Orthopedic & Muscular System: Current Research

Effectiveness of Cellular Phone-Based Interventions for Weight Loss in Overweight and Obese Adults: A Systematic Review

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Abstract

Background: In response to the rapid increase in obesity and its association with chronic diseases, World Health Organization has declared an immediate need for effective and widely-accessible interventions for weight management. Cellular phones are portable, convenient, and popular among people of varying economic status and geographic regions; hence, they offer a viable medium for delivering weight loss interventions.

Objective: To determine whether cellular phones are an effective medium for delivering weight loss interventions in adults who are overweight or obese.

Methods: A literature search was conducted to retrieve articles published prior to February 2012. Studies were included if they: 1) included adults with a body mass index (BMI) of 25 or higher and with no known chronic condition, 2) delivered a weight loss intervention using a cellular phone, 3) measured weight, BMI, waist circumference, body fat or any other proxy for weight loss, 4) had a comparison group, and 5) were published in English. At least two reviewers independently screened all titles and abstracts and reviewed the included articles.

Results: 193 unique citations were screened; of those, six studies met inclusion criteria. Mobile interventions varied from phone calls and short message service (SMS) messaging to emails, websites and podcasts. Among studies of one-way interactive interventions (i.e., the researcher could contact the participants, but the participants could not respond), one high quality randomized controlled trial (RCT) showed a small but statistically significant effect in weight reduction, favoring the intervention, and one low quality study reported no significant difference compared to printed material. Of the four studies on two-way interactive interventions (i.e., there was open communication between researchers and participants), two RCTs demonstrated statistically significant difference for weight and waist circumference, while one showed no significant difference. When compared to a clinic-based intervention, one low quality study showed that an internet/SMS weight loss intervention was inferior to regular clinic visits.

Conclusion: Due to the small number of high quality studies, modest evidence was found for the effectiveness of cellular phones in the delivery of weight loss interventions for people who were overweight or obese.

Keywords: Obesity; Weight loss; Cellular phone; Mobile communication device; Systematic review

Introduction

Since 1980, the prevalence of obesity has more than doubled worldwide and according to Statistics Canada, roughly 4.6 million Canadian adults were classified as overweight or obese [1,2]. Chronic diseases such as hypertension, type 2 diabetes, cardiovascular disease and stroke are often a result of carrying this excessive weight [3-6]. The ramifications of being overweight and obesity extend beyond the aforementioned health consequences. In 2008, obesity accounted for $4.6 billion of the Canada economy [7] and the costs reached as high as $147 billion in the United States of America [8,9]. It has been shown that as little as a 5-10% reduction in weight decreases the risk for hypertension [10], coronary artery disease [11], and diabetes mellitus [12] by up to 20%.

Body mass index (BMI) is commonly used as a measure of this health risk and is defined as a person's body mass in kilograms divided by height in meters squared. The World Health Organization (WHO) has defined overweight as anyone with a BMI of 25.0 to 29.9 kg/m² and obese as anyone with a BMI greater than or equal to 30 kg/m² [2]. The rapid increase in obesity, its correlation with other serious diseases and its significant economic impact have led WHO to declare an immediate need for effective and widely-accessible weight loss interventions for

large-scale public health delivery [3].

Smartphone's are capable of supporting a variety of functions, including high-speed data access to the internet, in addition to voice calling and short message service (SMS) messaging. Data access enables smart phones to be connected to social media, email, face-to-face video calling and numerous applications, while feature phones lack data access, but maintain the capabilities of voice calling and SMS messaging. Cellular phone use in Canada has risen from 100,000 in 1987 to over 21 million in 2008 [13], suggesting that it is a comparable alternative to printed material, face-to-face delivery and computer-based interventions for widespread deliverance of lifestyle

interventions. Current evidence suggests that text messaging may improve compliance with medication and medical appointments and supports a healthy life style [14-17]; hence the use of cellular phones has potential for facilitating healthy behaviors and improving health outcomes.

The increasing use of cellular phones among varying age groups, socio-economic backgrounds and ethnic groups make it a feasible medium for delivery of weight loss interventions [18,19]. Possible additional benefits to using cellular phones as a medium for weight loss interventions include cost-effectiveness, large scale delivery, portability, and the ability to deliver individualized information rapidly and in a variety of locations [5,6,20]. Moreover, information can be transmitted to a cellular phone without the user having to initiate a request, which is usually required to access a computerized program [5,6,20].

Mobile technology is rapidly advancing, which is reflected by new research including interventions delivered using smart phone applications and games [21]. It is likely that as cellular phones become more ubiquitous and technologically advanced, they will become a popular method of weight loss intervention delivery. Therefore, the purpose of this review is to determine if cellular phone is an effective medium for delivering weight loss interventions in adults who are overweight or obese.

