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The efficacy of eHealth interventions in weight management: a systematic review

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ABSTRACT

This current review aimed to evaluate the efficacy of eHealth interventions in weight manangement, targeting obese and overweight adults. Methods: Upon completion of the search procedure, a number of fourteen studies were included and analyzed relative to a set of inclusion and exclusion criteria previously established. Results: Only six out of fourteen studies reported statistically significant results, favoring the eHealth interventions. The included studies had several limitations, most of them related to their methodological design. Conclusion: The current understanding of this topic is still premature, but the present results offer a promising perspective on the efficacy of eHealth interventions in weight management. However, more studies are needed to provide conclusive results.

Keywords: *eHealth, weight loss, obesity, overweight.*

1. INTRODUCTION

Nowadays, obesity represents a bigger concern than malnutrition (Nath, n.d.)., with around 5% of the world's deaths attributed to obesity (Dobbs et al., 2014). Although it has been considered a problem belonging solely to the world's developed countries, recent studies show that obesity is quickly becoming a much more serious issue in under-developed countries. The rate of overweight and obese children is 30% higher in under-developed countries, compared to the developed ones (WHO, 2015). Perhaps the access to education plays an important role in forming healthy behaviours. Excess weight affects individuals both from a physical point of view, leading to various medical conditions, as well as psychologically, leading to depression, shame, guilt and social isolation (Mayo Clinic, 2015). The current paper aims to evaluate the efficiency of various types of eHealth interventions for reducing and maintaining a healthy weight, targeting obese and overweight adults, through their impact in weight indices (body mass index and weight measured in kilograms).

In the scientific literature, there are a great number of qualitative and quantitive reviews that provides a global perspective on the efficiency of these types of interventions, but they have numerous limitations. These limitations, as well as a brief overview of each published review, are presented in the following paragraphs.

The systematic review published by Coons et al. (2012) suggests that the current knowledge in the research literature is very premature to draw a conclusion on the efficacy of the technology-driven intervention in weight management. Moreover, many already available studies have faced serious methodological lacks. One of the limitations of this review is that it includes solely studies published in 2010 and 2011. Also, the keywords the authors used in searching relevant studies are not mentioned, the authors only presenting the inclusion criteria. Not a single tool for evaluating the quality of the studies has been mentioned.

The review written by Raaijmakers et al. (2012) aims to evaluate the efficiency of technology-driven interventions in weight loss, quality of life and treatment compliance. One of the limitations of this review is including multiple types of designs, such as cvasi-experimental ones or cohort and cluster studies, which cannot be extrapolated to entire populations. Raaijmakers et al. have also examined specific intervention components, and have observed that the best results on weight loss and weight management are obtained when all, or a large number of the essential components has been included, namely: self-monitoring, feedback and therapist interaction, social support, using a programme based on structured theories and using an individually tailored program.

Another review published in the scientific literature in 2011 was the one written by Manzoni et al. Its limitations consist of including only studies published between 2008 and 2011, not using any tool to determine the quality of the papers included and not mentioning the key-words used to find the relevant studies within the scientific databases. Also, the authors have chosen studies exclusively focused on computer-delivered interventions. The results of this paper are in accordance with the ones presented above, namely that there is not enough evidence to support the efficiency of eHealth interventions. The results are modest, although somewhat promising for confirming their utility.

Stephens and Allen (2013) have written a systematic review in which they only include 7 studies, which focus exclusively on interventions delivered through mobile technology. Along these, other limitations include restrictive keywords, not mentioning the inclusion criteria and not using a tool to assess the quality of the studies included. Also, the bibliographic references were very restrictive, the authors having included only 15 studies. Contrary to previous research, this review supports the efficiency of technology-driven interventions to aid weight management, although these findings apply only to interventions ran through mobile technology (text messages and smartphones).

The systematic review authored by Wickham & Carbone (2015) is strictly centered on adolescents aged between 12 and 18 years old. The limitations of this study are the impossibility to extrapolate the results to the adult population, the inclusion of only 8 studies, which center exclusively on mobile technologies as a method of treatment delivery. The results obtained by this research are pretty weak; while a reduction in BMI index has been reported accross seven studies out of eight, significant differences between groups couldn't have been detected.

Bacigalupo et al. (2013) have compiled a systematic review, with a view to research not only the efficiency of technological interventions on weight management, but also to examine and compare components and particularities of various interventions, in order to obtain a global perspective on this topic. The limits of this article are as follows: they include only six studies which exclusively focus on mobile technologies as a mehod of delivering treatment, the keywords used are not mentioned, and the inclusion criteria are vaguely phrased. This review's findings support the consensus in the scientific literature at the time, namely that more research on this topic is still necessary, for a clear conclusion to be safely drawn.

Khaylis et al. (2010) have focused on identifying the essential components of technological interventions, which positively influence the results. Thus, five key components which lead to the success of such interventions have been identified: self-monitoring, therapist feedback and a good patient-doctor communication, social support, usage of stuctured methods (CBT therapy) as well as an individually tailored program.

Arem and Irwin (2011) have authored a review which included studies published between 2001 and 2009. They have concluded that those interventions which have included at least one of the five essential components mentioned by Khaylis et al. (2010) have had a higher retention rate and more promising results for weight loss. The limits of this research are the fact that it only included 9 studies, many of which without a control group, it used restrictive keywords („obesity", „internet", „intervention") and vague inclusion criteria. Moreover, the quality of the studies included has not been assessed by any tool, and the research included only studies that use computerized interventions as a delivery method.

