

Nutrition and maternal weight outcomes: annex 3 - evidence identified

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Abbreviations

AHRQ: Agency for Healthcare Research and Quality

AMDR: acceptable macronutrient distribution range

BMI: body mass index

CI: confidence interval

df: degrees of freedom

FFQ: food frequency questionnaires

GDM: gestational diabetes mellitus

GI: glycaemic index

GL: glycaemic load

GRADE: Grading of Recommendations Assessment Development and Evaluation

GWG: gestational weight gain

HHS: United States Department of Health and Human Services

IOM: Institute of Medicine

KJ: kilojoule

LMIC: low/middle-income countries

MD: mean difference

MNT: medical nutrition therapy

NEC: nutrition education and counselling

OGE: Office of Government Ethics

OR: odds ratio

PPWR: postpartum weight retention

QE: quasi-experimental

RCTs: randomised controlled trials

RDN: registered dietitian nutritionists

SD: standard deviation

SGEs: Special Government Employees

SR: systematic review

USDA: United States Department of Agriculture

WMD: weighted mean difference

Evidence identified

This annex provides details of the systematic review (SR) evidence identified for the SACN report 'Nutrition and maternal weight outcomes' (2026) that met the inclusion criteria (see chapter 3 of the main report).

The methodological quality of each of the 24 SRs meeting the inclusion criteria was assessed using the AMSTAR 2 tool. The AMSTAR 2 ratings are provided for each of the SRs and further detail on the AMSTAR 2 assessment can be found in Annex 4.

Systematic reviews identified

This section details the SRs identified through the literature search (see Annex 2).

Abdollahi S, Soltani S, de Souza RJ, Forbes SC, Toupchian O and Salehi-Abargouei A. [Associations between maternal dietary patterns and perinatal outcomes: a systematic review and meta-analysis of cohort studies](#). Advances in Nutrition 2021: volume 12, issue 4, page 1,332.

Achón M, Úbeda N, García-González Á, Partearroyo T and Varela-Moreiras G. [Effects of milk and dairy product consumption on pregnancy and lactation outcomes: a systematic review](#). Advances in Nutrition 2019: volume 10, issue supplement 2, page S74.

Chatzakis C, Goulis DG, Mareti E, Eleftheriades M, Zavlanos A, Dinas K, and others. [Prevention of gestational diabetes mellitus in overweight or obese pregnant women: a network meta-analysis](#). Diabetes Research and Clinical Practice 2019: volume 158, page 107,924.

Dalrymple KV, Flynn AC, Relph SA, O'Keeffe M and Poston L. [Lifestyle interventions in overweight and obese pregnant or postpartum women for postpartum weight management: a systematic review of the literature](#). Nutrients 2018: volume 10, issue 11, page 1,074.

Dodd JM, Deussen AR, O'Brien CM, Schoenaker D, Poprzeczny A, Gordon A and others. [Targeting the postpartum period to promote weight loss: a systematic review and meta-analysis](#). Nutrition Reviews 2018: volume 76, issue 8, page 639.

Dodd JM, Grivell RM, Crowther CA and Robinson JS. [Antenatal interventions for overweight or obese pregnant women: a systematic review of randomised trials](#). BJOG 2010: volume 117, issue 11, page 1,316.

Flynn AC, Dalrymple K, Barr S, Poston L, Goff LM, Rogozińska E and others. [Dietary interventions in overweight and obese pregnant women: a systematic review of the content, delivery, and outcomes of randomized controlled trials](#). Nutrition Reviews 2016: volume 74, issue 5, page 312.

Girard AW and Olude O. [Nutrition education and counselling provided during pregnancy: effects on maternal, neonatal and child health outcomes](#). Paediatric and Perinatal Epidemiology 2012: volume 26, issue supplement 1, page 191.

International Weight Management in Pregnancy (i-WIP) Collaborative Group. [Effect of diet and physical activity based interventions in pregnancy on gestational weight gain and pregnancy outcomes: meta-analysis of individual participant data from randomised trials](#). BMJ 2017: volume 358, page j3991.

Jebeile H, Mijatovic J, Louie JCY, Prvan T and Brand-Miller JC. [A systematic review and meta analysis of energy intake and weight gain in pregnancy](#). American Journal of Obstetrics and Gynecology 2016: volume 214, issue 4, page 465.

Lamminpää R, Vehviläinen-Julkunen K and Schwab U. [A systematic review of dietary interventions for gestational weight gain and gestational diabetes in overweight and obese pregnant women](#). European Journal of Nutrition 2018: volume 57, issue 5, page 1,721.

Muktabhant B, Lawrie TA, Lumbiganon P and Laopaiboon M. [Diet or exercise, or both, for preventing excessive weight gain in pregnancy](#). Cochrane Database of Systematic Reviews 2015: volume 2015, issue 6, page Cd007145.

Ota E, Hori H, Mori R, Tobe-Gai R and Farrar D. [Antenatal dietary education and supplementation to increase energy and protein intake](#). Cochrane Database of Systematic Reviews 2015: issue 6, page Cd000032.

Pari-Keener M, Gallo S, Stahnke B, McDermid JM, Al-Nimr RI, Moreschi JM and others. [Maternal and infant health outcomes associated with medical nutrition therapy by registered dietitian nutritionists in pregnant women with malnutrition: an evidence analysis center systematic review](#). Journal of the Academy of Nutrition and Dietetics 2020: volume 120, issue 10, page 1,730.

Quinlivan JA, Julania S and Lam L. [Antenatal dietary interventions in obese pregnant women to restrict gestational weight gain to Institute of Medicine recommendations: a meta-analysis](#). Obstetrics and Gynecology 2011: volume 118, issue 6, page 1,395.

Shieh C, Cullen DL, Pike C and Pressler SJ. [Intervention strategies for preventing excessive gestational weight gain: systematic review and meta-analysis](#). Obesity Reviews 2018: volume 19, issue 8, page 1,093.

Streuling I, Beyerlein A, Rosenfeld E, Schukat B and von Kries R. [Weight gain and dietary intake during pregnancy in industrialized countries - a systematic review of observational studies](#). Journal of Perinatal Medicine 2011: volume 39, issue 2, page 123.

Syngelaki A, Sequeira Campos M, Roberge S, Andrade W and Nicolaides KH. [Diet and exercise for preeclampsia prevention in overweight and obese pregnant women: systematic review and meta-analysis](#). Journal of Maternal-Fetal and Neonatal Medicine 2019: volume 32, issue 20, page 3,495.

Tielemans MJ, Garcia AH, Peralta Santos A, Bramer WM, Luksa N, Luvizotto MJ and others. [Macronutrient composition and gestational weight gain: a systematic review](#). American Journal of Clinical Nutrition 2016: volume 103, issue 1, page 83.

Walker R, Bennett C, Blumfield M, Gwini S, Ma J, Wang F and others. [Attenuating pregnancy weight gain - what works and why: a systematic review and meta-analysis](#). Nutrients 2018: volume 10, issue 7.

Zhang R, Han S, Chen GC, Li ZN, Silva-Zolezzi I, Parés GV, and others. [Effects of low-glycemic-index diets in pregnancy on maternal and newborn outcomes in pregnant women: a meta-analysis of randomized controlled trials](#). European Journal of Nutrition 2018: volume 57, issue 1, page 167.

Zhang Y, Xia M, Weng S, Wang C, Yuan P and Tang S. [Effect of Mediterranean diet for pregnant women: a meta-analysis of randomized controlled trials](#). Journal of Maternal-Fetal and Neonatal Medicine 2022: volume 35, issue 24, page 4,824.

Systematic reviews identified by hand searching

This section details the SRs identified by hand searching.

Two systematic reviews (SRs) from the United States Department of Agriculture (USDA) were identified by hand searching. USDA published SRs on diet and nutrition during pregnancy and lactation and specific health outcomes in preparation for the [Dietary Guidelines for Americans, 2020 to 2025](#).

Donovan S, Dewey K, Novotny R, Stang J, Taveras E, Kleinman R, Raghavan R, Nevins J, Scinto-Madonich S, Kim JH, Terry N, Butera G and Obbagy J. [Dietary patterns during pregnancy and gestational weight gain: a systematic review](#). United States Department of Agriculture, Food and Nutrition Service, Center for Nutrition Policy and Promotion, Nutrition Evidence Systematic Review 2020.

Heymsfield S, Boushey C, Leidy H, Mattes R, Kleinman R, Callahan E, Butera G, Terry N and Obbagy J. [Frequency of eating during pregnancy and gestational weight gain: a systematic review](#). United States Department of Agriculture (USDA), Food and Nutrition Service, Center for Nutrition Policy and Promotion, Nutrition Evidence Systematic Review 2020.

Prioritised systematic reviews

The following sections provide the characteristics and findings of SRs prioritised for description in the main body of the report and for grading and drawing conclusions. See chapter 3 (Methods) for information on the process for SR prioritisation.

The text used throughout reflects the wording used by the SR authors. This includes the terms 'adequate' and 'excess' gestational weight gain (GWG).

Abdollahi and others (2021)

Title

'Associations between maternal dietary patterns and perinatal outcomes: a systematic review and meta-analysis of cohort studies'.

