingency approach, both also based on Bandura's work; the theory of planned behaviour (Ajzen, 1971) and the regulatory focus theory (Higgins, 1998). In our sample, studies claiming a theoretical framework did not show more positive results than studies that did not mention any framework.

When examining how well theory was embedded within each intervention, the vast majority of studies obtained an average score (between 10 and 16), compared to the maximum score of 28. Most studies focus on the effectiveness of new technologies without relating theory and technologies, which may explain why they do not reach a "strong" level of theory[5].

Research articles that referred to a theory often stated it was used as the framework to develop the intervention but did not state how it was used. Svetkey et al. (2015:2134) report that "*both interventions were designed by our research team based on Social Cognitive Theory and Transtheoretical Model*; and Shapiro et al. (2012:413) just state that "*the theoretical foundation (of the intervention) was social cognitive theory*". However, the vast majority of the studies did not report testing the theory or any of the variables highlighted in the theory. The exception was Shaw et al. (2013) who offered contributions based on the specific testing of theoretical variables on the behaviour of participants. Shaw et al. (2013) tested the effectiveness of text messages based on the Regulatory focus theory finding interventions based on the variables of focus within the theory (promotion and prevention) were more effective than neutral messages (Shaw et al., 2013).

Behaviour change techniques (BCTs) supporting digital interventions

As social scientists have pointed out, interventions to change behaviour are complex and involve various interacting components. Over time, psychology researchers have identified successful behaviour change techniques and researchers have proposed a list and taxonomy based on expert evaluations (Abraham and Michie, 2008; Michie et al. 2013). Behaviour change techniques are defined as observable, replicable and irreducible components of an intervention designed to alter or redirect causal processes that regulate behaviour (Michie et al., 2011). The articles did not contain sufficient detail to determine if some BCTs were used, or to determine discriminate between similar BCTs (for example, the first four BCTs in Michie's 2011 taxonomy concern information provision—of four different types of

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[5] The detailed calculation of theoretical level scores is available from the authors

information). The behaviour change techniques used in the studies in this review (as reported in the articles) included, in at least one intervention arm: information (all 15 studies); self-monitoring (15 studies); feed-back, (10 studies); social support (9 studies); goal setting (7 studies); prompts (7 studies); action planning or task setting (6 studies); rewards (2 studies) problem solving and relapse prevention (2 studies). Whilst this review does not attempt to establish the efficacy of BCTs (that has been established elsewhere) there are observations that can be made in reference to the use of some BCTs within a digital platform. The most commonly used BCTs are discussed in this light in the paragraphs below.

Traditional versus online monitoring

Self-monitoring of behaviour has been shown to be an effective technique to support behaviour change (Michie, Ashford et al., 2011), and traditional weight loss programs are based, to varying degrees, on individual coaching and remote self-assessment of participants' eating behaviour. This self-assessment, traditionally carried out on paper forms returned to the program organizers, can be replaced by the participant entering the information on digital devices, moving from remote reporting on paper to remote online reporting. All studies in this review involved self-monitoring in one or more intervention arms. Self-monitoring was included in the intervention arm(s) that were found to be effective compared to information only comparisons (Patrick et al., 2009), or no treatment controls (Haapala et al., 2009; Lee et al., 2010); and also in studies finding no difference between interventions and information-only comparison (Brindal et al., 2018; Shapiro et al., 2012; Svetkey et al, 2015). Most of these were interventions containing multiple BCTs. However, two studies directly analysed the impact of replacing remote reporting on paper with remote online reporting. Womble et al. (2004) compared a paper and pencil intervention versus a website device, Burke et al. (2011) compared a PDA intervention with a paper and pencil one; both confirmed that the digital device was as effective as the traditional paper and pencil method. Compared to the traditional paper diary recording, digital devices offered enhanced practicality, whether in the form of a website or a mobile PDA, and these studies indicated that this self-monitoring was executed just as effectively on a digital platform.

Traditional versus digital feedback

Feedback has been an essential element of theories of learning and instruction (Mory, 2004). The feedback technique is also a major instrument for changing health behavior (Brug et al.,

1998; di Clemente et al., 2001). Ten studies included feedback in one or more intervention arms. Feedback was also present in the intervention arm(s) of effective interventions (Patrick et al., 2009; Hurkmans et al., 2018), and in those found to be no different to controls (Brindal et al., 2018; Svetkey et al, 2015; Burke et al., 2011; Womble et al., 2004). Again, most of these were interventions containing multiple BCTs. Napolitano et al. (2013) compared Facebook interventions (one with information and social interaction/support, the other with feedback added alongside other BCTs) finding the enhanced Facebook intervention to be more successful than the information-based version and the no treatment control. On the other hand, Tate et al. (2006) compared digital and non-digital feedback directly in the form of automated counselling and human counselling, finding both effective, but human counselling more effective in the longer term. These studies suggest that feedback provided through a digital platform may contribute to effectiveness, but there are elements of human feedback that may not easily translate to a digital platform.

