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Interventions for Weight Management in Pregnancy

*Overview of Systematic Review
and Meta-Analysis Studies*

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Executive Summary

More than two-thirds of women of childbearing age are overweight or obese, and these numbers have increased dramatically in the last few decades in Canada (Adamo et al., 2013). Further, average weight gain in pregnancy has increased over the last four decades from 10 to 15 kg and a significant number of women are exceeding pregnancy weight gain recommendations.

The increasing prevalence of preconception overweight and obesity and excessive gestational weight gain is a significant risk factor for adverse maternal and infant outcomes. The risks may involve the pregnancy, birth, and later life for both the woman and her infant (Furber et al., 2013). One important downstream risk is childhood obesity (Adamo et al., 2013).

Weight management strategies are increasingly focusing on pregnancy as a potentially key time to target weight management to address the rapidly increasing prevalence of obesity in the population. Interventions have been effective in promoting smoking cessation during pregnancy, suggesting that future weight management interventions hold promise (Campbell, Johnson, Messina, Guillaume, & Goyder, 2011a). Further, as many women are concerned about the health of their babies during pregnancy and are in frequent contact with prenatal care providers, pregnancy may be a powerful stage in the life course for the promotion of healthy lifestyle behaviours for the purpose of weight management among women (Skouteris et al., 2010).

The evaluation of interventions to limit gestational weight gain has been the topic of numerous reviews and, taken together, the findings are mixed. This is largely due to heterogeneity in intervention type (diet or physical activity, psychological support, or some combination of the above) and intensity (intensive clinical intervention vs. hands-off approach). Variable or ineffective knowledge transfer from prenatal care providers to pregnant women may be partially responsible for the limited treatment effects seen in some interventions (Ferraro, 2014).

However, recommendations from the literature may help inform more effective interventions. Strategies are needed that:

- engage prenatal care providers to develop consistent messages (Campbell et al., 2011a);
- that train and prepare prenatal care providers to counsel women about healthy weight gain in pregnancy (Campbell et al., 2011b); and
- that address weight bias attitudes among prenatal care providers (Mulherin, Miller, Barlow, Diedrichs, & Thompson, 2013).

Dialogue between pregnant women and prenatal care providers that reflects each woman's unique situation and risk profile and motivates women to adopt healthy behaviours is needed before and throughout pregnancy (Institute of Medicine, 2009).

Prenatal care providers can be confident recommending:

- routine physical activity (in those without contraindications);

- providing nutritional guidance and caloric literacy (given that the caloric requirements of pregnancy are modest);
- encouraging pregnant women to maintain a food diary and physical activity log; and
- tracking gestational weight gain (GWG) (Ferraro, 2014).

Additional recommended strategies include:

- greater emphasis on psychological factors;
- body image and motivational strategies;
- attitudinal and motivational changes through education;
- cost-effective interventions; and
- interventions that consider the role of family, community, and environmental supports (Phelan, Jankovitz, Hagobias, & Abrams, 2011).

As the research on the health impacts of excessive weight gain during pregnancy continues to mount and novel prenatal interventions attempt to facilitate behaviour change, prenatal care providers and pregnant women require tools and strategies to help improve maternal-fetal outcomes. Collectively, pregnant women and care providers can work together with open dialogue to ensure optimal health and wellness for mom and baby (Ferraro, 2014).

Purpose

This review, conducted by the Saskatchewan Prevention Institute, is the second of two reports focusing on healthy weights during pregnancy. The first report, *Maternal Obesity, Excessive Gestational Weight Gain and Pregnancy Outcomes* (2010), examined the relationship between overweight/obesity and excessive gestational weight gain (GWG) and health outcomes for the woman and her child. This second report aims to: (1) determine the effectiveness of dietary, physical activity, and behaviour or lifestyle interventions for weight management in pregnant women, with otherwise uncomplicated pregnancies, to improve maternal and infant outcomes; and (2) explore the factors that influence intervention effectiveness.

These reports are to serve as foundational documents for knowledge translation and exchange activities by the Saskatchewan Prevention Institute. The aim is to increase knowledge among prenatal care providers of the link between maternal overweight/obesity and excessive GWG, and adverse pregnancy and child outcomes; and to inform the selection, design, delivery, and evaluation of interventions to manage weight during pregnancy.

The increasing prevalence of preconception overweight and obesity and excessive GWG is a significant risk factor for adverse maternal and infant outcomes. The risks may involve the pregnancy, birth, and later life for both the woman and her infant (Furber et al., 2013).

There are well documented risks associated with overweight and obesity in pregnancy and the severity of many pregnancy-related risks increases as the level of obesity increases. The most common health

effects of maternal overweight/obesity on the mother include hypertension (pre-existing and pregnancy-induced), preeclampsia, diabetes mellitus (pregestational and gestational), and the need for caesarean section. The most common health outcome of maternal obesity on the newborn is macrosomia or a large-for-gestational-age neonate (LGA). Furthermore, macrosomia has been associated with the following pregnancy outcomes: caesarean birth, prolonged labour, birth trauma, cephalopelvic disproportion, birth asphyxia, and increased risk of perinatal mortality (Saskatchewan Prevention Institute, 2010). More recent evidence also points to a potential increased risk of preterm birth in women with a high pre-pregnancy Body Mass Index (BMI) (McDonald, Han, & Beyene, 2010). Infants of these women are also less likely to be breastfed (Amir & Donath, 2007) and more likely to be overweight in childhood (Margerison Zilko, Rehkopf, & Abrams, 2010).

Two independent factors that increase an individual's risk of obesity during childhood include high infant birth weight and high maternal BMI (Dodd, Grivell, Crowther, & Robinson, 2010). Therefore, maternal overweight and obesity and high GWG are associated with childhood obesity (Adamo et al., 2013).

In addition, overweight and obese women and excessive GWG represent a significant and increasing challenge in obstetric practice. Maternal obesity is now the most common high-risk obstetric condition (Quinlivan, Julania, & Lam, 2011).

As most of the adverse outcomes of overweight/obese pregnancies show strong associations with pre-pregnancy BMI, a reasonable assumption is that the ideal intervention would be to reduce weight prior to pregnancy (Oteng-Ntim, Varma, Croker, Poston, & Doyle, 2012). However, no trials have been identified that target overweight or obese women who are planning to conceive who have not already contacted medical services for assistance in fertility. Also, given that many pregnancies are unplanned, it would be difficult to define a target population which included all at-risk women. Further, even in the case of planned pregnancy, very few women would consult a health care provider before conceiving and fewer still are likely to then agree to postpone their family planning for a number of months or years in order to lose weight (Birdsall, Vyas, Khazaezadeh, & Oteng-Ntim, 2009). This is not to say that messages and programs promoting healthy weights should not be directed at women of childbearing age generally, but that in order to have the most direct and effective impact on pregnancy and child health, we have chosen to start by examining interventions focusing on pregnancy.

It has been suggested that pregnancy is an optimal time for promoting health behaviour change as women are particularly motivated to ensure the health of their baby, and it is generally a time of increased contact between the woman and the health system (Oteng-Ntim et al., 2012; Campbell et al., 2011a; Skouteris et al., 2010). Therefore, the focus of this review is on interventions during pregnancy designed to manage weight gain and limit excessive GWG. Although it is acknowledged that maternal weight prior to pregnancy can have a significant impact on the health of the mother and infant, interventions focused on weight prior to pregnancy are outside the scope of this review.

Background

Pregnancy Weight Trends

Research indicates that more than two-thirds of North American women of childbearing age are overweight or obese, a prevalence comparable to other developed nations, and that these numbers have increased dramatically in the last few decades in Canada and elsewhere (Adamo et al., 2013).

Average weight gain in pregnancy has increased over the last four decades from 10 to 15 kg and a significant number of women are exceeding pregnancy weight gain recommendations (Adamo et al., 2013). Studies on GWG in the United States and Europe indicate that about 20-40% of women are gaining weight above the recommendations. Excessive weight gain during pregnancy and subsequent postpartum weight retention may contribute to the increasing prevalence of overweight and obesity among women of childbearing age (Davies, Maxwell, & McLeod, 2010).

Factors Associated with Pregnancy Weight

Although pre-pregnancy BMI largely determines GWG, there are many other factors that can affect a woman's weight such as genetic characteristics, underlying health issues, socioeconomic status, and attitude toward weight gain. The amount a woman gains can also depend on her living and working environment, including cultural norms and beliefs, access to healthy foods, opportunities for physical activity, as well as family and partner support (Health Canada, 2010).

Women who gain too much weight during pregnancy are more often giving birth for the first time, Aboriginal¹, individuals with less than secondary education, and less than 25 years old (Lowell & Miller, 2010).

Pregnancy Weight Gain Guidelines

Health Canada's Prenatal Nutrition Guidelines (2010) outline recommendations for pregnancy weight gain which are based on the U.S. Institute of Medicine's (IOM) Weight Gain During Pregnancy Guidelines (2009). The IOM guidelines provide reference ranges for optimal weight gain in pregnancy for underweight, normal weight, overweight, and obese women based on women's pre-pregnancy BMI. BMI is weight in kilograms divided by height in meters squared (kg/m^2).

The following table outlines the current guidelines based on pre-pregnancy BMI (Institute of Medicine, 2009, p. 2):

¹ Aboriginal was defined as those who self-identified as Aboriginal and were born in Canada among those who responded to the 2006 Maternity Experiences Survey (Lowell & Miller, 2010).

Table 1. New Recommendations for Total Weight Gain During Pregnancy, by Pre-pregnancy BMI

Pre-pregnancy BMI	Total Weight Gain	
	Range in kg	Range in lbs
Underweight (< 18.5 kg/m ²)	12.5-18	28-40
Normal weight (18.5-24.9 kg/m ²)	11.5-16	25-35
Overweight (25.0-29.9 kg/m ²)	7-11.5	15-25
Obese (≥ 30.0 kg/m ²)	5-9	11-20

There is some controversy surrounding the IOM guidelines. Some questioned the scientific rigour of the initial guidelines as they were based on population-based observational studies and studies that did not account for other confounding variables (Furber et al., 2013). However, revisions in 2009 were based on a wider review of maternal and fetal outcomes (fetal size, risk of unplanned caesarean birth, and excessive postpartum weight retention) (IOM, 2009). The updated IOM recommendations have also met with controversial reactions from some who believe that the weight gain targets are too high, especially for overweight and obese women; that weight gain targets do not address concerns regarding postpartum weight retention; and that the guidelines do not differentiate degrees of obesity, especially for morbidly obese women (ACOG, 2013a). While the new guidelines are more stringent than previous recommendations, particularly for obese women, the proportion of women gaining above recommended levels is likely to increase, unless successful interventions can interrupt trends towards higher weight gains (Skouteris et al., 2010).

Most obstetrical caregivers in Canada record pre-pregnancy weight in the prenatal record, although documentation of maternal height is inconsistent (Davies et al., 2010). Recent evidence from the United States suggests that many obstetrician-gynaecologists use BMI data to screen for overweight/obesity.

Despite the widespread use of BMI, there is increasing attention on the shortcomings of BMI as a measure of obesity. Criticisms include BMI being a poor surrogate for body fatness, the application of population level standards to individuals neglecting individual differences within groups, and BMI being a poor indicator of health that distracts from behavioural, environmental, and social factors that influence weight (Nicholls, 2013; Sharma, 2013).

