ARTICLE REVIEW

Smartphone Apps as a Technological Innovation for Weight Reduction: A Systematic Review & Meta-analysis

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ABSTRACT

Received 24 December 2020
Accepted 23 March 2021

Introduction The new technological innovation can have a vast potential for interventions to help weight loss and combat obesity. The current meta-analysis aimed to compare the effectiveness of smartphone applications (apps) with other methods for promoting weight loss.

Methods PubMed, Ovid and Science Direct were searched from 2014 all-inclusive up to May 2019 for relevant studies that assessed any smartphone/mobile phone app intervention with anthropometric measurement. Statistical analysis performed to examine mean difference (95% CI) of body weight, body mass index and waist circumference. Six articles were included for meta-analysis.

Findings According to the results, compared with conventional or other interventions, smartphone app interventions showed statistically non-significant decreases in body weight, body mass index and waist circumference. Intervention through smartphone apps alone does not produce substantial evidence of weight loss, even though they might be useful for specific groups.

Originality/value There remain prospects to explore regarding the use of smartphone apps in combination with other approaches to aid and promote weight loss, as smartphone use has been proven to influence health-related behavioural modification.

Keywords BMI - Mobile phone apps - Smartphone app - Weight loss.

INTRODUCTION

Obesity is a risk factor for non-communicable diseases (NCD) with continually increasing trends globally. Currently, obesity so prevalent within the world population that it is beginning to replace infectious diseases and undernutrition as the most significant contributor to ill health.[1] Obesity is defined as a body mass index (BMI, weight divided by height squared) of ≥30 kg/m and overweight as a BMI of 25–29.9 kg/m.[2, 3] The risk factors for obesity result from a combination of genetic susceptibility, increased availability of high-energy foods such as fast food, and decreased requirement for physical activity due to advancements of transportation systems and technology in modern society.[4] Moreover, there is an association between stress and obesity; there is significant overlap of the neurobiology of the former with the neurobiology of appetite and energy regulation. High stress levels alter eating patterns and increase highly palatable (HP) food consumption, subsequently increasing adaptations, including changes in the metabolism of the body and other energy homeostasis–related hormones. Such changes to the metabolism might thereby also affect dopaminergic activity, influencing food motivation and HP food intake.[5]

Obesity also plays a role as an essential risk factor for other NCD such as diabetes mellitus, coronary heart disease, certain forms of cancer and sleep breathing disorders.[6] This means that obesity is not considered an appearance or cosmetic problem that affects the population, but is an epidemic NCD that threatens global well-being. Knowing that energy-restricted diets are difficult to sustain when fast food and social feasts are readily available, it is unlikely that recommendations for further reducing energy intake will reverse the current tendency to increased body weight. In all likelihood, activity levels will have to increase in response to an environment engineered to be more physically demanding.[7]

The technology approach in improving the weight loss may have a few components such as physical activity, diet control and many more. For example, physical inactivity is an independent risk factor for chronic diseases and conditions that threaten a country's health. However, only a small proportion of the population is currently meeting the regular physical activity levels recommended, which are associated with substantial benefits for health and quality of life.[8] One effective approach to promoting physical activity is via technology-based interventions; using further methods to promote participant adherence is associated with more significant benefits.[9] The availability of smartphone applications (apps) as new technological innovations for weight loss is increasing globally. Many smartphone apps are being rapidly developed and studied. This new technological innovation has vast potential for improving current interventions for promoting positive behavioural changes leading to successful weight loss intervention.[10]

Smartphone apps and other similar technical innovations can serve as an innovative and motivating means of managing weight in the population in view that almost every single person has at least one smartphone available to them at all hours. In the past 2 years alone, there has been a great increase in the proportion of people in many emerging nations who own a smartphone. Such swift changes notwithstanding, the richer countries in the survey have reported higher smartphone ownership levels than the poorer countries, and the smartphone ownership rates in advanced economies might grow even further.[11] Smartphone ownership rates are highest among the richer economies: South Korea, 88%; Australia, 77%; Israel, 74%; the US, 72%; Spain, 71%. Malaysia (65%), Chile (65%), Turkey (59%) and China (58%), the world's largest smartphone market, also have relatively high smartphone ownership rates.[12]