Traditional versus digital social support

Social support has been shown to play an important role in changing social norms related to obesity and enhancing weight-loss outcomes (Leahey et al., 2011; Wing and Jeffery, 1999). Today, information technologies have completely changed social networking, and social network sites are hugely successful, Facebook being an emblematic case of this phenomenon. Nine studies included feedback in one or more intervention arms. Several researchers have tried to provide social support on digital devices. Seeking to reproduce the social support provided to participants in classical weight loss programs within a digital environment, Turner-McGrievy and Tate (2011) tested the added value of interactions on the Twitter social network. In a 4-month period, this interactive method did not increase the efficacy of a simple Podcast weight loss intervention. As mentioned above, Napolitano et al. (2013) used Facebook in a weight loss intervention for college students, finding the enhanced Facebook intervention more successful than the simpler version and the no treatment control. Within this enhanced Facebook intervention they provided a buddy for personal support, demonstrating that social support provided through digital means can contribute to success.

Participant interaction with digital interventions

Interventions delivered through digital devices have the ability to deliver high reach with low cost (Cugelman, Thelwall et al., 2011). However, to enable behaviour change this requires

effective participant interaction. Some studies measured aspects of participant interaction. Shaw et al. (2013) measured the acceptability of a SMS delivered intervention, with users finding it useful, and beneficial. Overall, participants reported favourable reactions to the digital communication medium. Lee et al. (2010) tested a gamified smartphone App, finding effective, but also finding users were satisfied with the App, reporting it was useful, easy and interesting. Importantly, Lin et al. (2018) showed that engagement increases the intervention efficacy. More specifically, engagement – measured in their study as the frequency of participants' use of various intervention components of the weight loss program – was correlated to weight loss in the personal coaching program as well as in the digital weight loss program for the first six months. This finding is supported by other studies conducted retrospectively (Johnson and Wardle, 2011; Serrano et al., 2016). In particular, Johnson and Wardle (2011) analysed the logs of 3,621 users of a commercial weight loss application; they show that engagement is positively correlated to declared weight loss.

Discussion

Social marketing, as a constantly evolving field of research and application, regularly adopts and integrates new technology into practice. Digital technology has become part of everyday life and has been incorporated into social marketing programs across a number of behavioural contexts. This systematic review aimed to examine whether interventions delivered through digital technology are effective in weight loss or weight management, and then to further examine aspects of those digital interventions. The fifteen studies identified in this SLR were conducted by teams of researchers from the fields of medicine, nutrition and clinical psychology, rather than specifically in social marketing. The evaluations found some evidence that digital interventions can support weight loss for adults, finding digital interventions to be more effective in some cases, or as effective as in other cases in comparison to interventions using traditional methods.

Weight loss interventions and theoretical frameworks

Evidence for the effectiveness of interventions based on theories of behaviour change has been emphasized by various authors (Albarracin et al., 2005; Angus et al., 2013). In this review, only half of the interventions mentioned theory, and strength of theory integration was generally low. There is a general agreement in social science on the importance of integrating

a theoretical framework to evaluate the effectiveness of programs addressing health behavioural changes. However, this review highlights a potential weakness of the medically-based research on digital weight loss interventions that has been conducted to date in relation to theory testing. It appears that when working with new digital devices, researchers in the medical world do not integrate the theory any more than the developers of commercial applications (West et al., 2013). It therefore remains important for any developer of digital interventions to embed a relevant theoretical framework to increase the likelihood of behaviour change and digital devices appropriation. Equally, it is important to take medical evidence into account, which is particularly noticeable when researchers compare the effectiveness of traditional evidence-based programs and commercial applications on smartphones. For example, when comparing a commercial website and a therapist-led program on the Internet, Gold et al. (2007) expressed concern about the poor results of the commercial program and about the lack of consideration of the results of medical studies by commercial program developers. Rivera and colleagues also make this point, having reviewed 393 mobile apps for weight loss and weight management, showing that these apps generally lack *important evidence-based features, do not include health care experts in their development process and have not undergone rigorous scientific testing* (Rivera et al., 2016).

Behaviour change techniques (BCT) are another important element for researchers and developers to consider in the construction of interventions. However, without a theoretical basis, even the abundant literature on behaviour change techniques may be insufficient to design an intervention for a new situation (Foy et al., 2005). The integration of behaviour change techniques is considered a positive factor for the effectiveness of health programs; however, they should not be considered to be mere substitutes for the theories that underlie them. Some authors have noted that the inclusion of too few BCTs in digital interventions may render them ineffective, whereas too many may be confusing and counterproductive (Cugelman, Thelwall et al., 2011).