Study design

Systematic review with meta-analysis.

Funding

North Khorasan University of Medical Sciences, Bojnurd, Iran.

Declaration of interest

World Health Organization; Canadian Institutes of Health Research; University of Toronto, and McMaster Children's Hospital, Canadian Foundation for Dietetic Research; Population Health Research Institute; Hamilton Health Sciences Corporation; Helderleigh Foundation (Canada).

Methods

Aim

To summarise the evidence from prospective cohort studies examining the associations between maternal dietary patterns and perinatal (maternal and neonatal) outcomes and synthesise these results.

Search criteria**Search dates**

Inception to 25 October 2019.

Search design

Prospective cohort or nested case-control studies. Cross-sectional, case-control, clinical trials, and review studies were excluded.

Language

No restriction.

Population

Adult mothers (≥ 18 years). Studies that included women with pre-existing diseases, twins or higher-order multiple pregnancies, and induced pregnancy were also excluded.

Intervention or exposure and comparators

Association between dietary patterns and all events that occur for the mother or offspring (perinatal outcomes).

Maternal outcomes

Maternal outcomes were:

- caesarean delivery
- maternal depression
- gestational weight gain (GWG)
- gestational diabetes mellitus (GDM)
- gestational hypertensive disorders

Offspring outcomes

Offspring outcomes were:

- low birth weight
- preterm birth
- stillbirth

- fetal growth restriction
- obesity
- birth size parameters

Statistical analyses

Random effects model.

Heterogeneity

Cochran's Q test and I^2 statistic.

Publication bias

Inspection of Begg's funnel plots. Duval and Tweedie's 'trim and fill' method was used to correct funnel plot asymmetry.

Sensitivity and meta-regression analyses performed

'Leave-one-out' approach.

Included studies

Number of studies

There were 66 studies, of which 17 reported GWG and 10 were included in the meta-analysis.

Number of participants

Excess GWG

The number of participants with excess GWG by dietary pattern was:

- healthy dietary pattern $n = 71,719$
- unhealthy dietary pattern $n = 2,076$
- mixed dietary pattern $n = 159$

GWG

The number of participants with GWG by dietary pattern was:

- healthy dietary pattern $n = 9,803$

- unhealthy dietary pattern n = 3,356
- mixed dietary pattern n = 764

Inadequate GWG

The number of participants with inadequate GWG by dietary pattern was:

- healthy dietary pattern n = 71,390
- unhealthy dietary pattern n = 1,917

Age of participants

Not reported.

Countries

The included studies were conducted in the following countries:

- United States of America (USA): 7
- Spain: 2
- Brazil: 2
- Portugal: 1
- Mexico: 1
- Singapore: 1
- Norway: 1
- The Netherlands: 1
- Ethiopia: 1

Ethnicity of population

Not reported.

Body mass index (BMI) category

Not reported.

Intervention or exposure

Association between dietary patterns (healthy, unhealthy and mixed patterns) and GWG, excessive GWG, and inadequate GWG.

Foods in each diet were selected based on the dietary recommendations for the prevention of chronic disease.

A healthy diet was characterised by high intakes of fruits, vegetables, whole grains, low-fat dairy products, vegetable oils, and fish.

An unhealthy diet was characterised by refined grains, foods high in saturated fats, red meat, processed meat, fast foods, and high sugary foods.

A combination of both healthy and unhealthy foods was labelled as mixed.

Main results

The meta-analysis showed that the highest adherence to a healthy dietary pattern was significantly associated with more weight gain when compared with the lowest adherence; however, the association was weak (9 studies, 9,803 participants; Hedges' g : 0.15; 95% confidence interval (CI): 0.03, 0.28; $P = 0.01$), although there was no significant association with the odds of excessive GWG (as a dichotomous outcome) comparing extreme categories of healthy dietary pattern (6 studies, 71,719 participants; odds ratio (OR): 0.87; 95% CI: 0.73, 1.04; $P = 0.13$).

Inadequate GWG in relation to maternal dietary pattern was reported in 9 articles, of which 5 were included in the meta-analysis. These analyses revealed no significant association between healthy diet and the odds of inadequate GWG (5 studies, 71,390 participants; OR: 0.98; 95% CI: 0.83, 1.17; $P = 0.88$). In subgroup analyses, there was no significant association between healthy dietary patterns and the odds of inadequate GWG. There were insufficient data to conduct analyses of unhealthy or mixed diets in this regard.

Sensitivity analysis revealed that the study by Tieleman and others was responsible for the heterogeneity for inadequate GWG ($I^2=51.8\%$) and removal of this study changed the estimates from non-significant to significant for the association between maternal healthy dietary pattern and lower risk of inadequate GWG (OR: 0.94, 95% CI: 0.9, 0.98; $P = 0.003$; $I^2 = 0.0\%$, P -heterogeneity = 0.48).

Comments

Risk of bias and quality

Risk Of Bias In Non-randomized Studies - of Exposures (ROBINS-E) tool was used. Most studies were at high risk of bias due to uncontrolled or residual confounding.

Grading of Recommendations Assessment, Development and Evaluation (GRADE) certainty of evidence was “very low” for GWG.

Confounding factors

Authors noted a main study limitation was incomplete adjustment for confounders and measurement bias related to outcome assessment.

Limitations (from the authors)

The authors noted the following limitations:

- those who follow a diet may be more likely to engage in other healthy behaviours
- limited number of dietary patterns in the included studies
- unable to directly adjust for residual confounders
- subjectively categorised diet as “healthy,” “unhealthy,” and “mixed” dietary patterns, as described and presented by the primary study
- unhealthy foods may appear in healthy diets

AMSTAR 2 overall confidence rating

Moderate.

AMSTAR 2 additional confidence rating

Moderate.

Achón and others (2019)

Title

'Effects of milk and dairy product consumption on pregnancy and lactation outcomes: a systematic review'.

Study design

Systematic review.

Funding

The paper was sponsored by the Interprofessional Dairy Organization, (INLAC), Spain.

Declaration of interest

Author disclosed no conflicts of interest.

Methods

Aim

To evaluate the influence of milk and dairy product consumption on pregnancy and lactation outcomes.

Search criteria

Search dates

Up to 15 May 2018.

Search design

There was no restriction on publication type or sample size. All categories of epidemiological studies were included.

Language

For inclusion, an article had to be published in English or Spanish.

Population

Participants were healthy pregnant or lactating women without diagnosis of a pathological condition, aged 18 years or older and were classified as "normal weight" or "normal BMI".

Intervention or exposure and comparators

The effects of milk and dairy intake on pregnancy or lactation outcomes. Fortified dairy products were not considered.

Outcomes

Fetal growth, birth weight and length, head circumference, body weight gain, premature birth, miscarriage, congenital malformations, gestational age, infant growth, infant weight, infant length, infant head circumference, infant body composition, infant BMI, milk ejection, and human milk nutritional value.

Statistical analyses

The overall effects of milk and dairy products on pregnancy and lactation within each study were described and the point estimates and statistical tests described in the original studies were also summarised.

Heterogeneity

Due to the heterogeneity among studies, few studies met the inclusion criteria; therefore, it was not possible to perform a meta-analysis.

Publication bias

Not reported.

Sensitivity and meta-regression analyses performed

Not performed.

Included studies

Number of studies

The final number of studies included was 17 (6 were prospective cohort studies, 3 were intervention studies, 3 were retrospective cohort studies, 3 were cross-sectional studies, and 2 were case-control studies). Two reported on GWG.

Number of participants

The 17 studies involved over 237,555 women.

Age of participants

All participants were over 18 years of age.

Countries

Participants came from the following countries:

- 53.3% from India

- 21.5% from Denmark
- 14.5% from the USA
- 5.9% from Sweden
- 1.5% from China
- 1.4% from The Netherlands
- 1.1% from Italy
- 0.4% from Spain

The remaining participants were from Iran, Malawi, Portugal and Russia.

The 2 studies that reported on GWG were in Portugal and India.

Ethnicity of population

Not reported.

BMI category

All participants had a "normal BMI".

Intervention or exposure

Milk or dairy intake on pregnancy or lactation outcomes. In most studies, the intake of milk and dairy products was evaluated through dietary information with appropriate and validated questionnaires.

Main results

Two prospective cohort studies evaluated gestational weight gain in response to maternal milk and dairy product intake.

For pregnant women in India, milk product intake in the third trimester was positively associated ($P < 0.001$) with gestational weight gain between the second and third trimester (35).

In a study of pregnant Portuguese women (33), a reduction in total dairy intake between the first ($350.1 \pm 149.5\text{g/d}$) and second trimester ($340.6 \pm 228.9\text{g/d}$) was negatively associated with maternal weight gain during pregnancy ($\beta = -0.007$, $P = 0.020$).

Comments

Risk of bias and quality

National Heart Lung and Blood Institute Study Quality Assessment Tools were used. Both studies reporting on GWG were scored 'good' (A), that is a final value ≥ 10 out of 12 to 14.

Confounding factors

The study in women in India adjusted for: maternal age, weight and height; gestational age at delivery; educational level; parity and energy intake.