There are three additional meta-analyses identified in the literature, namely the one written by Neve, Morgan, Jones and Collins (2010), the one by Kodama et al. (2011) and the one by Hutchesson et al. (2015). The meta-analysis published by Neve et al. only includes studies which use computerized interventions, as a treatment delivery method. Furthermore, the authors fail to mention the key-words used to find relevant articles. Similarly, the study penned by Kodama et al. only examined studies which employ computerized interventions and does not cover the key-words with which the search for relevant articles was ran. Both meta-analyses show only modest differences between experimental groups and strongly argue the importance and necessity of more research on this topic, for correctly assesing the efficiency of this types of technological interventions on weight management.

A meta-analysis authored by Hutchesson et al. (2015) has included 84 studies, taking into account all methods of implementing technology-aided interventions as well as studies which target both obesity treatment and maintaining the weight loss state. Researchers have concluded that technology-driven interventions have only modest results compared to lack or minimal interventions. It is interesting to note that there was no significant difference between studies using eHealth interventions and studies which deliver treatment through a combination of eHealth and face-to-face interventions. Therefore, currently, we cannot make clear recommendations regarding how efficient technological interventions are. There are a number of promising results on this topic, although the small number of studies renders definite confirmation impossible.

To conclude, the current understanding, as depicted in the recent scientific literature is quite limited, with reviews and meta-analyses on this topic facing major methodological limitations. However, all allude to promising results when it comes to the efficiency of technological interventions. The continued examination of this topic is therefore essential. The current paper has been presented as a systematic review, with an aim to adress this imperative gap in understanding, which prevents significant advancements from occuring. It seems that the majority of reviews and meta-analyses already available in the scholarly literature face the issues regarding the heterogenity of the papers included for examination. Due to this limitation, the current study opted to incude relevant research which reports results solely in terms of BMI and weight changes.

2. METHODOLOGY

Search strategy

Four databases (Psychinfo, PubMed, Scopus, Web of Science) were searched using the following search string: (eHealth OR technology-based OR computer-based OR web-based OR internet OR mobile OR smartphone OR phone OR digital game) AND (overweight OR obesity) AND (weight loss OR weight manangement OR weight maintenance). This process yielded a significant number of articles, which were then assesed in terms of their relevance, relative to the set of inclusion and exclusion criteria previously established.

Inclusion criteria

Studies were included in this present review if they met all of the following criteria: (1) the participants were over 18 years old, (2) the participants were obese or overweight (having a body mass index greater than 25 kg/m2), (3) the intervention had technological components, (4) the intervention aimed to reduce weight and/or maintain weight loss, (5) studies compared an eHealth intervention with a control group, which could be either an „active care", „no care" an „usual care", or a „placebo", (6) the results of the intervention were expressed in terms of changes in BMI and/or weight, (7) the participants were randomly assigned to the intervention groups. The technologial component mentioned above refers to delivering the intervention either via a mobile application, via the internet or via a computer program. Initially, the search resulted in a large number of studies that were analyzed based on their abstracts. After removing the duplicates and the articles that did not meet the inclusion criteria, a total of 14 studies were included in the current review and were analyzed accordingly.

Data extraction

The remaining articles were analyzed in terms of the following indicators: (1) year of publication, (2) the country in which the studies were conducted, (3) target population, (4) participant selection methods, (5) sample size, (6) participants' demographic characteristics, (7) study design, (8) the type of control group (9) retention rate, (10) studies' duration, (11) description of the technological component, (12) key components of the interventions, (13) statistical analysis, (14) obtained results.

Assessment of the quality of the studies

The Quality Assessment tool for Quantitative Studies was used in order to estimate the quality of the included studies. The tool was developed by the Effective Public Health Practice Project (EPHPP) in 1988 and its purpose was to provide high quality systematic reviews, as well as to offer an overview of the included studies in terms of „strong quality" studies, „moderate quality" studies and „weak quality" studies. It comprises eight sections, namely: selection bias, study design, confounders, blinding, data collection methods, withdrawls and drop-outs, intervention integrity and analyses (National Collaborating Centre for Methods and Tools, 2008).

The tool content validity has been tested using an iterative process that involved the evaluation of the „instrument's content and categories for clarity, completeness and revelance, and an overall comparison with similar types of tools". The test-retest fidelity was also calculated, obtaining a Kappa index of 0.74 (National Collaborating Centre for Methods and Tools, 2008, apud Thomas et al., 2004).

3. RESULTS

Selection of studies

Upon completion of the search procedure, a total of 331 studies were identified, with no additional study included from other sources. After removing the duplicates, 298 titles and abstracts were evaluated, with 256 studies being removed. Fourty-two studies remained to be evaluated on the basis of their content. Twenty-eight were then excluded for the following reasons: two of them did not meet the target population criteria, three were not an eHealth intervention, one was written in another language than English, fiftheen did not report any data on BMI and/or weight and seven were not a randomized controlled trial or a clinical controlled trial. Finally, a number of fourteen studies were included in the current review and analyzed accordingly. An overview of the data can be seen in Figure 1.

Quality assessment

The quality of the included studies was estimated using the Quality Assessmet Tool for Quantitative Studies. The articles were rated on a scale of 1 to 3, where 1 represents high-quality studies, 2 represents moderate quality studies and 3 represents weak quality studies. Seven studies were rated with a global score of 2 (e.g., Appel et al., 2011; Bennett et al., 2015), while the other seven studies were rated with a global score of 3 (e.g., Azar et al., 2015; Bumjo et al., 2015). Unfortunately, the current review does not include any high-quality studies, as according to the Quality Assessment Tool for Quantitative Studies.

Selection bias. All studies were rated with 3, in regards to the selection bias criteria. The participants were either volunteers, recruited through newspaper advertisements or from clinical centers (e.g., Bumjo et al., 2015) or were individually selected by the researchers themselves.

Study design. Most of the studies were randomized controlled trials (e.g., Bennett et al., 2009), with the exception of six, which were clinical controlled trials. Regarding the latter, the researchers did mention that their participants were randomly assigned to the intervention or control groups. However, as the methods used for the radomization were not discussed, the studies were classified as clinical controlled trials (e.g., Rothert et al., 2006).