Limitations and future research avenues for social marketing

The objective of our research was to provide a comprehensive assessment of the efficacy of previously developed digital programs focused on weight loss, to provide knowledge that may assist others when building social marketing programs with and for overweight adults at a

community or national level. This review is limited by a small pool of studies, and therefore conclusions must be treated with caution. This limited evidence base, along with the lack of digital weight loss interventions captured in other reviews (Carins & Rundle-Thiele, 2014; Kubacki, Rundle-Thiele et al., 2015) suggests there is a need for more studies to comprehensively test the effectiveness of such interventions. We limited our review to articles whose authors reported controlled weight loss results in relation to interventions at least partially supported by digital devices. This led our systematic review to focus on research in the medical field. This focus presents two limitations that should be noted. First, a publication bias has been particularly highlighted in the medical field (Guyatt, et al., 2011) as well as its possible impacts (Schmucker et al., 2017). While it seems unlikely that properly conducted studies could have led to negative results (weight gain), it is likely that a publication bias may have favored the publication of positive results (versus non conclusive results). Changing this state of affairs is beyond the reach of any review, but it is important that the limitation be mentioned, and the calls for publication standards to mitigate this bias to be reiterated (Kittelman et al., 2018). Second, the medical articles in this review only provide partial information on the theoretical frameworks used for the development of the digital interventions, and therefore do not enable theory-based recommendations. This may be a limitation of the reporting within the studies articles included in this review, or it may be an indication of a low level of theory use.

Research avenues

There is a general agreement in social science on the importance of integrating a theoretical framework to develop and evaluate programs addressing health behavioural changes. Given the importance of theory in behaviour change (Rundle-Thiele, David et al., 2019), we suggest future studies should embed strong theory within the intervention, and compare digital versions against both traditional delivery modes and no treatment controls to rigorously test efficacy. This review also highlights the importance of adopting a rigorous methodology when reporting social marketing interventions. Many interventions were not included in this review because they did not provide complete or quantitative data on the results. Developing and utilising strong evaluation methodologies will assist social marketers to demonstrate the efficacy of their discipline.

Implications for practice and public policy

Some studies in this review found digital intervention to be effective (compared to a control), but versions supplemented with human elements to be even more effective. One of the recognised advantages of digital programs is the potential to extend reach at low cost. Therefore, developing interventions that combine digital elements within traditional programs may reduce the cost of individualized programs, but retain some advantages, such as the human touch, of traditional programs. Given their low cost and the size of the overweight population, it appears that public policies should integrate these digital technologies more strongly in their efforts to combat obesity. Others have noted that digital technologies are increasingly used in social marketing to augment programs rather than completely replace traditional forms (Kubacki, Rundle-Thiele et al., 2015), which suggests that combined modes are a promising avenue for future research. The use of digital devices also appears promising because it offers advantages for creating targeted and segmented intervention programs. Research has shown that programs that include different strategies designed for different segments can offer solutions that are more closely aligned to needs and wants of each segment, and may improve outcomes (Dietrich, Rundle-Thiele, et al., 2015). Algorithms make it possible to program personalized elements based on the existing data of the participants, which suggests that digital applications may be important for segmented programs.

Implications for interactions with consumers

Social marketing has long recognised the importance of a strong consumer orientation, and increasingly the need to co-create programs with users (Dietrich, Rundle-Thiele et al., 2016). It was rare for studies in this review to include consumers in the creation of programs. With the exception of Patrick et al. (2009), researchers did not report that consumers participated in the creation of the program. Yet, a rich literature indicates that customer involvement reinforces the perceived quality of service (e.g. Bitner et al., 1997). As noted by Prahalad and Ramaswamy, "the interaction between the (organization) and the consumer is becoming the locus of value creation and value extraction" (Prahalad and Ramaswamy, 2004:5). The co-creation of digitally-based or digitally-supported programs thus seems to be a promising way to improve the proposed programs. Along the same lines, the use of social media, as shown by Shawky et al (2019) is likely to be a promising way to build engagement with the desired behavioural change.

Conclusion

Social marketing continues to evolve and pursue innovation to enhance the delivery of programs (French & Russell-Bennett, 2015; Kubacki & Rundle-Thiele, 2017; Rundle-Thiele, David et al., 2019; Wymer, 2011). Underpinned by principles that include consumer orientation, and value delivery (Andreasen, 2002; French & Russell-Bennett, 2015), social marketing requires an understanding of the contemporary life of consumers, and the production of solutions that people will value. Given the digital nature of today's society both are likely to involve digital technology. Incorporating digital technologies into social marketing programs offer effective ways to increase reach and engagement, delivering similar outcomes more cost-effectively (Cugelman, Thelwall et al., 2011). This review indicates the potential for digital interventions to encourage weight loss and weight management, and emphasises the need for further research to rigorously develop and test digital interventions in this behavioural context. Future social marketing programs can employ digital technologies to increase program reach and efficiency, but also to enhance the value users ascribe to the program by co-creating digital programs with users, and by taking advantage of the nature of digital platforms to deliver elements that users want and need at convenient and appropriate times.