Market researcher Newzoo had estimated that smartphone user numbers worldwide would exceed 3 billion in 2018, of which the Asia-Pacific region would account for more than 50%. Smartphone user numbers are expected to surpass 3.8 billion by 2021.[13] Smartphones have become universal and offer a unique platform for aiding behavioural weight loss program delivery. A smartphone's technological capabilities may resolve a traditional weight loss program's limitation while also reducing participant, interventionist and healthcare provider costs and burden. Awareness of the benefits offered by smartphones for losing weight has led to the swift growth and propagation of weight loss apps. Each app has varied built-in features and functioning mechanisms.[11]

Technical innovations via smartphones provide significant opportunities for promoters of physical activity to reach the population. With increased physical activity, favourable outcomes such as a reduction in BMI are achievable. Besides, smartphone intervention can motivate the willingness to engage in physical activities and dietary monitoring because it can help monitor a person's level of physical activity or dietary monitoring daily or periodically and promotes a sense of satisfaction.[10]

Evidence is still lacking for the effectiveness of smartphone app intervention and weight loss intervention as compared to other methods. The present review provides information to healthcare providers on innovative means of empowering their patients in terms of weight reduction utilizing smartphone apps. This systematic review aimed: (1) To compare the effectiveness of smartphone apps as compared with other methods for promoting weight loss, and (2) to conduct a meta-analysis of published studies to determine the current state of evidence regarding the effectiveness of smartphone app-based interventions for promoting weight loss in an adult population.

METHODOLOGY

Search Strategy

We conducted a systematic literature search of three databases from their inception through 2014 to identify studies examining the effectiveness of a smartphone app intervention compared with a control intervention in achieving weight loss or weight reduction by a different intervention approach: Medline (via PubMed; National Library of Medicine, Bethesda, MD USA; started in 1966), Ovid (MEDLINE®, 1946 to May 24, 2019), and ScienceDirect (Elsevier, 1997). Briefly, our literature search strategy combined synonyms for the smartphone app (the intervention of interest) with synonyms for the three outcomes: weight, body mass index and waist circumference. The search period was from 2014 all-inclusive up to May 2015. There were non-English language restrictions. We also manually reviewed the reference lists from relevant original research and review articles through snowballing.

Study Selection

Two members of the study team (FI, HH) independently screened studies for inclusion criteria and extracted the data. We included all studies that assessed a smartphone app intervention compared to a control group with weight-related health measures (i.e. body weight, BMI or waist circumference). We included studies performed in populations of children and adults. The exclusion criteria were: the primary outcome was not weight/BMI/waist circumference, non-original articles (reviews, editorials, non-research letters) and non-RCT (randomised controlled trial) study design (case reports, case series or observational study), participants with comorbidities or conditions such as like pregnancy, intervention using short messaging services (SMS) or any text messaging. Figure 1 shows a summary of the study selection process.