Methods

Criteria for study inclusion

Studies were included in the review if they: 1) included participants aged 18 years or older, with a BMI of 25 or higher, and with no known chronic condition at the time of enrolment; 2) included weight loss interventions delivered by a cellular phone; 3) reported outcome measures including weight, BMI, waist circumference, body fat or any other proxy for weight loss; 4) were randomized controlled trials (RCTs), controlled clinical trials (CCTs), or controlled before-and-after studies; and 5) were published in English. Devices were considered cellular phones if they had the capacity to make and receive telephone calls and SMS texts over a radio link protocol covering a wide geographical area. Smartphone capabilities, such as data access to the internet and ability to support applications, were not eligibility requirements in this review.

Literature search, quality asssessment and data extraction

An electronic database search using MEDLINE, EMBASE, CINAHL, the Cochrane Library and PsycINFO was conducted in February 2012. Appendix 1 presents the search strategy developed for MEDLINE. At least two reviewers (JC, VG, RL, NM, JW) screened each title and abstract for relevance based on the study inclusion criteria. Any discrepancies were discussed among the reviewers and disagreement was resolved by a third independent reviewer on the team. Abstracts with missing information were included in the full paper review.

All included studies were assessed by two independent reviewers for methodological quality using the 11-item PEDro Scale [22], which was designed for rating methodological quality of RCTs (Appendix 2) [23](Table 3).Ten of the items pertain to internal validity of a trial. The remaining item pertains to external validity and is, therefore, not included in the calculation of the total PEDro score (range=0-10). A score of six or higher indicates high methodological quality [22]. Data extraction was performed using a standardized data extraction form developed by the researchers. It recorded information including study design, research setting, sample size, participant recruitment

process and attrition rate, quality appraisal, participant characteristics, intervention characteristics (i.e., interactivity and duration), outcomes measures and results. Any disagreement between the reviewers was resolved by a third independent reviewer.

Data analysis

The study designs and types of interventions were initially assessed for methodological and conceptual similarities. Since the application of cellular phone-based intervention varied widely in the included studies, a meta-analysis would be inappropriate. Hence, we summarized the results narrative. Our preliminary review indicated that the frequency of interactions between researchers and participants via cellular phone varied between studies; hence, we categorized the interventions into two groups: 1) one-way interaction, in which the researcher could contact the participants, but the participants could not respond; 2) two-way interaction, in which there was open communication between researchers and participants.

For each study, we reported results of the outcome measures separately and in their natural units. For continuous variables, effect size, such as standardized mean difference (Cohen's d), was calculated between the experimental group (EG) and the comparison group (CG), if possible. According to Cohen, an effect size of 0.2 is considered a small effect, 0.5 a medium effect, and 0.8 a large effect [24].

Results

A total of 298 articles were retrieved, and 193 remained after duplications were removed (Figure 1). Of those remaining, 154 articles were excluded after the title and abstract screening. Of the 39 studies that advanced to the full article review; 33 did not meet the inclusion criteria (Table 1) [5,18,20,21,25-29,30-51], leaving six studies included in this review (Table 2) [6,19,35,48,52,53]. Most included studies incorporated the use of cellular phone as a part of a multifaceted weight loss program, rather than a standalone intervention.

Interventions involving one-way interaction

Two studies examined weight loss interventions involving one-way interaction via cellular phone. One study was a cluster RCT [53] and the second was a CCT [35]. Lombard et al. [53] investigated 250
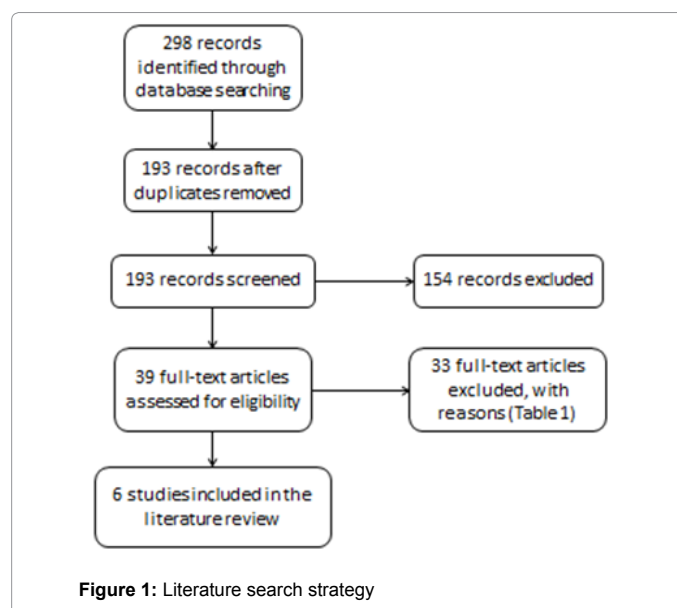

