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Technology-based interventions for weight management: current randomized controlled trial evidence and future directions

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Abstract

Obesity is a prevalent health care issue associated with disability, premature morality, and high costs. Behavioral weight management interventions lead to clinically significant weight losses in overweight and obese individuals; however, many individuals are not able to participate in these face-to-face treatments due to limited access, cost, and/or time constraints. Technological advances such as widespread access to the Internet, increased use of smartphones, and newer behavioral self-monitoring tools have resulted in the development of a variety of eHealth weight management programs. In the present paper, a summary of the most current literature is provided along with potential solutions to methodological challenges (e.g., high attrition, minimal participant racial/ethnic diversity, heterogeneity of technology delivery modes). Dissemination and policy implications will be highlighted as future directions for the field of eHealth weight management.

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Compliance with ethical standards

Conflict of interest Andrea T. Kozak, Joanna Buscemi, Misty A.W. Hawkins, Monica L. Wang, Jessica Y. Breland, Kathryn M. Ross, and Anupama Kommu declare that they have no conflict of interest.

Human and animal rights and Informed consent This article does not contain any studies with human participants or animals performed by any of the authors.

Keywords

Technology-based weight management; eHealth; Review; Recommendations; Dissemination; Randomized controlled trials

Introduction

Over one-third of the US population is obese, with another one-third overweight and at high risk for future obesity (Ogden et al., 2014). Obesity can impair quality of life and puts individuals at risk for developing serious chronic conditions, including cardiovascular disease, Type 2 diabetes, and cancer (Johnston et al., 2012). As a result, obesity is the fifth leading cause of death worldwide (Carter et al., 2013), with estimates attributing 20 % of US deaths to obesity and physical inactivity (Archer et al., 2012). Therefore, it is not surprising that obesity and its associated conditions cost health care systems billions of dollars per year (Archer et al., 2012).

Currently considered the gold standard, behavioral weight loss treatment consistently produces reductions of up to 10 % of body weight and further leads to improvement in related health outcomes (Archer et al., 2012; Coons et al., 2012; Fildes et al., 2015). Typically delivered face-to-face and in a group format, this treatment package works by helping individuals change diet and physical activity habits through a number of cognitive behavioral techniques including self-monitoring of weight and weight-related behaviors (e.g.., caloric intake and physical activity), cognitive restructuring, and social support (Johnston et al., 2012). Behavioral weight loss interventions can be expensive and require significant session time commitments from participants (e.g., weekly to monthly face-to-face contact usually lasting 16–26 weeks; Coons et al., 2012; Johnston et al., 2012). It can also be difficult for individuals who live far from academic medical centers to access these interventions (Butryn et al., 2011). Technology-based behavioral interventions (i.e., “eHealth” interventions) have been used to address barriers associated with face-to-face weight loss treatment. These interventions use electronic delivery modalities such as smartphone applications (apps), websites, and/or online social media networks, to deliver behavioral weight loss treatment. Related terms include mHealth or telemedicine, which refer specifically to the use of mobile or non-mobile phones and/or applications in health management. The term eHealth will be used as this review examined several digital health strategies that included mobile and more traditional electronic delivery methods.

Over the past 5 years, many reviews and meta-analyses have synthesized the available evidence for eHealth interventions for weight loss, maintenance, and associated health behaviors (Bennett et al., 2014; Burke et al., 2015; Castelnuovo et al., 2014; Coons et al., 2012; Harris et al., 2011; Neve et al., 2010; Rao et al., 2011; Reed et al., 2012; Siopis et al., 2015; Stephens & Allen, 2013; Tang et al., 2014; Wieland et al., 2012). In 2010, the American Heart Association published a Society of Behavioral Medicine (SBM)-endorsed systematic review of eHealth interventions for weight loss and maintenance from years 2002–2010 that included all types of technology (e.g., text messages, mobile devices, web-based interventions; Rao et al., 2011). A total of 24 studies were included (18 weight loss, 6 weight maintenance) and results supported web-based interventions for weight loss among obese individuals, but not weight maintenance. There was not enough evidence to draw conclusions about mobile devices; however, this review found some evidence that mobile technologies effectively promoted self-monitoring of physical activity and diet.

In 2012, Coons and colleagues updated Rao's systematic review to include studies from 2010 to 2011 (12 weight loss trials, 1 weight maintenance trial). Coons et al. (2012) found that only 4 of the 12 eHealth interventions produced significantly greater weight loss than control interventions; however, the interpretation of these findings was limited by methodological shortcomings. The number of eHealth weight loss trials has increased at an exponential rate since the review conducted by Coons et al. (2012). Thus, in the present review, we summarize the most recently published randomized controlled trials (RCTs) examining the efficacy of eHealth weight loss and weight maintenance interventions, including the common intervention components of these trials, technological functionality, and findings. We also provide strengths of these recently published RCTs as well as methodological concerns and recommendations for possible solutions. Dissemination strategies and policy implications as future directions are also presented.