Prenatal Care and Practices

Practice Guidelines for Pregnancy Weight Management

While the current IOM guidelines recognize that interventions will be needed to assist women, particularly those who are overweight or obese at the time of conception to meet the recommendations, there is a lack of clear policy about the way in which normal weight, overweight, and obese women's weight gain should be managed prior to and in pregnancy (Campbell et al., 2011b; Dodd et al., 2010).

Some health professional bodies have developed recommendations related to obesity during pregnancy. The Society of Obstetricians and Gynaecologists of Canada developed the 'Obesity in Pregnancy' Clinical Practice Guideline which includes these recommendations (Davies et al., 2010, p. 165-6):

1. Periodic health examinations and other appointments for gynaecologic care prior to pregnancy offer ideal opportunities to raise the issue of weight loss before conception. Women should be encouraged to enter pregnancy with a BMI < 30 kg/m² and ideally < 25 kg/m².
2. BMI should be calculated from pre-pregnancy height and weight. Those with a pre-pregnancy BMI > 30 kg/m² are considered obese. This information can be helpful in counselling women about pregnancy risks associated with obesity.
3. Obese pregnant women should receive counselling about weight gain, nutrition, and food choices.
4. Obese women should be advised that they are at risk for medical complications such as cardiac disease, pulmonary disease, gestational hypertension, gestational diabetes, and obstructive sleep apnea. Regular exercise during pregnancy may help to reduce some of these risks.
5. Obese women should be advised that their fetus is at an increased risk of congenital abnormalities, and appropriate screening should be done.
6. Obstetric care providers should take BMI into consideration when arranging for fetal anatomic assessment in the second trimester. Anatomic assessment at 20 to 22 weeks may be a better choice for the obese pregnant patient.
7. Obese pregnant women have an increased risk of Caesarean section, and the success of vaginal birth after Caesarean section is decreased.
8. Antenatal consultation with an anaesthesiologist should be considered to review analgesic options and to ensure a plan is in place should a regional anaesthetic be chosen.
9. The risk of venous thromboembolism for each obese woman should be evaluated. In some clinical situations, consideration for thromboprophylaxis should be individualized.

Current guidelines regarding pregnancy weight gain from the American College of Obstetricians and Gynecologists (2013a) recommend discussing appropriate weight gain, diet, and exercise at the initial visit and periodically throughout the pregnancy. In the case of an overweight or obese woman who is gaining (or wishes to gain) less weight than recommended but has an appropriately growing fetus, individualized care and clinical judgement are recommended. Additional guidelines regarding weight gain among overweight/obese pregnant women (2013b) recommend that women be counselled prior to conception, and be encouraged to adopt lifestyle changes to minimize their risk of developing complications during pregnancy related to being overweight or obese. Further, a woman's BMI should be measured at the initial prenatal visit.

Current guidelines from the National Institute for Health and Clinical Excellence (NICE) in the UK recommend that all women, regardless of BMI, should be provided with information and advice on diet and physical activity early on in their pregnancy (NICE, 2010; Furber et al., 2013). According to NICE, women with BMI greater than 30 kg/m² should plan to lose weight before conception and that pregnant women identified as obese at initial antenatal appointments should be advised about the potential risks of losing weight while pregnant, and provided with information and support about appropriate diet and

exercise. NICE guidance discourages dieting when pregnant and obese because of risk of harm to the unborn child.

Health Canada outlines recommendations for prenatal care providers in its Prenatal Nutrition Guidelines for Health Professionals (2010):

- Encourage women with a high BMI to improve their weight before becoming pregnant. Let them know how being overweight during pregnancy can negatively affect their health and the health of their babies.
- Use Canada's Food Guide and Canada's Physical Activity Guide to describe healthy eating and physical activity patterns.
- Encourage women to record and assess their level of activity and the type and amount of food they eat.
- Find out if women need help to eat well and be active. For example, some women may need nutrition counselling with a Registered Dietitian. Others may require social support and better access to healthy foods or opportunities for physical activity.
- Consult your local public health unit or community health centre for print resources and information about programs that are adapted to the needs of cultural groups in your area.
- Work with each pregnant woman to set a weight gain goal early in her pregnancy. Base this goal on her pre-pregnancy BMI and other relevant considerations, such as her health status prior to pregnancy.
- Ask women what they expect to happen with their weight during pregnancy. If possible, have this discussion in the preconception period or early in the pregnancy. Let women know why gestational weight gain is important (for example, it nourishes the growing baby) and why weight loss is not recommended (as it could affect the baby's growth).
- Talk to women about GWG. When women learn what to expect about weight changes that take place during pregnancy, they may not feel as anxious about these changes.
- Advise women about eating well during pregnancy. Most women know that they need to eat more food when they are pregnant to support their baby's growth and development but they do not always know how much more. Usually, pregnant women only need modest increases in energy (calories) and greater increases in vitamin and mineral intake.
- Advise women about being active during pregnancy. Describe the benefits of having an active lifestyle during pregnancy. Encourage pregnant women to identify strategies (such as locating safe places to walk in their neighbourhood) that help them be active during pregnancy. Some women may need more support to overcome financial, social, physical or cultural barriers to being physically active during pregnancy. Become familiar with community programs and initiatives that provide opportunities for physical activity for pregnant women at low or no cost.

Despite the existence of the various guidelines, overweight/obesity and excessive GWG continues to escalate for many women, and the focus therefore needs to be on more effective interventions and minimizing the risk of complications during pregnancy (Dodd et al., 2010).

Weight Monitoring during Pregnancy

There is conflicting evidence and practice with respect to weight recording throughout pregnancy (Skouteris et al., 2010). One view is that routine weighing should be included in the standard prenatal care for women who enter pregnancy overweight or obese. Another view is that routine weighing does not impact health outcomes and may produce unnecessary anxiety. Further, monitoring of BMI across pregnancy may be problematic because of the lack of reliability of anthropometric equipment used in prenatal clinics, the lack of anthropometric testing skills in midwives and physicians, and poor measurement recording procedures.

Weight monitoring guidelines vary across countries. Current UK prenatal care guidelines recommend that maternal height and weight should be recorded for all women only at the initial booking visit, and preferably before 10 weeks gestation, to allow the calculation of BMI. For women who are overweight/obese in pregnancy, the guidelines recommend a reassessment of weight during the third trimester, not to monitor excessive GWG, but rather to allow for preparation of the equipment and personnel that will be required during labour and delivery. Maternity care guidelines in Australia recommend weighing at the first antenatal booking, and also recommend routine weighing for women whose clinical management is likely to be influenced. In contrast, routine weighing at each prenatal visit through pregnancy is a component of standard maternity care in the United States (as recommended by the IOM) and in Canada (Skouteris et al., 2010).

Dietary Intake of Pregnant Women

It is well known that during pregnancy the nutritional requirement is enhanced resulting in women generally increasing their food intake. However, cultural beliefs, such as “eating for two” may contribute to a caloric intake above the ordinary demands of pregnancy (Oteng-Ntim et al., 2012).

A review of the energy and macronutrient intakes of pregnant women from developed countries found that, generally, dietary intakes of pregnant women do not align with country-specific energy and macronutrient recommendations (Blumfield, Hure, Macdonald-Wicks, Smith, & Collins, 2012). Many women consume diets low in fiber and high in both total and saturated fat during pregnancy, not unlike the dietary patterns reported by non-pregnant women.

Health Canada (2010) recommends following Canada’s Food Guide (<http://hc-sc.gc.ca/fn-an/food-guide-aliment/index-eng.php>). It recommends that pregnant women need just a little more food, a few more calories, in the second and third trimesters. For most women, this means an extra two or three Canada Food Guide Servings from any of the food groups each day in addition to their recommended number of Canada Food Guide servings per day (Health Canada, 2011).

Current IOM recommendations for obese pregnant women is a weight gain between 5.0 and 9.1 kg during the pregnancy period, and weight loss has generally been discouraged during pregnancy, even among obese pregnant women. However, observational studies indicate that some obese pregnant women lose weight during pregnancy. Furthermore, some obese pregnant women may intentionally lose weight (Furber et al., 2013).

A review conducted to evaluate the effectiveness of interventions that reduce weight in obese pregnant women did not identify any randomized controlled trials designed to reduce weight in obese pregnant women (Furber et al., 2013). It concluded that until the safety of weight loss in obese pregnant women can be established, there can be no practice recommendations for these women to intentionally lose weight during the pregnancy period. Further study is required to explore the potential benefits, or harm, of weight loss in pregnancy when obese, before weight loss interventions in pregnancy can be designed.

Physical Activity of Pregnant Women

The beneficial outcomes of being physically active are well recognized, including improving cardiovascular condition and glucose tolerance, building bone and muscle mass, and reducing risks of obesity and its complications. Exercise in pregnancy has been reported to improve maternal and fetal health outcomes through a reduction in risk of preterm birth and labour complications. For the infant, moderate intensity exercise during pregnancy has been associated with a reduction in fat mass at birth and in childhood (Sui, Grivell, & Dodd, 2012). However, the great majority of women who are pregnant are physically inactive, and even women who were physically active prior to their pregnancy tend to reduce their activity as their pregnancy progresses (Choi, Fukuoka, & Lee, 2013).

A fear of harming self/unborn baby, general physical discomfort, and discouragement to undertake physical tasks by people around them contribute to a general decline in physical activity among pregnant women (Campbell et al., 2011a). Further, traditional medical advice for exercising women has been to reduce their habitual levels of exertion in pregnancy and for non-exercising women to refrain from initiating strenuous exercise programs. This advice was based on concerns that exercise could affect early and late pregnancy outcomes by increasing core body temperature, thereby increasing the risk of congenital anomalies and shifting oxygenated blood and energy substrates to maternal skeletal muscle and away from the developing fetus, leading to disturbances in growth (Davies et al., 2003).

However, current joint recommendations by the Society of Obstetricians and Gynaecologists of Canada (SOGC) and the Canadian Society for Exercise Physiology (CSEP) recommend that all women should be encouraged to participate in regular physical exercise during their pregnancy (Davies, Wolfe, Mottola, & MacKinnon, 2003). The recommendations specify pregnant women exercise four times weekly at moderate intensity. It should be noted that these recommendations do not specifically address the issue of exercise recommendations for pregnant women who are overweight or obese.

Healthy women with uncomplicated pregnancies can integrate physical activity into their daily living and can participate without significant risks either to themselves or to their unborn child (CSEP, 2013). The SOGC and the CSEP jointly recommend that in uncomplicated pregnancies, women with or without a previously sedentary lifestyle should be encouraged to participate in aerobic and strength-conditioning exercises as part of a healthy lifestyle (Davies et al., 2003).

In 2013, CSEP updated its Physical Activity Readiness Medical Examination for Pregnancy (PARmed-X for Pregnancy available at <http://www.csep.ca/cmfiles/publications/parq/parmed-xpreg.pdf>), a tool for health care providers to evaluate pregnant patients who want to enter a prenatal fitness program and for ongoing medical surveillance of exercising pregnant patients.

Exercise in pregnancy affects health outcomes for the woman through improved cardiovascular function and restriction of weight gain, a reduction in the risk of preterm birth, and favourable effects on labour and birth. Benefits for the infant include reduced fat mass at birth, which extends into childhood (Dodd, Crowther, & Robinson, 2008). However, the benefits of introduction of exercise in pregnancy for previously sedentary women remain to be established. The ongoing health effects of interventions during pregnancy on infant and child health, particularly in relation to the development of childhood obesity, remain uncertain.

Approach

The aim of this report is to review the published literature to determine the effectiveness and characteristics of dietary, physical activity, and behaviour or lifestyle interventions for weight management in pregnant women.