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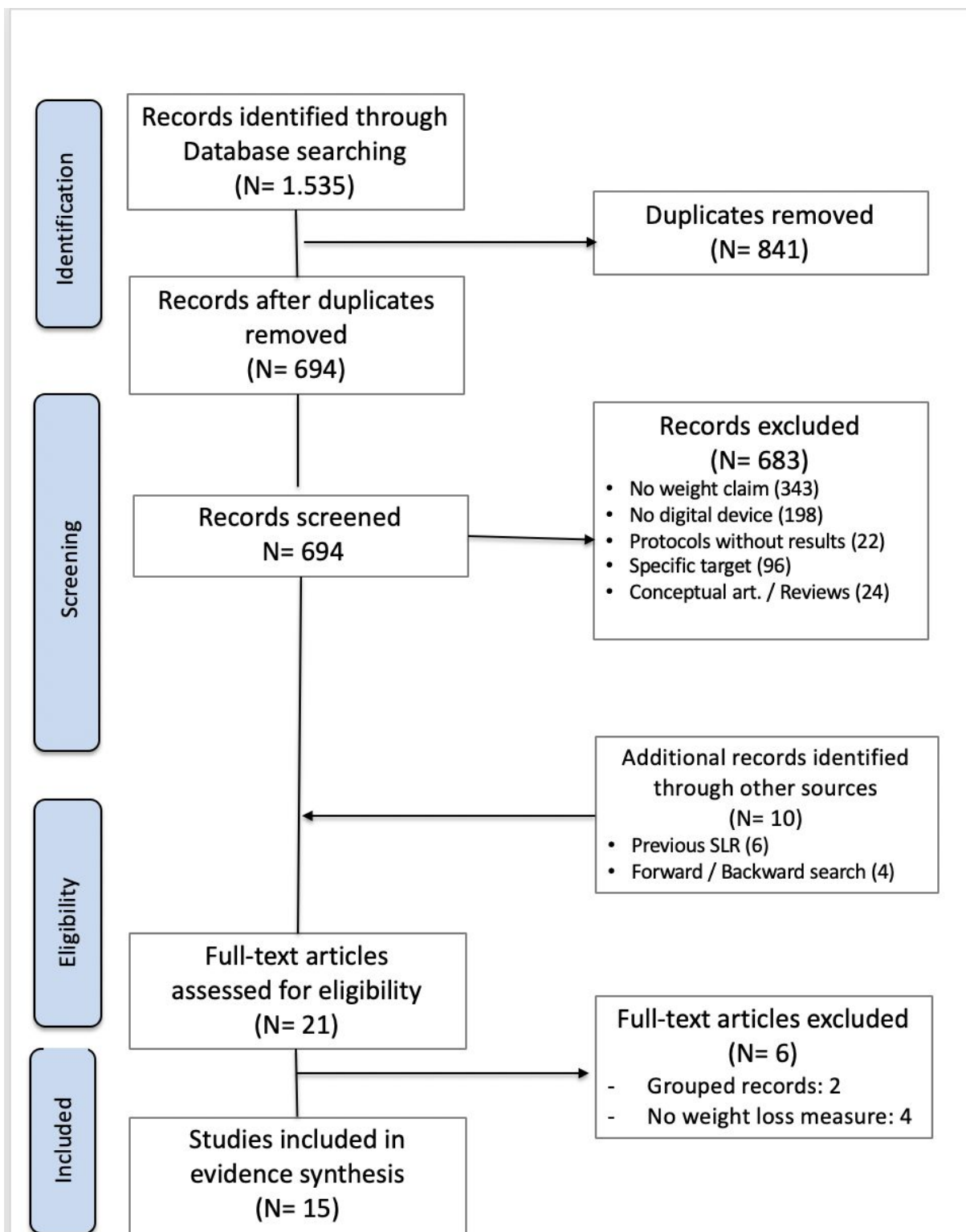Figure 1_PRISMA Flowchart of study selection process