Overview of current knowledge regarding eHealth weight management

Search strategy for review

Two of the study authors searched PsycINFO, PubMed, and CINAHL from October 2011 to October 2015. The following search terms were used in various combinations: accelerometer, activity tracker, application, body mass index, body weight, blue tooth, bluetooth, bodyweight, calori*, caloric restriction, carbohydrate, carbs, cell phone, cellular phone, cholesterol, compact disks, computer, computers, connected scale, device, diet, digital, electronic, electronic email, electronic scale, email, exercise, fat, fitness monitor, fitness tracker, fruit, hand held, handheld, ipad, ipod, internet, lifestyle, mHealth, mobile phone, mobile sensor, modem, modems, multimedia message service, online, online systems, obese, obesity, overweight, overweight, palm pilot, pda, physical activity, podcast, resistance training, sedentary, sedentary lifestyle, short message service, smart phone, smartphone, social media, sodium, sugar, tablet, technology, text message, vegetable, web, webcasts, website, weight change, weight gain, weight loss, weight maintenance, weight regulation, wireless, wireless scale, wireless technology. Studies were included in the review if they met the following criteria: (1) randomized controlled trial (RCT), (2) inclusion of a weight loss outcome variable such as weight, weight change, body mass index, or waist circumference, (3) inclusion of an eHealth intervention platform with a participant interface, (4) published in English, and (5) published in a peer-reviewed journal.

Web-based interventions for weight management

Web-based interventions (i.e., weight loss and maintenance programs accessed via the Internet) have demonstrated efficacy for small to moderate weight loss in obese individuals (Manzoni et al., 2011; Neve et al., 2010; Tang et al., 2014). However, the observed weight losses vary widely, likely due to the heterogeneity of intervention components (Neve et al., 2010). The small weight losses observed in early web-based interventions that primarily included static, educational materials have been significantly improved by adding interactivity and key components of traditional in-person behavioral weight management programs, such as self-monitoring of caloric intake, physical activity, and body weight, and regular feedback regarding goal progress (e.g., reinforcement for meeting goals, recommendations and strategies for further improvement if goals were not met; Thomas et al., 2015).

Efforts to improve the weight loss outcomes of web-based interventions have continued. Importantly, frequent use of web-based intervention materials (e.g., website logins, video views) has been associated with better weight loss outcomes (Leahey et al., 2014; Manzoni et al., 2011; Neve et al., 2010). It is beneficial to assess what factors can motivate individuals to be active participants in web-based trials. Dennison et al. (2014) found that provision of brief telephone support (2 calls) for participants taking part in a web-based intervention significantly improved program engagement (i.e., participants completed significantly more web-based program modules) compared to those who did not receive telephone support. Although there was a trend in the expected direction regarding weight loss, the authors stated that the lack of a significant effect between groups may have been due to the fact that a large proportion of the individuals randomized to receive calls refused calls or were unable to be contacted. Leahey et al. (2015) demonstrated that financial incentives led to significantly better adherence (i.e., number of logins, lesson views, and frequency of self-monitoring) compared to those who were not compensated in a trial examining a web-based intervention. Better adherence was related to significantly greater percent weight loss, no matter what group an individual was assigned to during the trial.

Despite continued work to improve outcomes from web-based weight loss and maintenance interventions, the weight losses observed from these programs tend to be smaller than the 7–10 % weight losses observed in traditional in-person interventions (Butryn et al., 2011; Cadmus-Bertram et al., 2013; Dennison et al., 2014; Leahey et al., 2014, 2015; Patrick et al., 2011; Thomas et al., 2015; Webber & Rose, 2013). Further, there has been only limited research on the impact of web-based interventions for weight loss maintenance. A recent study by Thorndike et al. (2012) found no benefit of providing a web-based weight maintenance program following the completion of a worksite weight loss program. However, a previous review conducted by Neve et al. (2010) reported similar levels of maintenance for web-based maintenance interventions compared to face-to-face interventions, and less weight regain compared to no-contact control groups.

Mobile technologies for weight management

Mobile interventions for weight management are typically delivered through apps, text messaging, social media interventions, wearable sensors, or some combination of these components. Given the variation in intervention components across these methods, we review the recent findings by modality.