Figure 1: Literature search strategy

Study	Reasons for exclusion
Ferrer-Roca 2004 [55]	The cellular phone intervention was used for blood glucose monitoring rather than weight loss
Park 2005 [41]	All participants had a chronic condition (diabetes)
Sung 2005 [46]	The intervention was not for weight management
Tufano 2005 [48]	Review paper
Scherr 2006 [44]	All participants had a chronic condition (cardiac disease)
Joo 2007 [32]	No control group
Hurling 2007 [31]	Some participants had a BMI below 25 at baseline
Kim 2008 [34]	All participants had a chronic condition (diabetes)
Morak 2008 [3]	No control group
Gerber 2009 [18]	Did not include outcome measure related to weight loss
Park 2009 [5]	All participants had a chronic condition (hypertension)
Vespasiani 2009 [49]	All participants had a chronic condition (diabetes)
Wohlers 2009 [50]	No outcome measure related to weight loss (this was a usability study)
Heron 2010 [20]	Review paper
Kaufman 2010 [33]	Review paper
McCrady-Spitzer 2010 [38]	Review paper
McGraa 2010 [39]	Some participants had a BMI below 25 at baseline
Mattila 2010 [21]	Review paper
Mattila 2010 [21]	No control group
Prestwich 2010 [42]	Some participants had a BMI below 25 at baseline
Rossi 2010 [43]	All participants had a chronic condition (diabetes)
Svensson 2010 [47]	Review paper
Zheng 2010 [51]	Descriptive paper of the intervention
Bexelius 2011 [25]	Some participants had a BMI below 25 at baseline
Boucher 2011 [27]	Editorial
Daley 2011 [28]	No cellular phone intervention used
Fukuoka 2011 [29]	No control group
Hitman 2011 [30]	Editorial
Lee 2011 [35]	Some participants had a BMI below 25 at baseline
Maddison 2011 [36]	Study protocol
Mori 2011 [40]	All participants had a chronic condition (diabetes)
Seto 2011 [45]	All participants had a chronic condition (heart failure)
Blasco 2012 [26]	All participants had a chronic condition (acute coronary syndrome)

Table 1: Excluded studies and reasons for exclusion (n=33)

mothers who were randomized by elementary school for one year. The EG attended four interactive group meetings facilitated by a dietitian to discuss goal-setting and steps to achieving healthy-eating behavior. From weeks 4 to 52, they received weekly personalized text messages, this contained information on nutrition, behavioral change and physical activity. The CG received usual care consisting of a single, non-interactive 30-minute lecture on general physical activity and diet recommendations, and a pedometer for self-monitoring. After one year, the EG had lost weight while the CG showed an increase in weight and waist circumference (EG: weight=-0.2kg, [95% confidence interval - CI: -0.9,-0.5], waist circumference=-1.3 cm [95% CI: -2.4,-0.2]; CG: weight=0.8 kg [95% CI: 0.1, 1.5], waist circumference=0.1 cm [95% CI: -1.0, 1.2]). Effect size for body weight change, adjusted for baseline, weight, age, income, education and clustering in the multivariable analysis, was -0.99 (95% CI: -1.90, -0.08). We were unable to estimate the effect size for waist circumference due to insufficient data. This study received a PEDro score of 9 out of 10.

In a CCT, Lee et al. [35] compared a 12-week self-management program plus bi-weekly text messaging to encourage weight management behaviors (i.e., EG) to a one-hour walking program held three times per week (i.e., CG). Both groups (n=108 women) received brief instructions on how to exercise and brochures on healthy diets. The study reported a decrease in body weight, BMI and percentage of body fat in both groups, although none achieved statistical significance. We were unable to calculate the effect size since no measure of variability was reported. The dropout rate in this study was high, with 55.0% in the EG and 54.2% in the CG. Given the methodological issues, this study received a PEDro score of 2.

Interventions involving two-way interaction

Four studies investigated the effect of two-way interactive weight loss interventions delivered by cellular phones. These included three RCTs [6,19,54] and one CCT [52]. In the first RCT (PEDro score=7), Haapala et al. [19] investigated the effectiveness of a 12-month intervention that used a cellular phone-operated weight loss application (app), Weight Balance. A total of 125 participants were randomized into the cellular phone app group (i.e., EG) or the control group (i.e., CG). This app allowed participants to report their current weight and receive SMS messages with feedback regarding their weight. It also calculated the amount of food that individuals should be eating, and the number of days until they reached their goal. These messages also encouraged participants to increase their daily physical activity and reminded them to report their weight. At 12 months, all anthropometric measures were found to have decreased significantly for participants with access to the application compared to the group with no intervention. The standardized mean difference was -0.50 (95% CI = -0.94, -0.23) for body weight and -0.59 (95% CI = -0.94, -0.23) for waist circumference.

The second RCT (PEDro score=5), by Patrick et al. [6], randomized 78 participants to receive monthly printed material on weight control (i.e., CG) or a personalized weight loss program involving cellular phone use (i.e., EG). The latter received personalized SMS and multimedia message service (MMS) messages two to five times a day, printed material, and a brief monthly call by a health counselor. This 16-week study measured body weight as the primary outcome. The results indicated a statistically significant effect (standardized mean difference=-3.06; 95% CI=-3.88, -2.24), favoring the EG.

In the third RCT (PEDro score=6), Turner-McGreevy and Tate [54] examined whether a combination of podcasts, Twitter and a diet and physical activity monitoring app, all delivered via cellular phone, could assist people in weight loss. The comparison group was granted access to the same podcasts, plus printed material. After the 6-month intervention period, there was no significant difference in changes in body weight between groups. The standardized mean difference was 0 (95% CI=-0.40, 0.40).