Table 1_Description of the studies included in the SLR

Studies 2018-2004	Sample & duration	Study Objective(s)	Behavioural Objective	Intervention Treatments	Findings
Brindal *et al.,* 2018 *JMIR*	146 overweight adults AUSTRALIA 24 weeks	Evaluate efficacy of two mobile Apps RCT[1] (2 groups) • Supportive App • Static App	WL through partial meal replacement	Supportive: Tools to support behaviour change and monitor progress and compliance with behavioural objectives Static: Information only	• WL for both Supportive (6.7%) and Static (5.4%) groups at 6 months. • No sig. difference in mean WL for Supportive App compared to Static App at 6 months. • No sig. difference between groups in number of people achieving clinically meaningful (>5%) WL (exact proportions not reported)
Hurkmans *et al.,* 2018 *JMIR*	63 overweight adults 18-65 yrs BELGIUM 12 weeks	Evaluate efficacy of mobile App compared to conventional (in-person delivery) RCT (4 groups) • App • Conventional • Combined • Control	WL through diet and PA	App: Digital diet & PA advice and tools to support behaviour change and option for social support Conventional: Personalised plan and coaching sessions Combined: Digital diet & PA advice and tools to support behaviour change and option for social support **PLUS** Personalised plan and half number conventional coaching sessions Control: waitlist (nothing provided)	• Absolute WL (or % WL) for each group not reported • Sig. more participants in all 3 intervention groups had clinically meaningful (>5%) WL compared to Control group (numbers not reported) • Combined group had higher number of people with >5% WL, and decreased BMI, compared to App group (but not Conventional group). No sig. diff. between the Conventional group and App group for people >5% WL, and decreased BMI. (Exact proportions within each group not reported).
Svetkey *et al.,* 2015 *Obesity* Lin, Grambov *et al.,* 2018 *JMIR*	207 overweight adults USA 104 weeks	Evaluate efficacy of mobile App compared to conventional (in-person delivery) RCT (3 groups) • App • Coaching • Control	WL through moderate calorie restriction, healthy dietary pattern, moderate PA, limited alcohol	App: Tools to set goals, manage behaviours and monitor progress. Included prompts and social support (buddy) Coaching: Six weekly sessions with coach and monthly calls (social support). App used to self-monitor progress, which is fed through to coach Control: Diet and exercise handouts	• WL for App group: 0.87kg (6m), 1.48kg (12m) & 0.99kg (24m); Coaching group: 3.07kg (6m) 3.58kg (12m) & 2.45kg (24m); Control: 1.14kg (6m), 2.25kg (12m) & 1.44kg (24m). • No sig. differences in mean WL between groups at 24 months. • App group did not differ from Control at any measurement point (6, 12 & 24 months); Coaching group lost sig. more weight than Control at 6 months, but not at 12 and 24 months. • Percentage of participants with clinically meaningful (>5%) WL at 24m did not differ between groups (App=25.5%, Coaching=27.5%, and Control=22.0%). • Engagement is correlated to WL for both interventions at 6m; engagement correlated to WL in Coaching group at 12m (but not in App group).

[1] RCT: randomized controlled trial

Studies 2018-2004	Sample & duration	Study Objective(s)	Behavioural Objective	Intervention Treatments	Findings
Napolitano et al., 2013 *Obesity*	52 college students USA 8 weeks	Evaluate efficacy of <u>Facebook</u>-based program RCT (3 groups) • Facebook • Facebook *Plus* • Control	WL through calorie control, moderate PA	<u>Facebook</u>: Private Facebook group with handouts and podcasts and invitation to healthy activity and eating events. <u>Facebook *Plus*</u>: Private Facebook group with handouts and podcasts and invitation to healthy activity and eating events *Plus* Daily SMS and feedback and social support <u>Control:</u> waitlist (nothing provided)	• WL for Facebook group: 0.46kg (4w), 0.63kg (8w); Facebook Plus group: 1.7kg (4w), 2.4kg (8w); and Control group: 0.28kg (4w), 0.24kg (8w). • Facebook Plus group had sig. greater weight loss than Facebook and Control groups at 2 months. No sig diff between Facebook and Control groups at 2 months. • (Proportion of participants achieving clinically meaningful WL (>5%) not reported).
Shaw et al., 2013 *Am J Med* **Shaw et al., 2013** *JMIR*	120 overweight adults USA 12 weeks	Evaluate efficacy of different types of <u>SMS</u> messages RCT (3 groups) • Promotion • Prevention • Control	WL through regular PA, low-calorie healthy diet, and monitoring body weight	<u>Promotion</u>: Messages framed on promotion success (rewarding oneself) <u>Prevention</u>: Messages based on preventing failure (avoid temptation) <u>Control:</u> General health messages	• WL for Promotion group: 14.6 lbs (3m); Prevention group: 15.3 lbs (3m); Control:9.7 lbs (3m) • Sustained WL occurred in all groups, with no sig. diff between groups at 1 month or 3 months. • A priori pairwise comparisons found greater sustained WL in the prevention group than control at 3 months, but no difference between other pairs (prevention vs promotion; promotion vs control). • (Proportion of participants achieving clinically meaningful WL (>5%) not reported).
Shapiro et al., 2012 *Prev Med*	170 overweight adults USA 52 weeks	Evaluate the efficacy of <u>SMS</u> messages RCT (2 groups) • SMS • Control	WL through self-monitoring of diet and exercise	<u>SMS</u>: Daily SMS/MMS messages to provide information, tips, reinforcement <u>Control</u>: only monthly emails	• WL for SMS group: 3.72 lb (6m) 3.64 lb (12m); Control: 1.53 lb (6m) 2.27 lb (12m) • No sig. difference in mean WL between SMS and control at 12 months. Participants with greater adherence (higher response rate to self-monitoring requests) had greater WL at 6 and 12 months. • (Proportion of participants achieving clinically meaningful WL (>5%) not reported).
Burke et al., 2011 *Am J Prev Med*	210 overweight adults USA 24 weeks	Evaluate the efficacy of <u>PDA</u> program RCT (3 groups) • PDA • PDA *Plus* • Paper	WL through self-monitoring of diet and exercise	<u>PDA:</u> PDA equipped with self-monitoring tools and weekly message <u>PDA *Plus*</u>: PDA equipped with self-monitoring tools and weekly message **PLUS** algorithm to provide daily tailored feedback messages <u>Paper:</u> paper diaries	• WL for PDA group: 5.5%; PDA Plus group: 7.3%; Paper: 5.3% • No sig. diff between groups • A higher proportion of PDA+ participants (63%) achieved ≥5% WL compared to PDA (49%) and Paper (46%) groups. • Higher adherence to self-monitoring was observed in both PDA groups versus Paper group.

