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## Systematic review

### Effect of lifestyle-coaching including telemonitoring and telecoaching on gestational weight gain and postnatal weight loss. A systematic review.

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# **Effect of lifestyle-coaching including telemonitoring and telecoaching on gestational weight gain and postnatal weight loss. A systematic review.**

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## **Abstract:**

**Background:** Obesity during pregnancy, excessive gestational weight gain (GWG) and postpartum weight retention (PPWR) are associated with health risks for mothers and their offspring. Face-to-face lifestyle interventions can reduce GWG and PPWR, but are resource-demanding and effects on long-term maternal and fetal outcomes are scarce.

**Objectives:** to explore the existing literature about the effect of technology-supported lifestyle interventions including telemonitoring and – coaching on GWG and PPWR.

**Methods:** The PudMed, MEDLINE, CINAHL, EMBASE (incl. The Cochrane databases) and Web of Science databases were searched for relevant studies published since 2000. Inclusion criteria were: lifestyle interventions to optimize GWG or PPWR with at least mobile applications or websites, focusing on physical activity, healthy eating and/or psychological wellbeing, including self-monitoring with telemonitoring and telecoaching.

**Results:** The technology-supported interventions in seven study protocols and four pilot studies differed in terms of the used behavior change models, their focus on different lifestyle issues, their intervention components for telemonitoring and telecoaching. Technology-supported interventions including telemonitoring and – coaching can optimize GWG and PPWR, although not all results are significant. Effects on physical activity and healthy eating are inconsistent.

**Conclusion:** Technology-supported lifestyle interventions might affect GWG and PPWR, but more research is needed to examine the effectiveness, the usability and the critical features of these interventions.

**Key words:** telemedicine, telemonitoring, telecoaching, mentoring, pregnancy, postpartum, weight gain, weight loss, life style, prenatal nutrition

## Introduction

The prevalence of obesity has doubled worldwide since 1980<sup>1</sup>. Around 35% of adult women aged 20-39 year in the United States are obese and pre-pregnancy obesity was estimated at 20,5% in 2009<sup>2, 3</sup>. In European cohorts, maternal obesity occurs between 7 to 25% of women<sup>4</sup>. Obesity during pregnancy is associated with increased perinatal risks for mother and baby, complicated breastfeeding and postpartum weight retention (PPWR)<sup>5, 6</sup>. Maternal obesity affects the offspring's postnatal neurodevelopment and metabolism<sup>7</sup>. Maternal obesity and excessive gestational weight gain (GWG) are associated with an adverse adolescent cardio-metabolic profile<sup>8</sup>, overweight in adolescents and obesity issues in their future<sup>5</sup>. PPWR can lead to long-term obesity and perinatal complications in a next pregnancy<sup>5, 8-10</sup>.

Pregnancy can be an opportunity to encourage a healthy lifestyle and adequate GWG. Lifestyle intervention programs can reduce GWG<sup>8, 11-16</sup> and PPWR<sup>10, 12, 15, 17-19</sup>, although most trials cannot significantly reduce adverse maternal and neonatal outcomes<sup>20-22</sup>. However, these lifestyle intervention programs are time-consuming and expensive, and studies report a non-compliance around 23%<sup>20, 23</sup>, the immediate effects of lifestyle interventions on health outcomes such birth weight above 4 kg, might compensate these additional expenditures<sup>24</sup>, but resources available to healthcare professionals stay limited. Therefore innovative means of lifestyle support should be considered, e.g. complementary websites, apps, text messages<sup>25</sup>.

Mobile health or mHealth is a part of eHealth and is defined as medical and public health practice supported by mobile devices (e.g. mobile phones, patient monitoring devices, ...) <sup>26, 27</sup>. mHealth provides trusted information at low cost, easy access behavioral change interventions<sup>26, 28</sup>, which are flexible in use, while eliminating some barriers of traditional face to face and web interventions<sup>27</sup>. The majority of pregnant women seek pregnancy-related information online<sup>29-31</sup> and they prefer interactive internet-delivered interventions. Approximately 70% of pregnant women were interested in using a website or mobile application to obtain optimal GWG<sup>29</sup>.

A range of perinatal apps and websites is available, with different aims and features<sup>28</sup>, but the evidence base is often weak and effectiveness on clinical outcomes and health related behavior during pregnancy is lacking<sup>32</sup>. Self-monitoring and personalized feedback seem to favor their effectiveness<sup>13, 16</sup>. Therefore, telemonitoring and telecoaching might be meaningful technology-supported interventions. Telemonitoring is the exchange of necessary information for diagnosis, treatment and prevention of diseases and injuries, through information and communication technology, to deliver healthcare services at a distance<sup>33</sup> and can include self-monitoring. Telecoaching is a technology-supported interaction between patient and healthcare professional to empower and support patients at a distance with the use of information and communication technologies<sup>34, 35</sup>.

Recently, two systematic reviews and meta-analyses about effects of technology-supported lifestyle interventions on perinatal weight management were published, but without a specific focus on telecoaching<sup>36, 37</sup>. The systematic review and meta-analysis of Sherifali et al.<sup>36</sup> on electronic-based lifestyle interventions in perinatal overweight and obese women (including also women with gestational diabetes, diabetes type 1 or 2) reported on the positive impact of e-based lifestyle interventions on PPWL, but not on GWG. All studies used behavior goal setting, lifestyle counselling or skills training, self-monitoring and feedback (whether or not through telecoaching), which seems to be indispensable techniques. Another systematic review and meta-analysis on the effectiveness of eHealth technologies for weight management in perinatal women, found a significant positive effect to limit GWG, lose postnatal weight, increase physical activity and reduce caloric intake in perinatal women who were overweight or obese<sup>37</sup>. Given the diversity of mHealth interventions with different outcome effects, the specific aim of this systematic review is to critically evaluate the existing literature about lifestyle-interventions including telemonitoring with self-monitoring and telecoaching in mobile and web applications for pregnant and postpartum women aiming to achieve GWG in the range of the Institute of Medicine (IOM) guidelines for weight gain in pregnancy and to limit PPWR.