Confounders. Eight studies controlled for at least 80% of the confounded variables (e.g., Thomas et al., 2015), while three controlled between 60% and 79% of them (e.g., Laing et al., 2014). The other three studies controlled for less than 60% of the counfounded variables (e.g., Patrick et al., 2009).

Blinding. Only one study was rated with 3 (Bumjo et al., 2015), meaning that the assessors were aware of the intervention or exposure status of participants and the participants were aware of the research question. Six studies were rated with 1 (e.g., Patrick et al., 2009; Rothert et al., 2015), while seven studies were rated with 2 (e.g., Thomas et al., 2015)

Data collection methods. With regard to data collection methods, three studies were self-report (e.g., Azar et al., 2015). For the rest, data was collected by the researchers themselves (Leahey et al., 2014).

Withdrawals and drop-outs. In five studies, less than 20% of the participants withdrew from the study, being rated with 1 (e.g., Patrick et al., 2009). Seven studies were rated with 2, meaning that between 21% and 40% withdrew from the study (e.g., Lin et al., 2105). Only one study had more than 40% of the participants withdrawing from the study, therefore rated with 3 (Rothert et al., 2006). For the study conducted by Sherwood et al. (2006), no data regading this aspect were reported.

Intervention integrity. Four studies were rated with 1, meaning that between 80% and 100% of participants completed the intervention (e.g., Appel et al., 2011), five studies were rated with 2, meaning that between 60% and 79% of participants completed the intervention (e.g., Azar et al., 2015), and five studies were rated with 3 – less than 60% of participants completed the intervention (e.g., Rothert et al., 2006).

Analyses. Nine studies were conducted in clinical centers (e.g., Appel et al., 2015; Harvey-Berino et al., 2004), while the other five were conducted at the community level (e.g., Patrick et al., 2009; Sherwood et al., 2006). All studies used appropriate statistical methods. All studies, except for one (Leahey et al., 2014), used intention-to-treat as a level of analysis.

Characteristics of included studies

Studies' objectives. All the identified studies aimed to evaluate the efficacy of eHealth interventions in weight manangement, conceptualized in changes in weight and body mass index.

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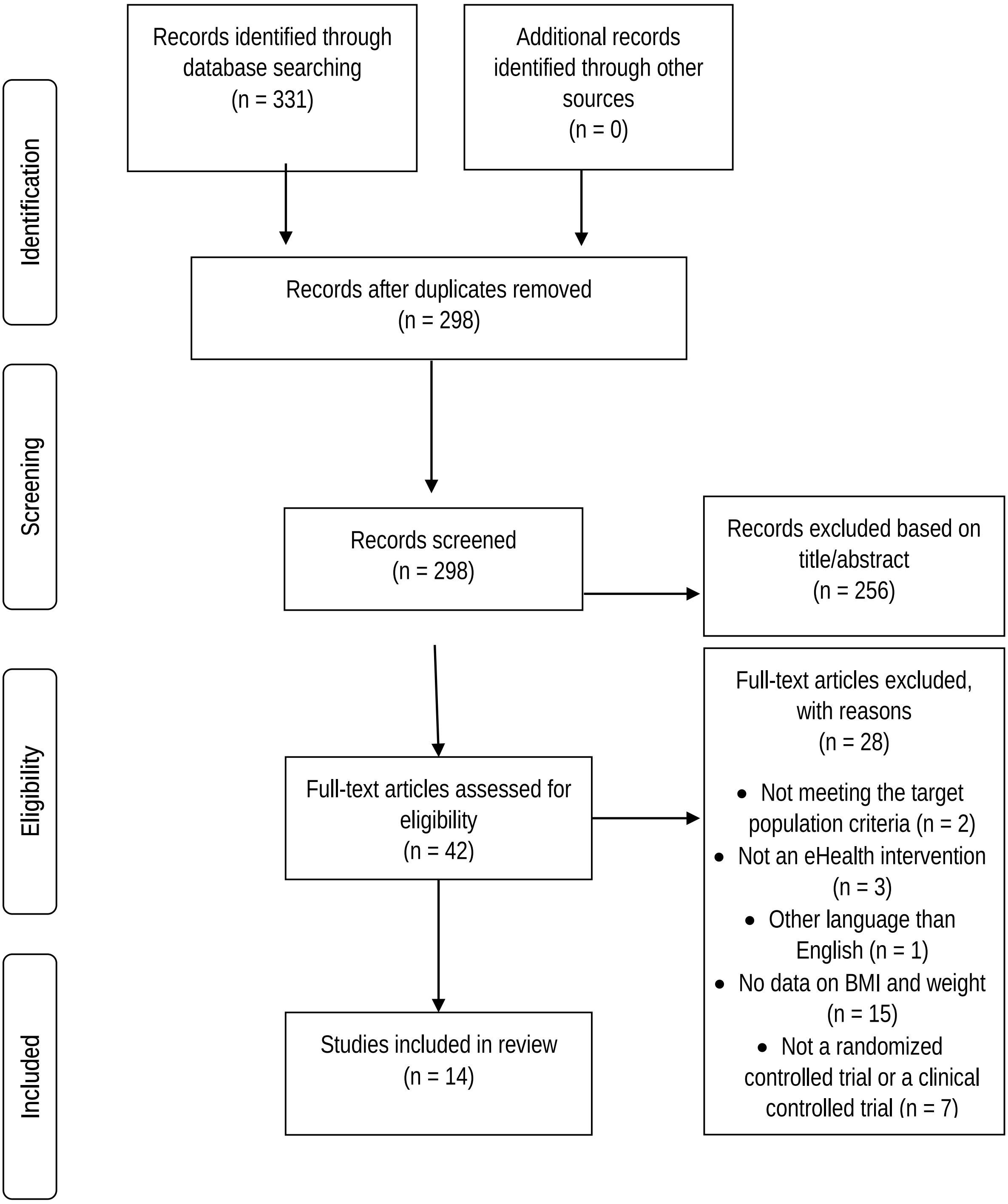