The study in Portuguese women adjusted for the mother's:

- weight, height and prepregnancy BMI
- weight gain during gestation
- smoking status
- neonatal sex
- gestation age
- socioeconomic characteristics
- educational level
- energy intake
- compliance to Mediterranean diet (score)

Limitations (from the authors)

The authors noted the following limitations:

- the observed association should be carefully interpreted as the retrospective nature of case-control studies make them particularly susceptible to bias; disease and exposure have already occurred at the outset of a case-control study, and there may be differential reporting of exposure information between cases and controls based on their disease status
- there is no way to discriminate if final conclusions refer to the additive effects of the whole diet rather than the individual effects of the different food groups, as Ahmadi and colleagues point out in their article

AMSTAR 2 overall confidence rating

Critically low.

AMSTAR 2 additional confidence rating

Low.

Chatzakis and others (2019)

Title

'Prevention of gestational diabetes mellitus in overweight or obese pregnant women: a network meta-analysis'.

Study design

Network meta-analysis.

Funding

Received no funding.

Declaration of interest

None to declare.

Methods**Aim**

To compare the efficiency of physical exercise, metformin, vitamin D and probiotic to identify the optimal intervention for the prevention of the development of GDM.

Search criteria**Search dates**

Not reported.

Search design

Randomised controlled trials (RCTs).

Language

Not reported.

Population

Overweight and obese pregnant women (BMI 25kg/m² or higher). Women with pre-existing diabetes were excluded. There were no differences in the baseline patient characteristics (including the BMI at randomisation) among the studies.

Intervention or exposure and comparators

Administration of metformin, exercise programs, vitamin D and probiotics compared with placebo or no intervention.

Primary outcome

Development of GDM.

Secondary outcomes

Secondary outcomes were:

- preeclampsia
- increased GWG
- intrauterine death
- preterm birth
- caesarean sections
- macrosomia
- large-for-gestational-age
- pregnancy-induced hypertension
- admission to a neonatal intensive care unit

Statistical analyses

Random effects model.

Heterogeneity

A common heterogeneity across all comparisons was assumed and compared with previously derived empirical distributions for heterogeneity.

Publication bias

Comparison adjusted funnel plot.

Sensitivity and meta-regression analyses performed

Inconsistency plot using the ifplot command in Stata.

Included studies**Number of studies**

There were 23 studies, of which 4 reported on the effects of probiotic consumption on GWG.

Number of participants

The number of participants in the included studies were $n = 4,237$ (23 studies).

Info from author provided via correspondence: the 4 studies participating in the outcome of weight gain are Callaway, Asgharian, Okesene-Gafa and Lindsay.

Age of participants

Not reported.

Countries

Unable to identify relevant probiotic studies.

Ethnicity of population

Not reported.

BMI category

Not reported.

Intervention or exposure

Administration of probiotics compared with placebo or no intervention.

Main results

Direct meta-analysis: probiotics vs placebo for GWG: Mean Difference (MD): 0.2 (95% CI: -0.69 to 1.10).

Network meta-analysis: probiotics vs placebo for GWG: MD: 0.5 (95% CI: -10.91 to -11.92).

Comments

Risk of bias and quality

Cochrane risk of bias tool 2 was used. Probiotic studies were of “low risk” or “some concerns”.

Confounding factors

Confounding factors were as follows:

- one study of interest adjusted for baseline BMI
- adjustment was not reported for other probiotic trials

Limitations (from the authors)

The authors noted the following limitations:

- overall level of evidence was moderate-to-low
- network meta-analyses ranking can be misleading if interpreted “as it is”

AMSTAR 2 overall confidence rating

Low.

AMSTAR 2 additional confidence rating

Moderate.

Dalrymple and others (2018)

Title

‘Lifestyle interventions in overweight and obese pregnant or postpartum women for postpartum weight management: a systematic review of the literature’.

Study design

Systematic review.

Funding

Tommy’s Charity: United Kingdom (UK) (Registered charity no. 1060508); Kathryn Dalrymple is funded by the British Heart Foundation (FS/17/71/32953); Sophie Relph is funded by Guy’s and St Thomas’ Charity.

Declaration of interest

The authors have no relevant interests to declare.

Methods

Aim

To evaluate the effectiveness of lifestyle interventions in overweight or obese pregnant and/or postpartum women for managing postpartum weight up to 2 years after giving birth.

Search criteria

Search dates

1 January 2000 to 23 January 2018.

Search design

RCTs.

Language

English language only.

Population

Pregnant or postpartum (up to 2 years after birth) women, with a BMI 25kg/m^2 or higher and aged 18 years or over.

Intervention or exposure and comparators

Diet or diet and physical activity initiated during pregnancy, postpartum or both, compared to standard care.

Outcomes

The outcome was maternal postpartum weight or body composition data more than 3 months and less than 2 years after delivery.

Statistical analyses

Not applicable.

Included studies**Number of studies**

There were 18 studies, of which 5 reported on diet-only interventions compared with standard antenatal care.

Number of participants

Number of participants in the included studies were:

- $n = 2,559$ (18 studies)
- $n = 987$ (5 studies)

Age of participants

Participants were 18 years and over.

Countries

The included studies were conducted in the following countries:

- Australia: 1
- Denmark: 1
- Sweden: 2

- UK: 1
- USA: 10
- Not reported: 1

Ethnicity of population

Reported for one RCT.

BMI category

BMI category was 25kg/m² or higher.

Intervention or exposure

The studies used a variety of strategies to modify dietary intake. The approaches included dietary counselling, a low-carbohydrate diet, an energy-restrictive diet, and educational kits which focused on dietary habits, including portion sizes, fruit and vegetable intake, nutritious snacks and reading food labels.

Main results

One of the 5 diet only interventions, one reported a significant effect on postpartum weight retention (PPWR) weight when compared to controls:

At the end of the intervention the intervention group weight was 6.1kg lower (-8.4, -3.2kg) compared with 1.6kg lower (-3.5, -0.4kg) in the control group ($p < 0.001$).

The difference was maintained at the 1-year follow-up for the intervention group, -10.0kg (-11.7, -5.9kg) compared with -4.3kg (-10.2, -1.0kg) in the control group ($p = 0.004$).

Comments

Risk of bias and quality

The Cochrane Handbook for Systematic Reviews of Interventions tool was used to assess the validity and bias of each included publication. Performance bias was not included due to the nature of the interventions. The diet only intervention trials were assessed as follows:

- 2 of the 5 had high risk of bias
- 2 of the 5 had moderate risk of bias

- 1 of the 5 had low risk of bias

Confounding factors

Not reported.

Limitations (from the authors)

The authors noted the following limitations:

- the level of missing information in the published reports due to the drop-out rates from randomisation to the study end points
- disparities were notable across the studies, particularly regarding participant characteristics and also the type, setting, intensity and duration of the intervention
- the heterogeneity between the study designs and intervention types, precluding meta-analysis
- the small sample sizes of the included studies, which can affect power and reliability of the data
- only studies published in English were analysed

AMSTAR 2 overall confidence rating

Critically low.

AMSTAR 2 additional confidence rating

Critically low.

Dodd and others (2018)

Title

‘Targeting the postpartum period to promote weight loss: a systematic review and meta-analysis’.

Study design

Systematic review with meta-analysis.

Funding

J.M.D. is supported through National Health and Medical Research Council Practitioner Fellowship (ID 627005). S.P. is supported through a National Institutes of Health grant (DK087889).

Declaration of interest

J.M.D., A.R.D., C.M.O'B., D.A.J.M.S., A.P., and A.G. have no relevant interests to declare. S.P. received a research grant (not in field of women's health) from Weight Watchers International, Inc.

Methods

Aim

To evaluate postpartum dietary and/or physical activity interventions to promote weight loss and improve health in a subsequent pregnancy.

Search criteria

Search dates

Inception to November 2017.

Search design

Published and ongoing randomised trials.

Language

No language restrictions.

Population

Women who had given birth to a healthy singleton infant and (1) were overweight or obese; (2) had a normal BMI upon commencing pregnancy but whose GWG exceeded the Institute of Medicine guidelines; or (3) had retained weight at the time of trial recruitment as defined by the trial authors.

Studies were excluded if underweight women were recruited.

Intervention or exposure and comparators

Dietary and/or lifestyle intervention to promote weight loss in women in the postpartum period was compared with standard postnatal care or no intervention to promote weight loss were included.

Primary outcomes

The primary outcomes were as follows:

- mean change in weight (kg) between trial entry and end of intervention
- mean change in weight (kg) between trial entry and final assessment (after completion of the intervention, to determine weight maintenance)
- proportion of women who returned to their pre-pregnancy weight at final assessment
- proportion of women whose BMI was within the normal range (18.5 to 24.9kg/m²) following completion of the intervention
- proportion of overweight or obese women who lost 5% or more of their pre-pregnancy body weight following completion of the intervention

Secondary outcomes

The secondary outcomes were as follows:

- maternal outcomes related to pregnancy and to birth outcomes in a subsequent pregnancy included GDM; preeclampsia; gestational hypertension; preterm birth before 37 weeks; GWG below, within, or above the Institute of Medicine recommendations; caesarean birth; and post-partum haemorrhage
- infant outcomes related to birth outcomes in a subsequent pregnancy included birth weight in kilograms, birth weight 4.0kg or more, birthweight 2.5kg or less, neonatal intensive care admission and breastfeeding
- a range of longer-term maternal and child health outcomes were considered, including maternal type 2 diabetes, maternal essential hypertension and childhood obesity

Statistical analyses

Fixed effects model.