## Methods

### Search strategy

The PubMed, MEDLINE, CINAHL, EMBASE, Cochrane database and Web of Science databases were searched between March and May 2016 with a systematic search string of relevant terms (appendix 1). Additional eligible studies were searched in the online trial registry [www.clinicaltrials.gov](http://www.clinicaltrials.gov), hot topic meetings and relevant conferences. The search was limited to papers published in English and published after 2000, because of the great technological advancement of mobile phones and eHealth since then.

### Study eligibility criteria

The inclusion criteria were defined according to Participants involved, Intervention-type, type of Comparison group, Outcome of interest and Study design. The study had to include prenatal or postnatal women, 18 years and older, without conditions or diseases that might influence the eating pattern and physical activity, like gestational diabetes, diabetes Type 1 or 2 or other co-morbidities and pregnancy complications. Primipara as well as multipara were included. Randomization and study initiation had to occur during pregnancy or within the first postnatal year. The intervention had to be a technology-supported lifestyle intervention including at least a mobile or a web-based application aiming to improve at least GWG or PPWR and at least one of the following: physical activity (PA), healthy eating (HE) and/or psychological wellbeing. The interventions should use self-monitoring with telemonitoring and telecoaching or feedback tailored to the self-monitored data. Self-monitoring is the systematic observation and recording of ongoing goal-directed activities<sup>38</sup>, through manual data input or through electronic transfer. The control group of the selected studies could receive no intervention, a lifestyle intervention which is not technology-supported or usual care for the given setting. The studies had to focus on at least GWG or postpartum weight loss. Additionally outcomes were: physical activity (PA), healthy eating (HE), psychological wellbeing

and/or the development of gestational diabetes mellitus (GDM). Studies had to be quantitative, randomized controlled trials (RCT), pilot, feasibility studies or a published study protocol of an RCT.

### Study selection process

Two reviewers (LM, MB) independently screened titles and abstracts to determine eligibility based on the inclusion criteria. If an abstract did not offer enough information, the full text was evaluated. Any discrepancies between the two appraisers (LM, MB) was discussed with a third reviewer (AB). The snowball method was used to find relevant studies which were not previously detected.

### Data extraction

Table 1 summarizes study methodologies, while table 2 shows the interventions. All disagreements were resolved by consensus and if necessary a third author was consulted (AB).

### Study quality assessment

The methodological quality of the included studies was assessed independently by two researchers (LM, MB) using the Cochrane Risk of Bias tool<sup>39</sup>. The same criteria were used to criticize the quality of study protocols, although we could only assess if measures are taken to avoid bias. All disagreements were resolved by consensus and if necessary the third author was consulted (AB). The results of this quality assessment could be found in table 3.

## Results

### Study selection

The results of the search strategy are outlined in figure 1. After removing duplicates, 2871 studies were left to screen of which nine studies met the inclusion criteria for this systematic review: seven study protocols for randomized controlled trials (RCT)<sup>40-46</sup> and two pilot RCT's<sup>47, 48</sup>. An additional search in

May 2017 generated two additional pilot studies<sup>49, 50</sup>, presenting the pilot results of study protocols included earlier<sup>43, 45</sup>, resulting in a total of nine different studies.

### Study characteristics

Table 1 describes the study characteristics, while table 2 describes the intervention characteristics and outcome measures of the included studies. Three studies focus their intervention on the pregnancy period<sup>43, 44, 48, 49</sup>, five on the postpartum period<sup>41, 42, 45-47, 50</sup> and one study covered both periods<sup>40</sup>. BMI-classes of women in the included studies differed with focus on all BMI-classes<sup>41, 51</sup>, studies selected women with a BMI > 25 kg/m<sup>2</sup><sup>43, 44, 47, 49</sup>, a BMI between 25 and 40 kg/m<sup>2</sup><sup>45, 48, 50</sup>, 18.5-35 kg/m<sup>2</sup><sup>40</sup> or 18.5-29 kg/m<sup>2</sup><sup>46</sup>. Phelan et al.<sup>42</sup> choose participants with a BMI > 25 kg/m<sup>2</sup> or a BMI between 22-24.9 kg/m<sup>2</sup> if they reported a PPWR of 4.5 kg or more. The control groups received standard care<sup>40, 42, 43, 46, 47, 49</sup> or a lifestyle intervention not supported by technology in the control group<sup>41, 44, 45, 50</sup>. One study protocol administered a technology-supported intervention as a control, that did not intend to improve lifestyle but was focusing on generic pregnancy information, considered usual care<sup>48</sup>. The primary outcomes investigated in the trials were: GWG, PPWR or postpartum weight loss (PPWL). Secondary outcomes of interest were dietary habits/HE, PA, psychological wellbeing, development of GDM, and feasibility, engagement, usability, patient satisfaction, acceptability, efficacy and experiences (table 2).