Figure 1. PRISMA flow-diagram of the study selection process

Table 1. *Quality assessment of the studies using Quality Assessment Tool for Quantitative Studies*

	Selection bias	Study design	Confounders	Blinding	Data collection methods	Withdrawals and drop-outs	Intervention integrity	Analyses	Global rating
Appel et al., 2011	3	1	1	2	1	1	7	8	3
Azar et al., 2015	3	1	1	2	3	2	8	8	3
Bennett et al., 2009	3	1	2	2	1	1	10	8	3
Bumjo et al., 2015	3	1	2	3	1	2	7	8	3
Harvey-Berino et al., 2002	3	1	1	1	1	2	8	7	2
Harvey-Berino et al., 2004	3	1	1	1	1	2	8	8	2
Krukowski et al., 2011	3	1	1	2	1	1	10	8	2
Laing et al., 2014	3	1	2	1	1	2	8	8	2
Leahey et al., 2014	3	1	3	2	1	1	7	8	3
Lin et al., 2015	3	1	3	1	1	2	10	8	2
Patrick et al., 2009	3	1	3	1	1	1	7	7	3
Rothert et al., 2006	3	1	1	1	3	3	10	7	3
Sherwood et al., 2006	3	1	1	2	3	3	10	7	2
Thomas et al., 2015	3	1	1	1	1	2	8	8	2

Note: 1 = strong; 2 = moderate; 3 = weak.

Year of publication and participants' nationality. All studies have been published between 2002 and 2015 in the United States, specifically in the states of Baltimore, Cambridge, Seol, Burlington, Los Angeles, Rhode Island and in different regions of the California, Georgia and Minnesota.

Target population. All studies targeted overweight or obese adults. Three studies targeted the overweight population (e.g., Patrick et al., 2009), seven studies targeted the obese population (e.g., Krukovski et al., 2011) and four studies targeted both (e.g., Laing et al., 2014). In some of the studies, the obese adults also suffered from hypertension, cholesterol and diabetes (Appel et al., 2011), Metabolic Syndrome (Bumjo et al., 2015), hypertension only (Bennett et al., 2009) and diabetes, hypertension and Metabolic Syndrome (Thomas et al., 2015).

The selection of participants. Participants were either volunteers or were selected by the researchers themselves from clinical centers.

The samples were generally comprised of more women than men, except for four studies, in which men accounted for 82% (Thomas et al., 2015), 52.5% (Bennett et al., 2009), 50% (Bumjo et al., 2015) or 100% (Azar et al., 2015) of the population, respectively. Six studies included Afro-American participants. Considering all studies, the average age was 48.8 years. The participants had an average BMI of 31.5 kg/m2 and an average weight of 96.1 kg. The sample sizes ranged from 64 to 2762 participants, with a total of 7074 participants being included in the intervention and control groups.

Study design. Most of the studies were randomized controlled trials (e.g., Thomas et al., 2015), except for six of them which were clinical controlled trials (e.g., Rothert et al., 2006).

Description of the technological component. Most studies used a website (either by itself or combined with other technological components) to deliver the intervention (e.g., Azar et al., 2015; Bennett et al., 2009; Thomas et al., 2015). Two studies used a smartphone application (Bumjo et al., 2015; Laing et al., 2014), one study used e-mails (Sherwood et al., 2006), two studies used text messages (Lin et al., 2015; Patrick et al., 2009) and one study used phone calls (Sherwood et al., 2006). A website designed to deliver the intervention was combined with phone calls and e-mails in the following studies: Appel et al., 2011; Harvey-Berino et al., 2002; Harvey-Berino et al., 2004 and Rothert et al., 2006.

Key-components of the intervention. The interventions' key components were as follows: self-monitoring strategies, goal setting, feedback sessions or progress reports, social support, brochures/informational materials regarding weight management, organizing competitions between participants, the use of a tailored intervention for each participant, problem solving discussions with the counselor. The informational materials offered information about behavioral change techniques, environment stimuli control, a healthy lifestyle, how to replace unhealthy with healthy food, eating on emotional considerations, body perceptions and the benefits of adopting an active lifestyle.

The control group. The control groups were defined either as „active care" (e.g., Appel et al., 2011; Bumjo et al., 2015), „no care" (Azar et al., 2015), „usual care" (e.g., Bennet et al., 2009; Laing et al., 2014) or „placebo" (Thomas et al., 2015).

Retention rate. With regard to retention rate, between 5.5% and 70% of participants withdrew from the studies. The numbers were so high partially because the respective sample sizes were high; for exemple, the study conducted by Rothert et al. (2006) included a sample size of 2862 participants.

Studies' duration. The studies were conducted over a period between 6 weeks to 6 months, but the researchers continued to keep in touch with the participants for follow-up sessions. Therefore, considering the follow-up sessions, two studies ran accross a 24 months period, (Appel et al., 2011; Sherwood et al., 2006), one study for 18 months (Harvey-Berino et al., 2002), three studies for 12 months (Harvey-Berino et al., 2004; Leahey et al., 2014; Lin et al., 2015), five studies for six months (Bumjo et al., 2015; Krukovski et al., 2011; Laing et al., 2014; Rothert et al., 2006; Thomas et al., 2015), one study for four months (Patrick et al., 2009) and two studies for three months (Azar et al., 2015; Bennett et al., 2009).