Heterogeneity

τ^2 , I^2 and χ^2 statistics, with heterogeneity considered significant if the I^2 statistic exceeded 30% and either the τ^2 statistic was greater than zero or the chi-squared statistic revealed $P < 0.10$.

Publication bias

Not reported.

Sensitivity and meta-regression analyses performed

Sensitivity analyses performed to evaluate: intervention intensity, nature of intervention, maternal BMI subgroup, and trial quality.

Included studies

Number of studies

There were 27 studies, of which 2 reported on the effects of dietary intervention alone vs standard postnatal care or no intervention.

Number of participants

The number of participants were as follows:

- n = 4,610 (27 studies)
- n = 75 (2 studies)

Age of participants

Not reported.

Countries

The included studies were conducted in the following countries:

- Sweden: 1
- USA: 1

Ethnicity of population

Not reported.

BMI category

Not reported.

Intervention or exposure

Dietary intervention alone vs standard postnatal care or no intervention.

Main results

Women who were provided with a dietary intervention in the postpartum period were more likely to have significant weight loss at the completion of the intervention compared with women who received no intervention (MD, 1.82kg; 95% CI, 2.19 to 1.44kg). One of these trials reported weight change at 12 months and found that women who received a dietary intervention alone maintained significant weight loss compared with women who received no dietary intervention (MD, 9.30kg; 95%CI, 13.71 to 4.89; 30 women).

The results showed evidence of statistical heterogeneity for the reported weight-related outcomes. Consideration of maternal BMI category did not influence the magnitude or direction of effect.

Comments

Risk of bias and quality

Cochrane risk of bias tool was used. Just over half of the studies described the methods used to generate the randomisation sequence. Only 7 studies described adequate allocation concealment.

Confounding factors

Not reported.

Limitations (from the authors)

The authors noted the following limitations:

- at 12 months post-partum, data from only 4 trials involving 420 women were available
- both the high rate of post-randomisation loss to follow-up and the participant withdrawal rate of approximately 25% identified in this review introduce significant potential for attrition bias, as does the lack of reporting of outcomes beyond completion of the intervention

AMSTAR 2 overall confidence rating

Critically low.

AMSTAR 2 additional confidence rating

Critically low.

i-WIP (2017)

Title

‘Effect of diet and physical activity based interventions in pregnancy on GWG and pregnancy outcomes: meta-analysis of individual participant data from randomised trials’.

Study design

Systematic review and meta-analysis of individual participant data (IPD).

Funding

National Institute for Health Research Health Technology Assessment programme (No 12/01/50).

Declaration of interest

All authors have completed the [International Committee of Medical Journal Editors \(ICMJE\) uniform disclosure form](#) and declare: no support from any organisation for the submitted work. HH reports grants from the German Ministry of Education and Research, the Bavarian Ministry of Agriculture and Nutrition, the Bavarian Ministry of Health, the Helmholtz Center Munich, the Else Kröner-Fresenius Foundation, AOK Bavaria, Amway, and the German Research Foundation outside the submitted work. BWJM reports funding from ObsEva during the conduct of the study.

Methods

Aim

To assess the effects of diet and physical activity based interventions, primarily on GWG and on maternal and offspring composite outcomes.

Search criteria

Search dates

January 1990 to February 2017.

Search design

Randomised trials.

Language

No language restrictions.

Population

Pregnant women of any weight status without GDM at baseline.

Intervention or exposure and comparators

Interventions based on diet, physical activity, and mixed interventions in pregnancy, on maternal and offspring outcomes compared with routine care.

Primary outcomes

The primary outcomes were as follows:

- GWG
- a composite of maternal outcomes
- a composite of offspring outcomes

Secondary outcomes

The secondary outcome was individual maternal and offspring complication.

Statistical analyses

Random effects model.

Heterogeneity

I^2 statistic, the estimated interstudy variance (τ^2), and approximate 95% prediction intervals, which indicate the potential intervention (or interaction) effect in a new population similar to those included in the meta-analysis.

Publication bias

Contour enhanced funnel plots alongside visual examination and statistical tests for asymmetry (Egger's test for continuous outcomes or Peter's test for binary outcomes).

Sensitivity and meta-regression analyses performed

IPD meta-analysis performed and sensitivity analyses by excluding studies with high risk of bias, analysing the primary outcomes separately for each intervention type (diet, physical activity, and mixed), excluding participants not adherent to the intervention, by analysing change in BMI instead of weight gain, and excluding maternal weight gain

estimates from pregnancies that ended before 37 completed weeks of gestation to avoid systematic differences.

Included studies

Number of studies

There were 103 studies of which 36 were included in IPD analysis. Of the 103 studies, 12 reported on the effects of dietary interventions alone on GWG, and 4 of these were included in the IPD analysis.

Number of participants

The number of participants were as follows:

- n = 25,486 (103 studies)
- n = 12,526 (36 studies)
- n = 2,017 (12 studies)
- n = 1,168 (4 studies)

Age of participants

Of 35 IPD studies mean (standard deviation (SD)):

- intervention: 30.0 (5.1)
- control: 30.1 (5.2)

Countries

The included studies were conducted in the following countries:

- Norway: 1
- Brazil: 1
- Ireland: 1
- Denmark: 1

Unable to identify relevant non-IPD studies.

Ethnicity of population

Intervention vs control, n (%) for 27 IPD studies:

- White (including Russians and Australians): 4,562 (88.0) vs 4,217 (87.2)
- Asian: 157 (3.0) vs 156 (3.2)
- Black: 292 (5.6) vs 292 (6.0)
- Central and South American: 67 (1.3) vs 64 (1.3)
- Middle Eastern (including Iranian and Turkish) 37 (0.7) vs 37 (0.8)
- Other 71 (1.4) vs 68 (1.4)

BMI category

Intervention vs control, n (%) for 34 IPD studies:

- Normal (18.5 to 24.9kg/m²): 1,974 (31.7) vs 1,842 (31.8)
- Overweight (25 to 29.9kg/m²): 1,578 (25.3) vs 1,523 (26.3)
- Obese (Above 30kg/m²): 2,680 (43.0) vs 2,434 (42.0)

Intervention or exposure

Diet based interventions on GWG.

Main results

Effects of diet-based interventions on GWG:

- IPD (n = 4 studies): MD: -0.72kg (95% CI: -1.48 to 0.04). $I^2 = 0.0\%$.
- IPD and non-IPD (n = 12 studies): MD: -2.84kg (95% CI: -4.77 to -0.91). $I^2 = 92.3\%$.

No strong evidence was found of a treatment-covariate interaction for baseline BMI when treated as a continuous covariate (-0.02kg change in intervention effect per one unit increase in BMI, 95% CI -0.08 to 0.04kg), or when compared as overweight versus normal (-0.11kg, -0.77 to 0.55kg), obese versus normal (0.06kg, -0.90 to 1.0kg), and obese versus overweight (-0.09kg, -1.05 to 0.86kg).

Comments

Risk of bias and quality

Cochrane risk of bias tool was used.

Overall, trials had a low risk of bias in random sequence generation (71%, 73 out of 103). More than 90% (34 out of 36) of studies that contributed to the IPD were assessed as low risk of bias in this domain compared with 58% (28 out of 67) of the non-IPD studies. Two IPD studies (2 out of 36) and one non-IPD study (3 out of 67) were considered high risk for allocation concealment. Blinding of outcome assessment was appropriate in 44% (16 out of 36) of IPD and 33% (22 out of 67) of non-IPD studies. Fewer IPD studies (5 out of 36) were assessed as high risk of bias for incomplete outcome data than non-IPD studies (15 out of 67).

Authors found visual and statistical evidence (Egger's test $P = 0.04$) of small study effects in the contour enhanced funnel plots for the IPD meta-analysis of the overall effect on GWG. The asymmetry of the plot was not improved by the addition of study level data from non-IPD studies to the meta-analysis. When studies with high risk of bias were excluded from the analysis, the symmetry of the funnel plot improved (Egger's test $P = 0.61$).

Confounding factors

IPD analysis adjusted for baseline weight and clustering using analysis of covariance in each trial.

Limitations (from the authors)

The authors noted the following limitations:

- owing to the variation in reporting, ethnicity of women could only be broadly classified as white or non-white. Findings were limited by the smaller number of non-white compared with white mothers
- the majority of the population has a medium to high education status, a factor favouring compliance with interventions

AMSTAR 2 overall confidence rating

Low.

AMSTAR 2 additional confidence rating

Moderate.

Muktabhant and others (2015)

Title

‘Diet or exercise, or both, for preventing excessive weight gain in pregnancy’.

Study design

Systematic Review with meta-analysis.

Funding

Thai Cochrane Network, Thailand.

Thailand Research Fund/Distinguished Professor Award, Thailand.