### Methodological quality assessment

A summary of the methodological quality assessment can be found in table 3. Selection bias was minimized in most of the studies and randomization was fulfilled<sup>40-43, 47-49</sup>. The three study protocols generated from clinicaltrials.gov and one pilot study were not clear about the randomization procedure<sup>44-46, 50</sup>. Due to the nature of the intervention, none of the studies blinded participants, leading to high risk of performance bias. In three studies<sup>42, 43, 46, 49</sup>, outcome assessors were blinded. This was unclear in five studies<sup>40, 41, 45, 47, 48, 50</sup> and in one study<sup>44</sup> outcome assessors were not blinded,

which could influence detection bias. However, the risk is low, as the measuring instruments (e.g. scale, pedometer, ...) could warrant sufficient objectivity. Follow-up data could only be generated in the pilot RCT's and these were available for four studies<sup>47-50</sup>, but not for Pollak et al.<sup>48</sup>. The latter sufficiently excluded selective loss-to-follow-up, leading attrition. Three pilot RCT's<sup>47, 49, 50</sup> were unclear about the risk for reporting bias and one was low risk<sup>48</sup>. Four study protocols had detailed descriptions how to prevent methodological bias<sup>40-43</sup>. The three study protocols generated from clinicaltrials.gov provided less details and therefore seem to have a high risk of bias.

### Intervention characteristics

The technology-supported lifestyle interventions were delivered by a variety of media: website<sup>40, 42</sup>, mobile application<sup>41, 44, 45, 50</sup>, SMS<sup>48</sup> or a combination of website and SMS<sup>43, 46, 47, 49</sup>.

### Telemonitoring

All of the technology-supported lifestyle interventions use self-monitoring and mostly recorded two or more items: weight, PA, HE and/or goal achievement (table 2).

All but two<sup>41, 46</sup> of the included studies ask their participants to self-monitor their **weight**. They entered their weight in a weight gain/loss tracker in a web or mobile application<sup>40, 42, 44, 45, 50</sup>, which was then visualized in a weight gain/loss grid<sup>40, 44, 45, 50</sup> or they received a text message in which they were asked to respond with their actual weight. The latter text message could be followed by a feedback text message<sup>43, 47-49</sup>.

**Physical activity** was monitored with a pedometer or accelerometer to track daily step count and to check if their daily goals were met<sup>41, 44-48, 50</sup> or they kept a web diary about the quantity of PA<sup>42</sup>. Some of the interventions were based on goalsetting, e.g. engaging in 30 minutes of moderate to vigorous PA on at least 5 days per week<sup>40, 42, 43, 49</sup>.

**Healthy eating or food intake** was monitored with a web diary to record food intake<sup>42, 44</sup> or goalsetting, where participants could choose goals out of a list in the application<sup>40, 48</sup> or they could set personal goals<sup>43, 47, 49</sup>. Participants had to indicate online or with SMS which goals they achieved.

Although several studies indicated that they investigated outcome measures related to **psychological wellbeing** at certain measure points, none of the included studies measured psychological wellbeing with self-monitoring. Fernandez et al.<sup>40</sup> and Pollak et al.<sup>48</sup> used a depression scale, three studies measured self-efficacy using a survey or a self-efficacy scale<sup>42, 43, 48, 49</sup>.

### Telecoaching

There are several manners for telecoaching in technology-supported lifestyle interventions, e.g. weight gain/loss trackers, personalized or automatic generic feedback, encouraging and informational messages, forums, videos.

### *Feedback*

A weight gain/loss tracker or grid gives immediately visual feedback about weight gain/loss<sup>40, 42, 44, 45, 50</sup>. Redman (44) gives personalized feedback, information and tools about weight management in pregnancy. Participants can also receive personalized feedback tailored to their self-monitored data to reinforce successes and/or offer motivational support and recommendations to achieve their goals<sup>42, 43, 45, 47-50</sup>. Kernot et al.<sup>41</sup> provides personal feedback regarding individual achievements. Next to tailored feedback messages, generic customized text messages are used to give information, to encourage positive health behavior and individual behavior change<sup>42, 43, 46, 49</sup>.

### *Peer encouragement*

Additional to telecoaching, several mobile and web applications use peer encouragement via forums, e.g. Facebook or with a message board<sup>41-43, 47, 49</sup> and offer supplementary behavioral skills training via links and videos<sup>43, 47, 49</sup>, the possibility to ask questions to a professional in a Facebook-group<sup>43, 49</sup> or on a study-specific message board<sup>42</sup>, daily tips to increase physical activity, awards and virtual gifts

for individual and team achievements<sup>41</sup>, or healthy recipes<sup>44</sup>. Phelan et al.<sup>42</sup> offer monthly group meetings in addition to telecoaching. These sessions introduced new weight loss topics, further reinforced messages of the online program, provided opportunities to problem-solve barriers to weight loss and provided additional support and education on selected topics.

#### *Behavior change strategy*

The majority of the included interventions used goalsetting as behavior change strategy<sup>40, 42, 43, 45, 47-50</sup>.

Other used behavior change strategies: Fishbein and Yzer's Integrative Model of Behavioural

Prediction and Fogg's behavior Model for Persuasive<sup>40</sup>, Theory of Planned Behavior and Fun Theory<sup>41</sup>,

the Social Cognitive Theory<sup>42, 48</sup> and the CALO-RE taxonomy of behavior change techniques<sup>43, 49</sup>.

#### **Intervention outcomes**

Only four studies<sup>47-50</sup> reported intervention results, as the others are all study protocols. Therefore, it was not possible to report on robust outcomes. As the identified technology supported interventions differed in content, counseling techniques and media used, it was difficult to find consistent outcomes across the included studies. Table 4 shows the available intervention results.