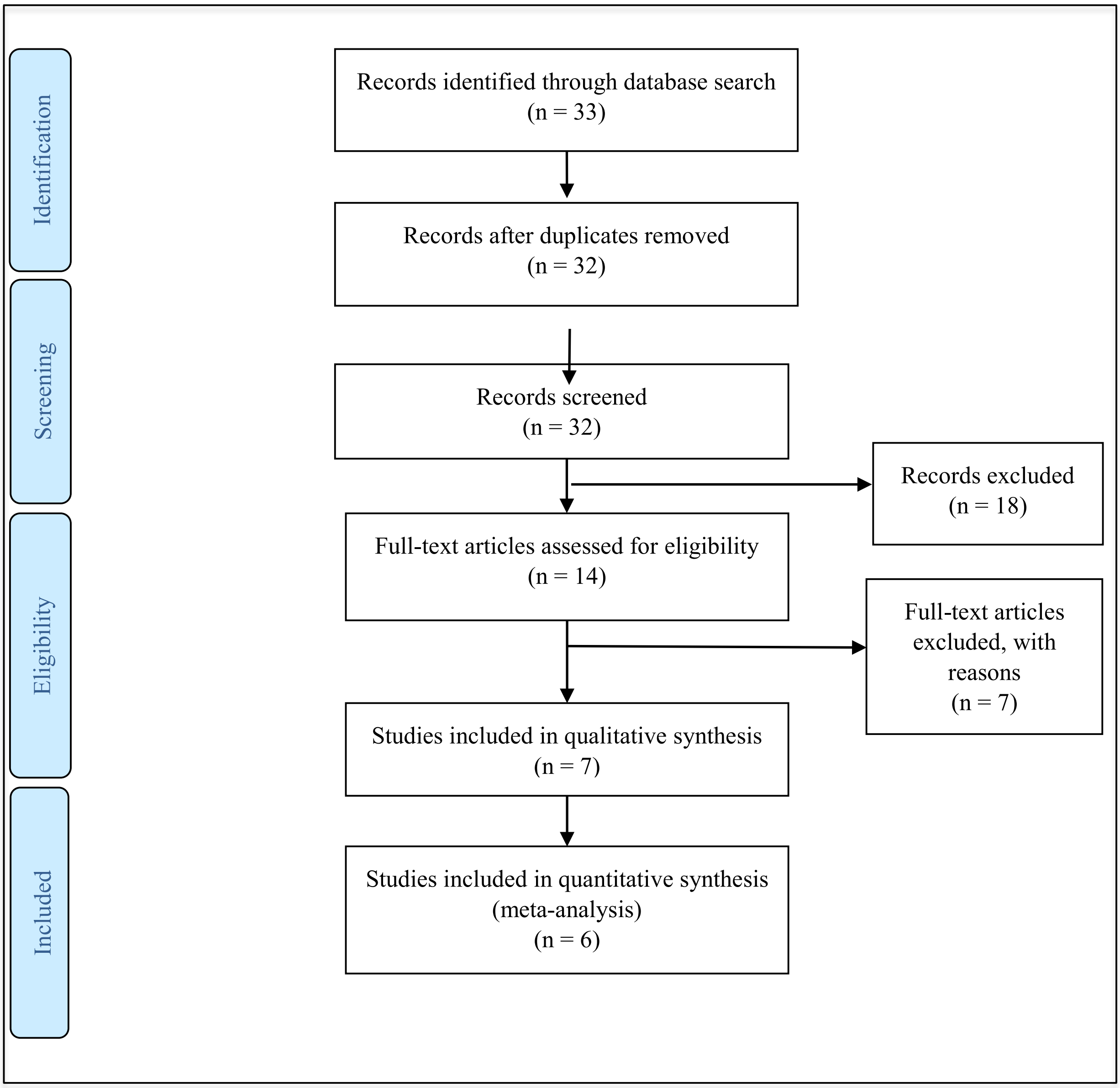

Figure 1 PRISMA flow chart

Data Extraction and Quality Assessment

Two investigators (FI, HH) independently abstracted articles that met the selection criteria and resolved discrepancies by consensus with two team members (SJ, NFA). Data (author, year, participants, length of intervention, sample size, study outcomes) from the articles selected were extracted to a table developed in Microsoft Excel. The study outcomes recorded were mean and standard deviation (SD) of body weight, BMI and waist circumference. These values were captured as the mean changes from baseline to the end of the intervention, with variations reported as SD. When there were several publications from the same cohort, the study with the most extended follow-up was selected; when the follow-up was equivalent, we selected the study with the most cases, the publication that used internal comparisons, or the most recent study. The risk of bias was assessed following Cochrane recommendations considering random sequence generation, allocation concealment, participant and personnel blinding, outcome assessment blinding, incomplete outcome data, and selective reporting and other bias. Each criterion was categorized as clearly low risk, not sure, or high risk. For criteria for which there were differences between the evaluators, further discussion continued until a consensus decision involving all team members (FI, HH, SJ, MRH, NFA, AMN) was reached.

Statistical Analysis

For each study, the net effect size was calculated as the change in body weight–related parameters resulting from treatment from baseline to the end of the intervention in the intervention group, minus the change in body weight–related parameters in the control group during the same period. The standard errors (SEs) and confidence intervals (CIs) were converted to SDs for analysis. For studies without SD data, we calculated the variance from the CIs or test statistics.

For body weight and BMI, weighted mean differences (WMDs) were estimated using random-effects models. Heterogeneity was quantified with the I^2 statistic, which describes the proportion of total variation in study estimates as a result of heterogeneity. To assess the robustness of our findings, we performed sensitivity analyses by excluding non-randomized studies or studies that did not report the intervention in the control group. We also assessed the relative influence of each study on pooled estimates by omitting one study at a time. Finally, we assessed publication bias by using funnel plots. The statistical analyses were performed using Review Manager software, version 5.3 (The Nordic Cochrane Centre, The Cochrane Collaboration, London, UK).