Finally, Joo et al. [52] conducted a CCT to compare a 12-week internet/cell phone-based intervention (i.e., EG) with an intensive clinic-based weight loss program, involving weekly/bi-weekly visits with registered nurses, nutritionists and exercise trainers (i.e., CG). The EG received educational information, weekly SMS prompts for

Authors &Country	Study Design	Sample Characteristics	Length of Intervention	Dropout	Intervention	Results[1]
One-way Interactivity						
Lombard et al. (2010) [53] Australia	Cluster RCT	**EG: (n= 127)** Age: 40.6 ± 4.8 years Female: 100% Trades/University Degree: 54.3% Weight: 73.2 ± 13.8 kg BMI: 27.5 ± 5.1 Waist Circumference: 94.8 ± 12.6 cm CG (n:123): Age: 40.3 ± 4.8 years Female: 100% Trades/University Degree: 46.3% Weight: 74.6 ± 16.1kg BMI: 28.1 ± 5.8 Waist Circumference: 96.8 ± 14.8 cm	12 months	**EG:** 18 **CG:** 17	**EG:** Interactive group sessions that focused on goal setting, and behavioural change. Pedometers + text messages were given to reinforce nutrition, physical activity and behavioural change. **CG:** One non-interactive lecture with general dietary and physical activity guidelines. Participants were given brochures + a pedometer to use at their discretion.	**Body weight:** EG: ↓ 0.2 kg (95% CI: -0.9, -0.5) CG: ↑ 0.8 kg (95% CI: 0.1, 1.5) **Effect size[2]:-0.99** (95% CI: -1.90, -0.08) **Waist Circumference:** EG: ↓ 1.3 cm (95% CI: -2.4, -0.2) CG:↑ 0.1 cm (95% CI: -1.0, 1.2) **Effect size:Unable to calculate**
Lee et al. (2011) [35] Korea	Controlled clinical trial	**EG (n=60):** Age: 47 years Female: 100% College degree: 20% Weight: 67.5 kg BMI: 28.14 **CG (n=48):** Age: 45 years Female: 100% College degree: 19% Weight: 70.25 kg BMI: 27.84	12 weeks	**EG:** 33 **CG:** 26	**EG:** Home-based obesity-control program including exercise, diet, monthly group workshops & phone counseling, 2 health education sessions, and bi-weekly SMS messages. **CG:** Structured exercise intervention (three 1-h walking classes per week) with an exercise coordinator as well as the same orientation and 2 health education sessions as the EG	**Body weight:** EG: ↓ 1.9 kg CG: ↓ 3.1 kg *p*= 0.23 **BMI:** EG: ↓ 1.1 kg/m² CG: ↓ 1.2 kg/m² *p*= 0.61 **% BF:** EG: ↓ 2.6% CG: ↓ 3.0% *p*= 0.75 **SMD: Unable to calculate**
Two-way interactivity						
Haapala et al (2009) [19] Finland	RCT	**EG (n=62)** Age: 38.1 ± 4.7 years Female: 79% University degree: 95.2% BMI: 30.6 ± 2.7 Weight: 87.5 ± 12.6 kg Waist Circumference 98.5cm ± 10.3 cm **CG (n=63):** Age: 38 ± 4.7 years Female: 76% University degree: 90.3% Weight: 86.4 ± 12.5 kg BMI: 30.4 ± 2.8 Waist Circumference: 96.6 ± 10.4 cm	12 months	**EG:** 17 **CG:** 23	**EG:** Weight reduction program delivered via text messages weekly advising the participants to reduce their food intake and increase their PA, and report their weight daily via text messages or through the program's website and provided immediate automatically-generated tailored feedback. **CG:** Participants were offered no advice on diet or PA.	Intention-to-treat analysis **Body weight:** EG: ↓ 3.1 ± 4.9 kg CG: ↓ 0.7 ± 4.7 kg *p*= 0.008 **SMD:-0.50** (95% CI: -0.85, -0.14) **Waist Circumference:** EG: ↓ 4.5 ± 5.3 cm CG:↓ 1.6 ± 4.5 cm *p*= 0.008 **SMD:-0.59** (95% CI: -0.94, -0.23)