During pregnancy, only the txt4two was able to significantly limit gestational weight gain in the intervention group compared to the control group, but there was no difference in the amount of women exceeding the IOM recommendations for adequate GWG<sup>49</sup>. The Preg CHAT had no effect on GWG<sup>48</sup>. Also, only the txt4two intervention had an impact on PA. Women in the intervention group were significant less likely to reduce their minutes of total daily activity<sup>49</sup>. Preg CHAT as well as txt4two had no impact on HE<sup>48, 49</sup>.

During the postpartum period, the participants using the Healthy4Baby intervention had significant more weight loss than the standard care group, moreover the majority of women using the Healthy4baby website found the tool helpful for weight control during pregnancy<sup>47</sup>. In the WIC E-Moms, there was no significant difference in PPWL between intervention and control group, but

women with high adherence to the E-Moms intervention had significant more weight reduction compared to the control group<sup>50</sup>. There were no significant differences regarding PA and HE in the Healthy4Baby intervention<sup>47</sup>.

## Discussion

### Principal results

The aim of this systematic review was to appraise the existing literature on technology-supported lifestyle-interventions for weight management in prenatal and postnatal women, specifically with telemonitoring through self-monitoring and telecoaching. The overall findings highlight the existence of several telemonitoring and telecoaching concepts, using various media, whether or not combined and differing in focus of self-monitoring, telecoaching and outcome measures. As only four studies completed the pilot phase<sup>47-50</sup> and the others were study protocols without results<sup>40-42, 46</sup>, it is not possible to report on robust results. Three studies<sup>49, 50, 52</sup> did show a significant positive effect on GWG or PPWL, however these are only small and low powered pilot studies. These promising results for GWG and PPWL were amplified through two studies, the RCT of Fit Moms<sup>53</sup> and the pilot study of SmartMoms<sup>54</sup>, of whom respectively the pilot study<sup>42</sup> and the study protocol<sup>44</sup> were included in this review and the systematic reviews and meta-analyses on electronic-based lifestyle interventions in perinatal women mentioned earlier<sup>36, 37</sup>. A systematic review and meta-analysis on eHealth interventions for the prevention and treatment of overweight and obesity in adults found significantly greater weight loss in eHealth weight loss interventions compared to control or minimal interventions (other mode of delivery, e.g. face-to-face, or other eHealth interventions)<sup>55</sup>.

### Content and set up of technology-supported lifestyle interventions

As the available results are not conclusive and the included studies use multi-component interventions, it is not clear which element and which combinations generate the effect. Therefore, we would like to suggest some features to take into account in the development of future technology-

supported lifestyle interventions. Different elements and techniques are necessary to facilitate behavior change and reduce GWG<sup>28, 56</sup>. It is not clear yet, which critical elements should be combined to significantly reduce GWG and PPWR<sup>55</sup>. Web-based interventions applying self-regulatory features with tailored feedback and advice on PA and dietary intake during pregnancy, promote healthy GWG<sup>57</sup>. Self-monitoring of behavior, feedback on performance and behavior goalsetting are the most commonly used techniques to reduce GWG. Though, these techniques were used in effective as well as ineffective interventions<sup>16</sup>. Although we could not prove self-monitoring to be a motivational cue to action, self-weighing during pregnancy and postpartum together with a lifestyle intervention is an important strategy to limit GWG and PPWR in overweight and obese women at risk of GDM, as it might work as immediate feedback on behavior, next to knowledge and skills learned in the lifestyle intervention<sup>58</sup>. In a systematic review of eHealth and overweight and obesity in adults, self-monitoring led to greater weight loss<sup>55</sup>. The systematic review of Brown et al.<sup>13</sup> concluded that the active components of healthy lifestyle interventions to limit GWG are a combination of individualized diet and PA plans, self-monitoring and personalized feedback. Women and health care professionals both prefer interventions composed with several technology components, i.e. websites, video messages and apps<sup>28, 49</sup>. Qualitative research indicates that women prefer apps and trustworthy websites including clear and focused information, among others on lifestyle, and links to more detailed information and local support services<sup>51, 59, 60</sup>. They want to use interactive and personalized formats with tools to self-monitor nutrition, PA and weight, weight-control tips, safe and realistic PA instructions and information on HE, safe foods and quick low-cost recipes. Maternal follow-up should be noninvasive by email, app alerts or SMS<sup>59, 60</sup>. Therefore the development of mHealth interventions should be at least based on co-creation with end users<sup>28</sup>.

#### Focus of mHealth interventions

Despite diet and PA interventions are effective to limit excessive GWG<sup>61, 62</sup>, pregnant women have difficulties to meet PA and nutrition guidelines<sup>63</sup>. A web-based behavior intervention focusing on PA,

using a pedometer without telecoaching, was able to elevate PA, but not to prevent excessive GWG. This might be dedicated to the increased caloric intake in the intervention group. Therefore, it is important to focus on HE as well as on PA for optimal GWG, and additional innovative strategies as GWG counseling and dietary modifications combined in a multi-behavior web-based intervention could be valuable<sup>64</sup>.