Search Strategy

A search was performed in MEDLINE and PubMed. Search terms included: (“nutrition” or “diet”) and (“exercise” or “physical activity” or “sports”) and (“behavioural” or “lifestyle”) and (“pregnancy” or “gestation” or “maternal”) and (“weight gain” or “weight change” or “pregnancy outcome”). Studies were also located by reviewing reference lists and bibliographies in selected articles.

The starting point for the search was on research evidence at the highest point in the hierarchy of quantitative evidence (National Collaborating Centre for Methods & Tools [NCCMT], 2010). The proposed hierarchy of quantitative evidence outlined in Table 2 is based on study designs that are considered stronger - that is, more free of bias - than others. The top of the hierarchy of quantitative evidence is the strongest evidence for a question on intervention effectiveness. While no study is ever totally free of bias, the potential for bias is greater as you move down the hierarchy. This approach is not based on an assumption that only systematic reviews or randomized controlled trials should be considered quality evidence as all study designs are forms of research evidence.

Table 2. Hierarchy of quantitative evidence (NCCMT, 2010)

Systematic reviews of randomized controlled trials
Randomized controlled trials
Systematic reviews of non-randomized or cohort studies
Cohort studies
Case control studies
Case series
Case report
Ideas, editorials, expert opinions
Animal research
In vitro (test tube) research

Multiple systematic reviews that pertained to the aim of this report were identified. As such, the literature search did not extend to other study designs. However, some additional relevant literature has been included that provided insight on this topic. Literature that provided an overview of maternal weight management interventions (Birdsall et al., 2009; Campbell et al., 2011b) as well as literature on weight bias (Mulherin et al., 2013; McVey et al., 2013) and emerging interventions applied to non-pregnant populations that hold promise for pregnant women is also discussed (Bacigalupo et al., 2013; Phelan et al., 2011; Shaw et al., 2009).

A systematic review is a summary of the clinical literature, a critical assessment and evaluation of all identified research studies that address a particular clinical issue (Agency for Healthcare Research & Quality, 2013). The researchers use an organized method of locating, assembling, and evaluating a body of literature on a particular topic using a set of specific criteria. The results are put together in a meaningful way, beyond just describing each study in detail. A systematic review is typically done prior to a meta-analysis that, where appropriate, combines statistical results from individual studies to give an estimate of the overall effect (NCCMT, 2010).

Nineteen systematic reviews were identified between 2008 and 2013 that assessed the effect of interventions on maternal weight management and excessive GWG. A few of these reviews also included a focus on prevention of overweight/obesity prior to pregnancy; however, this will not be addressed in this review. Of these reviews, ten were systematic reviews, eight were systematic reviews and meta-analyses, and one was a systematic review, meta-analysis and thematic synthesis of qualitative evidence. An overview of the reviews/analyses is provided in Appendix 1.

Of the nineteen reviews, ten included only randomized trials and nine included both randomized and non-randomized trials. There was considerable overlap in the included studies across the reviews.

The majority of the reviews assessed interventions focused on excessive weight gain during pregnancy, targeted pregnant women of all weights (normal, overweight, or obese) with otherwise uncomplicated pregnancies, and compared interventions with usual or standard prenatal care provided to pregnant women.

Several reviews aimed to evaluate lifestyle interventions as a means to manage GWG (Choi et al., 2013; Hill et al., 2013; Muktabhant et al., 2012; Oteng-Ntim et al., 2012; Thangaratinam et al., 2012; Campbell et al., 2011a; Gardner et al., 2011; Brown et al., 2010; Dodd et al., 2010; Ronnberg & Nilsson, 2010; Skouteris et al., 2010; Streuling et al., 2010; Dodd et al., 2008). Other reviews included a focus on other specific types of interventions including dietary interventions (Thangaratinam et al., 2012; Quinlivan et al., 2011; Streuling et al., 2011b; Tanentsapf et al., 2011; Dodd et al., 2010) and physical activity interventions to manage GWG (Choi et al., 2013; Sui et al., 2012; Streuling et al., 2011a). One review focused on prenatal interventions to reduce weight in obese pregnant women (Furber et al., 2013).

Review Quality

The online resource www.healthevidence.org (healthevidence.org, 2013) was accessed to assist with assessing the quality of the review studies. This online resource rates the methodological quality of

systematic reviews that evaluate the effectiveness of public health interventions. Sixteen of the nineteen reviews were included and assessed for quality. Of these, eleven were rated as strong quality (rating 8 to 10 / 10), four were rated as moderate quality (5 to 7 / 10), and one rated as weak quality (1 to 4 / 10). The ratings are included in the table in Appendix 1. The reviews rated as strong quality were given greater weight in the discussion of their findings in this report.

Results

Interventions used to manage weight in the general population include lifestyle interventions that use techniques such as ‘information giving’ related to lifestyle, including nutrition (calorie restriction and eating behaviour modification) and exercise behaviour modification, such as increasing walking (Furber et al., 2013). The delivery of information is variable including the use of written material, internet, telephone contact and/or mail-based, and group-based or individualized contact. Psychological interventions are also used. These include techniques that aim to facilitate behaviour change such as self-help, peer support, counseling, cognitive behavioural therapy, problem-solving therapy, goal setting, motivational interview techniques, and therapist contact. Complementary therapies such as acupuncture and meditation have also been incorporated into relevant interventions. In non-pregnant populations, pharmacological agents have also been utilized to reduce weight as well as bariatric procedures such as gastric bypass surgery and laparoscopic adjustable banding.

The above were typical of the interventions targeting pregnant women in the studies included in the reviews discussed here, with the exception of pharmacological agents and bariatric procedures and to a lesser extent, complementary therapies.

The interventions targeting pregnant women are often multicomponent, combining one or more techniques (Furber et al., 2013). One review described these as ‘complex interventions’ that contained several interacting components and included both a dietary and physical activity component (Campbell et al., 2011a).

Another common feature of the studies included in the various reviews is a shared goal to promote behavioural change and give women an awareness of the impact of body weight on maternal and infant health (Ronnberg & Nilsson, 2010). Beyond this, however, there was a significant heterogeneity in the mode, intensity, frequency, and duration of the interventions carried out.

Intervention Mode, Intensity and Timing

There was significant variation in intervention mode and intensity across the studies included in the reviews. For example, one review included interventions ranging from an intensive 10 consultations of one-hour duration with a dietitian in one trial to only one session with a dietitian at enrolment in another trial (Campbell et al., 2011a). Some of the interventions combined face-to-face dietary counselling with additional supportive material such as newsletters and phone calls, supportive software packages, and use of food diaries. Regular monitoring of weight, use of weight charts, and plotting weights for feedback to participants was also used in some of the studies. Other interventions included

group exercise sessions and active lifestyle counselling. Intervention duration ranged from recruitment in early pregnancy to later pregnancy.

Typical dietary interventions included a balanced diet consisting of carbohydrates, proteins, and fat and maintenance of a food diary (Thangaratinam et al., 2012). Typical physical activity interventions included light intensity resistance training, weight bearing exercises, and walking for 30 minutes. Mixed approach interventions included counselling sessions, education concerning the potential benefit of diet and physical activity, and feedback on weight gain in pregnancy. The mixed approach typically used techniques of behavioural modification to give the women insight into controlling periods of emotional eating and preventing binge eating sessions.

One review found a wide range of training and experience among the prenatal care providers delivering the interventions (Furber et al., 2013). Another review found most of the interventions were delivered by a health care provider with particular expertise in nutrition/psychology or public health; most commonly a dietitian (Campbell et al., 2011a).

The majority of the interventions across the various reviews occurred during the first and second trimesters due to the focus on preventing excessive GWG. There do not appear to be any studies that initiated an intervention during pregnancy and continued to the postpartum period. This is likely due to the challenges of targeting interventions in the postpartum period as adjustment to motherhood makes it hard for postpartum women to prioritize their own health behaviour efforts and to adopt a new behaviour (Choi et al., 2013).

Target Audience

Twelve reviews focused on managing weight in pregnant women at any weight (normal weight, overweight, and obese). The remaining seven reviews focused only on overweight or obese pregnant women. Most of the reviews focused on women with otherwise uncomplicated pregnancies, although there were a small number of studies that included women with gestational diabetes and other health complications.

Intervention Effectiveness

While there is widespread agreement that pregnancy is a key time to target weight management to address the rapidly increasing prevalence of overweight and obesity as well as associated adverse health outcomes for the mother and infant, conclusions about the overall effectiveness of interventions applied to date are mixed.

A common primary outcome used to assess intervention effectiveness across the various studies was GWG (typically based on IOM recommendations). Other common outcomes included infant birth weight, nutritional habits, fitness level, postpartum weight retention, obstetric maternal outcomes (including pre-eclampsia, gestational diabetes, gestational hypertension, preterm delivery, gestational age at delivery, caesarean section rates, induction of labour, postpartum haemorrhage, and infection),

perinatal death, and relevant childhood outcomes related to body size/body composition (Thangaratinam et al., 2012; Dodd et al., 2010).

Many of the reviews were critical of the overall quality of the studies conducted (Dodd et al., 2010; Ronnberg & Nilsson, 2010; Streuling et al., 2010; Streuling et al.; 2011a; Tanentsapf et al., 2011; Brown et al., 2012). Specific concerns included poor methodological quality, high attrition rates, lack of detail on randomization methods, small sample sizes, inconsistent results across studies, limited effectiveness of interventions on GWG and other maternal and infant outcomes, wide variation in the types of interventions, and lack of theoretical frameworks. It appears that the situation described by the Institute of Medicine in 2009 (p. 277) remains the same; “existing research is inadequate to establish the characteristics of interventions that work reliably to assist women in meeting . . . guidelines for gestational weight gain”.

A common recommendation across the various reviews was an urgent need for more well-designed studies with adequate sample sizes to be able to recommend effective interventions. Until this past decade, the number of studies in this area of research has been relatively small because inadequate GWG has historically been the primary prenatal weight-related concern (Walker, 2007).

Following is an overview of findings on effectiveness based on the type of interventions reviewed. Findings from additional reviews of weight management interventions that are not specific to pregnancy are discussed given their emerging relevance to this topic (i.e., psychological interventions and mobile technology).

Dietary

The provision of a dietary intervention alone is of uncertain benefit in limiting weight gain during pregnancy based on the findings from the reviews that focused on dietary interventions.

The results of one systematic review that assessed dietary interventions among pregnant women who were overweight or obese found uncertain benefit in limiting weight gain during pregnancy (Dodd et al., 2010). This review also found evidence to be lacking of an effect of dietary interventions on other important maternal health outcomes including gestational diabetes, pre-eclampsia, induction of labour, and caesarean section, as well as infant health outcomes.

Another review found that while dietary intervention alone appears effective in reducing total and weekly GWG and incidence of cesarean section, there was no significant evidence for preventing excessive GWG overall (Tanentsapf, Heitmann, & Adegboye, 2011). Further, dietary intervention seems to have no effect on infant birth weight and gestational duration, and there is no strong evidence that dietary intervention significantly reduces the incidence of preeclampsia, gestational diabetes, or macrosomia.

Alternatively, one review found dietary interventions in overweight or obese women is associated with lower GWG without an associated effect on birth weight (Quinlivan et al., 2011). The authors conclude that dietary interventions can limit GWG in overweight and obese women to IOM-recommended levels.