Studies 2018-2004	Sample & duration	Study Objective(s)	Behavioural Objective	Intervention Treatments	Findings
Turner-McGrievy and Tate, 2011 *JMIR*	96 overweight adults USA 24 weeks	Evaluate efficacy of Podcast programs RCT (2 groups) • Podcast • Podcast + App	WL through calorie reduction and increased PA	Podcast: Access to website containing podcasts Podcast + App: Podcast features + monitoring application + interaction with counselor and other participants on Twitter	• WL for Podcast group: 2.3kg (3m), 2.6kg (6m); Podcast + App group: 2.4kg (3m), 2.6kg (6m). • No sig. diff. in mean WL between groups at 6 months. • (Proportion of participants achieving clinically meaningful WL (>5%) not reported)
Lee W, et al., 2010 *J Telemed Telecare*	36 overweight adults KOREA 6 weeks	Evaluate efficacy of mobile App Case-control trial (2 groups) • Gamification • Control	WL through calorie control and exercise	Gamification: Personalised information, monitoring and gamification Control: nothing provided	• WL in Gamification group (1.9kg; 3.2%) compared to Control (0.5kg; 0.85%) at 6 weeks. • Sig greater mean WL in Gamification group. • (Proportion of participants achieving clinically meaningful WL (>5%) not reported).
Harvey-Berino et al., 2010 *Prev Med*	480 overweight adults USA 26 weeks	Evaluate efficacy of an Internet-based program RCT (3 groups) • Internet • In-person • Hybrid	WL through calorie restriction and exercise	Internet: All components delivered through the internet In-person: Delivered in person Hybrid: Weekly alternating in-person and Internet	• WL for In-person group (8kg); Internet group (6kg) hybrid group (6kg) at 6 months • Mean WL for In-person group sig. greater than Internet or hybrid groups. • No sig. diff. between groups for proportion achieving clinically meaningful WL (>5%) (In-person=65%; hybrid=59%; Internet=53%). • Higher proportion achieving greater than clinically meaningful WL (>7%), for In-person group compared to Internet (but not Hybrid). No sig. diff between Internet and Hybrid on this measure. • No sig. diff. between groups in adherence. • Sig. higher perceived social support for In-person group compared to Internet (but not Hybrid). No sig. diff between Internet and Hybrid on this measure.
Haapala et al., 2009 *Public Health Nutr*	125 overweight adults FINLAND 52 weeks	Evaluate efficacy of a mobile phone based program RCT (2 groups) • Intervention • Control	WL through self-directed diet and exercise modification	Intervention: Support program for self-directed dieters. Self-reporting of intake, PA and weight produced automatic tailored SMS Control: waitlist (nothing provided)	• WL in Intervention group (4.5kg); Control (1.1kg) at 12 months. • Sig. greater mean WL in Intervention group compared to Control • The percentage achieving clinically meaningful (>5%) WL was 45% in the Intervention group and 20% in the control group.