#### mHealth and behavior change theories

The majority of the studied lifestyle interventions are based on one or more behavior change theories. Although a meta-analysis found no difference in positive effects of lifestyle interventions on GWG whether or not based on a health behavior theory, it seemed that effective interventions did contain different behavior change techniques<sup>11</sup>. Individual goalsetting with continuous feedback and reinforcement about their own goals, especially in overweight and obese women can be useful to help women towards an optimal GWG<sup>13</sup>. Moreover, the focus of clear, detailed and personalized advice for goalsetting should take the psychological wellbeing of the women into account<sup>65, 66</sup>, and not only focusing on GWG, to avoid feelings of anxiety, stigmatization and embarrassment<sup>67</sup>.

#### mHealth combined with in-person healthcare?

During pregnancy, women have regular contact with healthcare professionals for medical check-ups<sup>12, 67-69</sup>. Additional and extended personalized health advice is effective but very time consuming<sup>25</sup>. As mHealth interventions are suitable for behavior change therapies to stimulate frequent engagement, consistency over time and immediate feedback on behavior<sup>70</sup>, it might support a healthy lifestyle for new mothers and real time feedback could contribute to the efficacy of technology-supported lifestyle interventions<sup>70</sup>. Thus, a combination of in-person healthcare and mHealth could lead to effective lifestyle support, while reducing the workload to healthcare workers. Systematic reviews and meta-analyses showed greater weight loss when eHealth was added to standard care<sup>55</sup> and when in-person and phone sessions were added to e-based platforms<sup>37</sup>.

### Timing and frequency of the mHealth intervention

The starting point of the included interventions varied and the best moment is unknown. On the one hand, women prefer to receive information early in pregnancy, to create healthy eating habits prenatal<sup>69</sup>, and it seems to be the right time to engage women in a healthy lifestyle including PA, HE and weight, without focusing solely on weight<sup>67</sup>. On the other hand, many women did not find pregnancy to be a good moment to address weight management, because of concerns about pregnancy and complications. Motivation might be better prior to conception or after childbirth. However, the postpartum is a challenging period for women, because of exhaustion, work resumption after six months and social support seems to be desirable<sup>37</sup>.

There seems to be a dose-related influence between adherence and the effect on weight. Higher adherence to the intervention leads to greater postnatal weight loss<sup>47, 50</sup>. Therefore it's crucial that lifestyle interventions are accessible to the target population and they must include strategies to promote continued engagement with the program<sup>32</sup>.

Further research is necessary to comprehend the optimal composition of technology elements to influence efficiently behavior change<sup>28</sup> and an in depth evaluation of different technologies and the impact on health outcomes is necessary<sup>27, 49, 71</sup>.

### Strengths and limitations

To our knowledge, this is the first systematic review about technology-supported lifestyle coaching focusing on weight and PA, HE and/or psyche, focusing on self-monitoring with telemonitoring and telecoaching, for women of all BMI-classes. We limited our study population to women without gestational diabetes or diabetes type 1 or 2, because these conditions might (positively) influence the eating pattern and motivation for a healthy lifestyle, without an effect of intervention. This systematic review is strong in its broad and in depth search strategy in several scientific databases to detect all

relevant studies, as well as in the quality assessment of the studies. Due to the specific and narrow scope, the available results were limited. However, we wanted to get a clear view on the existing literature and ongoing studies on this focused topic, specifically on self-monitoring with telemonitoring and telecoaching for this target group of pregnant and postnatal women. Although we could not find consistent evidence for these interventions yet, this systematic review provides a valuable insight to develop future technology-supported lifestyle interventions.

#### Heterogeneity in the intervention designs

Despite the many studies on telemonitoring and telecoaching during pregnancy and postpartum, only few met our inclusion criteria and many of them are still ongoing. After all, technology-supported lifestyle coaching is a rather recent perinatal application. The pilot study results are difficult to compare, because of the heterogeneity of the interventions, the population and time frame used. The effects could not be clearly attributed to the different components of the intervention. The results should be interpreted with caution. Some study populations include women with overweight and obesity only, while others includes all BMI categories. Intervention effects could differ according to the population, as women with pre-pregnancy overweight and obesity seem to be more motivated to engage in healthier dietary behavior through online self-monitoring activities, probably they might be more aware of the importance to limit GWG to the IOM recommendations<sup>57</sup>.

#### Study quality

Despite most included studies had clearly described study designs, it was difficult to critically appraise study quality and possible bias because they're all study protocols and pilot studies. The risk for bias was not always clear, and is therefore questionable. The small sample sizes are to expect for pilot studies. Study protocols generated in [clinicaltrials.gov](https://clinicaltrials.gov) reported very little measures to analyze bias. Therefore, all studies should be completed to make a full substantiated quality assessment.

## Implications for future research

There is a need for completed randomized controlled trials of strong quality to test the efficacy and acceptability of technology-supported lifestyle interventions. Furthermore, there's a need for long-term health outcomes for mother and child. Interventions should not only focus on weight, PA and HE, but also on psychological wellbeing and it's possible influence on GWG and PPWL. For interventions focusing on the postpartum period, research should involve the influence of breastfeeding on PPWL. As ideally, overweight and obesity should be addressed in the preconception period, where the postpartum period could be seen as a preconceptional period for the next pregnancy, to initiate healthy lifestyle changes. Besides, we know that returning to pre-pregnancy weight is important to prevent adverse maternal and neonatal outcomes in the consecutive pregnancy<sup>8</sup>. When the mother adopts to a healthy lifestyle, it may contribute to a healthier lifestyle for the family as a whole<sup>17</sup>. While finishing this paper, a promising research protocol (INTER-ACT)<sup>72</sup> was published, which takes into account all the above mentioned suggestions for further research.