A review that compared dietary, physical activity, and mixed approaches found dietary interventions to be the most effective and associated with reductions in GWG and improved obstetric outcomes without any adverse effects (Thangaratinam et al., 2012). The authors concluded that dietary interventions are most effective in reducing complications such as pre-eclampsia, gestational diabetes, gestational hypertension, and preterm delivery. With the lack of individual data on important factors such as age, ethnicity, socioeconomic status, compliance, and other risk factors, the authors were limited in their explanation for the benefit observed with diet compared with other methods, but provided some possible reasons for this finding. First, the net benefit gained might be linked to the vigour with which the components of the intervention are delivered. In 'mixed approaches', the individual components might not be delivered to the same standard as in studies that focus on diet alone. Second, compliance might have been better in trials with a diet-only intervention than other methods because of its relative simplicity and perceived safety in contrast with physical activity in pregnancy. Third, specific components of the diet, such as fibre, might have benefits that are not evident with other interventions. Raised triglyceride concentrations in pregnancy are associated with the risk of pre-eclampsia. The high fibre in the dietary intervention of the included studies could have influenced the beneficial effect observed with reduction in the rates of pre-eclampsia.

Two other reviews suggested some promising components of dietary interventions. One review found that the use of calorie goals and structured meal plans that facilitated adherence to calorie goals had a positive effect on reducing GWG (Phelan et al., 2011). Another review found that a diet with less intake of protein, but higher intake of carbohydrates (for example, by reducing the amount of meat in the diet) appeared to be associated with lower GWG, but the authors cautioned the need to account for the well-known increased protein requirements in pregnancy (Streuling, Beyerlein, Rosenfeld, Schukat, & von Kries, 2011b).

Physical Activity

Three reviews focused on physical activity interventions. The findings across these reviews were inconsistent.

One review found that for women who are overweight or obese, provision of a supervised physical activity intervention appears to be beneficial in limiting weight gain during pregnancy (Sui et al., 2012). Although the interventions were very diverse, including walking, cycling and resistance training, and varied in the timing of initiation, the direction and magnitude of treatment effect was similar across trials. However, the effect of a physical activity intervention on other maternal and infant health outcomes was unclear, with the included studies primarily reporting outcomes reflecting exercise tolerance, and cardiovascular and metabolic changes. The authors of this review concluded that there remains a lack of high-quality research evidence to assess the impact on maternal and infant health, and that well-designed randomized trials are required to evaluate the effect of exercise during pregnancy for women who are overweight or obese on relevant clinical outcomes.

Another review and meta-analysis found that interventions varied by intensity, duration (10-32 weeks), and mode of activity (Streuling et al., 2011a). In general, women exercised about three times a week for at least 20 minutes up to 1 hour performing aerobics, running, cycling, water aerobics, or muscle

strengthening. All interventions started in the first or second trimester and persisted to the third trimester or until delivery. Interestingly, they found that GWG was not the main outcome in any of these studies; rather, GWG was reported as a secondary outcome. Intervention trials to increase physical activity during pregnancy showed a significantly lower average GWG in the intervention groups compared with the controls.

A third review concluded that, in general, a combination of physical activity and diet intervention has shown to be more effective than a physical activity intervention alone in weight management (Choi et al., 2013).

Mixed Approach

Several reviews focused on combined dietary and physical activity interventions. The findings across these reviews were mixed.

One systematic review and meta-analysis concluded that supervised physical activity plus diet interventions are effective in managing weight, regardless of body weight status in pregnant women (Choi et al., 2013). They found that supervised physical activity plus diet has a significantly lower average GWG for overweight and obese pregnant women. They conclude that, in general, a combination of physical activity and diet intervention is more effective than a physical activity intervention alone in weight management. Advice alone to promote physical activity, without a personalized physical activity prescription or goal for physical activity, along with diet intervention, is not effective enough to prevent excessive GWG.

This is supported by another systematic review and meta-analysis that reported that interventions based on physical activity and dietary counseling, usually combined with supplementary weight monitoring, appear to be successful in reducing GWG (Streuling, Beyerlein, & von Kries, 2010). Interventions confined to either physical activity or diet alone do not appear to reduce GWG. In all identified studies, oral or written recommendations regarding diet and physical activity were provided, mostly combined with personal counseling. Five interventions with additional weight monitoring or a predetermined goal of maximal GWG appeared to be more effective than those without. No other specific intervention strategy, such as structured exercise programs or individual nutrition counseling, appeared to be particularly effective.

Other reviews did not report as promising results on the effectiveness of combined lifestyle interventions. One review concluded that despite intense and often tailored interventions to prevent excessive weight gain during pregnancy, there was no statistically significant effect on GWG and that interventions showed no clear evidence of effect or lack of effect (Campbell et al., 2011a). Further reviews made similar conclusions. The authors of one review concluded they could not recommend any one intervention for preventing excessive weight gain during pregnancy because most of the studies identified were of poor quality and the effects of the interventions were generally small (Muktabhant, Lumbiganon, Ngamjarus, & Dowswell, 2013). The authors of another review found that while combined dietary and activity interventions were associated with restricted GWG, they concluded that the findings needed to be interpreted with caution as the available studies were of poor to medium quality (Oteng-

Ntim et al., 2012). A further review concluded that there is limited information available assessing the benefits and harm associated with dietary and lifestyle interventions for overweight and obese pregnant women; therefore, further evaluation through randomized trials with adequate power is required (Dodd et al., 2008).

Behaviour Change

Another review sought to deconstruct previous intervention evaluations so as to identify defining features of effective interventions (Gardner, Wardle, Poston, & Croker, 2011). The authors state that interventions based on behaviour change theory are those that employ the use of constructs that can help individuals become more motivated for action (e.g. goal setting, self-efficacy, readiness to change). Further, the success of a theory-based intervention is determined by how well the principles of behaviour change are applied and tested in order to improve health outcomes.

Gardner et al. (2011) further suggest that interventions based on theory may be more effective, and that interventions based on specific and achievable behavioural targets (e.g. 'consuming an additional portion of fruit per day') may be more successful in promoting change than those with more vague recommendations (e.g. 'eating a healthier diet'). Only two trials included in this review reported to be theory-based: one was informed by Social Learning Theory and the other based on multiple theories (the Precede–Proceed Model, the Transtheoretical Model, and the Behaviorally Grounded Model). The behaviour change techniques most commonly used in the studies included in this review were self-monitoring of behaviour, performance feedback, and setting goals, suggesting that intervention developers generally conceptualize excessive GWG as a self-regulatory issue, whereby pregnant women are motivated to adopt a healthy diet and increased physical activity but have problems in revising their behaviour accordingly. Interestingly, Gardner et al. found that the theory-based interventions had less impact on weight outcomes than did interventions which did not report a theory base.

However, given the lack of detail regarding how theory was used to develop these two interventions, and underuse of theory in behavioural GWG interventions more generally, Gardner et al. (2011) stated that it remains unclear whether the 'wrong' theories were used, appropriate theories were poorly applied, or the expected link between use of theory and effectiveness is not always present. They maintained that examination of behaviour change techniques can be informative in revealing implicit theoretical assumptions about the underpinnings of expected change.

Gardner et al. (2011) cite attitudinal research suggesting that many pregnant women are indifferent to GWG and may fail to recognize the importance of weight gain restriction. They recommend that targeting attitudinal and motivational change through the provision of information about the link between GWG and adverse maternal and neonatal outcomes, or prompting the formation of an intention to act, may be useful alternative routes to changes in diet or physical activity.

Expanding on the previous review and including a greater number of studies, a related review concluded that, overall, studies based on theory were as effective as non-theory-based studies at limiting GWG (Hill et al., 2013). More specifically, the authors found that provision of information, motivational

interviewing, behavioural self-monitoring, and providing rewards contingent on successful behaviour appear to be key strategies when intervening in GWG. The authors also suggested that combining behaviour change techniques with dietary interventions may be most effective.

The most common behaviour change techniques in Hill et al.'s (2013) review were providing general information on the consequences of behaviour, behavioural goal setting, prompting self-monitoring of behaviour, and outcome goal setting. Several interventions also provided feedback on performance, provided instruction on how to perform the behaviour, used action planning, prompted review of behavioural goals, set graded tasks, provided information on where and when to perform the behaviour, and prompted self-monitoring of behavioural outcome. A smaller number of interventions prompted review of outcome goals and utilized barrier identification/problem solving, provided rewards contingent on successful behaviour, used follow-up prompts, planned social support/social change, provided information on consequences of behaviour to the individual, used stress management/emotional control training, and provided motivational interviewing. One intervention prompted rewards contingent on effort or progress towards a behaviour and facilitated social comparison. An average of 5.5 (range 1-12) techniques were reported per intervention. In general, Hill et al. found that more techniques were reported in effective interventions and there was a trend for interventions with a larger number of techniques to report greater differences in GWG between the intervention and control groups.

Further support for behavioural strategies can be drawn from an article that summarizes intervention components shown to be effective in promoting successful weight control outside of pregnancy with the aim of exploring potential applications in pregnancy (Phelan et al., 2011). The authors found that the more behavioural strategies utilized, the greater the reported effects – especially when combined with a strong dietary plan. The studies that included a greater number of behavioural strategies (such as daily diet monitoring, weight monitoring, and calorie goals) found positive effects.

Psychological Interventions in the General Population

A variety of individual and group psychological therapies have been used in general weight loss treatments (Shaw, O'Rourke, Del Mar, & Kenardy, 2005). According to Shaw et al., behavioural and cognitive behavioural therapies are the most commonly used psychological therapies for weight loss. Attitude and relationship techniques are also often utilized in designing comprehensive psychological interventions for individualized weight loss programs. Psychotherapy is less commonly used. Behaviour therapy and cognitive behaviour therapy appear to be the psychological treatments of choice, as they have been demonstrated to facilitate better maintenance of weight loss than other therapies. Behavioural treatments appear to work primarily by enhancing dietary restraint by providing adaptive dietary strategies and by increasing motivation to be more physically active. Therapy aims to provide the individual with coping skills to handle various cues to overeat and to manage lapses in diet and physical activity when they occur. Treatment also provides motivation essential to maintain adherence to a healthier lifestyle once the initial enthusiasm for the program has waned. Therapeutic techniques derived from behavioural psychology include stimulus control, goal setting, and self-monitoring. When cognitive techniques are added to behaviour therapy, they appear to improve program success and reduce weight regain. These strategies are aimed at identifying and modifying aversive thinking patterns

and mood states to facilitate weight loss. Interest in using cognitive behaviour therapy to achieve more modest and sustainable weight loss and improved psychological well-being is increasing (Shaw et al., 2005).

Group therapies have also been trialed in obesity management with mixed success. Group treatments for obesity combine therapy and education. They are widely used in commercial programs and in self-help programs. Group treatments do not generally promote deep exploration of psychological issues. Instead, they utilize social support, problem solving, and imparting information and encouragement to facilitate weight loss. There has been limited research into group processes and testing whether group interventions are more or less effective than individual treatment (Shaw et al., 2005).

Shaw et al. (2005) conclude that psychological interventions ideally should be used in the context of a multi-component weight loss program to gain their maximum benefit; that is, diet and physical activity combined with psychological interventions. However, in spite of the increased comprehensiveness of weight management interventions, results of trials continue to remain disappointing. There are still major gaps in our understanding of the roles of diet, exercise, and psychological therapies in weight reduction.

Mobile Technology in the General Population

One systematic review of seven studies assessed the effectiveness of mobile technologies in weight loss in the general population (Bacigalupo et al., 2013). While not specific to pregnant women, it is included here given the increasing use of mobile technology in interventions targeting the general population and pregnant women, as well as its advantage of portability and ability to be used outside the healthcare setting (and the home).