Patrick et al. (2009) [6] USA	RCT	**EG (n=39)** Age: 47.4 ± 7.1 years Female: 76% Weight: 89.8 ± 17.2 kg BMI: 32.8 ± 4.3 **CG (n=39)** Age: 42.4 ± 7.5 years Female: 84% Weight: 88.0 ± 13.1 kg BMI: 33.5 ± 4.5	4 months	**EG:**13 **CG:**13	**EG:** Personalized SMS and MMS messages sent two to five times daily, printed materials, and brief monthly phone calls from a health counsellor **CG:** Receipt of monthly printed materials about weight control. Printed material differed from that given to the EG	**Body weight** (adjusted for baseline weight, age, sex) : EG: ↓ 2.5 ± 0.6 kg CG: ↓ 0.5 ± 0.6 kg p:0.04 **SMD:-3.06** **(95% CI: -3.88, -2.24)**
Joo et al. (2010) [32] Korea	Controlled clinical trial	**EG (n= 410)** Age: 36.9 ± 10.4 years Female: 52% Weight: 74.2 ± 11.1 kg BMI: 27.0 ± 2.7 Waist circumference: 90.5 ± 7.5 cm **CG (n= 515)** Age: 41.9 ± 9.8 years Female: 89% Weight: 71.3 ± 11.3 kg BMI: 28.1 ± 3.6 Waist circumference: 92.4 ± 7.8 cm	12 weeks	**EG:** 290 **CG:** 338	**EG:** Internet-based obesity control intervention involving educational information, plus two weekly SMS prompts, delivered via cellular phone, to reinforce healthy behaviours and access to a website which provided a weekly diet regimen, a daily food diary, and information about nutrition and exercise. **CG:** Visits to a local public health centre at 1 to 2-week intervals. Participants were taught behavioural modification strategy, nutrition and exercise by registered nurses, nutritionists and exercise trainers.	**Body weight:** EG: ↓ 1.1 ± 3.7 kg CG: ↓ 4.7 ± 2.6 kg *p* < 0.001 **SMD:0.59 (95% CI: 0.36, 0.83)** **BMI:** EG: ↓ 0.4 ± 1.4 kg/m² CG: ↓ 1.9 ± 1.0 kg/m² *p* < 0.001 **SMD:0.21 (95% CI: -0.02, 0.44)** **Waist circumference:** EG: ↓ 2.6 ± 4.3 cm CG: ↓ 6.7 ± 3.1 cm *p* < 0.001 SMD:0.23 (95% CI: 0.00, 0.46)
Turner-McGrievy et al. (2011) [54] USA	RCT	**EG (n=47)** Age: 42.6 ± 10.7 years Female: 77% College education or less: 51%, graduate degree: 49% BMI: 32.9 ± 4.8 **CG(n=49):** Age: 43.2 ± 11.7 years Female: 73% College education or less: 39%, graduate degree: 61% BMI: 32.2 ± 4.5	6 months	**EG:**5 **CG:** 5	**EG:** Podcast + enhanced mobile media. The latter involve the use of a diet and PA monitoring app and Twitter to connect with other study participants on a cellular phone. **CG:** Podcast + a book with calorie and fat content of a variety of food	**Body weight:** 0-3 months EG: ↓ 2.4 ± 3.4 kg CG: ↓ 2.3 ± 3.3 kg 3-6 months EG: ↓ 0.2 ± 3.0 kg CG: ↓ 0.3 ± 1.8 kg *p*:0.88 **SMD: 0.00 (95% CI: -0.40, 0.40)**

Effect size (i.e., standardized mean difference) was calculated using Cohen's d where possible

2Effect size for this cluster RCT was calculated by the study authors, after adjusting for baseline weight, age, income, education and clustering in the multivariable analysis

Legend: BMI: Body Mass Index; CI: Confidence interval; CG: Comparison Group; EG: Experimental Group; MMS: Multimedia message service; PA: Physical activity; RCT: Randomized controlled trial; SMD: Standardized mean difference; SMS: Short Message Service

Table 2: Study characteristics of mobile-phone delivered interventions for weight loss

behavior modification, and online resources on healthy eating and exercise [52]. Compared to the EG, participants in the CG showed greater reductions in body weight (SMD=0.59; 95% CI=0.36, 0.83), BMI (SMD=0.21; 95% CI=-0.02, 0.44) and waist circumference (SMD=0.23; 95% CI=0.00, 0.46). This was the only included study that conducted an economic evaluation. The authors reported that, among the protocol completers, the cost per person achieving the target weight reduction was $975 in the CG, compared to $1,637 per person in the EG. The latter was more expensive because they included the costs for website development and upgrade, as well as information technology personnel. These results, however, should be interpreted with caution due to methodological issues, such as a high dropout rate (67.8%; 628 of 925 enrolled participants).

Discussion

Based on the six studies reviewed, we found evidence supporting cellular phone-based weight loss interventions in overweight and obese adults; however, the results should be interpreted with caution due to

the small number of high quality papers. Interventions delivered by cellular phones varied from text messaging and websites to mobile apps that monitor diet and physical activity. Two studies used cellular phone as a single weight loss intervention, while four used it as a part of a multifaceted intervention. The heterogeneity of the interventions has rendered a meta-analysis inappropriate. The level of interactivity of the interventions did not seem to affect the findings. Among studies of one-way interactive interventions, one high quality RCT showed a small but statistically significant effect in weight [53], favoring the intervention; and one low quality study reported no significant difference compared to printed material. Of the four studies on two-way interactive interventions, two RCTs (one high quality [19] and one low quality [6]) demonstrated moderate effects for weight and waist circumference, supporting the intervention; while one high quality RCT showed no significant difference [54,55]. However, when compared to a clinic-based intervention, one low quality study showed that an internet/SMS weight loss intervention was inferior to regular clinic visits. Based on the PEDro scores, three of the six studies were deemed as high quality; however, it should be noted that one of these studies [54] did not apply proper blinding even it has a score of 6.