## Conclusion

This systematic review on the effects of technology-supported lifestyle coaching on GWG and PPWL could not report robust results as we could only include study protocols and pilot studies with provisional results. Besides, the included interventions differed in content, type of coaching and technology used. The results indicate a positively influence on GWG and PPWL, but results are not always significant. Moreover, effects on PA and HE are inconsistent. More research is needed to examine the effectiveness, the usability and the critical features of the intervention. In recent years, mHealth is upcoming and currently randomized controlled trials with e-health interventions are recruiting. Shortly, a lot of results are expected.

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### Author Disclosure Statement

No competing financial interests exist.

### Conflicts of interest

Authors declare no potential conflicts of interest.

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## Abbreviations:

GWG: gestational weight gain

PPWR: postpartum weight retention

IOM: Institute of Medicine

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

Incl.: inclusive

PA: physical activity

HE: healthy eating

GDM: gestational diabetes mellitus

RCT: randomized controlled trial

PPWL: postpartum weight loss

BMI: body mass index

SMS: short message service

I: intervention group

C: control group

pregn.: pregnancy

pp: postpartum

BF: breastfeeding

w: weeks

m: months

d: days

prim.: primary outcomes

sec.: secondary outcomes

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## Appendix 1: Search string for Pubmed

This search string was used in the Pubmed database and was adapted for use in other databases.

"pregnancy"[MeSH Terms] OR "pregnancy"[tiab] OR "pregnancies"[tiab] OR "pregnant"[tiab] OR "gestation"[tiab] OR "Postpartum Period"[Mesh] OR "postpartum"[tiab] OR post partum[tiab] OR puerperium[tiab] OR postnatal[tiab] OR post natal[tiab] OR prenatal[tiab] OR pre natal[tiab] OR ante natal[tiab] OR antenatal[tiab] OR gestation\*[tiab]

### AND

"Mobile Applications"[Mesh] OR app[tiab] OR apps[tiab] OR application\*[tiab] OR "Cell Phones"[Mesh] OR ((cellular[tiab] OR cell[tiab] OR smart[tiab] OR mobile[tiab] OR portable[tiab]) AND (phone\*[tiab] OR telephone\*[tiab])) OR smartphone\*[tiab] OR cellphone\*[tiab] OR iphone\*[tiab] OR ipad\*[tiab] OR android[tiab] OR ios[tiab] OR "Telemedicine"[Mesh:NoExp] OR mobile health[tiab] OR mhealth[tiab] OR ehealth[tiab] OR e health[tiab] OR telehealth[tiab] OR tele health[tiab] OR "Wireless Technology"[Mesh] OR wireless[tiab] OR "Remote Sensing Technology"[Mesh] OR remote[tiab] OR "Social Media"[Mesh] OR social media[tiab] OR web[tiab] OR "Internet"[Mesh] OR "Internet"[tiab]

### AND

"Life Style"[Mesh] OR life style\*[tiab] OR lifestyle\*[tiab] OR "Diet"[Mesh] OR diet[tiab] OR diets[tiab] OR nutrition[tiab] OR "Physical Fitness"[Mesh] OR physical fitness[tiab] OR wellbeing[tiab] OR well being[tiab] OR "Weight Gain"[Mesh] OR weight gain\*[tiab] OR "Weight Loss"[Mesh] OR "weight loss"[tiab] OR weightloss[tiab] OR "weight reduction"[tiab] OR "weight retention"[tiab] OR "Diabetes, Gestational"[Mesh] OR "gestational diabetes"[tiab] OR "pregnancy diabetes"[tiab] OR "gdm"[tiab] OR "Motor Activity"[Mesh] OR "physical activity"[tiab] OR "Exercise"[Mesh] OR exercise[tiab] OR "Walking"[Mesh] OR Walking[tiab]

**FILTER: starting from 2000/01/01**

Table 1: Study characteristics

Author & country	study name	study design	aim	population characteristics (recruitment: gestational age/pp period; start BMI)	n	intervention/control	intervention duration
<b>Pregnancy</b>							
Willcox et al., 2015; Willcox et al., 2017, Australia	<b>txt4two</b>	RCT study protocol + RCT	to test the feasibility of an mHealth intervention promoting healthy nutrition, physical activity and GWG in women who begin pregnancy overweight or obese.	pregn: 10-17w6d; pre-pregn BMI > 25kg/m <sup>2</sup>	100	I: txt4two mobile application intervention + <b>standard</b> care; C: standard care including brief information brochures with HE and PA advice	pregn: 10-18w (until 36 w)
Redman, 2017a, USA*	<b>SmartMoms</b>	RCT study protocol	to determine how to help manage weight gain during pregnancy.	pregn: 1st trim; BMI ≥ 25 kg/m <sup>2</sup>	54	<b>I1:</b> SmartMoms-Clinic (in-person program); <b>I2:</b> SmartMoms-Phone mobile application. C: no intervention	pregn: 1st trimester (6 m)
Pollak et al., 2014, USA	<b>Preg CHAT</b>	pilot study	to assess the feasibility, acceptability and preliminary efficacy of a SMS based intervention to help pregnant overweight and obese women gain an appropriate amount of weight.	pregn: 12-21w; pre-pregn BMI of 25-40	35	<b>I:</b> SMS intervention Preg CHAT; C: Text4baby, a generic texting intervention	pregn: 12-21w (16w)
<b>Postpartum</b>							
Kernot et al., 2013, Australia	<b>Mums Step it up-program</b>	RCT study protocol	to evaluate program effectiveness to increase PA, wellbeing, weight, sleep quality and quantity and depressive symptoms; evaluate role of TPB constructs, feasibility, engagement of Mums Step it Up	PP <12m	126	<b>I1:</b> Mums Step it Up <b>Program</b> = pedometer + app; <b>I2:</b> pedometer only, no app, written advice; <b>C:</b> written advice and tips	PP < 12m (50d)
Phelan et al., 2015, USA	<b>Fit Moms</b>	RCT study protocol	to determine if the enhanced WIC plus internet postpartum weight loss program produce significant greater weight losses than the standard WIC at 6 and 12 months.	PP: 6w - 12m; BMI >25kg/m <sup>2</sup> or BMI 22-24,9kg/m <sup>2</sup> and pre-pregn weight + 4,5kg.	408	<b>I:</b> e-intervention. C: standard WIC program for 12 months	PP: 6w - 12m (12m)
Herring et al., 2014, USA	<b>Healthy4Baby</b>	pilot RCT	to evaluate of feasibility, acceptability, initial short-term	PP: 2w-12m; early pregn BMI> 25kg/m <sup>2</sup> , PPWR >5kg	18	<b>I:</b> SMS + e-intervention; C: standard care	PP 2w - 12m (14w)