Bacigalupo et al.'s (2013) review is the first to focus exclusively on mobile technologies for weight loss. There are published systematic reviews of mobile technology being employed in interventions across various health conditions such as smoking cessation, weight loss, anxiety, diabetes management, eating disorders, alcohol use, healthy eating, and physical activity.

According to Bacigalupo et al. (2013), current weight loss interventions are drawing on interest in the use of digital technologies because it can be designed and used to persuade people to modify their attitudes or behaviours and to enhance levels of surveillance over behaviours. Also, these technologies have the potential to provide acceptable and cost-effective interventions by transferring treatment, rehabilitation, and prevention of overweight and obesity to self-care in the community. In general, self-care in the community, especially when employing technology, frequently involves self-monitoring, which fits well as self-monitoring has been described as the cornerstone of effective behavioural weight loss intervention programs.

All the interventions included in this review involved the participants being educated about weight loss via diet and exercise, and carrying with them in their waking hours a mobile device (i.e. a text pager, mobile phone or other) as a motivator for behaviour change. In some, the mobile device was a medium through which the participant received a motivational message. In others, it was used to record what

had been eaten or record the amount of physical activity, or both. One technology did all by reporting the current daily energy balance.

The review identified five key components for effective technology-based weight loss interventions: self-monitoring, counsellor feedback and communication, social support, use of a structured program, and use of an individually tailored program.

Bacigalupo et al. (2013) found a strong level of evidence for mobile technology interventions in the short-term and moderate evidence in the medium-term. The trials show consistent evidence that weight loss occurs as a result of mobile technological based/assisted interventions, and that clinically significant weight loss is achievable for at least a proportion of overweight or obese participants. However, none of the studies (apart from one that followed up after 36 weeks) conducted a post-intervention follow-up to determine sustained long-term benefits or behaviour change, and none of the studies examine long-term weight loss. Six of the interventions are of six-month duration or significantly less, and just one study utilized a longer intervention period.

Bacigalupo et al. (2013) conclude that further research is warranted to better determine long-term benefits and tackle shortcomings in the evidence including small sample size, relatively narrow age range of users, and length of study. Cost-effectiveness of the interventions was not addressed by any of the studies. They state that the results should be treated with caution given the high risk of bias of three of the studies, and the short follow-up lengths of all included studies. Also, the participants may have potentially come from a certain level of literacy and socioeconomic status because of the use of mobile phone and Internet resources within the interventions.

Qualitative Analysis

One systematic review included qualitative studies to offer insight on the limited effectiveness of interventions to date (Campbell et al., 2011a). The authors discuss that perceptions of obesity, food, and nutrition are socially bound, that is, they are viewed differently by different groups of women and that the social context in which people live may influence the success of dietary or physical activity interventions for pregnant women. Their analysis included eight qualitative studies; only studies conducted in the UK were included.

The authors identified three major themes related to women's views of weight management in pregnancy: (1) conflicting and contradictory messages; (2) pregnancy as a time of transition and change; and (3) a perceived lack of control.

A consistent theme was the contradictory nature of information available to women regarding weight management during pregnancy. Where advice was given, it addressed healthy eating rather than weight management issues. Information, when given, was also often contradictory and confusing.

Advice about healthy dietary patterns and physical activity behaviours in pregnancy appeared to be strongly influenced by the views of the peer support structures around women during pregnancy.

Women reported that information and advice came from three main sources during pregnancy: family and friends, the media, and prenatal care providers. Women reported strong encouragement to rest and to increase their intake of certain food types such as milk and cheese.

Professionals themselves were often uncomfortable to initiate a discussion around weight management due to the perceived sensitivities of overweight or obese women. They feared 'victimizing' women, and women withdrawing from prenatal care as a consequence.

A second theme related to pregnancy as transient and a transitional time. Pregnancy is seen as a unique time, when the needs of the unborn child take precedence over the mother's needs, and a time of transition with temporary dietary cravings, nausea, and physical discomfort are shaping patterns of behaviour. Women expressed ambivalence toward eating behaviour; justifying over-eating during pregnancy as a temporary stage. Some women welcomed the freedom they perceived that pregnancy gave them to eat without limitations, with excess eating being perceived to be positive for the baby.

Women described a general decline in physical activity during pregnancy. A range of factors contributed to this including: anxiety about risks to the unborn baby, general physical discomfort, discouragement to undertake physical tasks by people around them, poor access to exercise facilities, and a sense that pregnancy was a time to take it easy and opt out of certain tasks.

Attitudinal changes, related to a great extent to pre-pregnancy factors, also occur. Women who reported no change in body image perceptions during pregnancy generally had positive body images and a lack of concern with weight prior to conception. The changes in body image experienced by some women can be both positive and negative and can change across the duration of the pregnancy. For overweight and obese women, pregnancy can be a time where they feel more comfortable with their body image. Pregnancy was seen as a time when being large was socially acceptable and, therefore, conferred a sense of confidence that had been lacking in their non-pregnant state.

In contrast, negative attitudes to body change were mainly reported by women of normal weight who perceived their new pregnant shape as less physically attractive, uncontrollable, attention-provoking, and limiting in respect to certain activities. Some women used negative language such as 'fat', 'bloated' and 'frumpy' to describe their pregnant state.

A third theme that emerged was the sense of loss of control women experience during pregnancy. This included the more passive role they were sometimes encouraged to take, food provided by women's mothers, and being encouraged to rest. Some described weight gain as inevitable and desirable and not something over which they could exert much control.

Women described more restricted access to gym facilities and normal physical activities were less available to them. As well as limitations imposed, the physical demands of pregnancy restricted activity and influenced dietary patterns. Feelings of fullness, nausea or hunger, and physical discomfort in later pregnancy all contributed to changing a woman's normal patterns of behaviour.

The authors juxtaposed the findings of the quantitative and qualitative reviews to explore the extent to which the interventions responded to the factors identified in the qualitative studies that influence dietary and physical activity health behaviours in pregnancy.

They found that some aspects of the interventions did address issues raised by the qualitative studies. The lack of information or contradictory information was addressed by all of the interventions. Giving consistent information throughout pregnancy and delivering it in a variety of formats did not make a substantial difference in the included studies. Women's health behaviours were influenced by the beliefs and attitudes of her partner, peers and wider family. This exerts a powerful influence and may serve to undermine the messages of prenatal care providers. Interventions at a community level may support interventions that are targeting the behaviour of individuals.

None of the interventions trained those providers involved in delivering prenatal care with specific skills to address issues of healthy dietary and physical activity behaviours in pregnancy. Instead, they relied on nutritionists, dieticians, or fitness instructors to deliver the interventions.

It was clear that prenatal care providers themselves felt uncomfortable addressing issues of weight management in pregnancy, particularly with women who were overweight or obese. The health messages therefore may not have been consistent.

The interventions in the included trials did not seek to address the wider, social factors that contribute to poor weight management, such as ready access to energy dense foods, increasing reliance on cars, a shift towards physical inactivity, and exposure to health damaging aspects of our environment. Pregnancy did appear to be a time of change, when women were adopting behaviours that were perceived to be better for the baby. Many women also described it as a time when they sensed a loss of control and a time of transition, after which normal patterns of dietary limitation and exercise would resume. The dietary cravings and physical limitations experienced by some women may also increase a sense of powerlessness. Facilitating behaviour change may be more effective among women where a sense of control is felt or interventions are delivered in such a way as to re-establish a sense of control.

The interventions all assumed compliance with the underlying values implicit within them, that is, that weight gain and overweight is not good. For some women these may be attitudes that are hard to accept, as pregnancy may be a time when they feel comfortable, able to eat with fewer limitations, and that being overweight is more socially acceptable. As such, health messages may not have been accepted and adopted by participants.

The authors conclude that the qualitative studies allowed insight into the experiences of diet and physical activity of women during pregnancy. Women's attitudes and consequent behaviours varied considerably and were influenced by their pre-pregnancy behaviours and attitudes. These were influenced and shaped by their social context. Interventions need to be responsive to the context in which women will be experiencing pregnancy.

Implications for Further Research and Practice

Several implications for further research and practice were discussed in the various reviews. They have been categorized and are presented here. Some of the conclusions are mixed, thus warranting further study.

Type of Intervention

While the evidence is mixed, combined dietary and physical activity interventions or interventions predominantly based on diet (versus primarily physical activity based) appear to be more effective. This must be interpreted with caution, however, as most of the studies identified were of poor quality, the interventions were not always rigorous or consistent, and the effects of the interventions were generally small.

Feasibility

One review discussed that an effective intervention must not only be based on realistic recommendations but also is feasible for prenatal care providers to implement (Ronnberg & Nilsson, 2010). Intensive programs including regular, one-to-one dietary consultations, sponsored physical activities, and/or behavioural intervention therapies are not likely to be an option for all pregnant women in the current healthcare delivery system. The authors state that, overall, there is a lack of consideration of the cost-effectiveness of interventions in published studies and call for future studies to consider that most maternity care programs have limited resources. Another review did discuss preliminary research indicating that diet based interventions may be less expensive than interventions based on physical activity (Thangaratinam et al., 2012).

Intensity

One review found that more intensive interventions involving frequent contacts (e.g., weekly nutritional counseling) and emphasis on caloric restriction may be more appropriate for preventing excessive GWG among overweight/obese women compared with low intensity behavioural intervention aiming to decrease high-fat foods and increase physical activity (Tanentsapf et al., 2011). However, as noted above, the ability of healthcare programs to deliver time-intensive interventions at a population level is unknown.

Another review found that the significant variation across studies related primarily to the intensity of the intervention provided (Dodd et al., 2010). This uncertainty of both the effect of an intervention and its optimal intensity significantly limits the ability to generate reliable recommendations relating to care in clinical practice. An additional review found greater GWG reduction where interventions were initiated earlier, and weight outcomes measured as late as possible, in pregnancy (Gardner et al., 2011).

High-Risk Women

One review found that average GWG reduction was higher among overweight women, suggesting that behavioural interventions may be more beneficial when targeted at at-risk women (Gardner et al., 2011).

Another review suggests that the development of reliable instruments with which to identify women at high risk of excessive GWG may be an effective way to focus limited resources (Ronnberg & Nilsson, 2010).

Behaviour Change Theory

According to one review, the use of relevant behaviour change theory in developing complex interventions is more likely to result in an effective intervention than a purely empirical or pragmatic approach, and that understanding the role of theory is essential in the design and evaluation of interventions as increasing knowledge alone is not enough to produce substantial changes in healthy lifestyle behaviours (Brown et al., 2012). In fact, providing education, information, and advice is merely a first step in the process of behaviour change. While knowledge has a major part to play, pregnant women's confidence to achieve personal control over diet and exercise can be limited by factors such as fatigue, nausea, and physical discomfort. Helping pregnant women to overcome these motivational barriers could increase women's confidence to perform these behaviours. Brown et al. state that future interventions may be more successful in helping women adopt these healthy lifestyle behaviours by using a more comprehensive goal-setting approach that takes into account the cognitive, emotional, and behavioural factors related to achievement.

Another review suggests that as the application of behaviour change theory in GWG interventions is refined, more favourable results may be reported (Hill et al., 2013). The authors argue that the most effective of the weight management interventions involve a mixture of behaviour change techniques including providing information on the consequences of behaviour to the individual, providing rewards contingent on successful behaviour, prompting self-monitoring of behaviour, and motivational interviewing.