Several limitations in the review process should be taken into consideration while interpreting our findings. First, while we conducted a comprehensive literature search, this review only included studies published up to February 2012. Second, by limiting studies to the ones that included participants with no known chronic conditions, the generalizability of results is limited as most people who are obese have a number of co-morbid conditions, such as hypertension and cardiovascular disease. Third, only English articles were included due to the cost for translation. The exclusion of foreign articles might result in selection bias. Fourth, we did not contact study authors to obtain additional information for studies with insufficient data for an effect size calculation or search the reference lists of included articles. Finally, we did not limit the type of cellular phones applications in the current review. The heterogeneity in the types of interventions has limited our ability to derive a robust conclusion.

Although our literature search was not limited to any particular year, all eligible studies were published in or after 2009; hence, this is a relatively new field. The versatility of using cellular phone to deliver lifestyle interventions is particularly attractive to people living in areas where local access to weight management program is limited. However, we found none of the included studies explored the use of cellular phone-based interventions in rural and remote regions or for underserved populations. This knowledge gap should be a focus of future studies. Also, participants in these studies were at their middle age (mean age ranged from 37 to 47 years). Since cellular phone ownership is ubiquitous among young people, the effects of cellular phone-based intervention may be different for the younger age group.

Findings from this review are comparable with the current evidence on the use of cellular phone-based interventions for supporting healthy behaviors. Fjeldsoe et al. [15] examined the use of SMS for supporting healthy behaviors, including smoking cessation, increased physical activity and participation in chronic disease self-management. Their review, which included a variety of study designs, found 13 out of 14 studies demonstrated an improvement in healthy behaviors. The authors also concluded that tailored content and interactivity were important features of successful SMS interventions. A second narrative review by Wei et al. [17] concurred that the use of SMS could improve individual's self-management behaviors, including adherence to medication and medical monitoring.

Findings from the recent Cochrane reviews, however, were less enthusiastic. De Jongh et al. [14] identified four RCTs that assessed the effects of cellular phone messaging to facilitate self-management. They found moderate quality evidence in improving self-efficacy in patients with diabetes and medication adherence in those with hypertension, but no statistically significant effect on the compliance with peak expiratory flow measurement in patients with asthma. In the second review, Vodopivec et al. [16] found limited evidence supporting the use of SMS to deliver preventive health care, including prenatal support, use of vitamin C, smoking cessation and childhood weight control. All included studies had a follow up period of 12 months or less. Similar

Study	1. Eligibility criteria specified1	2.Random allocation	3. Concealed allocation	4. Baseline Similarity	5. Blinding of subjects	6. Blinding of health professio-nal	7. Blinding of assessors	8. Measures of key outcomes in >85%	9. ITT2	10. Between group statistical comparison	11. Point and variability measures	Total score3
One-way Interactivity												
Lombard (2010) [53]	P4	1	1	1	1	0	1	1	1	1	1	9
Lee (2011) [35]	P	0	0	1	0	0	0	0	0	1	0	2
One-way Interactivity												
Haapala (2009) [19]	P	1	0	1	0	1	1	0	1	1	1	7
Patrick (2009) [6]	P	1	1	1	0	0	0	0	0	1	1	5
Joo (2010) [32]	P	0	0	0	0	0	0	0	0	1	1	2
Turner-McGrievy (2011) [54]	P	1	0	1	0	0	0	1	1	1	1	6

1 This item influences external validity of a study. It is different from the remaining PEDro items, which pertains to internal validity. Therefore, it is not included in the calculation of the final PEDro score (http://www.pedro.org.au/english/downloads/pedro-scale/).

2ITT indicates the statistical analysis involved an intention-to-treat analysis.

3 The total score is the sum of Items 2-11 (higher score=higher quality). A score of ≥ 6 indicates a study of high methodological quality.

4P:Present

Table 3: Assessment of study methodological quality

to the previous reviews, our review also highlights two major issues in research on cellular phone-based interventions: 1) limited number of high quality studies; 2) lack of long term follow-up.

Findings from our systematic review suggest that of weight loss interventions delivered by cellular phones may be effective for overweight adults. Continued research in this area will help to inform community-based interventions and clinical practice. The versatility of mobile technologies provides tremendous opportunities for delivering health-related interventions across geographic locations; hence, there is an opportunity to evaluate interventions that are tailored for people living in rural and remote communities. Lastly, studies with a longer follow-up period will be needed. This type of information, along with rigorous cost-effectiveness analyses, can illustrate the sustainability of weight loss interventions delivered by cellular phones.

References

1. Adamo KB, Langlois KA, Brett KE, Colley RC (2012) Young children and parental physical activity levels: findings from the Canadian health measures survey. Am J Prev Med 43: 168-175.

2. World Health Organization (2011) Obesity and overweight: WHO fact sheet 2011.

3. Morak J, Schindler K, Goerzer E, Kastner P, Toplak H, et al. (2008) A pilot study of mobile phone-based therapy for obese patients. J Telemed Telecare 14: 147-149.