Outcomes. For the current article, out of the cases which had more than one final outcome reported, we selected for the analysis procedures only the last reported outcome. Studies in which the reported weight changes was in „pounds" were converted into kilograms. Six studies reported statistically significant results, favoring the eHealth interventions (Appel et al., 2011; Azar et al., 2015; Bumjo et al., 2015; Leahey et al., 2014; Rothert et al., 2006; Thomas et al., 2015). One of the studies also reported statistically significant results, but favoring the in-person interventions (Krukowski et al., 2011). Two studies reported insignificat, but promising results, concluding that eHealth interventions had the potential of being effective (Bennett et al., 2009; Patrick et al., 2009). The others five studies did not report statistically significant differences between the intervention and control groups (Harvey-Berino et al., 2002; Harvey-Berino et al., 2004; Laing et al., 2014; Lin et al., 2015; Sherwood et al., 2006). Regarding the significant studies, it is notable that the treatment was delivered via phonce calls, an website specially designed and e-mails (Appel et al., 2011), solely via a website (Azar et al., 2015; Leahey et al., 2014; Rothert et al., 2006; Thomas et al., 2015) or via a smartphone application (Bumjo et al., 2015). Each of these studies included the following key components: (1) self-monitoring strategies, goal setting, feedback sessions, informative materials, social support (Appel et al., 2011), (2) solely self-monitoring strategies (Azar et al., 2015), (3) self-monitoring strategies, feedback sessions, informative materials (Bumjo et al., 2015), (4) self-monitoring strategies, goal setting, feedback sessions, informative materials, organizing competitions between participants (Leahey et al., 2014), (5) self-monitoring strategies, informative materials, social support, individually tailored treatment (Rothert et al., 2006), (6) self-monitoring strategies, goal setting, feedback sessions, social support and informative materials (Thomas et al., 2015).

Table 2. *Selected characteristics of included studies*

Study	Sample characteristics	Intervention group	Control group	Results	Study design
Appel et al., 2011	N=415 obese adults 63,6% women 41.0% afro-americans Age=54.0 years BMI=36.6 kg/m^2 Weight=103.8 kg	A. eHealth intervention: phone calls, access to a website specially designed for the intervention and monthly feedbacks via e-mail B. hybrid intervention: individuals or group meetings, access to a website specially designed for the intervention and monthly feedbacks via email	C. control group: active care	Intention-to-treat: Weight loss: A: -4.6 kg (SD 0.6) B: -5.1 kg (SD 0.8) C: -0.8 kg (SD 0.6) A vs C: p<0.001 B vs C: p<0.001 A vs B: p=0.63	CCT
Azar et al., 2015	N=64 adults Age=46.3 years 100% men BMI=35.0 kg/m^2 Weight=111.05 kg	A. eHealth intervention: online group meetings	B. control group: no care	Intention-to-treat Weight loss: A. -3.6 kg B. -0.4 kg p=0.0002 Changes in BMI: A. -1.4 kg/m^2 B. -0.4 kg/m^2 p=0.0010	CCT

Study	Sample characteristics	Intervention group	Control group	Results	Study design
Bennett et al., 2009	N=101 obese adults 47.5% women 31.0% afro-americans Age=54.4 years BMI=34.6 kg/m^2 Weight=98.5 kg	A. hybrid intervention: access to a website, in-person meetings, phone calls	B. control group: usual care	Intention-to-treat: Weight loss: A. -2.28 (SD 3.21) B. +0.28 (SD 1.87) Completers: Weight loss: A. -2.71 (SD 3.34) B. +0.34 (SD 2.04)	RCT
Bumjo et al., 2015	N=446 obese adults 50.0% women Age=48.5 years BMI=29.41 kg/m^2	A. eHealth intervention: access to a smartphone application	B. control group: active care	Intention-to-treat: Weight loss: A. -3.28 kg B. -3.07 kg p<0.001 Changes in BMI: A. -1.07 kg/m^2 B. -0.81 kg/m^2 p<0.001 Per protocol analysis: Weight loss: A. -2.31 kg B. -1.22 kg p<0.001 Changes in BMI: A. -0.84 kg/m^2 B. -0.48 kg/m^2 p<0.001	RCT

Study	Sample characteristics	Intervention group	Control group	Results	Study design
Harvey-Berino et al., 2002	N=122 overweight adults 85.0% women Age=48.4 years Weight=88.6 kg BMI=32.2 kg/m^2	A. eHealth intervention: online group meetings, e-mails twice a week B.hybrid intervention: individual meetings and phone calls twice a week	C. control group: active care (in-person treatment, with minimal support)	Completers: Weight loss: A: -5.7 kg (SD 5.9) B: -10.4 kg (SD 6.3) C: -10.4 kg (SD 9.3) p<0.05	CCT
Harvey-Berino et al., 2004	N=255 overweight and obese adults 82.0% women Age=49 de years Weight=84.2 kg BMI=30 kg/m^2	A. eHealth intervention: online group meetings, e-mails twice a week B. hybrid intervention: group meetings, phone calls twice a week	C. control group: active care (in-person treatment, with minimal support)	Intention-to-treat: Weight loss: A. -4.7 kg (SD 6.9) B. -3.9 kg (SD 5.9) C. -4.2 kg (SD 7.9) p=0.77	CCT
Krukowski et al., 2011	N=323 obese adults 93.0% women 28.0% afro-americans Age=46.6 years Weight=97.5 kg BMI=35.8 kg/m^2	A. eHealth intervention: online group meetings	B. control group: active care	Intention-to-treat: Weight loss: A. -8.0 kg (SD 6.1) B. -5.5 kg (SD 5.6) p<0.01	CCT
Laing et al., 2014	N=212 overweight and obese adults 73.0% women 13.0% afro-americans Age=43.3 years BMI=33.4 kg/m^2	A. eHealth intervention: usual care combined with access to a smartphone application	B. control group: usual care	Intention-to-treat: Weight loss: A. -0.3 kg B. +0.2 kg p=0.63	RCT
Leahey et al., 2014	N=230 BMI=34.4 kg/m^2	A. eHealth intervention: access to an online platform, access to a website specially designed for the intervention B. intervention A + the opportunity to attend an additional group session	C. grup de control: usual care	Weight loss (%): A. 2.2% kg (SD 0.6%) B. 3.3% kg (SD 0.6%) C. 1.2% kg (SD 0.9%) A vs C: p<0.001 B vs C: p<0.001	RCT