RESULTS

Study Selection

The search strategy retrieved 33 articles from different sources, and seven articles were included in this review: six articles on quantitative or meta-analysis, and one study on qualitative synthesis (Figure 1). All included articles were from different studies. The studies had been published in 2014–2017 and the sample sizes were 20–365. The studies were all RCTs. In many of the control groups, the interventions were those such as health education using traditional interventions or intensive counselling.

Meta-analysis of Smartphone App Intervention and Body Weight

Six clinical trials analysed data from 770 participants (Figure 2). Compared with the control group, smartphone app interventions resulted in non-significant decreases in body weight, with the pooled estimates of the net change in body weight being -1.62 kg (95% CI -3.61 to 0.36; I^2 = 93%). Subgroup analysis was done only for age (<40 years or >40 years), baseline BMI (overweight or obese) and duration of intervention (<3 months or >3 months). The funnel plot showed reasonable symmetry, which suggested no evidence of publication bias. In the sensitivity analysis, the exclusion of individual studies did not substantially modify estimates.

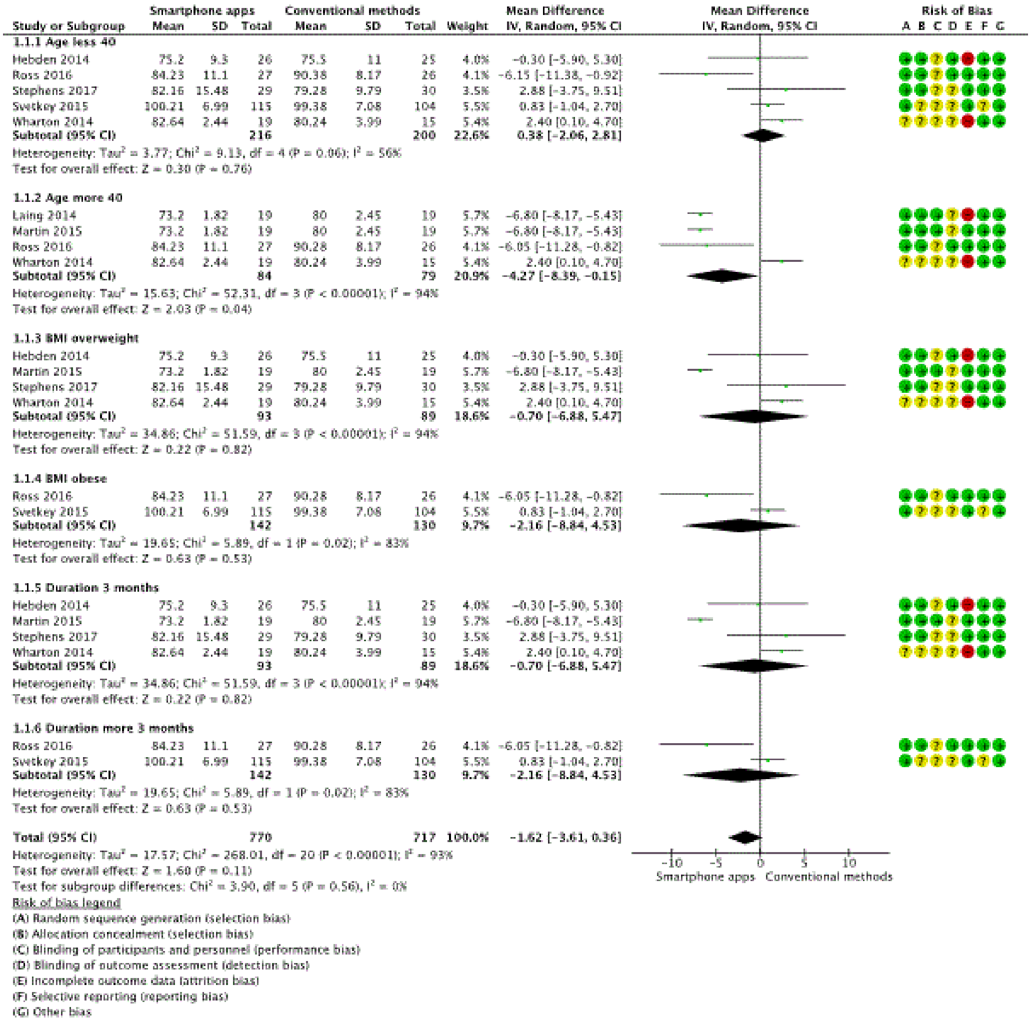

Figure 2 Forest plot of meta-analysis of smartphone app intervention and body weight

Meta-analysis of Smartphone App Intervention and BMI

Four clinical trials analysed data from 93 participants. The pooled results indicated a non-significant net difference in BMI between the smartphone app and control intervention groups (WMD 0.26 kg/m^2, 95% CI -0.83 to 1.34; $I^2 = 68\%$) (Figure 3). The funnel plot showed reasonable symmetry, which suggested no evidence of publication bias. In the sensitivity analysis, the exclusion of individual studies did not substantially modify estimates.