Personal digital assistants (PDAs) and smartphone apps—These interventions typically aim to promote adherence to self-monitoring, facilitate goal achievement, and enhance supportive accountability to engage in behavior change. Apps are programmed to allow participants to record weight, dietary intake, and physical activity and may provide opportunities to connect with a remote coach or other intervention participants (Allen et al., 2013; Carter et al., 2013; Fukuoka et al., 2015; Wharton et al., 2014). Findings from recent randomized controlled trials investigating the efficacy of apps for weight loss are equivocal. Spring et al. (2013) found that participants who received a PDA for self-monitoring and feedback, biweekly coaching calls, and the standard of care in-person treatment (Managing Obese Veterans Everywhere or *MOVE!*) group lost more weight at 12 months than participants in the standard of care in-person treatment group (*MOVE!*) alone. Fukuoka et al. (2015) found participants who received a combination of in-person treatment and a smartphone app lost more weight at 5 months compared to participants who received educational materials, a pedometer, and no in-person contact. Carter et al. (2013) randomized 128 participants to receive either a smartphone app, web-based intervention, or a diary for paper and pencil self-monitoring. Although participants who received the smartphone app lost more weight than those who received a web intervention, the smartphone app group did not outperform the paper and pencil group in terms of weight loss at 6 months. Other studies found no benefit for smartphone apps over alternative interventions (Allen et al., 2013; Wharton et al., 2014). Overall, results support the feasibility of self-monitoring using apps, but findings are mixed in terms of weight loss outcomes.

Text messaging interventions—Weight loss studies use text messages to provide personalized feedback regarding goal attainment or self-monitoring, reminders, behavioral tips to help support weight loss, or some combination of these messages (Napolitano et al., 2013). Text messaging interventions vary widely in terms of text content and frequency of text delivery. In recent trials, message frequency varied across studies from 4 times per day for a year (Shapiro et al., 2012) to once per day for 8 weeks (Napolitano et al., 2013) to twice weekly for 12 weeks (Donaldson et al., 2014).

Several recent studies have demonstrated some support for text messaging for weight loss (Donaldson et al., 2014; Herring et al., 2014; Lin et al., 2014) compared to a no-contact control. Donaldson et al. (2014) found that participants who received tailored feedback on goal attainment via text for 12 weeks lost significantly more weight than a no treatment control. Herring and colleagues found that a 14 week behavioral intervention plus text messaging resulted in greater weight loss than usual care among postpartum women. Finally, Lin et al. (2014) found that participants receiving an intensive 6 month intervention plus daily texting lost weight, while the no treatment control group gained weight. However, results from other studies do not support text messaging interventions over alternative weight loss interventions (Shapiro et al., 2012; Steinberg et al., 2013). The majority of trials that found evidence for benefits of text messaging compared relatively intensive bundled interventions (e.g., in-person treatment plus text messages) to very low dose treatment controls. The studies that did not find between group differences compared text messaging interventions alone to relatively low-dose interventions (e.g., monthly educational e-newsletters; Shapiro et al., 2012). Some authors have noted that adherence to text messaging is an important predictor of weight loss, meaning that the more participants respond to text prompts (e.g., texting study staff self-monitoring data), the better their weight loss outcomes

(Lin et al., 2014; Shapiro et al., 2012). Taken together, results from interventions including text messaging components have been promising, but more research is needed to determine the ideal text frequency and content, as well as to determine the relative efficacy of text messaging alone compared to other low cost, lower dose interventions.

Social media interventions—Social media use is widespread, and provides a convenient platform for engaging participants remotely to promote weight loss. Additionally, social media may increase social support to facilitate health behavior change and goal attainment. Two recent studies have investigated the efficacy of using popular social media platforms for weight loss (Napolitano et al., 2013; Turner-McGrievy & Tate, 2011). Napolitano et al. (2013) randomized 52 college students to a Facebook, Facebook Plus, or Waitlist Control group. Both intervention conditions joined a Facebook group in which a moderator posted intervention materials and allowed participants to interact with other study participants. Participants in the Facebook Plus condition also received text messages supporting weight loss efforts. After 8 weeks, participants in the Facebook Plus group lost significantly more weight than the Facebook only and control groups; however, there were no significant differences between the Facebook only group and control. Turner-McGrievy and Tate (2011) randomized two groups to either receive educational podcasts or podcasts plus Twitter interaction, but found no significant differences in weight loss between groups at 6 months. Using social media as a tool for encouraging weight loss is an emerging area, but more research is necessary to determine if these platforms have efficacy to promote weight loss.

Wearable sensors—This type of technology allows for continuous data collection of physiology and behaviors such as galvanic skin response, heart rate, temperature, physical activity, and sedentary behavior (Kumar et al., 2014). Empirical work to examine the impact of wearable devices is limited. Shuger et al. (2011) investigated whether the SenseWear Armband (SWA) lead to significant weight loss over the course of nine months. The SWA provides in-the-moment information about minutes of physical activity, steps, and calories burned. One hundred and ninety-seven overweight and obese individuals (mean age = 46.9) were randomly assigned to receive (1) the SWA alone, (2) the SWA plus group-based behavioral weight loss treatment, (3) group-based behavioral weight loss treatment, or (4) self-directed weight loss. At nine month posttest, participants in the SWA plus group-based behavioral weight loss treatment condition lost significantly more weight than those in the self-directed weight loss condition. However, the SWA alone group was no better than the self-directed weight loss condition. Given the paucity of RCT data on wearable sensors, it is too soon to make a definitive statement about the efficacy of this new type of technology for weight management.