Study	Sample characteristics	Intervention group	Control group	Results	Study design
Lin et al., 2015	N=124 obese adults 84.6% women Age=50.7 years BMI=37.8 kg/m^2 Weight=102 kg	A. eHealth intervention: daily tailored text messages	B. control group: usual care	Intention-to-treat: Weight loss: A. -2.2 kg B. -1 kg p=0.151	RCT
Patrick et al., 2009	N=65 overweight adults 80.0% women 17.0% afro-americans Age=44.9 years BMI=33.2 kg/m^2 Weight=89.0 kg	A. eHealth intervention: daily tailored text messages, monthly phone calls	B. control group: usual care	Intention-to-treat (LOCF): Weight loss: A. -2.10 kg (SD 0.51) B. -0.5 kg (SD 0.51) p=0.03 Completers: Weight loss: A. -2.46 kg (SD 0.64) B. -0.47 kg (SD 0.64) p=0.04	RCT
Rothert et al., 2006	N=2762 overweight and obese adults 83.0% women 36.0% afro-americans Age=45.4 years BMI=33.5 kg/m^2 Weight=92.3 kg	A. eHealth intervention: tailored weight management plan delivered via a web platform	B. control group: active care	Intention-to-treat (LOCF): Weight loss (%): A. -0.9% kg (SD 0.1) B. -0.4% kg (SD 0.1) p<0.0001 Completers: Weight loss (%): A. -3% kg (SD 0.3) B. -1.2% kg(SD 0.4) p<0.0001	CCT
Sherwood et al., 2006	N=1801 overweight and obese adults 72.0% women Age=50.7 years BMI=33.8 kg/m^2	A. eHealth intervention (phone intervention): interactive lessons, phone calls B. eHealth intervention (email intervention):	C. control group: usual care	Intention-to-treat: Weight loss: A. -0.93 kg (SD 0.22) B. -0.73 kg (SD 0.22) C. -0.59 kg (SD 0.22) p=0.55	RCT

		interactive lessons delivered via e-mail			

Study	Sample characteristics	Intervention group	Control group	Results	Study design
Thomas et al., 2015	N=154 overweight and obese adults 18.0% women Age=53.2 years Weight=94.9 kg BMI=35.0 kg/m^2	A. eHealth intervention: multimedia behavioral lessons, access to a website specially designed for the intervention	B. control group: placebo	Intention-to-treat: Weight loss: A. -5.4 kg (SD 5.6) B. -1.3 kg (SD 4.1) p<0.001	RCT

Note: BMI = body mass index; SD = standard deviasion; CCT = clinical controlled trial; RCT = randomized controlled trial.

4. DISCUSSION

This paper aimed to evaluate the efficacy of eHealth interventions in weight manangement. Considering the current premature understanding in the scientific literature regarding this topic, as well as the heterogeneity of the available studies, we have opted for a systematic review, seeing as how other advanced types of research would not have been particularly revealing. Following the examination of fourteen studies, six reported statistically significant results, favoring the eHealth interventions. Two studies, although reporting insignificant results, concluded that eHealth interventions had the potential of being effective.

This review addresses the limits of previous studies, thus bringing original contributions to the scientific literature. First of all, studies that used any kind of technological components were included, bringing incremental value over reviews that focused exclusively on interventions delivered via a computer (Arem et al., 2011; Enwald & Huotari, 2010; Kodama et al., 2012; Wieland et al., 2012; Manzoni et al., 2011) or exclusively on interventions delivered via a smartphone (Bacigalupo et al., 2013; Shaw & Bosworth, 2012; Stephens & Allen, 2013). A single review previously identified has included studies containing both types of eHealth interventions, but the respective studies were published only between 2010 and 2011 (Coons et al., 2012). Secondly, no other review or meta-analysis identified used a quality assessment tool for evaluating the included studies. In this respect, the present review employed the Quality Assessment Tool for Quantitative Studies developed by the Effective Public Health Practice. This tool aims to provide high quality systematic reviews, having a test-retest fidelity index of 0.74. Additionally, the current paper used a more inclusive search string compared to previous ones. Furthermore, the included studies were published between 2002 and 2015, given a broad overview of the evolution of the literature over thirteen years.

Due to the small number of studies included in this paper and also due to their heterogeneity, only six out of fourteen studies reported statistically significant results. Heterogeneity was an issue also faced by previous researches (Coons et al., 2012, Raaijmakers et al., 2015, Hutchesson et al., 2015, Bacigalupo et al., 2013). Studies have varied considerably with regard to sample size, duration of the intervention and target population. Moreover, the majority of the participants were volunteers and the male population was under-represented in most of the studies, which limits the sample's degree of representativeness.

The included studies have several limitations, including the following: for some, it could be noted the contamination of the intervention groups with specific elements that should be found only in the control groups and vice versa. This means that eHealth interventions used not only virtual interactions, but also in-person interactions; on the other hand, in-person interventions also had technological components. This fact makes it difficult to compare the two groups and draw a conclusion on the efficacy of eHealth interventions in weight management. Moreover, in this situation, specific components that leads to a successful intervention are hard to define.

Another limitation would be the inclusion criteria of the participants. In all studies, participants could take part in the experiment only if they had access to a smartphone or a computer, limiting the sample's degree of representativeness. Consequently, the population to which the results can be generalized is the one with a higher economic status. A possible solution to this issue would be to equip the participants with devices needed to follow the intervention, but this approach would be quite expensive for the researchers. Similarly, if the interventions have technological component, it is important to differentiate between participants in regards to their age as older people may have some difficulties interacting with technology. It is already known that the rate of mobile phone and text messages usage is higher for adolescents and young adults than for elderly population (Tuckel & O'Neill, 2004). With this in mind, participants should be stratified based on their age for the statistical analysis.