			efficacy of technology-based weight control program				
Teheran University of Medical Sciences, Iran*	<b>A Lifestyle Program on Healthy Weight in Postpartum Period</b>	RCT study protocol	to examine the impact of lifestyle intervention on postpartum weight loss.	PP + BF; BMI before pregn: 18,5 - 29 kg/m <sup>2</sup> , sedentary according to the International Physical Activity Questionnaire	100	I: SMS + e-intervention; C: general information via pamphlet about PP period and tips for stress management.	PP (12w)
Redman, 2017b*; Gilmore et al., 2017, USA	<b>WIC E-Moms - SmartLoss application</b>	study protocol + pilot RCT	to optimize postnatal weight loss and improve diet quality with E-Moms app.	PP < 2m; BMI: 25 - 40kg/m <sup>2</sup>	40	I: e-intervention. C: standard advice and services for nutrition and weight management after pregn from the WIC clinic.	PP <2m (4m)
<b>Pregnancy + postpartum</b>							
Fernandez et al., 2015, USA	<b>e-Moms</b>	RCT study protocol	to decrease prevalence of excessive GWG and the amount of PPWR	pregn < 20 w ; BMI: 18,5-35kg/m <sup>2</sup>	1722	<b>I1:</b> e-intervention in pregn; <b>I2:</b> e-intervention in pregn + PP; <b>C:</b> e-material unrelated to weight management	pregn <20w + PP (24m)

\*: study protocols retrieved from clinicaltrials.gov

I = Intervention group; C = Control group; pregn = pregnancy; pp = postpartum; BF: breastfeeding; w = weeks; m = months; d = days

**Table 2: Intervention characteristics**

authors & ref.	intervention focus	technology used	self-monitoring	telecoaching	data collection	primary and secondary outcomes
<b>Pregnancy</b>						
Willcox et al., 2015; Willcox et al., 2017	GWG, PA, HE	SMS: weight-related behaviour goalsetting	weight: weight gain tracker, scale, SMS: individual goal checking	personalized SMS: encouragement, tips, goal achievement; website: videos, information; forum-support (Facebook) with other participants and professionals, tips, information	baseline, 36w. intervention feasibility: programme metrics, self-report; scale: GWG; questionnaire: HE (food frequency questionnaire), PA (Pregnancy Physical Activity Questionnaire), acceptability (self-report Likert scales)	Prim: feasibility; sec: GWG, PA, HE, acceptability
Redman, 2017a*	GWG, PA, HE	mobile application	weight: digital scale; HE: food intake, PA: accelerometer	mobile application: information from weight management counsellor: prenatal weight management + tools, personalized weight/activity graphs, receipt of SmartTips, personalized feedback from counsellors	no information available	Prim: proportion of women exceeding IOM guidelines of GWG; sec: GW, PA and diet in relation to development of GDM
Pollak et al., 2014	GWG, PA, HE	SMS: weight-related behaviour goalsetting	Weight, target achievement	SMS: personalised feedback + tips on goal achievement	22w, 32 w. Questionnaire: psychological wellbeing, HE, PA, usability, acceptability to the text message. Scale: weight.	Prim: Weight (efficacy), feasibility, acceptability
<b>Postpartum</b>						
Kernot et al., 2013	PPWL, PA, psychological wellbeing	Facebook-app: goalsetting, peer encouragement	PA: pedometer	Forum (Facebook): support and peer encouragement; personalized automatic feedback; encouraging tips and awards	baseline, 8 w, 6m post-baseline. Accelerometer: PA; EPDS: psychological wellbeing; scale: weight.	Prim: PA; sec: weight, psychological wellbeing, feasibility, engagement
Phelan et al., 2015	PPWL, PA, HE, psychological wellbeing	website: education, behavioral self-regulatory strategies, encouragement, social support, web diary.	Weight: scale; PA: accelerometer; HE + PA: web diary	website: personalised automatic feedback and information on weight loss, online weight management lessons, simple meal plans, links; forum-support; SMS: encouragement, tips; **additional to telecoaching**: institutional-level support, group meetings	baseline, 6m, 12m. Anthropometric measures: weight; Questionnaires: HE (24-hours recalls, 26-item Eating Behavior Inventory, Eating Disorders Examination-Questionnaire), psychological wellbeing (TFEQ: the Eating Inventory, 10-item EPDS, 10-item perceived stress scale), self-	Prim: PPWL; sec: PA, HE, psychological wellbeing