Strengths and challenges of eHealth weight management studies

Table 1 describes the appealing features of eHealth weight management interventions. Despite the growing interest and potential efficacy of eHealth interventions, several methodological issues should be considered when evaluating existing protocols and designing future treatments. Each methodological challenge will be presented individually, followed by relevant solutions to address each challenge.

Challenge #1: study participation issues

Participant attrition rates from eHealth interventions are problematic because they often exceed 20 % (Neve et al., 2010; Rao et al., 2011). Further, adherence is often described as an important aspect of eHealth RCTs; however, many authors do not include this information when reporting results of RCTs. Also, some authors of eHealth weight management trials have incorrectly used the terms “adherence” and “engagement” interchangeably, which has also been a problem for other health-related treatment studies (Graffigna et al., 2014). It has been suggested that engagement is a process that consists of multiple phases, and adherence is dependent upon being in the later stages of engagement (See Graffigna et al., 2014 for a model and description of phases). Assessing how frequently participants have logged into a website or responded to text messages, for example, is likely capturing adherence rather than engagement as conceptualized recently by Graffigna et al. (2014).

Recommendations to address study participation issues

Individuals are more likely to drop out of trials if they are not meeting weight loss goals (Yackobovitch-Gavan et al., 2015). Two important determinants of weight loss via eHealth interventions include frequency of logins and including interactive intervention components (Gold et al., 2007). Researchers should program their apps to track use and prompt participants to engage with the program when use declines or stops for an extended period of time. This approach is most relevant for “pull” interventions which require accessing intervention materials when participants feel they are most needed (Klasnja et al., 2015). Further, many devices (e.g., wearable sensors) have the capability of allowing for “push” interventions which deliver eHealth interventions on the basis of participant behaviors (e.g., activity levels). “Push” interventions are best examined via a microrandomized trial design as there will be numerous randomization opportunities rather than a single opportunity provided by an RCT. Multiple randomization opportunities might be particularly helpful in reducing attrition from studies that are testing interventions with many components.

In one of the few studies focused on weight loss in men, Patrick et al. (2011) found that higher levels of adherence (e.g., logging into the study website to set goals) were associated with significantly more weight loss in a completer sample accounting for 96.8 % of participants. Additionally, Shapiro et al. (2012) found a significant link between better adherence (e.g., number of text message responses) and more weight loss based on an intent-to-treat analysis. Therefore, these findings suggest that adherence to eHealth interventions may serve as an important factor in weight loss outcomes, indicating that future studies should measure and report adherence data, especially given the complexities of capturing participant engagement.

Challenge #2: minimal diversity in participant samples

As with many traditional behavioral weight loss studies, the majority of participants enrolled in eHealth intervention studies have been women (Neve et al., 2010; Wieland et al., 2012). Additionally, many eHealth studies do not have representative enrollment of individuals who identify as African-American or Hispanic, despite data suggesting these demographic groups are more likely to be overweight and obese (Ogden et al., 2014). A recent systematic review of eHealth trials among diverse samples found only six trials included samples wherein at least 50 % of participants reported a racial/ethnic minority background (Bennett et al., 2014). Further, some study authors have refrained from even including race/ethnicity data (Reed et al., 2012).

Recommendations for recruiting diverse samples

Researchers using eHealth weight management interventions need to recruit more diverse samples. For example, there are opportunities to attract men to participate in eHealth intervention studies. Ellis et al. (2013) surveyed 486 males between the ages of 16–24 and found that a large majority owned a cell phone (96.3 %) and used Facebook (90.1 %). When queried about their online activities, these males reported accessing video (85.1 %) and information (79.4 %) websites (content unspecified) more frequently than bulletin boards (39.2 %) or forums (62 %; Ellis et al., 2013). A little over half of these participants reported seeking help for problems via the internet and over 80 % stated they were pleased with the help they had received. Further, in a review of the representation of men in behavioral weight loss trials, there was a trend for more men to be enrolled in studies using Internet delivered treatment compared to conventional treatment (Pagoto et al., 2012). Therefore, males might be more likely to enroll in studies testing eHealth weight management treatment over conventional treatment, particularly if the Internet serves as the delivery mode and participants have access to weight loss videos. Finally, Crane et al. (2015) examined whether men could benefit by offering them an internet-based program with customized strategies to help achieve six 100 cal reductions over the course of the day in addition to other intervention components. This approach should be considered in future studies since it lead to significantly more weight loss than a wait-list control group and many more experimental group participants lost 5 % of their initial body weight.