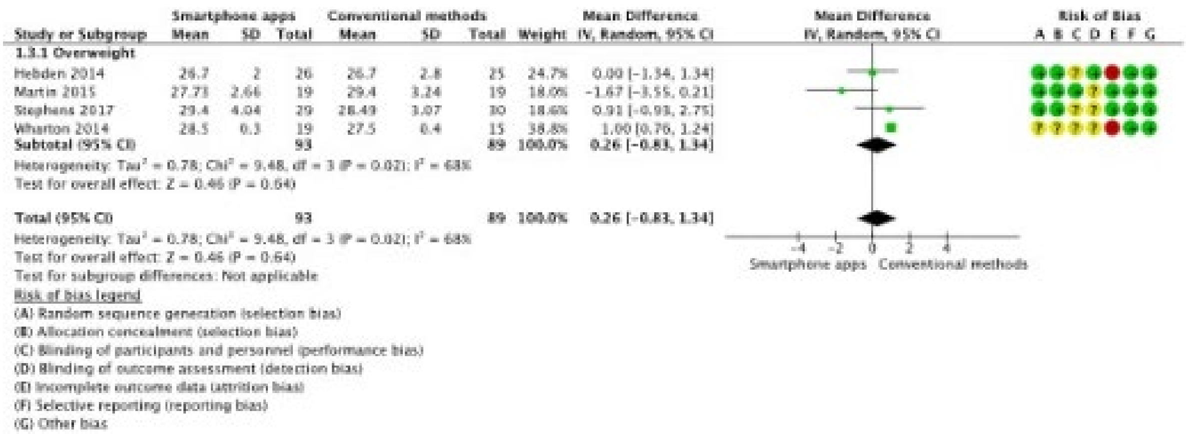

Figure 3 Forest plot for smartphone app intervention and BMI

Meta-analysis of Smartphone App Intervention and Waist Circumference

Only two clinical trials analysed data from 48 participants, reporting the outcome in the reduction of waist circumference. The pooled results indicated a non-significant net difference in BMI between the smartphone app and control intervention groups (WMD -5.2 cm, 95% CI -0.15 to 4.60; $I^2 = 93\%$) (Figure 4). The funnel plot showed reasonable symmetry, which suggested no evidence of publication bias. In the sensitivity analysis, the exclusion of individual studies did not substantially modify estimates.

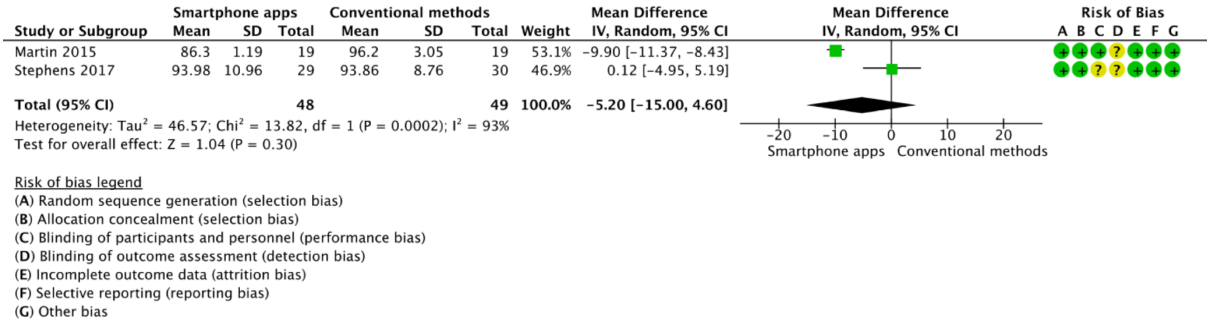

Figure 4 Forest plot for smartphone app intervention and waist circumference

Evaluation of Risk of Bias

Randomization was considered adequate in most of the studies (Figure 5). The random sequence generation was unclear for the participants of only one study.[14] Regarding allocations, two studies had unclear risk of blinding.[14,15] Two studies reported participant and personnel blinding.[16,17] The research blinded to the allocation of participants. We were able to locate the original study protocols of most of the studies. As we found no discrepancies between the outcomes the authors had originally intended to measure and that reported in the studies, the risk of reporting bias for this domain was deemed low.