4. Must A, Spadano J, Coakley EH, Field AE, Colditz G, et al. (1999) The disease burden associated with overweight and obesity. JAMA 282: 1523-1529.

5. Park MJ, Kim HS, Kim KS (2009) Cellular phone and Internet-based individual intervention on blood pressure and obesity in obese patients with hypertension. Int J Med Inform 78: 704-710.

6. Patrick K, Raab F, Adams MA, Dillon L, Zabinski M, et al. (2009) A text message-based intervention for weight loss: randomized controlled trial. J Med Internet Res 11: e1.

7. Obesity in Canada, Public Health Agency of Canada and Canadian Institute for Health Information (2011), Ottawa, Canada

8. Centers for Disease Control and Prevention (2012) Overweight and obesity: economic consequences.

9. Finkelstein EA, Trogdon JG, Cohen JW, Dietz W (2009) Annual medical spending attributable to obesity: payer-and service-specific estimates. Health Aff (Millwood) 28: w822-831.

10. He J, Whelton PK, Appel LJ, Charleston J, Klag MJ (2000) Long-term effects of weight loss and dietary sodium reduction on incidence of hypertension. Hypertension 35: 544-549.

11. Ashley FW Jr, Kannel WB (1974) Relation of weight change to changes in atherogenic traits: the Framingham Study. J Chronic Dis 27: 103-114.

12. Uusitupa MI (1996) Early lifestyle intervention in patients with non-insulin-dependent diabetes mellitus and impaired glucose tolerance. Ann Med 28: 445-449.

13. Health Canada (2009) It's your health: safety of cell phones and cell towers. Health Canada, Ottawa, ON

14. de Jongh T, Gurol U, I Vodopivec J, V Car J, Atun R (2012) Mobile phone messaging for facilitating self-management of long-term illnesses. Cochrane Database of Systematic Reviews.

15. Fjeldsoe BS, Marshall AL, Miller YD (2009) Behavior change interventions delivered by mobile telephone short-message service. Am J Prev Med 36: 165-173.

16. Vodopivec J, V de JT, Gurol U, I Atun R, Car J (2012) Mobile phone messaging for preventive health care. Cochrane Database of Systematic Reviews.

17. Wei J, Hollin I, Kachnowski S (2011) A review of the use of mobile phone text messaging in clinical and healthy behaviour interventions. J Telemed Telecare 17: 41-48.

18. Gerber BS, Stolley MR, Thompson AL, Sharp LK, Fitzgibbon ML (2009) Mobile phone text messaging to promote healthy behaviors and weight loss maintenance: a feasibility study. Health Informatics J 15: 17-25.

19. Haapala I, Barengo NC, Biggs S, Surakka L, Manninen P (2009) Weight loss by mobile phone: a 1-year effectiveness study. Public Health Nutr 12: 2382-2391.

20. Heron KE, Smyth JM (2010) Ecological momentary interventions: incorporating mobile technology into psychosocial and health behaviour treatments. Br J Health Psychol 15: 1-39.

21. Mattila E, Lappalainen R, Pärkkä J, Salminen J, Korhonen I (2010) Use of a mobile phone diary for observing weight management and related behaviours. J Telemed Telecare 16: 260-264.

22. Maher CG, Sherrington C, Herbert RD, Moseley AM, Elkins M (2003) Reliability of the PEDro scale for rating quality of randomized controlled trials. Phys Ther 83: 713-721.

23. PEDro. Retrieved from http://www.pedro.org.au/english/downloads/pedro-scale/. (2013) The George Institute for Global Health.

24. Cohen J (1988) Statistical Power Analysis for the Behavioral Sciences, Lawrence Erlbaum Associates,

25. Bexelius C, Sandin S, Trolle LY, Litton JE, Lof M (2011) Estimation of physical activity levels using cell phone questionnaires: a comparison with accelerometry for evaluation of between-subject and within-subject variations. Journal of Medical Internet Research 13, e70.

26. Blasco A, Carmona M, Fernández-Lozano I, Salvador CH, Pascual M, et al. (2012) Evaluation of a telemedicine service for the secondary prevention of coronary artery disease. J Cardiopulm Rehabil Prev 32: 25-31.

27. Boucher JL (2011) The Obesity and Diabetes Epidemics: How Do We Turn the Tide? Diabetes Spectrum 24: 123-125.

28. Daley A, Stokes-Lampard H, Wilson S, Rees M, Roalfe A, et al. (2011) What women want? Exercise preferences of menopausal women. Maturitas 68: 174-178.

29. Fukuoka Y, Kamitani E, Bonnet K, Lindgren T (2011) Real-time social support through a mobile virtual community to improve healthy behavior in overweight and sedentary adults: a focus group analysis. Journal of Medical Internet Research 13, e49. Maturitas 68: 174-178.