More emphasis needs to be placed on enrolling under-served members of racial/ethnic groups who are at a high obesity risk in eHealth treatment trials. Multiple strategies should be implemented prior to recruiting diverse samples. For example, hiring staff members who have similar race and ethnicity backgrounds as the participant groups of interest (Ejiogu et al., 2011; Kong et al., 2014) and providing training opportunities that build cultural competence and sensitivity in staff members are recommended (Ejiogu et al., 2011; Faseru et al., 2010). There should be consistency between the program content of eHealth interventions and cultural values and traditions as recommended by members of focus groups (Kong et al., 2014). Providing letters of support from respected leaders in the community might help increase study enrollment of African-Americans given the unfortunate history of exploiting this group in research such as the Tuskegee Study (Ejiogu et al., 2011). Enrollment of diverse samples can be achieved by recruiting at churches, advertising in healthcare clinics in racially/ethnically diverse communities, and playing advertisements on radio stations that target particular racial or ethnic groups (e.g., Spanish speaking radio stations; Faseru et al., 2010; Otado et al., 2015). Researchers can also now take advantage of technology to assist with the recruitment of diverse samples by using social media [e.g., Facebook, LinkedIn, Twitter, Tumblr, and Craigslist (Ramo & Prochaska, 2012; Yuan et al., 2014)].

Challenge #3: inaccurate assessment tools

Difficulties measuring energy intake and expenditure—Many eHealth interventions specific to weight management center around and promote self-monitoring of caloric intake, energy expenditure, and weight using apps, websites, or devices (e.g., "Fitbit," "MyFitnessPal;" King et al., 2015). The lack of standardization of these electronic assessment tools, many of which are commercially available and widely sold but may lack a strong scientific base (King et al., 2015), may lead to inaccuracies (e.g., under- or over-estimation), especially for caloric intake (Illner et al., 2012; Sharp & Allman-Farinelli, 2014). These inaccuracies stem not only from the self-report biases found for conventional paper-and-pencil food/exercise diaries (i.e., underreporting food intake, difficulty in estimating accurate portions and/or exertion levels; Johansson et al., 2001; Schoeller, 1995) but also from the inability to find appropriate entries and/or inconsistent entries in some food/activity databases. Although activity monitors (e.g., accelerometers) have been shown to be more accurate, reliable, and practical than their food tracking counterparts (Bassett Jr & John, 2013; Johansson et al., 2001), even activity monitoring suffers from a lack of protocol standardization and inconsistent decision rule-reporting across studies. Inaccurate calculations of calories consumed versus expended may directly impact participant success in eHealth interventions employing these devices and applications, given the well-documented, historic finding of measurement reactivity: self-monitoring can serve as both an assessment tool as well as an intervention (Burke et al., 2011; Johnson & White, 1971).

Recommendations regarding assessment

Improving energy intake assessment—Given current difficulties in accurate energy intake and expenditure, efforts to improve these monitoring methods is paramount—not only in helping individuals participating in weight loss trials but also in ensuring trustworthy results from trials. The following recommendations are suggested to improve technological assessment of food intake and activity. Self-report diary methods (even web and app-based diaries using electronic food databases) have yet to overcome the issue of under-reporting food intake. Thus, one recommendation is to pursue food-tracking methods that remove as much self-report bias as possible, such as computerized volume estimates of portion sizes via digital photos (Jia et al., 2014; Martin et al., 2014). Though digital photos require more validation and are still a self-report method that can be associated with error, they represent a low-burden method (e.g., no measuring spoons/cups or scales necessary) which may increase adherence to self-monitoring and provide more objective, accurate estimates of food volume than participants' visual estimation. Additional novel technological solutions for dietary assessment, especially among children and adolescents, are reviewed in a 2014 special issue in the Journal of Human Nutrition and Dietetics (Adamson & Baranowski, 2014).

Improving energy expenditure assessment—In addition, future interventions can improve physical activity measurement by validating, following, and reporting standardized assessment protocols with specific details on data decisions, such as epoch lengths, number of valid days the device is worn, what constitutes a "valid" day of collection, and established cut-points for moderate-to-vigorous activity or METs. Readers should refer to a review by

Cain et al. (2013) for more detailed information regarding these recommendations pertaining to activity monitors.