Behavioural change models that may assist those planning programs for pregnant women to change or initiate weight management behaviours include Social Cognitive Theory, Theory of Planned Behavior (Choi et al., 2013), Social Learning Theory, Precede-Proceed Model, Transtheoretical Model, and Behaviorally Grounded Model (Gardner et al., 2011).

Goal Setting

One review identified goal setting and the associated self-monitoring and provision of feedback on performance as the most commonly used behaviour change techniques within weight management interventions during pregnancy (Gardner et al., 2011).

Another review found that interventions based on goal setting appear to be useful for helping women achieve optimal weight gain during pregnancy (Brown et al., 2011). The authors suggested that individualized purpose goals may help improve motivation. For example, ‘helping you to return to your pre-pregnancy weight faster’ may motivate a more weight-conscious individual, while reducing risk factors associated with birth might have a stronger motivational effect for women who are considered overweight or obese. Further, pregnant women who are actively involved in setting their own goals and given continuous feedback and reinforcement over the long term may be more effective.

Five suggested components of goal setting are (Brown et al., 2011):

- **Purpose goals:** The overall reason given to individuals for engaging in healthy eating and physical activity such as, ‘this will help you return to your pre-pregnancy weight faster’.
- **Target goals:** Task-specific guidance given to individuals to lead them in achieving the overall purpose goal such as, ‘engaging in moderate intensity exercise 3-5 times a week’.
- **Performance Feedback Indicators:** Providing specific/personalized information that enables individuals to assess progress towards goal attainment such as regular weight monitoring.
- **Goal proximity:** The frequency of the target or sub goals and the reinforcement schedule associated with the performance feedback.
- **Goal framing:** Whether goals are communicated as positive, approach-orientated goals, or negative avoidance-orientated goals (i.e. a woman may be trying to “achieve optimal GWG” or trying to “avoid gaining excess weight”). Individuals with primarily avoidance-orientated goals are thought to be at a higher risk of emotional distress and anxiety than individuals with primarily approach-orientated goals.

Weight Monitoring

One review found that weight monitoring was typically associated with effective interventions (Streuling et al., 2010). The authors of another review, however, felt that a focus on monitoring may be misplaced (Gardner et al., 2011). Gardner et al. cited three interventions which used monitoring showed no effect and the effectiveness of an intervention based on dietary change only which did not appear to involve weight monitoring. They discussed that this discrepancy may be understood in light of a distinction between weight monitoring for intervention evaluation purposes versus for reviewing and informing subsequent behaviour change. Crucial to this distinction is whether participants are informed of their weight, because raising participants’ awareness of weight gain may change behaviour: several change techniques relate to such feedback (e.g. providing feedback on performance, giving praise for progress towards weight gain targets, prompting review of weight gain targets, or diet and physical activity plans). Not sharing weight information with participants would not be expected to influence behaviour.

Weight monitoring was most commonly done by practitioners at the time of women’s regularly scheduled prenatal visits. Self-monitoring of weight was less common (Phelan et al., 2011).

Frequency of self-weighing during pregnancy remains a topic of debate. One review identified that the emotional impact of self-weighing was not directly measured in any of the included studies, and the

optimal frequency of weighing (daily, weekly) and context (part of larger treatment package vs alone) remain to be determined (Streuling et al., 2010). In the UK, practitioners are advised against weighing women during pregnancy based on anecdotal evidence of potential negative emotional impacts. Also, outside of pregnancy, concerns have been raised over the potential adverse effects of self-weighing on mood and increased risk of developing eating disorders. However, there is little evidence to support these concerns in or outside of pregnancy. Studies in non-pregnant populations have found no adverse impact of frequent self-weighing on depressive symptoms, binge eating, or eating disorder psychopathology, and found positive effects on weight control. None of the nine studies that used weight monitoring reported adverse effects; moreover, all reported either positive effects on GWG overall or in subgroups of low income, overweight, or normal weight women (Phelan et al., 2011).

Psychological Factors

Some have suggested that interventions to date may have had limited success possibly because psychological factors, such as mood, body image concerns, motivation and confidence, were not considered (Brown et al., 2012; Skouteris et al., 2010; IOM, 2009; Walker, 2007). There is research in non-pregnant women that supports the importance of addressing psychological factors for long term weight maintenance (Brown et al., 2012).

Pregnancy interventions conducted over the last decade have generally not included dedicated behaviour change assistance aimed at identifying and addressing behavioural, emotional, cognitive, and situational barriers that might impede behaviour change (Skouteris et al., 2010). Instead, interventions mostly involved providing women with counseling that offered educational materials and advice from a prenatal care provider as to what the women should do to maintain healthy eating and physical activity habits and/or weight management through pregnancy.

Communication between Prenatal Care Providers and Pregnant Women

One review explored the communication challenges between overweight women and prenatal care providers (Campbell et al., 2011b). Providers are often embarrassed to discuss issues of weight with overweight women, and that women themselves are also embarrassed. Providers can also find it difficult to raise this issue sensitively and are concerned that some women may stop attending prenatal appointments if they felt victimized. Campbell et al. (2011b) found that providers can be so sensitive or insensitive to women's body experiences regarding weight that they do not communicate health messages appropriately. Though aware of the risks and benefits of raising the issue, prenatal care providers report a lack of guidance on this issue.

Campbell et al. (2011b) also found that weight management information and advice from prenatal care providers may not be received or assimilated by many women during pregnancy. Available information is often vague, confusing, contradictory, and not linked to other weight management strategies. Overweight women may feel they are not receiving relevant, tailored information about appropriate diet and weight gain during pregnancy. Women's ability to carry out advice on diet and physical activity is limited by physical and psychological effects of a developing pregnancy, as well as lack of knowledge, supports, resources, and facilities. According to Campbell et al. (2011b), interventions that are

developed to meet the weight management needs of pregnant women may be facilitated by addressing the specific requirements of women of different ages and circumstances who are experiencing pregnancy, overweight, and a range of associated bodily experiences.

Another barrier, according to Campbell et al. (2011b), is that many prenatal care providers feel they have insufficient time to discuss weight issues with women during pregnancy and consider that it is too late to give advice on weight management once a woman is pregnant. Providers report that what women receive in terms of information and advice on weight management is often ad hoc, depending on a variety of factors including time available and perceived need.

Another issue related to communication between prenatal care providers and pregnant women is weight bias. Weight bias is the exhibition of prejudiced attitudes (e.g., attribution of negative labels such as lazy, unclean, and unintelligent) and discriminatory actions (e.g., teasing, providing inferior quality education, health, or other services) towards an individual based upon their weight and body size (Mulherin et al., 2013). The rates of weight bias among care providers exceed rates in the general population, which is problematic given that feeling stigmatized triggers emotional and physical symptoms of stress and undermines the adoption of health-promoting behaviours (McVey et al., 2013).

Surveys among Australian women who gave birth found that women with a higher BMI were more likely to report negative experiences of care during pregnancy and after birth, compared to lower weight women (Mulherin et al., 2013). Prenatal care providers perceived overweight and obese women as having poorer self-management behaviours, and reported less positive attitudes towards caring for overweight or obese pregnant women, than normal-weight pregnant women. Even care providers who reported few weight stigmatizing attitudes responded less positively to overweight and obese pregnant women.

Ongoing Patient-Provider Contact

Pregnancy interventions have the advantage of capitalizing on the ongoing contact that occurs as part of standard prenatal care. However, most women see providers monthly or less frequently early in pregnancy and then increase frequency of contact towards the end of pregnancy (Phelan et al., 2011). This pattern may be suboptimal for interventions to reduce excessive GWG, as more frequent visits earlier in the pregnancy would provide important opportunities for implementing the intervention.

Attitudes of Pregnant Women

Pregnancy is a time when women experience changes in their attitudes toward their bodies as their bodies change. Changes can vary from positive to negative and can vary across the duration of pregnancy, but may favour larger women due to perceived relaxation of prior pressure to diet and reduced stigma. Weight management interventions in pregnancy therefore may be facilitated by attending to the specific needs of women who vary in their attitude to weight, diet, and physical activity (Campbell et al., 2011b).

Further research to understand how low-income status or cultural/ethnicity influence women's attitudes toward physical activity, dietary behaviors, and weight management during pregnancy is needed (Choi et al., 2013). Understanding a woman's cultural customs, beliefs, and life circumstances is important. For example, a pregnant newcomer to Canada, from an area where maternal or infant mortality rates are high, may not wish to gain the recommended amount of weight and may fear that the weight will complicate her labour. In contrast, large weight gains in pregnancy may be valued in other communities (Health Canada, 2010).

Family and Community Factors

Two reviews discussed that intervention studies generally focus only on the individual level (e.g., providing counseling, feedback on their weights) and target pregnant women only (Choi et al., 2013; Campbell et al., 2011a). Exploration of community-related factors and development of interventions that target family, especially spouses, would be worthwhile since social support from one's spouse is reported as a major enabler of regular physical activity in childbearing and childrearing women. Intervention targets may need to broaden to the wider family and social network surrounding pregnant women since lay beliefs about physical activity, healthy dietary behaviours, and weight management often contradict messages from prenatal care providers. Health messages need to be clear and consistent and challenge lay beliefs about health behaviours in pregnancy and research evaluating action at a community level should be developed.

Timing of Intervention

Interventions to increase physical activity and healthy eating prior to women becoming pregnant may be better received than those that intervene when women are pregnant (Campbell et al., 2011b). Further, strategies aimed at preventing weight gain and obesity have proven to be easier and less costly than those aimed at treating already obese people (Tanentsapf et al., 2011).

Also, future research examining whether intervening earlier in pregnancy yields better outcomes and to identify the most effective frequency of contact (weekly, monthly) has been suggested (Phelan et al., 2011).

Mobile Technology

Given that there is an increase in the use of mobile phones, wireless devices, and social media among pregnant and postpartum women, these channels may be promising intervention modes. The use of mobile applications as a tool to give prompts, provide self-monitoring, and give feedback on the user's progress is promising and needs further evaluation (Choi et al., 2013; Bacigalupo et al., 2012).

Further Research

A research gap on evidence-informed interventions exists for this issue. There were numerous recommendations related to further research:

- Further meta-analysis is unlikely to help to refine the quality of evidence because studies demonstrated significant heterogeneity in relation to demography, outcome measurement, follow-up, and degree of intervention (Oteng-Ntim et al., 2012). A well-designed, large-scale prospective trial which examines combined prenatal lifestyle interventions that incorporates robust methodology in accordance with standards for evaluating complex interventions is recommended (Oteng-Ntim et al., 2012; Thangaratinam et al., 2012; Tanentsapf et al., 2011). Two such studies are currently underway (Thangaratinam et al., 2012).
- Research is needed that addresses the paucity of descriptive information on the intensity and duration of intervention, means of provision, and patient compliance (Thangaratinam et al., 2012).
- Further exploration of the potential for greater effectiveness of interventions among overweight and obese women, the long term outcomes of interventions, and the value of pre-pregnancy interventions is needed (Campbell et al., 2011a).
- Refining and testing the efficacy of interventions in the context of needs of demographic groups at special risk of obesity, such as low income and ethnic minority new mothers may be beneficial (Walker, 2007).
- Determining the combination of behaviour change techniques or underpinning theories that are most useful for limiting GWG (Hill et al., 2013) and a greater focus on intervention design, content, delivery, and evaluation based on behavioural science is suggested (Gardner et al., 2011).
- More detailed reporting is needed on the implementation process in studies. Process evaluations are also needed to identify the key components of an intervention that are effective (Brown et al., 2012).
- Further research is required into the nature and consequences of weight bias in prenatal care (Mulherin et al., 2013).