As Coons et al. (2012) claim, self-monitoring is a crucial element that leads to successful interventions in weight manangement. However, not all researchers have included this in their treatments, significantly reducing the chances of reaching significant results. Additionally, the study published by Khaylis et al. (2010) concluded that there were five key-components that every intervention has to include, namely: self-monitoring, counselor feedback, social support, structured program and individually tailored program. None of the included studies contained all of the above mentioned key-components. Automately delivered feedback through certain algorythms should also be questioned. One can never know for sure if the respective automated feedback received by each participant was approapriate to their specific situation. This issue was also addressed by Shaw and Bosworth (2012). In their review, the authors point out the importance of finding the most relevant text messages to be delivered to the participants in order to achieve best results.

Most of the studies used self-report as a method to collect data from the participants. Therefore, the results should be interpreted with caution as data collected through self-report methods may easily be falsified by participants either purposefully or due to a lack of interest. Self-monitoring can be classified as a biased method if collected through self-report. Fortunately, the evolution of technology leads to innovative methods for this topic. Nowadays, it is possible for dietary data to be automatically transmitted to researchers' devices via a wireless network (Coons et al., 2012).

Ultimately, not all of the studies respected the blinding principle. In half of them, either the assessors were aware of the interventions or the exposure status of participants, or the participants were aware of the research question. This leads to biased results. In addition, only four studies determined the appropriate sample size a priori.

Taking into account all of the above-mentioned limits, the results of the present review should be interpreted with caution. Although it is not possible at this point to indicate exactly which intervention components are more efficient, the results are promising. This findings are consistent with previous reviews (Coons et al., 2012; Manzoni et al., 2011; Bacigalupo et al., 2013). The current understanding of this topic is still premature, preventing us to reach clear conclusions about the efficacy of eHealth interventions in weight manangement, as there are very few studies which invalidate the efficiency of eHealth intervention, while the majority claim they can be effective (Harvey-Berino et al., 2002). Future research should aim to reduce biases in research design by randomizing the participants in different groups, reporting the effect size and the standard deviation, determining the appropriate sample size a priori, ensuring the samples' representativeness and abiding by the blinding principle. (6) self-monitoring strategies, goal setting, feedback sessions, social support and informative materials (Thomas et al., 2015).

Limitations

This study has several limitations. First of all, the limited number of studies included in the analyses is a reasonable explanation why it was impossible to capture a clear pattern that successfully leads to significant results. It is still unknown which intervention components and which treatment delivery methods lead to the best results. Therefore, future studies should consider including more studies in their analyses.

Secondly, studies were analysed only in relation to two indicators, namely changes in body mass index and changes in weight. Future studies should search for other relevant indicators, such as waist circumference, the amount of calory intake, level of cholesterol, blood pressure or the quality of one's life. In addition, the present review fails to take into account possible moderators in weight interventions.

Ultimately, the analysed studies were published exclusively in the United States, making it impossible for the results to be extrapolated to other regions, such as Europe. Moreover, some relevant studies might be omitted due to the examination of only four databases.

Conclusions

To sum up, the results of the present review offer a promising perspective on the efficacy of eHealth interventions in weight management. However, more studies are needed to provide conclusive results. Future researchers aim to study eHealth interventions should first of all consider building robust methodological design which would greatly minimize the observed biases.

REFERENCES

Appel, L. J., Clark, J. M., Yeh, H. C., Wang, N. Y., Coughlin, J. W., Daumit, G., ... & Noronha, G. (2011). Comparative effectiveness of weight-loss interventions in clinical practice. *New England Journal of Medicine, 365*(21), 1959-1968.

Arem, H., & Irwin, M. (2011). A review of web-based weight loss interventions in adults. *Obesity Reviews, 12*(5), e236-e243.

Azar, K. M., Aurora, M., Wang, E. J., Muzaffar, A., Pressman, A., & Palaniappan, L. P. (2014). Virtual small groups for weight management: an innovative delivery mechanism for evidence-based lifestyle interventions among obese men. *Translational behavioral medicine, 5*(1), 37-44.

Bacigalupo, R., Cudd, P., Littlewood, C., Bissell, P., Hawley, M. S., & Buckley Woods, H. (2013). Interventions employing mobile technology for overweight and obesity: an early systematic review of randomized controlled trials.*Obesity reviews, 14(4)*, 279-291.

Bennett, G. G., Herring, S. J., Puleo, E., Stein, E. K., Emmons, K. M., & Gillman, M. W. (2010). Web-based weight loss in primary care: a randomized controlled trial. *Obesity, 18(2)*, 308-313.

Coons, M. J., DeMott, A., Buscemi, J., Duncan, J. M., Pellegrini, C. A., Steglitz, J., ... & Spring, B. (2012). Technology interventions to curb obesity: a systematic review of the current literature. *Current cardiovascular risk reports,6(2)*, 120-134.

Dobbs, R., Sawers, C., Thompson, F., Manyika, J., Woetzel, J. R., Child, P., ... & Spatharou, A. (2014). *Overcoming obesity: An initial economic analysis*. McKinsey Global Institute.

Enwald, H. P. K., & Huotari, M. L. A. (2010). Preventing the obesity epidemic by second generation tailored health communication: an interdisciplinary review. *Journal of medical Internet research, 12(2)*.

Harvey-Berino, J., Pintauro, S., Buzzell, P., DiGiulio, M., Gold, B. C., Moldovan, C., & Ramirez, E. (2002). Does using the Internet facilitate the maintenance of weight loss?. *International journal of obesity, 26(9)*, 1254.