					weighing, self-monitoring; interview: PA (seven-day physical activity recall); accelerometer: PA.	
Herring et al., 2014	PPWL, PA, HE, psychological wellbeing	website (facebook) + SMS: behavioral goal attainment	adherence to behavioral strategies: SMS monitoring; weight: digital scale; PA: pedometer	SMS: 3-4x/week self-monitoring, personalized automatic feedback; website + video: behavioral skills Forum (Facebook): support	Baseline, 14w. anthropometric measures (weight, height); Questionnaires: HE (Dietary History Questionnaire II), PA (International Physical Activity Questionnaire), mood (EPDS), program satisfaction.	Prim: PPWL; sec: HE, PA, adherence, program satisfaction
Teheran University of Medical Sciences, 2015*	GWG, PA, HE	website + SMS	PA: pedometer	SMS: motivational messages; website: healthy eating guidelines, stress management	baseline, 12m. Anthropometric measures (weight, weight changes); 24h dietary recall: HE changes; pedometer: PA changes; questionnaires: stress management (Health Promoting Lifestyle Profile Scale), cognitive changes (questionnaires based on behavior change models)	Prim: weight changes (baseline - 12m PP); sec: HE, PA, PPWR, psychological wellbeing
Redman, 2017b*; Gilmore et al., 2017	PPWL, PA, HE	mobile application (SmartLossApp)	Weight: scale, weight graph; PA: accelerometer, step graph	mobile application: self-monitoring weight + PA, tips for PA, HE and behavior change, goalsetting PA; telephone, email or SMS: personalized support and treatment advice in case of deviant weight during 3 consecutive days;	Baseline, 8w, 16w. Anthropometrics (scale: weight, waist and hip circumferences, foot bioelectrical impedance analyzer: body composition); questionnaires (lifestyle interview, study specific screening questionnaire, breastfeeding Self-Efficacy Short Form)	Prim: weight changes (baseline - 6m PP); sec: PA, HE
<b>Pregnancy + postpartum</b>						
Fernandez et al., 2015	GWG, PPWR, PA, HE, psychological wellbeing	Website: <b>Pregn.</b> : online intervention with 5 behavioral targets. Pp: adapted behavioral targets.	weight: weight gain grid; HE: 24h dietary recall; depression scale; online surveys	SMS or email: feedback/alarm on inadequate GWG and excessive PPWR, informational content	Early and late <i>pregn, pp</i> : 6w, 6m, 12m, 18m. Online survey: weight, PA, HE (online 24-hour dietary recall), psychological wellbeing (depression)	Prim: GWG, PPWR

\*: study protocols retrieved from [clinicaltrials.gov](http://clinicaltrials.gov)  
prim: primary outcomes; sec: secondary outcomes

**Table 3: Quality assessment**

Risk of bias assessment	study design	Selection bias	Performance bias	Detection bias	Attrition bias	Reporting bias
<i>Willcox et al., 2015</i>	study protocol	+	-	+	?	?
<i>Willcox et al., 2017</i>	pilot RCT	+	-	+	+	?
<i>Redman, 2017a</i>	study protocol	?	-	-	?	?
<i>Pollak et al., 2014</i>	pilot study	+	-	?	-	+
<i>Kernot et al., 2013</i>	study protocol	+	-	?	?	?
<i>Phelan et al., 2015</i>	study protocol	+	-	+	?	?
<i>Herring et al., 2014</i>	pilot RCT	+	-	?	+	?
<i>Teheran University of Medical Sciences, 2015</i>	study protocol	?	-	+	?	?
<i>Redman, 2017b</i>	study protocol	?	-	?	?	?
<i>Gilmore et al., 2017</i>	pilot RCT	-	-	?	+	?
<i>Fernandez et al., 2015</i>	study protocol	+	-	?	?	?

**score**

- +
  - 
  - ?
- low risk of bias  
high risk of bias  
unclear or unknown risk of bias

**Table 4: intervention results**

authors & ref.	Study name	Weight	PA	HE
<b>Pregnancy</b>				
Pollak et al., 2014	<b>Preg CHAT</b>	GWG: I = C	I = C	I = C
Redman et al., 2017a	<b>SmartMoms</b>	No results		
Willcox et al., 2015; Willcox et al., 2017	<b>txt4two</b>	GWG: I < C (p=0.041) Proportion exceeding IOM GWG recommendations: I = C	Reducing minutes total daily PA: I < C (p=0.001); Sedentary or vigorous activity at 36w: I = C	I = C
<b>Postpartum</b>				
Herring et al., 2014	<b>Healthy4Baby</b>	PPWL: I > C (p=0.04)	I = C	I = C
Kernot et al., 2013	<b>Mums Step it up-program</b>	No results		
Phelan et al., 2015	<b>Fit Moms</b>	No results		
Redman, 2017b*; Gillmore et al., 2017	<b>WIC E-Moms – SmartLoss application</b>	Weight change: I = C weight change IA vs. NA: IA > NA (p=0.005)	No results	
Teheran University of Medical Sciences, 2015*	<b>A Lifestyle Program on Healthy Weight in Postpartum Period</b>	No results		
<b>Pregnancy + postpartum</b>				
Fernandez et al., 2015	<b>e-Moms</b>	No results		

\*: study protocols retrieved from [clinicaltrials.gov](http://clinicaltrials.gov)

GWG = gestational weight gain; PPWL = postnatal weight loss; I = intervention group; C = control group; IA = intervention adherence; NA: non-intervention adherence