Conclusion

While there is not a strong evidence base for interventions that work reliably to help women meet recommended pregnancy weight gain ranges (IOM, 2009), there is guidance from the literature to inform the development and implementation of weight management interventions. The challenge for prenatal care providers will be to help pregnant women create or maintain healthy attitudes and beliefs about their changing bodies, while supporting them to maintain healthy eating and activity patterns (Health Canada, 2010).

Interventions are needed to train and prepare prenatal care providers to counsel women about healthy weight gain in pregnancy (Campbell et al., 2011b) and strategies are needed that engage prenatal care providers to provide consistent messages (Campbell et al., 2011a). Further, strategies are needed to

recognize and combat weight bias in the training provided to prenatal care providers (Mulherin et al., 2013).

Dialogue between pregnant women and prenatal care providers about what motivates women to adopt healthy behaviours is suggested to leverage action across the continuum of prenatal care. This includes strong, consistent, and supportive messaging from providers before and early in pregnancy that reflects each woman's unique situation and risk profile. Further, a 'before, between, and beyond' approach to connect pregnancy care with general health care is recommended (IOM, 2009).

Prenatal care providers can be confident recommending routine physical activity (in those without contraindications), nutritional guidance, and caloric literacy given that the caloric requirements of pregnancy are modest, encouraging pregnant women to maintain a food diary and physical activity log, and tracking GWG (Ferraro, 2014). Additional recommended strategies include greater emphasis on psychological factors, body image and motivational strategies, attitudinal and motivational changes through education, cost-effective interventions, and interventions that consider the role of family, community, and environmental supports (Phelan et al., 2011).

As the GWG research continues to mount and novel prenatal interventions attempt to facilitate behaviour change, prenatal care providers and pregnant women require tools and strategies informed by evidence, and ongoing research is needed to evaluate the effectiveness of these interventions in improving maternal-fetal outcomes. Collectively, pregnant women and prenatal care providers can work together with open dialogue to ensure optimal health and wellness for mom and baby (Ferraro, 2014).

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Appendix 1: Overview of Published Systematic Review and Meta-Analysis Studies on Interventions for Weight Management in Pregnancy

Study (by year)	Objective	Study Design and Quality*	Types of Studies Included	Target Audience	Authors' Conclusions
Hill, B., Skouteris, H., & Fuller-Tyszkiewicz, M. (2013). Interventions designed to limit gestational weight gain: a systematic review of theory and meta-analysis of intervention components. <i>Obesity reviews: an official journal of the International Association for the Study of Obesity</i> , 14(6), 435-450.	To systematically evaluate the overall effectiveness of GWG interventions (relative to non-treatment control groups) derived from theories of behaviour change using a generalized health psychology perspective and assessing the behaviour change techniques reported in the interventions, augmenting this with statistical evaluation of their effectiveness via meta-analysis.	Systematic review and meta-analysis Quality Rating: Moderate	Randomized controlled trials, case-control studies, controlled trials, prospective intervention pilot studies, prospective cohort studies	Normal weight, overweight and obese pregnant women	Overall, studies based on theory were as effective as non-theory-based studies at limiting GWG. Furthermore, the provision of information, motivational interviewing, behavioural self-monitoring and providing rewards contingent on successful behaviour appear to be key strategies when intervening in GWG. Combining these behaviour change techniques with dietary interventions may be most effective.
Choi, J., Fukuoka, Y., & Lee, J. H. (2013). The effects of physical activity and physical activity plus diet interventions on body weight in overweight or obese women who are pregnant or in postpartum: a systematic review and meta-analysis of randomized controlled trials. <i>Preventive medicine</i> , 56(6), 351-364.	To review the effectiveness of physical activity (PA) and PA plus diet interventions in managing weight among overweight or obese (OW/OB) pregnant or postpartum women.	Systematic review and meta-analysis Quality Rating: Strong	Randomized controlled trials	Overweight and obese pregnant or postpartum women	PA plus diet interventions may require more than advice; supervised PA programs or personalized prescription/goals are needed to prevent excessive weight gain for OW/OB pregnant women and excessive weight retention for OW/OB postpartum women.

Study (by year)	Objective	Study Design and Quality*	Types of Studies Included	Target Audience	Authors' Conclusions
Furber, C. M., McGowan, L., Bower, P., Kontopantelis, E., Quenby, S., & Lavender, T. (2013). Antenatal interventions for reducing weight in obese women for improving pregnancy outcome. <i>Cochrane Database of Systematic Reviews</i> (1).	To evaluate the effectiveness of interventions that reduces weight in obese pregnant women.	Systematic review Quality Rating: Strong	Randomized controlled trials, quasi-random studies and cluster-randomized trials	Obese pregnant women	There are no trials designed to reduce weight in obese pregnant women. Until the safety of weight loss in obese pregnant women can be established, there can be no practice recommendations for these women to intentionally lose weight during the pregnancy period. Further study is required to explore the potential benefits, or harm, of weight loss in pregnancy when obese before weight loss interventions in pregnancy can be designed. Qualitative research is also required to explore dietary habits of obese pregnant women, especially those who are morbidly obese.
Thangaratinam, S., Rogozinska, E., Jolly, K., Glinkowski, S., Roseboom, T., Tomlinson, J. W., Kunz, R., Mol, B. W., & Khan, K. S. (2012). Effects of interventions in pregnancy on maternal weight and obstetric outcomes: meta-analysis of randomised evidence. <i>BMJ</i> , 344, e2088.	To evaluate the effects of dietary and lifestyle interventions in pregnancy on maternal and fetal weight and to quantify the effects of these interventions on obstetric outcomes.	Systematic review and meta-analysis Quality Rating: Strong	Randomized controlled trials	Normal weight, overweight and obese pregnant women	Dietary and lifestyle interventions in pregnancy can reduce maternal gestational weight gain and improve outcomes for both mother and baby. Among the interventions, those based on diet are the most effective and are associated with reductions in maternal gestational weight gain and improved obstetric outcomes.
Brown, M. J., Sinclair, M., Liddle, D., Hill, A. J., Madden, E., & Stockdale, J. (2012). A systematic review investigating healthy lifestyle interventions incorporating goal setting strategies for preventing excess gestational weight gain. <i>PloS one</i> , 7(7), e39503.	To explore the use of goal setting within healthy lifestyle interventions for the prevention of excess GWG.	Systematic review Quality Rating: Strong	Randomized controlled trials	Normal weight, overweight and obese pregnant women	Interventions based on goal setting appear to be useful for helping women achieve optimal weight gain during pregnancy. However, overweight and obese women may require more theoretically-designed interventions. Further high quality, theoretically-designed interventions are required to determine the most effective and replicable components for optimal GWG.
Muktabhant, B., Lumbiganon, P., Ngamjarus, C., & Dowswell, T. (2012). Interventions for preventing excessive weight gain during pregnancy. <i>Cochrane Database of Systematic Reviews</i> (4).	To assess the effectiveness of interventions for preventing excessive weight gain during pregnancy.	Systematic review Quality Rating: Strong	Randomized and non-randomized clinical trials	Normal weight, overweight and obese pregnant women	No one intervention for preventing excessive weight gain during pregnancy could be recommended because most of the studies identified were of poor quality and the effects of the interventions were generally small. There is an urgent need for more well-designed studies with adequate sample sizes to be able to recommend effective interventions.

Study (by year)	Objective	Study Design and Quality*	Types of Studies Included	Target Audience	Authors' Conclusions
Oteng-Ntim, E., Varma, R., Croker, H., Poston, L., & Doyle, P. (2012). Lifestyle interventions for overweight and obese pregnant women to improve pregnancy outcome: systematic review and meta-analysis. <i>BMC medicine</i> , 10, 47.	To determine the efficacy of antenatal dietary, activity, behaviour or lifestyle interventions in overweight and obese pregnant women to improve maternal and perinatal outcomes.	Systematic review and meta-analysis Quality Rating: Strong	Randomized and non-randomized clinical trials	Overweight and obese pregnant women	Antenatal lifestyle intervention is associated with restricted gestational weight gain and a trend towards a reduced prevalence of gestational diabetes in the overweight and obese population. These findings need to be interpreted with caution as the available studies were of poor to medium quality.
Sui, Z., Grivell, R. M., & Dodd, J. M. (2012). Antenatal exercise to improve outcomes in overweight or obese women: A systematic review. <i>Acta obstetrica et gynecologica Scandinavica</i> , 91(5), 538-545.	To review the literature systematically to assess the benefits and harms of an exercise intervention for pregnant women who are overweight or obese.	Systematic review Quality Rating: Not assessed	Randomized controlled trials and quasi-randomized trials	Overweight and obese pregnant women	A monitored physical activity intervention appears to be successful in limiting gestational weight gain; however, the effect on maternal and infant health is less certain.
Quinlivan, J. A., Julania, S., & Lam, L. (2011). Antenatal dietary interventions in obese pregnant women to restrict gestational weight gain to Institute of Medicine recommendations: a meta-analysis. <i>Obstetrics and gynecology</i> , 118(6), 1395-1401.	To estimate whether antenatal dietary interventions restrict maternal weight gain in obese pregnant women without compromising newborn birth weight.	Systematic review and meta-analysis Quality Rating: Moderate	Randomized controlled trials	Overweight and obese pregnant women	Antenatal dietary interventions in obese pregnant women can reduce maternal weight gain in pregnancy without an effect on newborn birth weight.

Study (by year)	Objective	Study Design and Quality*	Types of Studies Included	Target Audience	Authors' Conclusions
Streuling, I., Beyerlein, A., Rosenfeld, E., Hofmann, H., Schulz, T., & von Kries, R. (2011a). Physical activity and gestational weight gain: a meta-analysis of intervention trials. <i>BJOG: an international journal of obstetrics and gynaecology</i> , 118(3), 278-284.	To find out whether physical activity in pregnancy might help avoid high GWG.	Systematic review and meta-analysis Quality Rating: Strong	Randomized controlled trials	Normal weight, overweight and obese pregnant women	Physical activity during pregnancy might be successful in restricting GWG.
Streuling, I., Beyerlein, A., Rosenfeld, E., Schukat, B., & von Kries, R. (2011b). Weight gain and dietary intake during pregnancy in industrialized countries--a systematic review of observational studies. <i>Journal of perinatal medicine</i> , 39(2), 123-129.	To gain more evidence on whether diets with lower caloric/protein content or other diets might be associated with lower GWG.	Systematic review Quality Rating: Not assessed	Observational studies	Normal weight, overweight and obese pregnant women	GWG might be reduced by lower energy intake in pregnancy.
Tanentsapf, I., Heitmann, B. L., & Adegboye, A. R. (2011). Systematic review of clinical trials on dietary interventions to prevent excessive weight gain during pregnancy among normal weight, overweight and obese women. <i>BMC pregnancy and childbirth</i> , 11, 81.	To evaluate the effect of dietary interventions for reducing gestational weight gain.	Systematic review Quality Rating: Strong	Randomized controlled trials and quasi-randomized controlled trials	Normal weight, overweight and obese pregnant women	Dietary advice during pregnancy appears effective in decreasing total GWG and long-term postpartum weight retention, but so far there is limited evidence for further benefits on infant and maternal health.
Campbell, F., Johnson, M., Messina, J., Guillaume, L., & Goyder, E. (2011a). Behavioural interventions for weight management in pregnancy: a systematic review of quantitative and qualitative data. <i>BMC public health</i> , 11, 491.	To assess the effectiveness of behavioural interventions to prevent excessive weight gain in pregnancy and explore the factors that influence intervention effectiveness.	Systematic review, meta-analysis and thematic synthesis (qualitative evidence) Quality Rating: Strong	Controlled trials and qualitative studies	Normal weight, overweight and obese pregnant women	Despite intense and often tailored interventions there was no statistically significant effect on weight gain during pregnancy. Inadequate and often contradictory information regarding healthy weight management was reported by women in qualitative studies and this was addressed in the interventions but this in itself was insufficient to lead to reduced weight gain. It is suggested that multiple types of interventions, including community based strategies are needed to address this complex health problem.