Harvey-Berino, J., Pintauro, S., Buzzell, P., & Gold, E. C. (2004). Effect of internet support on the long-term maintenance of weight loss. *Obesity research, 12(2)*, 320-329.

Hutchesson, M. J., Rollo, M. E., Krukowski, R., Ells, L., Harvey, J., Morgan, P. J., ... & Collins, C. E. (2015). eHealth interventions for the prevention and treatment of overweight and obesity in adults: a systematic review with meta-analysis. *Obesity Reviews, 16(5)*, 376-392.

Khaylis, A., Yiaslas, T., Bergstrom, J., & Gore-Felton, C. (2010). A review of efficacious technology-based weight-loss interventions: five key components.*Telemedicine and e-Health, 16(9)*, 931-938.

Kodama, S., Saito, K., Tanaka, S., Horikawa, C., Fujiwara, K., Hirasawa, R., ... & Yamada, N. (2012). Effect of Web-based lifestyle modification on weight control: a meta-analysis*. International Journal of Obesity, 36(5)*, 675-685.

Krukowski, R. A., Tilford, J. M., Harvey-Berino, J., & West, D. S. (2011). Comparing behavioral weight loss modalities: incremental cost-effectiveness of an internet-based versus an in-person condition. *Obesity, 19(8)*, 1629-1635.

Laing, B. Y., Mangione, C. M., Tseng, C. H., Leng, M., Vaisberg, E., Mahida, M., ... & Bell, D. S. (2014). Effectiveness of a smartphone application for weight loss compared with usual care in overweight primary care patients: a randomized, controlled trial. *Annals of internal medicine, 161*(10_Supplement), S5-S12.

Leahey, T. M., Thomas, G., & Fava, J. L. (2014). Access to a Behavioral Weight Loss Website With or Without Group Sessions Increased Weight Loss in Statewide Campaign. *JCOM, 21(8).*

Lin, M., Mahmooth, Z., Dedhia, N., Frutchey, R., Mercado, C. E., Epstein, D. H., ... & Cheskin, L. J. (2015). Tailored, interactive text messages for enhancing weight loss among African American adults: the TRIMM randomized controlled trial. *The American journal of medicine, 128(8)*, 896-904.

Manzoni, G. M., Pagnini, F., Corti, S., Molinari, E., & Castelnuovo, G. (2011). Internet-based behavioral interventions for obesity: an updated systematic review. *Clinical Practice & Epidemiology in Mental Health, 7(1).*

Mayo Clinic (2015). Diseases and Conditions: Obesity. Retrieved from http://www.mayoclinic.org/diseases-conditions/obesity/basics/definition/con-20014834?p=1.

Nath, T. (n.d.). The Economic Cost of an Obese Society. Retrieved from http://www.investopedia.com/articles/personal-finance/041715/economic-cost-obese-society.asp

National Collaborating Centre for Methods and Tools (2008). *Quality Assessment Tool for Quantitative Studies*. Hamilton, ON: McMaster University. (Updated 13 April, 2010) Retrieved from http://www.nccmt.ca/resources/search/14.

Neve, M., Morgan, P. J., Jones, P. R., & Collins, C. E. (2010). Effectiveness of web-based interventions in achieving weight loss and weight loss maintenance in overweight and obese adults: a systematic review with meta-analysis.*Obesity reviews, 11(4),* 306-321.

Patrick, K., Raab, F., Adams, M. A., Dillon, L., Zabinski, M., Rock, C. L., ... & Norman, G. J. (2009). A text message–based intervention for weight loss: randomized controlled trial. *Journal of medical Internet research, 11(1).*

Raaijmakers, L. C., Pouwels, S., Berghuis, K. A., & Nienhuijs, S. W. (2015). Technology-based interventions in the treatment of overweight and obesity: A systematic review*. Appetite, 95*, 138-151.

Rothert, K., Strecher, V. J., Doyle, L. A., Caplan, W. M., Joyce, J. S., Jimison, H. B., ... & Roth, M. A. (2006). Web-based weight management programs in an integrated health care setting: a randomized, controlled trial. *Obesity, 14(2)*, 266-272.

Shaw, R., & Bosworth, H. (2012). Short message service (SMS) text messaging as an intervention medium for weight loss: a literature review.*Health informatics journal, 18(4),* 235-250.

Sherwood, N. E., Jeffery, R. W., Pronk, N. P., Boucher, J. L., Hanson, A., Boyle, R., ... & Chen, V. (2006). Mail and phone interventions for weight loss in a managed-care setting: weigh-to-be 2-year outcomes*. International Journal of Obesity, 30(10)*, 1565.

Stephens, J., & Allen, J. (2013). Mobile phone interventions to increase physical activity and reduce weight: a systematic review. *The Journal of cardiovascular nursing, 28(4)*, 320.

Thomas, J. G., Leahey, T. M., & Wing, R. R. (2014). An automated internet behavioral weight loss program by physician referral: a randomized, controlled trial. *Diabetes Care*, DC_141474.

Tuckel, P., & O'Neill, H. (2006, January). Ownership and usage patterns of cell phones: 2000–2005. In *Annual*

Conference of the American Association for Public Opinion Research, *Montreal, Quebec, Canada.*

Wickham, C. A., & Carbone, E. T. (2015). Who's calling for weight loss? A systematic review of mobile phone weight loss programs for adolescents. *Nutrition reviews, 73(6)*, 386-398.

Wieland, L. S., Falzon, L., Sciamanna, C. N., Trudeau, K. J., Brodney, S., Schwartz, J. E., & Davidson, K. W. (2012). Interactive computer-based interventions for weight loss or weight maintenance in overweight or obese people. *Cochrane Database Syst Rev, 8(8).*

World Health Organization [WHO] (2015). Obesity and Overweight. Retrieved from http://www.who.int/mediacentre/factsheets/fs31.