Challenge #4: heterogeneity of technology delivery mode and intervention components

There are a wide range of delivery modes (e.g., smartphone apps, text messaging, web-based) and intervention components being tested in eHealth weight management studies. This variety enriches the diversity of intervention design and delivery. However, it is difficult to compare eHealth weight management studies and summarize efficacy because researchers have frequently compared an eHealth treatment to a control group (e.g., wait list or face-to-face intervention), or to the same eHealth treatment combined with an in-person element. Few studies have compared two different eHealth interventions (e.g., text messaging vs. web-based interventions). There is also heterogeneity regarding the number of intervention components, with intervention components ranging from one to ten (Neve et al., 2010) and no two smartphone apps provide the exact same intervention components. Therefore, it is not currently possible to state which specific technology delivery mode (e.g., website, smartphone app, text messaging) is associated with the most weight loss or is the most efficacious regarding maintenance of weight loss (Tang et al., 2014). Finally, little is known about the long-term effects of eHealth interventions no matter what delivery mode or intervention components are being used. Overall, eHealth interventions are typically brief (e.g., many are <12 months), lacking a follow-up assessment beyond the posttest, and/or do not focus on weight loss maintenance.

Recommendations for determining efficacious delivery modes and components

More studies are needed comparing a single eHealth delivery mode intervention to a control condition in regards to weight loss maintenance. Additionally, studies examining the differences between two eHealth delivery mode types are essential. Research questions driving such studies may include: Does a social media intervention lead to more weight loss than a smartphone app? Is text messaging or a web-based intervention linked to better weight loss maintenance? Dismantling trials have been useful in teasing out the most efficacious components of cognitive-behavioral treatments for a number of anxiety disorders (Kaplan & Tolin, 2011; Resick et al., 2008) and more recently, irritable bowel syndrome and cancer (Gudenkauf et al., 2015; Ljótsson et al., 2014). The use of dismantling studies could serve as a useful approach to pinpoint the essential components of eHealth weight management treatments, independent of delivery mode. For example, utilizing the most essential components might lead to more weight loss than what is typically observed via technology. In addition to dismantling studies, the Multiphase Optimization Strategy (MOST) has recently been applied to eHealth weight loss interventions to determine which intervention components contribute to the greatest behavior change (Pellegrini et al., 2014).

Challenge #5: data security concerns

Weight loss technologies continue to advance, and increasingly include passive and continuous monitoring through wearable sensors (e.g., wrist-worn activity monitors and global positioning system (GPS)-enabled smart-phones) that unobtrusively sense and record behaviors (e.g., number of steps, purchasing patterns in food deserts) with little input or awareness from the participant (Cai et al., 2016). Researchers need to be mindful about the immense quantities of data regarding individuals' behavior patterns and consider the negative impact that potential breaches of privacy and security might have when such large-scale, geocoded data can be linked to personal health behaviors (King et al., 2015). Specifically, the digital "footprints" or "shadows" (Madden et al., 2007) created via information passively provided by the participants as they engage with technological devices can provide patterns of data which may increase the risk of re-identification even for data that have been de-identified (Cavoukian & Jonas, 2012), an issue that participants may not typically be informed of during the consent process.

Recommendations regarding maintaining data security

Several recommendations can be made in regards to taking the necessary steps to manage such "big data" security (Kshetri, 2014). Participants must always be adequately informed of the extensive nature of data being tracked and analyzed prior to consenting to device use as well as the potential for breaches of confidentiality and their impact. Although informed consent and confidentiality are principles that should be addressed in all trials, the consequences of breaches for big data may be more impactful given that they reflect a participant's digital footprint. It is also recommended that interventionists seek out and include experts in technologically based big data management to serve on trial protocol review committees or data safety and monitoring boards for any eHealth weight management trials conducted using wearable sensors given the risk of re-identification from digital footprints. Such data management experts can work with researchers to proactively manage big data in a way that optimizes security, such as encrypted storage and/or monitored transmission of wireless data.

Challenge #6: the issue of rapid innovation

Another challenge to eHealth weight management interventions is being able to stay abreast of emerging technology. Despite the multi-year process involved in securing funding and conducting RCTs, new devices, algorithms, programs, and apps appear rapidly through industry advances in technology. For example, the typical number of new apps available in the Apple iTunes store is approximately 1000/day with an estimated 1.5 million total iTunes apps and 1.6 million total Google play apps available by July of 2015 (Statistica, 2015). While not all eHealth weight management interventions use apps as their primary modalities, these statistics highlight the immense popularity, growth, and turnover of technological tools. In addition to app innovation, novel devices and other technology-based platforms that might also have potential to support weight loss efforts include virtual reality interventions, machine learning approaches, agile development, and body sensors that monitor diet (Amft & Troster, 2008).