Study (by year)	Objective	Study Design and Quality*	Types of Studies Included	Target Audience	Authors' Conclusions
Gardner, B., Wardle, J., Poston, L., & Croker, H. (2011). Changing diet and physical activity to reduce gestational weight gain: a meta-analysis. <i>Obesity reviews : an official journal of the International Association for the Study of Obesity</i> , 12(7), e602-620.	To review the effectiveness of interventions that aimed to reduce gestational weight gain through changes in diet or physical activity.	Systematic review and meta-analysis Quality Rating: Moderate	Randomized controlled trials, non-randomized control trials, time-series control trials, historical cohort studies	Normal weight, overweight and obese pregnant women	Diet and physical activity change was effective in reducing gestational weight gain, but there was considerable heterogeneity in outcomes.
Dodd, J. M., Grivell, R. M., Crowther, C. A., & Robinson, J. S. (2010). Antenatal interventions for overweight or obese pregnant women: a systematic review of randomised trials. <i>BJOG: an international journal of obstetrics and gynaecology</i> , 117(11), 1316-1326.	To assess the benefits and harms of antenatal dietary or lifestyle interventions for pregnant women who are overweight or obese.	Systematic review Quality Rating: Moderate	Randomized controlled trials	Overweight and obese pregnant women	The effect of providing an antenatal dietary intervention for overweight or obese pregnant women on maternal and infant health outcomes remains unclear.
Streuling, I., Beyerlein, A., & von Kries, R. (2010). Can gestational weight gain be modified by increasing physical activity and diet counseling? A meta-analysis of interventional trials. <i>The American journal of clinical nutrition</i> , 92(4), 678-687.	To review published data on interventions to reduce gestational weight gain by modulating diet and physical activity during pregnancy.	Systematic review and meta-analysis Quality Rating: Strong	Randomized and non-randomized trials	Normal weight, overweight and obese pregnant women	Interventions based on physical activity and dietary counseling, usually combined with supplementary weight monitoring, appear to be successful in reducing GWG.

Study (by year)	Objective	Study Design and Quality*	Types of Studies Included	Target Audience	Authors' Conclusions
Ronnberg, A. K., & Nilsson, K. (2010). Interventions during pregnancy to reduce excessive gestational weight gain: a systematic review assessing current clinical evidence using the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) system. <i>BJOG: an international journal of obstetrics and gynaecology</i> , 117(11), 1327-1334.	To determine whether published trials of interventions to reduce excessive gestational weight gain are of sufficient quality and provide sufficient data to enable evidence-based recommendations to be developed for clinical practice in antenatal care.	Systematic review Quality Rating: Strong	Randomized controlled trials, nonrandomized intervention studies and systematic reviews	Normal weight, overweight and obese pregnant women	The results of published intervention trials are of insufficient quality to enable evidence-based recommendations to be developed for clinical practice in antenatal care.
Skouteris, H., Hartley-Clark, L., McCabe, M., Milgrom, J., Kent, B., Herring, S. J., & Gale, J. (2010). Preventing excessive gestational weight gain: a systematic review of interventions. <i>Obesity reviews : an official journal of the International Association for the Study of Obesity</i> , 11(11), 757-768.	To identify and evaluate the effect of key variables designed to modify risk factors for excessive weight gain in pregnant women that have been targeted in interventions over the last decade.	Systematic review Quality Rating: Weak	Randomized controlled trials, nonrandomized intervention studies, case-control studies, prospective cohort studies	Normal weight, overweight and obese pregnant women	The findings were inconsistent in relation to what factors need to be targeted in intervention programs to reduce GWG. Consideration of psychological factors relevant to pregnancy, in addition to behavioural changes in relation to eating and physical activity, is suggested for future intervention studies.
Dodd, J. M., Crowther, C. A., & Robinson, J. S. (2008). Dietary and lifestyle interventions to limit weight gain during pregnancy for obese or overweight women: a systematic review. <i>Acta obstetrica et gynecologica Scandinavica</i> , 87(7), 702-706.	To assess the benefits and harm of dietary and lifestyle interventions during pregnancy to improve maternal and infant outcomes for pregnant women who are overweight or obese.	Systematic review Quality Rating: Not assessed	Randomized controlled trials	Overweight and obese pregnant women	There is limited information available assessing the benefits and harm associated with dietary and lifestyle interventions for overweight and obese pregnant women. Further evaluation through randomized trials with adequate power is required.

Additional systematic reviews not specific to pregnancy but included given their relevance to the topic:

Study (by year)	Objective	Study Design and Quality*	Types of studies included	Target Audience	Authors' Conclusions
Shaw, K. A., O'Rourke, P., Del Mar, C., & Kenardy, J. (2005). Psychological interventions for overweight or obesity. <i>Cochrane Database of Systematic Reviews</i> (2).	To assess the effects of psychological interventions for overweight or obesity as a means of achieving sustained weight loss.	Systematic review and meta-analysis Quality Rating: Not assessed	Randomized controlled trials	Overweight and obese adults	People who are overweight or obese benefit from psychological interventions, particularly behavioural and cognitive-behavioural strategies, to enhance weight reduction. They are predominantly useful when combined with dietary and exercise strategies. The bulk of the evidence supports the use of behavioural and cognitive-behavioural strategies. Other psychological interventions are less rigorously evaluated for their efficacy as weight loss treatments.
Bacigalupo, R., Cudd, P., Littlewood, C., Bissell, P., Hawley, M. S., & Buckley Woods, H. (2012). Interventions employing mobile technology for overweight and obesity: an early systematic review of randomized controlled trials. <i>Obesity Reviews</i> .	To study whether mobile technology is an appropriate medium for facilitating weight loss in overweight and obese adults.	Systematic review Quality Rating: Strong	Randomized controlled trials	Overweight and obese adults	Weight loss occurs in the short-term because of mobile technology interventions, with moderate evidence for the medium-term. Recommendations for improving the reporting and quality of future trials are made including reporting weight loss in percent to meet clinical standards, and including features such as long-term follow-up, cost-effectiveness and patient acceptability.

*** Quality ratings conducted by healthevidence.org. All reviews have been assessed for methodological quality by two independent reviewers using ten quality criteria. A final review quality rating for each review is assigned: strong (8 to 10 / 10), moderate (5 to 7 / 10), or weak (1 to 4 / 10).**

Appendix 2: Intervention Mode and Intensity from Select Reviews

Oteng-Ntim et al. (2012):

- Exercise and nutrition information (oral and newsletter), personalized graphs and behavioural counseling
- Physical exercise (group sessions, home-based exercise) and individualized nutrition plans
- Intensive intervention with 10 one-hour visits with dietician at each antenatal visit, dietary guidance provided
- Personalized weight measurement card
- Personalized 10 weeks of home-based supervised exercise (3 sessions per week)
- 3 group-based sessions per week, light resistance and toning exercise from the 2nd trimester
- One session of dietetic counseling and activity
- Nutritional regime for gestational diabetes
- Groups sessions on dietary and physical activity with a dietician and written brochures
- Antenatal clinic providing continuity of care, weighing on arrival, brief dietary intervention by food technologist and psychological assessment, and intervention if indicated
- Individual lifestyle counseling clinic including group exercise
- Group-based exercise and home exercise counseling
- Dietary and weight counseling; exercise groups provided
- 'Health book' used to record diet and exercise and contained healthy eating and exercise information
- Nutritional habits interview, weekly counseling and aqua aerobics sessions
- Individual counseling at each antenatal visit, dietary guidance, and optional activity sessions
- Individual counseling, 6 structured seminars on healthy living (healthy eating and walking)
- Individualized nutrition plan, exercise consisted of walking (3-4 times per week, used pedometers)
- Individualized session with dietician only at 1st visit, regular weight gain monitoring, moderate exercise 3-5 times/week
- Balanced low energy diet
- Low-energy diet instructed by dietician at recruitment
- Brochure at 1st prenatal consultation with nutritional and PA advice (1st intervention); brochure and active lifestyle education by a nutritionist in 3 one-hour group sessions (2nd intervention); all participants had nutritional habits evaluated every trimester with 3 7-day food records
- 6 individual sessions with dietician with individualized diet and PA plan and brochure, from recruitment to 6 months postpartum
- Group and home-based exercises (3-5 times/week for 30-45 min) and computer assisted Food Choice Map, dietary interviews, and counseling
- Dietary counseling by nutritionist and probiotic or placebo capsules and food products for home use, each trimester and 1, 6, and 12 months postpartum
- Individual counseling on diet and PA during 5 routine visits to public health nurse from weeks 8-9 to 37 weeks gestation; option to attend supervised group exercise
- 1 visit to interventionist promoting self-monitoring including appropriate weight gain, PA (30 min/day) and diet; also received 3 phone calls from dietician and weekly mail
- Regular prenatal visits with access to research dietician and psychologist; newsletters and phone calls between clinical visits with education and feedback related to weight gain, exercise, and healthy eating
- Diet regime and food diary
- 10 one-hour dietary consultation with dietician at each prenatal visit; individual recommendation on daily energy intake and dietary recommendations; food records used with individualized feedback

Gardner et al. (2011):

- Individually tailored counseling sessions on diet and PA corresponding with obstetrical appointments; delivered in clinic setting with dietician
- MI session on diet and PA with group support sessions and aerobic classes; delivered in clinic setting by midwife
- Dietary advice, tours, cooking demonstrations, individual counseling; delivered in community setting by nutritionists and health workers
- Brochure on nutrition and PA and group nutrition classes on behaviour change and PA methods; delivered in clinic setting by nutritionist
- Instruction in group and home-based PA, personalized feedback on food intake; delivered in community setting by professional trainers, student assistants, and dietician
- Primary counseling session and additional boosters (4 on PA and 3 on diet) and personalized PA plan and diet diary feedback; delivered in clinic setting by public health nurses
- Leaflet on healthy eating and PA and 5 motivational newsletters; delivered in hospital setting by healthcare providers
- Newsletters on diet and PA with feedback/targets provided based on weight gain; delivered in clinic setting by postgraduate staff with nutritional or clinical training
- Multicomponent intervention focusing on healthy eating and walking including written material, pedometer, food diary, six seminars; and at least 5 individual counseling sessions; setting and deliverers unclear
- 10 individual counseling sessions on diet; delivered in clinic setting by a dietician

Sui et al. (2012):

- Light resistance and toning exercise sessions (35-40 min, 3 times per week for 26 weeks)
- Circuit of 8 exercises (3 sessions)
- Closely monitored individualized exercise plans
- Weekly general stretching and muscle strengthening exercise sessions
- Stationary cycling sessions (35-50 min, 4 times per week)
- Supervised resistance, stretching, and relaxation exercise sessions (60 min, 3 times per week)
- Low intensity walking 5 times per week