United Nations Development Programme/United Nations Population Fund/UNICEF/WHO/World Bank Special Programme of Research, Development and Research Training in Human Reproduction (HRP), Department of Reproductive Health and Research, World Health Organization, Switzerland.

Declaration of interest

None known.

Methods

Aim

To evaluate the effectiveness of diet or exercise, or both, interventions for preventing excessive weight gain during pregnancy and associated pregnancy complications.

Search criteria

Search dates

Inception to 5 November 2014.

Search design

RCTs and cluster-RCTs. Quasi-RCTs were not eligible.

Language

No language restrictions.

Population

Pregnant women of any BMI.

Intervention or exposure and comparators

Any diet or exercise, or both, intervention (for example a healthy eating plan, low glycaemic diet, exercise intervention, health education, lifestyle counselling) compared with standard or routine care for preventing excessive weight gain in pregnancy.

Authors organised the main comparison into different intervention types, as follows:

- diet counselling only versus routine care
- diet and exercise counselling versus routine care
- diet interventions (for example low glycaemic diets) versus routine care; exercise (supervised or unsupervised) interventions only versus routine care
- diet and supervised exercise interventions versus routine care (authors defined diet as a special selection of food, or energy intake, to which a participant was restricted)

Primary Outcome

Excessive weight gain.

Additional outcomes

For the mothers:

- weight gain
- low weight gain as defined by investigators
- preterm birth
- preterm prelabour rupture of membranes
- pre-eclampsia or eclampsia
- hypertension (not prespecified)
- induction of labour
- caesarean delivery

- postpartum complication including postpartum haemorrhage, wound infection, endometritis, need for antibiotics, perineal trauma, thromboembolic disease, maternal death
- behaviour modification outcomes: diet, physical activity

For the newborns:

- birthweight (not prespecified)
- birthweight greater than 4,000g or greater than the 90th centile for gestational age and infant sex (macrosomia)
- birthweight less than 2,500g or less than the 10th centile for gestational age and infant sex
- complication related to macrosomia including hypoglycaemia, hyperbilirubinaemia, infant birth trauma (palsy, fracture, shoulder dystocia), respiratory distress syndrome

Statistical analyses

Random effects model.

Heterogeneity

Tau², I² and Chi² statistic. Substantial if an I² was greater than 30% and either a Tau² was greater than zero, or there was a low P value (less than 0.10) in the Chi² test for heterogeneity. If heterogeneity above 30% was identified, it was explored by sensitivity and subgroup analyses.

Publication bias

Funnel plots; if asymmetry was suggested by a visual assessment, exploratory analyses to investigate it was performed.

Sensitivity and meta-regression analyses performed

Sensitivity analyses to explore the effect of trial quality by excluding studies with risk of bias concerns from the analyses.

Subgroup analyses according to the risk of adverse effects related to poor weight control with the high-risk group comprising only overweight and obese women, or women with or at risk of diabetes mellitus; a mixed-risk group comprising women in the general population, including women of any body mass indices (BMIs), and a low-risk group comprising normal weight women or women with BMIs of less than 25kg/m². Where possible, subgroup analysis was performed for the following outcomes:

- excessive GWG
- mean GWG
- low GWG
- preterm birth
- caesarean section
- pre-eclampsia
- macrosomia

Included studies

Number of studies

There were 65 studies, of which 7 reported on the effect of diet counselling on mean GWG vs standard care.

Number of participants

The number of participants were as follows:

- n = 11,444 (65 studies)
- n = 492 (7 studies)
- n = 1,497 (5 studies)

Age of participants

Not reported.

Countries

The included studies were conducted in the following countries:

- Australia: 3
- Italy: 1
- Finland: 1
- USA: 1

- Denmark: 1

Ethnicity of population

Not reported.

BMI category

All BMI categories eligible. Fifty-five out of 65 studies reported age and BMI at baseline and these were similar between study and control groups, with a few exceptions.

Intervention or exposure

All the interventions considered in this review included modifying or restricting diet or increasing exercise, or both. However, there was considerable variation in the interventions used. Diet only (8 studies):

- low glycaemic load (GL) diet versus conventional healthy eating or routine or other care (7 studies)
- one study evaluated a supervised low calorie diet

Diet counselling or other (7 studies).

Main results

Diet counselling only versus routine care for mean GWG outcomes; data was very heterogeneous (I^2 greater than 90%) with 4 out of 7 studies finding a difference in mean GWG of greater than 4kg, with the other 3 studies finding little difference. Data was therefore not combined.

Diet interventions (low GL diet) versus routine care; Mean GWG; Due to substantial heterogeneity, data was not pooled.

Diet interventions (low GL diet) versus routine care; excessive GWG; Low GL dietary interventions significantly reduced the risk of excessive GWG in the intervention group compared with the control group (relative risk 0.74, 95% CI 0.55 to 0.99; participants = 833; studies = 2; I^2 = 46%; Analysis 2.1). The test for subgroup differences was not significant (Chi^2 = 1.30, df = 1 (P = 0.25), I^2 = 22.9%).

Diet interventions (low GL diet) versus routine care; low GWG; Only 1 study contributed data and found no statistically significant difference between intervention and control arms.

Comments

Risk of bias and quality

Cochrane risk of bias tool was used.

Out of 65 studies:

- 35 (54%) were at a low risk of bias overall
- 20 (29%) were at a moderate-to-high risk of bias overall
- 10 (17%) studies were at an unclear risk of bias

Confounding factors

Six studies had important baseline imbalances in the characteristics of the women in the intervention and control groups that might have impacted the results in favour of the intervention.

Limitations (from the authors)

Most included studies were carried out in developed countries, and it is not clear whether these results are widely applicable to lower income settings with fewer human and financial resources.

Meta-analyses were not performed according to BMI classification of degree of obesity, although several studies stratified results by BMI (overweight or obese or morbidly obese).

AMSTAR 2 overall confidence rating

High.

AMSTAR 2 additional confidence rating

High.

Tielemans and others (2016)

Title

‘Macronutrient composition and gestational weight gain: a systematic review’.

Study design

Systematic review.

Funding

Supported by Nestlé Nutrition (Nestec Ltd.), Metagenics Inc., and AXA (MJT, AHG, EALdJ, TV, JCK-dJ, and OHF).

Declaration of interest

None of the other authors reported a conflict of interest related to the study.

Methods

Aim

To assess whether energy intake and macronutrient intake (that is protein, fat, and carbohydrate) during pregnancy were associated with GWG.

Search criteria

Search dates

Not reported to 12th August 2015.

Search design

Intervention studies, cohort studies, case-control studies.

Language

No language restrictions.

Population

Women with singleton pregnancies either healthy or diseased.

Intervention or exposure and comparators

Macronutrient supplementation, energy intake, carbohydrate intake, protein intake and fat intake, compared with no supplementation, low-energy supplementation (comparator not applicable for cohort and case-control studies).

Primary Outcomes

The primary outcomes were as follows:

- GWG
- adequacy of GWG

Statistical analyses

Not applicable.

Included studies

Number of studies

There were 56 studies of which 10 were interventional (2 RCTs) and 46 were observational with a longitudinal design, except for one case-control study (which was conducted in a LMIC and so the results are not presented here).

Number of participants

The number of participants were as follows:

- n= 78,362 (56 studies)
- n = 1,520 (10 intervention studies)
- n = 76,642 (45 observational studies, excluding the case control study)

Age of participants

Range of 12 to 46 years.

Countries

Of the 56 studies:

- 28 were performed in high-income countries (3 were performed in the UK)
- 28 were conducted in low- and middle-income countries (LMIC)

The included studies were conducted in the following countries:

- USA: 9
- Brazil: 5
- Thailand: 4

- India: 3
- UK: 3
- Australia: 2
- Bangladesh: 2
- Denmark: 2
- Iran: 2
- Italy: 2
- The Netherlands: 2
- Pakistan: 2
- Taiwan: 2
- Canada: 1
- China: 1
- Columbia: 1
- Finland: 1
- France: 1
- Germany: 1
- Guatemala: 1
- Iceland: 1
- Indonesia: 1
- Ireland: 1
- Nepal: 1
- Poland: 1
- Philippines: 1

- Romania: 1
- Sweden: 1
- Tanzania: 1

Ethnicity of population

Not reported.

BMI category

All eligible.

Intervention or exposure

Macronutrient supplementation, energy intake, carbohydrate intake, protein intake, and fat intake.

Main results

The absolute change of weight during pregnancy was reported in 42 studies. Seventeen studies reported on the adequacy of GWG.

Forty-two studies reported on the association of energy intake with GWG (Supplemental Table 1). Twenty-three studies (55%) were performed in high-income countries, and 9 studies (21%) were of high-quality. Results of 5 intervention and 7 high-quality observational studies suggested that higher energy intake during pregnancy is associated with higher GWG. Results from observational studies were inconsistent for protein intake (n = 29) and carbohydrate intake (n = 18). Maternal fat intake (n = 25) might be associated with GWG as suggested by observational studies, although the direction of this association might depend on specific types of fat (for example saturated fat). Macronutrient intake was not consistently associated with the prevalence of inadequate or excessive GWG. Associations were comparable for high-income countries and low- and middle-income countries.