Studies 2018-2004	Sample & duration	Study Objective(s)	Behavioural Objective	Intervention Treatments	Findings
Patrick *et al.,* **2009** *J Med Internet Res*	65 overweight adults USA 16 weeks	Evaluate the efficacy of <u>SMS</u> messages RCT (2 groups) • Intervention • Comparison	WL through self-monitoring of diet and exercise	<u>Intervention:</u> Personalised SMS and MMS (2-5 day), brief monthly phone call from health counsellor <u>Comparison:</u> Monthly print materials	• WL in Intervention group (2.9kg; 3.2%); Comparison (0.9kg; 1%) at 4 months. • Sig. greater mean WL in Intervention group compared to comparison • (Proportion of participants achieving clinically meaningful WL (>5%) not reported).
Gold *et al.,* **2007** *Obesity*	125 overweight adults USA 48 weeks	Evaluate efficacy of <u>online</u> programs RCT (2 groups) • Vtrim • eDiets.com	WL through modification of diet and exercise	<u>Vtrim:</u> Therapist-led structured online program with weekly chat with therapist <u>eDiets.com:</u> Self-help commercial online program	• WL in VTrim group (7.3kg); eDiets.com group (3.6kg) at 6 months (results for completers) • Sig. greater mean WL in VTrim group than eDiets.com group. • VTrim group maintained a sig higher mean WL (5.5kg) compared to eDiets.com group (2.8kg) at 12 months (results for completers). • Sig. more participants achieved clinically meaningful (>5%) WL in the VTrim group (65%) compared to eDiets.com group (37.5%) at 12 months.
Tate *et al.,* **2006** *Arch Int Med*	193 overweight adults USA 26 weeks	Evaluate efficacy of <u>computer-tailored</u> counselling RCT (3 groups) • HC • AC • Control	WL through calorie restricted diet, meal replacement and exercise	<u>HC (Human counselling):</u> access to an electronic diary and message board + weekly e-mail feedback from a counsellor <u>AC (Automated counselling):</u> access to an electronic diary and message board + automated, tailored messages <u>Control:</u> no feedback	• WL for AC group: 5.3kg (3m), 7.3kg (6m); HC group: 6.1kg (3m), 4.9kg (6m); Control: 2.8kg (3m), 2.6kg (6m) (results for completers). • Sig. greater WL in AC and HC groups compared to Control. No sig. diff. between AC and HC group at 3 months. • Sig. greater WL by completers in HC compared to AC group and Control at 6 months. • Sig. more participants achieved clinically meaningful (>5%) WL in the HC group (52%) compared to the Control group (27%) at 6 months. The AC group (34%) did not differ from the other groups.
Womble *et al.,* **2004** *Obesity*	48 overweight women USA 52 weeks	Evaluate efficacy of <u>online</u> program RCT (2 groups) • eDiets.com • Paper	WL through modification of diet and exercise	<u>eDiets.com:</u> Self-help commercial online program <u>Paper:</u> Lesson book for modifying eating, activity (16 lessons)	• WL for eDiets.com group 0.7kg (0.9%) at 16w; 0.8kg (1.1%) at 52w; paper group 3.0kg (3.6%) at 16w; 3.3kg (4.0%) at 52w • Differences in mean WL between eDiets.com group and paper group at 16w and 52w were found not to be significant when conducted using completers only. • (Proportion of participants achieving clinically meaningful WL (>5%) not reported).

Table 2_Behaviour change theories and techniques, technical device and efficacy on weight loss

Studies 2018-2004	Theory / model mentioned	Strength of theoretical use	Intervention Treatments	Reported Behaviour Change Techniques	Digital Delivery Features	WL Observed	Treatment Differences
Brindal *et al.*, 2018 *JMIR*	Theory of Planned Behavior	13	Supportive App	Information Goal setting Prompts Rewards Self-monitoring Feedback	Digital Smartphone App (with gamification)	YES	No difference
			Static App	Information	Digital Smartphone App	YES	No difference
Hurkmans *et al.*, 2018 *JMIR*	*No theory mentioned*	5	App	Information Goal setting Self-monitoring Social support	Digital Smartphone App	YES	Not different from Conventional Greater WL than Control
			Conventional	Information Action planning/Tasks Self-monitoring Feedback Social support	Not Digital (in-person) NIL	YES	Not different from App Greater WL than Control
			Combined	Information Goal setting Action planning/Tasks Self-monitoring Feedback Social support	Hybrid Digital (Part in-person) Smartphone App	YES	**Greater WL than App** Not different from Conventional Greater WL than Control
			Control	NIL	NIL	NO	Less WL than treatment groups
Svetkey *et al.*, 2015 *Obesity* **Lin, Grambov *et al.*, 2018** *JMIR*	Social Cognitive Theory (SCT)	10	App	Information Goal setting Action planning/Tasks Prompts Self-monitoring Feedback Social support	Digital Smartphone App	YES	No difference (24 months)

Studies 2018-2004	Theory / model mentioned	Strength of theoretical use	Intervention Treatments	Reported Behaviour Change Techniques	Digital Delivery Features	WL Observed	Treatment Differences
			Coaching	Information Goal setting Action planning/Tasks Prompts Self-monitoring Feedback Social support	Limited Digital (in-person with limited features App)	YES	No difference (24 months)
			Control	Information	NIL	YES	No difference (24 months)
Napolitano *et al.,* 2013 *Obesity*	*No theory mentioned*	7	Facebook	Information Social support	Digital Facebook	YES	Not diff to Control
			Facebook *Plus*	Information Goal setting Prompts Self-monitoring Feedback Social support	Digital Facebook + SMS	YES	**Greater WL than Facebook and Control groups**
			Control	NIL	NIL	NO	Not diff to Facebook
Shaw *et al.,* 2013 *Am J Med* Shaw *et al.,* 2013 *JMIR*	Regulatory Focus Theory	22	Promotion	Information Action planning/Tasks Rewards Self-monitoring	Digital SMS (daily)	YES	Not different from control (3 months)
			Prevention	Information Action planning/Tasks Self-monitoring	Digital SMS (daily)	YES	Greater sustained WL than control (3 months) Not different from prevention
			Control	Information	Digital SMS (daily)	YES	Not different from promotion
Shapiro *et al.,* 2012 *Prev Med*	Social Cognitive Theory (SCT)	10	SMS	Information Goal setting Action planning/Tasks Prompts Self-monitoring	Digital SMS/MMS + website	YES	No difference
			Control	Information	Digital Email	YES	No difference