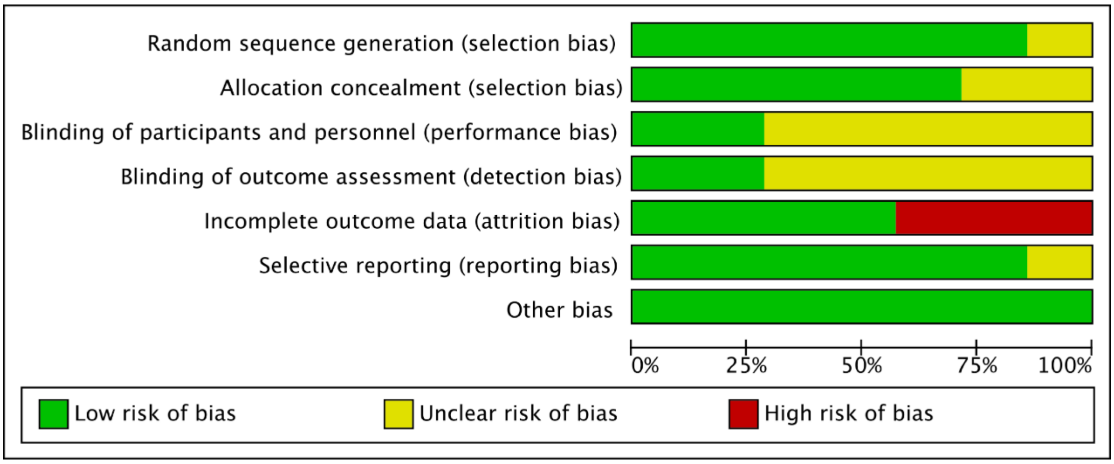

Figure 5 Risk of bias

DISCUSSION

Our meta-analysis suggests that app-based smartphone interventions do not cause significant weight reduction. However, the sensitivity analyses suggest that the effects differ based on the study parameters. In particular, there is evidence that smartphone apps have a significant positive effect on weight reduction when used by people aged >40 years (mean difference = -4.27, 95% CI -8.39, -0.15); however, the result needs to be interpreted with caution because of the high heterogeneity among the included studies ($I^2 = 94\%$). To the best of our knowledge, this is the first meta-analysis to establish the effectiveness of app-based smartphone interventions for increasing objectively measured weight reduction, BMI and waist circumference as other anthropometric measures. A previous meta-analysis of app-based physical activity interventions18 differs from the present study in that it reports on objective physical activity and weight loss data from RCTs published through 2007 to March 2019.

Despite these differences, our finding is consistent with the studies finding a non-significant decrease in weight reduction in comparison with the control. Another recent systematic review found that smartphone apps have a modest effect on physical activity and noted the limited number of RCTs available at that time to test the efficacy of smartphone apps for increasing physical activity.[19] Our study also suggests that the number of RCTs evaluating the efficacy of using a smartphone app remains limited.

The present meta-analysis suggests that, compared with various control interventions, smartphone app interventions reduced body weight non-significantly by -1.62 kg (95%CI -3.61, 0.36), reduced BMI by 0.26 kg/m^2 (-0.83, 1.34), and reduced waist circumference non-significantly by -5.20 cm (-15.00, 4.60). The mean reductions in body weight and BMI were non-significant; it would be expected for a single change in weight loss interventions, such as smartphone apps, to cause clinically significant weight loss compared with other control interventions. The results for BMI and waist circumference were similar. In the present review, many of the control group treatments were other interventions classified as conventional. This could have diluted the analysis, as it is possible that the treatment group in some of the studies showed a significant change while the control group also showed a similar significant result. In our sensitivity analyses, the results were not modified when we excluded one study that did not describe whether the control group had received any intervention.