Comments

Risk of bias and quality

Assigned a quality score to each article on the basis of 5 items, namely the study design, population size, exposure measurement (or, in intervention studies, the adequacy of blinding), outcome measurement, and adjustment for confounders and energy adjustment (or, in intervention studies, the adequacy of random assignment). Each item received

points from zero to 2, which led to a maximum of 10 points that represented the highest quality. Studies were considered of high quality when the quality score was ≥ 7 .

The quality score of the studies ranged from 2 to 10, and the median quality score was 5. Eleven of 56 studies received a quality score of ≥ 7 and, therefore, were considered as providing high-quality evidence.

Confounding factors

The majority of the studies did not receive any quality points for covariate adjustments because these studies did not adjust for relevant covariates, such as prepregnancy BMI or energy intake.

Limitations (from the authors)

The authors noted the following limitations:

- the overall low quality of the studies and, in particular, the insufficient adjustment for confounding factors in many of the included studies
- measurement of energy intake with the use of self-reporting methods such as FFQs
- only 13 of 31 observational studies that assessed the association of a macronutrient with GWG used a form of energy adjustment
- changes in energy intake during pregnancy were not evaluated in relation to increased energy requirements or altered physical activity levels in pregnancy
- also, associations of macronutrient intake could not be studied with different components of GWG such as the effect on maternal fat accretion, which is an important determinant of PPWR
- many studies did not take into account pregnancy complications
- not able to present results by maternal weight status because most studies did not report analyses stratified by BMI
- studies applied different definitions for GWG, used diverse measurement strategies for GWG, and adequacy of GWG was determined and/or categorised differently
- only a few studies reported the association of macronutrients on GWG adjusted for each other or for other foods or nutrients

AMSTAR 2 overall confidence rating

Low.

AMSTAR 2 additional confidence rating

Moderate.

United States Department of Agriculture (USDA) 2020 Dietary Guidelines Advisory Committee: Pregnancy and Lactation Subcommittee

Title

‘Dietary patterns during pregnancy and gestational weight gain: a systematic review’.

Study design

Systematic review with meta-analysis.

Funding

United States Department of Agriculture, Food and Nutrition Service, Center for Nutrition Policy and Promotion, Alexandria, VA.

Declaration of interest

Members of the 2020 Committee were appointed as Special Government Employees (SGEs). SGEs are selected based on recognised expertise or expert knowledge relevant to the Committee. In contrast, none of the members was appointed as Representative Members, who are individuals appointed for the purpose of presenting the points of view of outside interest groups or stakeholders.

USDA ethics officials conducted an annual review of each Committee member’s Office of Government Ethics (OGE) Form 450 to manage potential conflicts of interest throughout the proceedings. USDA ethics officials provided ethics training on 2 occasions to members of the 2020 Committee.

The approaches the Committee used to examine the evidence - systematic reviews, data analyses, and food pattern modelling - are rigorous, objective, and protocol driven, and are designed to minimise bias. Protocols for each question being addressed were developed

before examining any evidence and were presented at the Committee's meetings and posted to DietaryGuidelines.gov, providing transparency to the public throughout the Committee's deliberations.

The review of evidence was not based on any one member's expertise, nor were the final decisions for the scientific evaluation reached on an individual-by-individual basis. The Committee's review of the evidence was completed in a collaborative manner. The Committee came to its conclusions and advice to USDA and United States Department of Health and Human Services (HHS) together.

Methods

Aim

To investigate the relationship between dietary patterns consumed during pregnancy and GWG.

Search criteria

Search dates

January 2000 to November 2019.

Search design

RCTs, non-randomised controlled trials, prospective and retrospective cohort studies, and nested case-control studies.

Language

English.

Population

Pregnant women who were generally healthy.

Intervention or exposure and comparators

Studies that examine consumption of and/or adherence to either a:

- dietary pattern, that is the quantities, proportions, variety, or combination of different foods, drinks, and nutrients (when available) in diets, and the frequency with which they are habitually consumed including, at a minimum, a description of the foods and beverages in the pattern
- diet based on macronutrient distribution outside of the acceptable macronutrient distribution range (AMDR) and include:

- the macronutrient distribution of carbohydrate, fat, and protein of the diet
- at least one macronutrient outside of the AMDR

For dietary patterns described by foods and beverages consumed, the comparators are:

- consumption of and/or adherence to a different dietary pattern
- different levels of consumption of and/or adherence to a dietary pattern

For diets described by macronutrient distribution, the comparator is a different macronutrient distribution of carbohydrate, fat, and protein.

Primary outcomes

The primary outcomes were as follows:

- change in maternal body weight from baseline (before or during pregnancy) to a later time point during pregnancy and/or right before delivery
- weight gain in relationship to weight gain recommendations, based on pre-pregnancy BMI

Statistical analyses

Not applicable (narrative summary of the evidence).

Publication bias

Author states: "Publication bias may not be a serious concern for this body of evidence because at least a third of the studies reported non-significant findings while the others report significant findings or a mix of significant and non-significant findings."

Sensitivity and meta-regression analyses performed

Not applicable (narrative summary of the evidence).

Included studies

Number of studies

There were 4 RCTs and 19 prospective cohort studies (26 articles in total).

Number of participants

Sample sizes of the studies ranged from 35 to 66,597 participants.

Age of participants

Almost all of the studies were conducted in adult women (18 to 45 years).

Countries

High and very high Human Development Index countries.

Ethnicity of population

Thirteen of the 26 articles noted that the participants were predominantly or exclusively White (defined as $\geq 50\%$ of the participants). Nine studies did not report race or ethnicity. One reported that 89% of the participants were Malay. One noted that 100% of their participants were Japanese. One reported that the participants were predominantly Hispanic (approximately 41.3%). One noted that the participants were predominantly Asian (approximately 43.7%).

BMI category

Prepregnancy BMI: 7 studies enrolled predominantly or exclusively overweight or obese women. One enrolled women with metabolic risk factors, including women with obesity.

Intervention or exposure

Dietary patterns (24 studies). Diets based on macronutrient distributions outside of the AMDR (2 studies).

Main results

Five of the 8 articles showed that greater adherence to a dietary pattern (identified as beneficial by the study) was associated with lower GWG. Three articles showed that greater adherence to a dietary pattern (identified as beneficial by the study) was associated with greater GWG in all participants or only women with obesity. Four of the 5 articles that assessed maternal dietary patterns using a factor or cluster analysis showed one or more associations between adherence to dietary patterns and GWG. One article showed that greater adherence to a dietary pattern (identified as beneficial by the study) was associated with lower GWG. Four articles showed that greater adherence to a dietary pattern (identified as detrimental by the study) was associated with higher GWG. One study that assessed maternal dietary patterns using reduced rank regression showed that greater adherence to a dietary pattern was associated with higher GWG. Two RCTs showed that participants randomised to a dietary pattern (identified as beneficial by the study) had lower GWG. One RCT and one prospective cohort study showed no association between maternal consumption of a diet higher in fat (that is more than 35% of total energy from fat, which is greater than the AMDR) and GWG.

The dietary patterns examined were characterised by combinations of different foods and beverages, the patterns that were consistently shown to be associated with lower risk of excessive GWG were: higher in vegetables, fruits, nuts, legumes, and fish and lower in added sugar and red and processed meat.

Comments

Risk of bias and quality

The risk of bias of RCTs, including parallel group trials, cluster-randomised trials, and cross-over trials, was assessed using the "Cochrane risk-of-bias tool for randomised trials".

The risk of bias of non-RCTs was assessed using the Risk of Bias in Nonrandomized Studies-of-Interventions tool (ROBINS-I).

The risk of bias of observational studies was assessed using the Risk of Bias for Nutrition Observational Studies tool (RoB-NObs).

Risk of bias was graded as limited for both RCTs and cohort studies. Studies had risk-of-bias issues, including exposure misclassification, self-reported outcomes, and selection bias.

Confounding factors

Key confounders were not consistently controlled for in most of the studies.

Limitations (from the authors)

The authors noted the following limitations:

- there were few RCTs and thus data were primarily observational in nature, limiting the ability to determine causal effects of dietary patterns on GWG
- key confounders were not consistently controlled for in most of the studies
- studies had risk-of-bias issues, including exposure misclassification, self-reported outcomes, and selection bias
- most of the studies were not designed to assess the association between dietary patterns and GWG
- people with lower socioeconomic status, adolescents, and racially and ethnically diverse populations were underrepresented in the body of evidence

AMSTAR 2 overall confidence rating

High.

AMSTAR 2 additional confidence rating

High.

Walker and others (2018)

Title

'Attenuating pregnancy weight gain - what works and why: a systematic review and meta-analysis'.

Study design

Systematic review with meta-analysis.

Funding

Funding was as follows:

- Monash University, Australian Research Training Program Scholarship (R.W. and C.B.)
- Chinese Government Scholarship (J.M.)

Declaration of interest

The authors declare no conflicts of interest.

Methods**Aim**

To explore efficacy and intervention characteristics (trimester, duration, frequency, intensity, and delivery method) of interventions to prevent excessive GWG.

Search criteria**Search dates**

Inception to May 2018.