Studies 2018-2004	Theory / model mentioned	Strength of theoretical use	Intervention Treatments	Reported Behaviour Change Techniques	Digital Delivery Features	WL Observed	Treatment Differences
Burke *et al.,* 2011 *Am J Prev Med*	Social Cognitive Theory (SCT) Self-regulation model	11	PDA	Information Goal setting Self-monitoring Feedback	Digital PDA (self-monitoring software)	YES	No difference
			PDA *Plus*	Information Goal setting Self-monitoring Feedback (tailored)	Digital PDA (self-monitoring software)	YES	No difference
			Paper	Information Goal setting Self-monitoring Feedback Social support	Not Digital (in-person)	YES	No difference
Turner-McGrievy and Tate, 2011 *JMIR*	Social Cognitive Theory (SCT)	13	Podcast	Information Self-monitoring (paper)	Digital Podcast website	YES	No difference
			Podcast + App	Information Self-monitoring (app) Social support	Digital Podcast website + App + Twitter	YES	No difference
Lee W, *et al.,* 2010 *J Telemed Telecare*	*No theory mentioned*	2	Gamification	Information Self-monitoring	Digital Smartphone App (with gamification)	YES	**More WL than Control**
			Control	NIL	NIL	NO	Less WL than Gamification
Harvey-Berino *et al.,* 2010 *Prev Med*	*No theory mentioned*	10	Internet	Information Self-monitoring Social support	Website	YES	Less WL than In-person Not different from hybrid group
			In-person	Information Self-monitoring Social support	Not Digital (in-person)	YES	**More WL than Internet or hybrid groups**

Studies 2018-2004	Theory / model mentioned	Strength of theoretical use	Intervention Treatments	Reported Behaviour Change Techniques	Digital Delivery Features	WL Observed	Treatment Differences
			Hybrid	Information Self-monitoring Social support	Hybrid Digital (Part in-person) Website	YES	Less WL than In-person Not different from Internet group
Haapala *et al.*, 2009 *Public Health Nutr*	Systems contingency approach Self-efficacy theory	16	Intervention	Information Prompts Self-monitoring Feedback	Digital SMS + website	YES	**Greater WL than control**
			Control	NIL	NIL	YES	Less WL than Intervention
Patrick *et al.*, 2009 *J Med Internet Res*	*No theory mentioned*	10	Intervention	Information Goal setting Action planning/Tasks Prompts Self-monitoring Feedback	Digital SMS	YES	**Greater WL than comparison**
			Comparison	Information	NIL	YES	Less WL than Intervention
Gold *et al.*, 2007 *Obesity*	*No theory mentioned*	9	Vtrim	Information Action planning/Tasks Self-monitoring Feedback Social support	Digital Website	YES	**Greater WL than eDiets**
			eDiets.com	Information Goal setting Self-monitoring Feedback Social support	Digital Website	YES	Less WL than VTrim
Tate *et al.*, 2006 *Arch Int Med*	Cognitive-behavioral theory	12	HC (Human counselling)	Information Self-monitoring Feedback (counsellor) Social support	Hybrid Digital (part in-person) Website + e-mail	YES	**Greater WL than Control (3 mths) Greater WL than Control (6 mths)** Not different to AC (3mths) **Greater WL than AC (6 mths)**

Studies 2018-2004	Theory / model mentioned	Strength of theoretical use	Intervention Treatments	Reported Behaviour Change Techniques	Digital Delivery Features	WL Observed	Treatment Differences
			AC (Automated counselling)	Information Self-monitoring Feedback (automated) Social support	Digital Website	YES	Greater WL than Control (3 mths) Not different to Control (6 mths) Not different to HC (3mths) Less WL than HC (6 mths)
			Control	Information Self-monitoring Social support	Digital Website	YES	Less WL than HC & AC (3mths) Less WL than HC (6mths) Not different to AC (6mths)
Womble *et al.,* 2004 *Obesity*	*No theory mentioned*	10	eDiets.com	Information Prompts Self-monitoring Feedback (automated) Social support	Digital Website	YES	No difference
			Paper	Information Self-monitoring	NIL	YES	No difference