Recommendations for working within the context of rapid innovation

Partnering directly with industry may provide a viable and necessary option for staying relevant and bringing cutting edge technologies to the weight loss field. As devices evolve, weight loss providers should be aware of changing client preferences. There are now first and second generation "digital natives," who were born after 1980 and 1993, respectively (Joiner et al., 2013). Both groups of digital natives have been surrounded by technology from a very early age. Second generation digital natives in particular are very comfortable with and accepting of technology (Joiner et al., 2013), suggesting younger generations may prefer and consequently respond more favorably to eHealth interventions that adopt photo-based message platforms (e.g., Instagram, SnapChat) instead of regular text-only messaging. Social media groups for weight loss on websites like Facebook may be supplanted by geotracking/location-based services such as Foursquare, which would allow weight loss clients to identify other group members in their geographic area and potentially facilitate real-time, in-person support for weight loss efforts. Finally, innovative research designs and frameworks may be more efficient than the RCT, and may better accommodate the rapid innovation of technology. For example, the aforementioned MOST framework can be applied to optimize behavioral interventions. Other novel designs include the sequential multiple assignment randomized trial (SMART; Hartlieb et al., 2015) and micro-randomized trials (Liao et al., 2016), as well as the newly developed just-in-time adaptive interventions, which are a good example of “push” interventions (Klasnja et al., 2015). These options may improve our ability to more efficiently assess the efficacy of constantly changing technology.

Future directions for eHealth weight management interventions

The following section highlights key considerations and future directions for the dissemination and implementation of eHealth weight loss interventions to facilitate public health impact, as well as potential applications of such interventions within the context of health policy.

Dissemination and implementation

Key characteristics of influence for dissemination—Thus far, researchers have primarily focused on testing the efficacy of eHealth weight management interventions. However, consideration of dissemination potential and infrastructure is critical for moving evidence-based eHealth weight management programs into widespread use to promote change at the population level. Key characteristics that influence dissemination and implementation include acceptability, feasibility, reach, and cost; explicit consideration and integration of these characteristics during the initial design phase of eHealth interventions can facilitate efficient wide scale dissemination. eHealth weight management programs are particularly conducive to dissemination and implementation due to several advantages, many of which were previously mentioned, including demonstration of high acceptability and feasibility among users (Burhansstipanov & Schumacher, 2005; Shaw et al., 2013; Trude et al., 2015; Walker et al., 2010; Wallerstein & Duran, 2006); the ability to tailor content and strategies based on participant behaviors and characteristics without compromising efficacy (Evans-Campbell, 2008); potential for cultural adaptation of programs for racial/ethnic minority populations (Burhansstipanov & Schumacher, 2005; Wallerstein & Duran, 2006); and the ability to address several barriers to participating in onsite group-based or one-on-one weight management programs (e.g., lack of access to transportation, cost, significant in-person time commitment), thus maximizing the reach of such interventions to large segments of the population.

In addition to the aforementioned benefits, eHealth weight management interventions may be more cost-effective than standard face-to-face behavioral interventions as they require less face-to-face contact (Burhansstipanov & Schumacher, 2005), and the initial costs of investing in eHealth interventions may be recouped through long-term benefits such as reduced absenteeism or increased productivity among employed populations (Walker et al., 2010). Archer et al. (2012) found a wearable device was more cost-effective and lead to significantly more weight loss compared with an onsite group counseling program. In contrast, Gussenhoven et al. (2013) found no significant differences in regards to cost-effectiveness when comparing an eHealth treatment to other groups. More research is needed given these discrepant findings and the lack of studies that prioritize cost-effectiveness.

Dissemination challenges and solutions—Despite several characteristics of eHealth weight management interventions that lend themselves to dissemination and implementation, key challenges remain. The small-scale success of eHealth programs within well-controlled research studies does not guarantee similar results when scaled up for larger populations across a wider range of settings. Established efficacy in the scientific literature does not assure initial and/or continued demand for a program, and initial participant enthusiasm for eHealth interventions may decrease over time, particularly if aspects of the eHealth intervention lose relevance or appeal in comparison to other programs or tools produced in the fast-paced competitive technology industry. For example, developers of smartphone apps often struggle with user retention given the variety of available apps offering similar services or features and the fast rate at which new apps continue to be produced, both of which contribute to app competition (Adamson & Baranowski, 2014). User review panels to select from evidence-based programs that are best poised for dissemination, utilization of design and marketing teams to tailor and refine interventions as needed, and identification of dissemination field agents to generate awareness and provide training and support (Martin et al., 2014) may address these challenges.

Another concern is that the absence or reduction of face-to-face time for eHealth users may dilute intervention efficacy (Cain et al., 2013). In such cases, integrating eHealth weight management interventions that have demonstrated efficacy through studies (as opposed to eHealth interventions that have not been tested or demonstrated little or no success through studies) within existing systems can shift investment of resources to other activities and processes that maximize efficacy while facilitating widespread dissemination and implementation (Jia et al., 2014). Overall, eHealth weight management programs have high potential for wide dissemination (Statistica, 2015), and ongoing evaluation to ensure appropriate adoption and implementation is critical for achieving intended population health impact (Cavoukian & Jonas, 2012).