Search design

RCTs.

Language

No language restrictions.

Population

Women of all ages, ethnicities, and pre-pregnancy weight status with singleton pregnancies.

Intervention or exposure and comparators

Interventions designed to prevent excessive GWG. Comparators were standard care, an alternate intervention, or placebo.

Primary outcome

The primary outcome was GWG.

Statistical analyses

Random effects model.

Heterogeneity

I^2 statistic.

Publication bias

Funnel plots with Egger's test.

Sensitivity and meta-regression analyses performed

Sensitivity analyses were conducted to investigate the influence of a single study on the overall analyses.

Meta-regressions used 6 study characteristics as covariates to explain the heterogeneity between studies and explore whether study characteristics had a relationship with the effect sizes. Study characteristics were based on a previous review and included (i) the trimester in which the intervention commenced, (ii) duration (weeks—if a range the longest duration was used), (iii) frequency (1 to 3, 4 to 8, and more than 8 occasions of contact), (iv) intensity (less than 4, 4 to 8, and more than 8 hours of contact over the intervention), (v) delivery method (individual, group, and combination), (iv) diet (healthy eating advice, low-glycemic index (GI), calorie restricted, and probiotic).

Included studies

Number of studies

There were 89 studies, of which 16 were diet only interventions reporting GWG.

Number of participants

The number of participants were as follows:

- n= 25,345 (89 studies)
- n = 3,681 (16 studies)

Age of participants

Not reported.

Countries

The included studies were conducted in the following countries:

- USA: 3
- Australia: 3
- Finland: 2
- Italy: 2
- Egypt: 1
- Sweden: 1
- Turkey: 1
- Brazil: 1
- Ireland: 1
- Denmark: 1

Ethnicity of population

Not reported.

BMI category

Studies reported on women of: all BMIs (n = 51), healthy weight only (n = 3), healthy weight and overweight (n = 1), overweight and obese only (n = 21), or obese only (n = 13).

Intervention or exposure

Interventions designed to prevent excessive GWG.

Main results

Sixteen diet only studies reported a total of 3,681 participants. Four interventions delivered basic healthy eating advice, 4 were based on a low-GI diet, and 6 involved calorie-restriction. Ilmonen and others delivered dietary advice with a probiotic and Bosaues and others advised women to increase their fish intake in addition to general dietary advice. All studies commenced in the first or second trimester, had varying degrees of intensity and frequency and were delivered to women individually except for Walshe and others who delivered their intervention to both individuals and groups. Nine diet interventions were included in the meta-analyses. McCarthy and others did not report overall GWG for the entire intervention and control groups, therefore the GWG for sub-groups and their controls were used instead. The meta-analysis showed that dietary interventions were more effective than the control groups (weighted mean difference (WMD): -3.27; 95% CI: -4.96, -1.58, $p < 0.01$; $I^2 = 92.8\%$). Meta-regression revealed none of the study characteristics significantly influenced the pooled effect size.

Comments

Risk of bias and quality

The Cochrane risk of bias tool was used. A high risk of bias was allocated across domains and overall, 24% (n = 21) of interventions had a high risk of bias. Most studies had an unclear risk of bias for blinding participants, personnel, and outcomes as it was not possible to definitively assess whether minimal blinding inherent in dietary and lifestyle interventions impacted on outcomes.

The sensitivity analyses revealed that no single study introduced a large degree of bias to any of the meta-analyses. To explore whether the quality of studies, as rated by risk of bias, impacted on the meta-analyses, all studies with a high risk of bias were removed. This resulted in slight reductions in the heterogeneity of all diet only meta-analyses.

Confounding factors

Not reported.

Limitations (from the authors)

The authors noted the following limitations:

- the high levels of heterogeneity ($I^2 > 75\%$) in 3 of the 5 meta-analyses is a limiting factor
- there were very few studies within sub-groups for each meta-regression and therefore, caution should be taken when interpreting these data
- the analysis and interpretation of these data is further limited by the inconsistent outcome measures used for GWG
- using broad categories that cluster different measurements of GWG is not ideal, however, recent research has found using an early pregnancy weight (4 to 10 weeks gestation) is a reasonably accurate surrogate measure for pre-pregnancy BMI

AMSTAR 2 overall confidence rating

Low.

AMSTAR 2 additional confidence rating

Moderate.

Zhang and others (2022)

Title

‘Effect of Mediterranean diet for pregnant women: a meta-analysis of randomized controlled trials’.

Study design

Systematic review with meta-analysis.

Funding

Not reported.

Declaration of interest

No potential conflict of interest was reported by the authors.

Methods

Aim

To investigate the impact of Mediterranean diet on GDM.

Search criteria

Search dates

Inception to September 2020.

Search design

RCTs.

Language

Not reported.

Population

Pregnant women.

Intervention or exposure and comparators

Mediterranean diet versus standard diet.

Primary outcomes

The primary outcome was incidence of GDM.

Secondary outcomes

The secondary outcomes were as follows:

- GWG
- preeclampsia
- preterm delivery
- need for neonatal unit

Statistical analyses

Random effects model.

Heterogeneity

I² value greater than 50% indicated significant heterogeneity.

Publication bias

Owing to the limited number (less than 10) of included studies, publication bias was not assessed.

Sensitivity and meta-regression analyses performed

Sensitivity analysis was performed to detect the influence of a single study on the overall estimate via omitting one study in turn when necessary.

Included studies**Number of studies**

There were 4 studies, of which 3 reported on GWG.

Number of participants

The number of participants were as follows:

- n = 2,277 (4 studies)
- n = 2,040 (3 studies)

Age of participants

Range: 30.9 to 35 years.

Countries

The included studies were conducted in the following countries:

- UK: 2
- Spain: 1

Ethnicity of population

Not reported.

BMI category

Not reported.

Intervention/exposure

Mediterranean diet versus standard diet.

Main results

Compared with control intervention for pregnant women, Mediterranean diet resulted in lower GWG (SMD = -0.15; 95% CI = -0.26 to -0.05; $p = 0.004$). Heterogeneity: $\text{Tau}^2 = 0.00$; $\text{Chi}^2 = 1.76$, degrees of freedom (df) = 2 ($P = 0.41$); $I^2 = 0\%$. Test for overall effect: $Z = 2.85$ ($P = 0.004$).

Comments

Risk of bias and quality

Jadad score was used. Jadad scores of the 4 included studies varied from 3 to 5, all 4 studies were considered to be high-quality ones according to quality assessment.

Confounding factors

Not reported.

Limitations (from the authors)

The authors noted the following limitations:

- our analysis was based on only 4 RCTs and more clinical trials with large samples were needed to explore this issue
- although there was no significant heterogeneity, different methods of Mediterranean diet and various levels of glycaemic metabolism dysfunction may produce some bias
- it was unavailable to perform some important outcomes such as birth weight, macrosomia and the development of type 2 diabetes because of the limited data of current included RCTs

AMSTAR2 overall confidence rating

Critically low.

AMSTAR2 additional confidence rating

Critically low.

De-prioritised systematic reviews

The following sections provides information on the systematic reviews not prioritised for description in the main body of the report or for grading and drawing conclusions.

The text used throughout reflects the wording used by the SR authors. This includes the terms 'adequate' and 'excess' GWG.

Dodd and others (2010)

‘Antenatal interventions for overweight or obese pregnant women: a systematic review of randomised trials’.

Study design

Systematic review with meta-analysis.

Funding

None.

Declaration of interest

The authors have no competing interests to declare.

Methods

Aim

To assess the benefits and harms of antenatal dietary or lifestyle interventions for pregnant women who are overweight or obese.

Search criteria

Search dates

Inception to January 2010.

Search design

RCTs.

Language

No language restrictions.

Population

Pregnant women who were overweight (BMI $\geq 25\text{kg/m}^2$) or obese (BMI $\geq 30\text{kg/m}^2$).

Intervention or exposure and comparators

Antenatal dietary and/or lifestyle advice or intervention.

Primary outcome

The primary outcome was large for gestational age.

Secondary outcomes

The secondary outcomes were as follows:

- mean GWG
- hypertension
- pre-eclampsia or eclampsia
- gestational diabetes
- pre-term birth (before 37 weeks of gestation)
- induction need
- caesarean section
- postpartum haemorrhage
- perinatal death
- congenital abnormalities
- infant birthweight more than 4,500g
- infant birthweight less than 2,500g
- Apgar score of less than 7 at 5 minutes of age
- hypoglycaemia

- hyperbilirubinemia
- neonatal ICU admission
- birth trauma

Statistical analyses

Fixed effects model (random if $I^2 > 50\%$).

Heterogeneity

I^2 .

Publication bias

Not reported.

Sensitivity and meta-regression analyses performed

Not reported.

Included studies

Number of studies

There were 9 studies, of which 4 reported on the effects of antenatal dietary interventions on GWG.

Number of participants

The number of participants were as follows:

- $n = 743$ (9 studies)
- $n = 416$ (4 studies)

Age of participants

Not reported.

Countries

The included studies were conducted in the following countries:

- USA: 2

- Belgium: 1
- Denmark: 1

Ethnicity of population

Not reported.