Our meta-analysis shows that, when compared with conventional interventions, smartphone app interventions do not significantly favour weight loss. On the contrary, the pooled data show that when all individual studies are combined and averaged, the horizontal point of the diamond crosses the line of null effect for weight (0.38 kg, 95%CI -2.04 to 2.80), BMI (0.26 kg/m^2, 95%CI 0.83–1.34) and waist circumference (-5.2 cm, 95%CI -15.0 to 4.60 cm).

This could also be explained by the theory-based strategies for digital health behaviour change interventions by Morrison (2015).[20] In that review, the author stated that optimization of digital intervention delivery was challenged by low usage, high attrition and small effect sizes. The review provides several theory-based recommendations for optimizing overall user experiences for engaging with digital intervention.

However, another systematic review that included 12 articles demonstrated a beneficial impact of text messaging or a smartphone app for reducing overweight/obesity and increasing physical activity.[21] The results from the present meta-analysis demonstrated that interventions based on smartphone apps are associated with more weight loss than other types of interventions. Furthermore, a non-significant increase in physical activity was detected. Evidence from the present meta-analysis shows that smartphone app–based intervention may be useful tools for weight loss.

Some of the other previous meta-analyses found that smartphone apps were associated with significant changes in body weight and BMI as compared with the control group (-1.44 kg and -0.24 kg/m^2 respectively); however, such meta-analyses included only mobile interventions based on contact by SMS and multimedia message services (MMS), which we classified as other or conventional interventions in our review. That review found strong evidence from the included RCTs that weight loss occurs in the short-term because of smartphone technology interventions.[21]

We excluded from our meta-analysis interventions based only on text messaging and focused solely on smartphone apps, as text message interventions do not utilize the full potential of smartphone technologies. Well-designed apps expand the potential for technology-based health interventions to impact populations in ways that previously were not possible and not achievable without the capabilities of smartphone software.

One limitation of our review is the small number of available studies and sample sizes assessing the effectiveness of smartphone apps for weight loss, as well as the short follow-up period (3 months). Consequently, the CIs for the effect size estimates were quite large, which may have impeded the meta-analysis from determining a significant effect. Despite our strict inclusion criteria, the included studies were nevertheless highly diverse in terms of intervention format, target population and study design elements, and the heterogeneity scores suggest that the results do not reflect the same pool of data.

In particular, some control groups received minimal intervention, which potentially diluted the intervention effect. Also, although we attempted to focus solely on smartphone apps, some of the included studies included other items (e.g. activity trackers), which in themselves may alter physical activity. It is impossible to isolate the effects of the smartphone app component of these interventions.

Some of the selected studies lacked a separate control group. Hence, it limits our ability to draw causal inferences about intervention effectiveness, given the potential for temporal changes and other external variables to influence the results between pre- and post-test. Therefore, the results of these studies should not be used directly to inform decision-making on smartphone apps as a technological innovation for weight reduction. The primary utility of these studies lies in their ability to show proof of concept for an intervention effect to inform more robust experimental designs.

Most of the meta-analysis data subgroups had significant heterogeneity that could not be explained due to the limited availability of studies within each subgroup. Therefore, it limits our ability to identify potential predictors of between-trial heterogeneity. Several additional populations, interventions, outcomes and study design characteristics could have influenced this heterogeneity, but we were not able to investigate that in the present analysis. We encourage primary research authors to make these data available in future publications. Finally, there was the possibility of missing some relevant studies, especially if not captured by our search algorithm. However, we implemented a comprehensive verification strategy in an attempt to minimize this potential bias.

The use of smartphone apps for weight reduction is new and has emerging potential. More RCTs with larger sample sizes and more extended follow-up periods are needed to determine the effectiveness of smartphone apps, particularly in weight reduction and management programs for generally improving health. It should be considered an area for future research.

CONCLUSIONS

Smartphone app intervention alone does not produce substantial evidence of weight loss despite the fact it might be useful for specific groups, as reported by previous research and reviews. The inconsistency of the results are due to the studies' variability and limitations. However, there are still prospects to be explored regarding the use of smartphone apps in a combination of other approaches for assisting and promoting weight loss, as smartphone use has been proven to influence health-related behavioural modification. Future research trials on this intervention should be conducted with more participants and longer follow-up, with strict adherence to the protocol to produce quality results, which thus could generate significant results from the meta-analysis.

Conflict of Interests
The authors declare no conflicts of interest

Ethical approval
This article does not contain any studies with human participants or animals performed by any of the authors

Funding
None

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