Policy and application of eHealth interventions: using telemedicine as a model

To date, policy implications related to eHealth have been discussed under the scope of telemedicine, a more comprehensive definition of eHealth medical care that includes broader technologies but often refers to remote telecommunications-based clinical care. A position paper on behalf of the American College of Physicians supported the use of telemedicine but cautioned against relying on this form of health care delivery given the possibility of weakening the traditional patient-provider relationship (Castelnuovo et al., 2014). Though a valid concern, the benefits of receiving a eHealth management intervention may outweigh potential telemedicine risks (e.g., misdiagnosis) if the health concern is restricted to weight management through health behavior change, as opposed to diagnosis and treatment of acute illnesses. However, the monitoring and treatment of comorbid conditions (e.g., diabetes and obesity) or acute illnesses could warrant in-person visits with a health care provider. In such cases, health care provider permission to participate in an eHealth intervention is needed and may supplement, rather than replace usual care. Policies regarding the integration of eHealth weight management interventions within existing health care systems need to be tailored for different populations, and such interventions should be distinguished from other telemedicine methods that pose greater liability risks.

Another key policy consideration is the development of a sustainable reimbursement system for eHealth weight management interventions. While almost half of U.S. hospitals have telemedicine capabilities (Harris et al., 2011), payment and accountability for costs incurred by eHealth weight management interventions are not well established. The US Preventive Services Task Force (USPSTF) recommendation that clinicians screen all adults for obesity and "offer or refer obese patients to intensive, multicomponent behavioral treatment" (Grade B recommendation; USPSTF, 2012) along with the classification of obesity as a disease by the American Medical Association will facilitate reimbursement for weight management treatments on a large scale (Neve et al., 2010). However, the Centers for Medicaid and Medicare Services' current reimbursement policy on intensive behavioral treatment for obesity is limited to Medicare patients and restricted to service delivery by primary care physicians in a primary care setting (Centers for Medicare and Medicaid Services, 2011).

The extent to which eHealth interventions may fall under the category of reimbursable services has yet to be explored. Currently, state licensing boards determine where clinicians can practice and whether medical/clinical licenses are valid across state borders, and these policies vary substantially by state (Harris et al., 2011). States with policies that encourage private payer reimbursement for telemedicine tend to have higher telemedicine utilization, while states with policies requiring out-of-state providers to have special licenses tend to have lower utilization rates (Harris et al., 2011). Broadening telemedicine licensing policies and utilizing financial incentives for providers may increase adoption of telemedicine (Harris et al., 2011) and eHealth interventions within health care settings. Classifying eHealth weight management interventions as a subset of telemedicine is suggested to streamline the integration of such interventions into existing health care payment infrastructures.

Conclusions

Obesity is a costly national epidemic that that increases risk for co-morbidities and untimely death. Researchers have increasingly focused on the development of eHealth weight management interventions as a promising treatment option with high dissemination potential. Although weight losses experienced during these interventions tend to be smaller than those observed for in-person treatment, they potentially require less resources to deliver, might be more acceptable to future generations of "digital natives," and have the potential to reach more clients. Given these potential benefits, further investigations examining these interventions are needed, as critical questions in the field remain, including: (1) What are the long-term effects of eHealth weight management interventions?, (2) Which components of eHealth interventions are most efficacious/effective?, and (3) Which eHealth delivery modes are optimal for which populations? Answering these questions while implementing solutions to methodological issues are essential next steps to advance the science of weight control in the digital age.

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Table 1

Strengths of eHealth Weight Management Interventions

Ease of use	Behavior(s) can be tracked in real time and with minimal effort (e.g., participants can easily and discreetly look up nutrient content of foods and do not have to manually record; Coons et al., 2012, 2015) Portability of eHealth treatments may increase self-monitoring, which is a key component of traditional weight loss programs (Berkman et al., 2014; Burke et al., 2011, 2012; Stone et al., 2003)
In the moment feedback	Participants can receive "just in time" encouragement and reinforcement related to healthy eating and activity choices (Duncan et al., 2011)
Increased treatment access	e-Health treatments have been tested in a variety of settings outside of academic medical centers (e.g., worksites, primary care physician offices, community locations; Coons et al., 2012) Shift workers, rural dwellers, and individuals with limited financial resources who cannot participate in traditional behavioral treatment can have access to treatment via eHealth eHealth modalities preferred by at-risk subgroups could increase interest in treatment among those who need it most [e.g., text messaging might be appealing to individuals from lower socioeconomic backgrounds given that this communication medium is preferred by this group (Siopis et al., 2015)]
Tailored treatment	Participants can use their own device as opposed to devices chosen by researchers (Coons et al., 2015; Turk et al., 2013) Participants can receive individualized feedback, which has led to significantly more weight loss than generic feedback (Gabriele et al., 2011; Tate et al., 2006)