30. Hitman GA (2011) Mobile phone intervention for diabetes. Diabet Med 28: 381.

31. Hurling R, Catt M, Boni MD, Fairley BW, Hurst T, et al. (2007) Using internet and mobile phone technology to deliver an automated physical activity program: randomized controlled trial. J Med Internet Res 9: e7.

32. Joo NS, Kim BT (2007) Mobile phone short message service messaging for behaviour modification in a community-based weight control programme in Korea. J Telemed Telecare 13: 416-420.

33. Kaufman N (2010) Internet and information technology use in treatment of diabetes. Int J Clin Pract Suppl: 41-46.

34. Kim SI, Kim HS (2008) Effectiveness of mobile and internet intervention in patients with obese type 2 diabetes. Int J Med Inform 77: 399-404.

35. Lee CY, Lee H, Jeon KM, Hong YM, Park SH (2011) Self-management program for obesity control among middle-aged women in Korea: a pilot study. Jpn J Nurs Sci 8: 66-75.

36. Maddison R, Whittaker R, Stewart R, Kerr A, Jiang Y, et al. (2011) HEART: heart exercise and remote technologies: a randomized controlled trial study protocol. BMC Cardiovasc Disord 11: 26.

37. Mattila E, Korhonen I, Salminen JH, Ahtinen A, Koskinen E, et al. (2010) Empowering citizens for well-being and chronic disease management with wellness diary. IEEE Trans Inf Technol Biomed 14: 456-463.

38. McCrady-Spitzer SK, Levine JA (2010) Integrated electronic platforms for weight loss. Expert Rev Med Devices 7: 201-207.

39. McGraa KL (2010) The effects of persuasive motivational text messaging on adherence to diet and exercise programs across different personality traits. Fielding Graduate University.

40. Mori DL, Siberbogen AK, Collins AE, Ulloa EW, Brown KL, et al. (2011) Promoting Physical Activity in Individuals With Diabetes: Telehealth Approaches. Diabetes Spectrum 24: 127-135.

41. Park KS, Kim NJ, Hong JH, Park MS, Cha EJ, et al. (2005) PDA based Point-of-care Personal Diabetes Management System. Conf Proc IEEE Eng Med Biol Soc 4: 3749-3752.

42. Prestwich A, Perugini M, Hurling R (2010) Can implementation intentions and

text messages promote brisk walking? A randomized trial. Health Psychol 29: 40-49.

43. Rossi MC, Perozzi C, Consorti C, Almonti T, Foglini P, et al. (2010) An interactive diary for diet management (DAI): a new telemedicine system able to promote body weight reduction, nutritional education, and consumption of fresh local produce. Diabetes Technology & Therapeutics 12: 641-647.

44. Scherr D, Zweiker R, Kollmann A, Kastner P, Schreier G, et al. (2006) Mobile phone-based surveillance of cardiac patients at home. J Telemed Telecare 12: 255-261.

45. Seto E, Leonard KJ, Cafazzo JA, Masino C, Barnsley J, et al. (2011) Mobile phone-based remote patient monitoring improves heart failure management and outcomes: A randomized controlled trial. Journal of the American College of Cardiology 57.

46. Sung M, Gips J, Eagle N (2005) Mobile-IT Education (MIT. EDU): m-learning applications for classroom settings. Journal of Computer Assisted Learning 21: 229-237.

47. Svensson M, Lagerros YT (2010) Motivational technologies to promote weight loss--from internet to gadgets. Patient Educ Couns 79: 356-360.

48. Tufano JT, Karras BT (2005) Mobile eHealth interventions for obesity: a timely opportunity to leverage convergence trends. J Med Internet Res 7: e58.

49. Vespasiani G, Rossi MC, Di Bartolo P (2009) Comparison between the "diabetes interactive diary" telemedicine system and standard carbohydrate counting education: an open label, international, multicentre, randomized study. Diabetologia 52: S388.

50. Wohlers EM, Sirard JR, Barden CM, Moon JK (2009) Smart phones are useful for food intake and physical activity surveys. Conference Proceedings: Annual International Conference of the IEEE Engineering in Medicine & Biology Society 2009: 5183-5186.

51. Zheng H, Nugent C, McCullagh P, Huang Y, Zhang S, et al. (2010) Smart self management: assistive technology to support people with chronic disease. J Telemed Telecare 16: 224-227.

52. Joo NS, Park YW, Park KH, Kim CW, Kim BT (2010) Cost-effectiveness of a community-based obesity control programme. J Telemed Telecare 16: 63-67.

53. Lombard C, Deeks A, Jolley D, Ball K, Teede H (2010) A low intensity, community based lifestyle programme to prevent weight gain in women with young children: cluster randomised controlled trial. BMJ 341: c3215.

54. Turner-McGrievy G, Tate D (2011) Tweets, Apps, and Pods: Results of the 6-month Mobile Pounds Off Digitally (Mobile POD) randomized weight-loss intervention among adults. J Med Internet Res 13: e120.

55. Ferrer-Roca O, Cárdenas A, Diaz-Cardama A, Pulido P (2004) Mobile phone text messaging in the management of diabetes. J Telemed Telecare 10: 282-285.