BMI category

BMI category was 25kg/m² or higher.

Intervention or exposure

Antenatal dietary interventions vs standard care.

Main results

Women who received an antenatal intervention gained significantly less weight during pregnancy (4 studies; 416 women; WMD -5.37kg; 95% CI -6.61, -4.13; fixed-effects model). The I² statistic indicated a high degree of heterogeneity (93%), and when a random-effects model was subsequently used the result no longer remained statistically significant (4 studies; 416 women; WMD -3.10kg; 95% CI -8.32, 2.13; random-effects model).

Comments

Risk of bias and quality

Cochrane risk of bias tool was used.

Generation of the randomisation sequence using a random-number table, and allocation concealment using sealed opaque envelopes, was specifically stated for 5 trials, but was unclear in 4.

Blinding of participants and caregivers was achieved in only 1 of the trials.

Confounding factors

Not reported.

Limitations (from the authors)

Not reported.

AMSTAR2 overall confidence rating

Critically low.

AMSTAR2 additional confidence rating

Critically low.

Flynn and others (2016)

Title

‘Dietary interventions in overweight and obese pregnant women: a systematic review of the content, delivery, and outcomes of randomized controlled trials’.

Study design

Systematic review.

Funding

National Institute for Health Research Health Technology Assessment UK program 12/01/50, the European Union’s Seventh Framework Program (FP7/2007-2013), project Early Nutrition under grant agreement 289346, and Tommy’s Charity (Reg Charity 1060508, UK). The funders did not have any editorial input into the final manuscript.

Declaration of interest

The authors have no relevant interests to declare.

Methods**Aim**

To evaluate the published literature on diet and lifestyle interventions aimed at reducing obesity in pregnancy in order to identify effective approaches.

Search criteria**Search dates**

Not reported to March 2015.

Search design

RCTs.

Language

English language only.

Population

Pregnant women who were overweight (BMI 25kg/m² or higher or 23kg/m² or higher if high risk ethnicity) or obese (BMI 30kg/m² or higher).

Intervention or exposure and comparators

Defined dietary intervention implemented as part of interventions that were based on diet or a mixed approach comprising diet and physical activity components.

Primary outcomes

The primary outcomes were as follows:

- 'dietary and pregnancy outcomes'
- GWG

Statistical analyses

Not applicable.

Included studies**Number of studies**

There were 13 studies, of which 3 reported on diet-only interventions compared with standard antenatal care.

Number of participants

The number of participants were as follows:

- n = 4,276 (13 studies)
- n = 406 (3 studies)

Age of participants

Intervention groups: 29.6 years (13 studies).

Control groups: 29.8 years (13 studies).

Countries

The included studies were conducted in the following countries:

- Australia: 1
- USA: 1
- Denmark: 1

Ethnicity of population

Not reported.

BMI category

BMI category was 25kg/m² or higher.

Intervention or exposure

Diet-only interventions compared with standard antenatal care.

The 3 diet-only studies used a variety of strategies to modify dietary intake. The approaches included incorporating individualised feedback and suggesting healthier dietary choices to participants, using a nutritional regimen that followed dietary guidelines similar to those used in the treatment of GDM, and providing dietary counselling based on Danish recommendations for eating a healthy diet.

Two studies specified the dietary composition of the intervention target diet (carbohydrate intake ranged from 40% to 55% of the diet, protein intake ranged from 15% to 30% of the diet, and fat intake was 30% of the diet). Energy intake was individually restricted in 2 studies (provided energy targets by weight).

The intensity of the interventions varied from a 5-minute intervention at each antenatal visit to 10 1-hour consultations.

Collection tools included 7-day weighed food records, an audit of items consumed in the day before antenatal visits, and a diary notebook with daily food and beverage consumption. Only one study provided information on the dietary intake data analysis methods.

Main results

All three studies reported a significant reduction in GWG in the intervention group compared with the control group.

Comments

Risk of bias and quality

The Cochrane risk of bias tool was used. The findings of this assessment were that:

- in general, the studies had low risk of bias for adequate randomisation
- allocation concealment was described in 7 of 13 studies
- the blinding of outcome assessors was adequate in 5 studies
- attrition bias and the risk of bias due to selective reporting were low for the majority of studies

Confounding factors

Not reported.

Limitations (from the authors)

The authors noted the following limitations:

- limited by the variability of the studies included, which limited the ability to perform meta-analyses
- the focus on white European participants, for which results may not be extrapolated to other ethnic groups
- possibility of publication bias should be considered because those studies not published in the English language were not included
- antenatal interventions in women of all BMI categories were not included
- the Cumulated Index to Nursing and Allied Health Literature (CINAHL) database, which may have included nutrition journals not covered by the other databases, was not searched

AMSTAR 2 overall confidence rating

Low.

AMSTAR 2 additional confidence rating

Moderate.

Girard and Olude (2012)

Title

‘Nutrition education and counselling provided during pregnancy: effects on maternal, neonatal and child health outcomes’.

Study design

Systematic review with meta-analysis.

Funding

Not reported.

Declaration of interest

The authors declare they have no conflicts of interest.

Methods**Aim**

To quantify the effect of nutrition education and counselling (NEC) during pregnancy on maternal and neonatal health outcomes. This is especially the case for studies in low/middle-income countries (LMIC) where food insecurity and inadequate health services, a high burden of infectious disease and poor health care infrastructure contribute to and exacerbate nutritional deficiencies.

Search criteria**Search dates**

Inception to July 2011.

Search design

Experimental studies utilising a control group were included. Allowable study designs included RCTs, cluster RCTs, and quasi-experimental (nonrandomised; QE) intervention studies.

Language

English.

Population

Pregnant adults or adolescents.

Intervention or exposure and comparators

NEC intervention focused on improving maternal diet and nutritional status during pregnancy. The comparison group was a concurrent control or comparison group that did not receive NEC. In the event that both groups received NEC, the system of delivery, number of sessions and/or intensity differed.

Primary outcomes**Maternal outcomes**

GWG, PIH, haemorrhage, gestational diabetes, anaemia and mortality.

Neonatal and infant outcomes

Birth-weight, low birth-weight as defined by study authors, prematurity as defined by study authors, gestational age, intrauterine growth retardation or small-for-gestational age, mortality (stillbirths, perinatal, neonatal and infant mortality), neonatal and infant morbidity and infant growth.

Statistical analyses

Fixed models were used for primary analysis and random models were used when heterogeneity exceeded 50%.

Heterogeneity

Statistical heterogeneity was assessed in the pooled data by visual inspection of forest plots, using a chi-square test and calculating the I^2 statistic. Heterogeneity was considered substantial if the P-value of the chi-square was <0.10 and I^2 exceeded 50%.

Publication bias

Not reported.

Sensitivity and meta-regression analyses performed

Subgroup analysis according to country setting and category of NEC intervention. Study setting was defined based on World Bank classification of countries as low, lower middle-income, upper middle-income countries and high income countries. Low- and middle-income countries, including both lower middle and upper middle, were collapsed into an LMIC category.

Included studies

Number of studies

There were 34 studies, of which 19 reported on GWG (13 out of 19 reported data and were included in the meta-analysis).

Number of participants

The number of participants were as follows:

- n = 2,833 (19 studies)
- n = 1,752 (13 studies)

Age of participants

Not reported.

Countries

The included studies were conducted in the following countries:

- USA: 10
- India: 2
- Finland: 2
- Nepal: 1
- Egypt: 1
- China: 1
- Greece: 1

Ethnicity of population

Not reported.

BMI category

Not reported.

Intervention or exposure

NEC strategies typically focus on enhancing maternal diet quality by increasing the diversity and amount of foods consumed, adequate weight gain through consumption of sufficient and balanced protein and energy, and the consistent and continued use of micronutrient supplements, food supplements or fortified foods.

NEC strategies were split into:

- category 1 strategies provided NEC during pregnancy as the sole intervention; no additional messages or support were provided as part of the intervention (n=15 studies)
- category 2 strategies tested the effect of a package of health education messages that included an NEC component (n=6 studies); these additional health related messages included, for example use of alcohol and drugs
- category 3 strategies combined NEC with nutrition support including for example, food baskets, food supplements or micronutrient supplements (n = 13 studies)

Main results

Thirteen studies reported data on weight gain during pregnancy and were included in the meta-analysis. The duration of the weight gain period was not specified in most studies. Five studies were RCTs, 4 were conducted in developing countries and 3 were conducted with pregnant adolescents. Overall mean weight gain was significantly higher in intervention groups compared with control groups (0.45kg [95% CI 0.12, 0.79]. When stratified on category of NEC or study setting, significant differences between intervention and controls were only observed when NEC was provided with nutrition support (0.15kg [95% CI 0.00, 0.29]) or when studies were conducted in high-income settings (0.76kg [95% CI 0.20, 1.31]).

Two studies were not included in the meta-analysis because they did not report mean GWG or reported it as average weekly weight gain. In both studies the effect of NEC was not significantly associated with weight gain outcomes. One RCT and 2 QE studies aimed to reduce excessive weight gain during pregnancy. Because the intention of the

intervention was to reduce weight gain in pregnancy, these studies were not included in the meta-analysis. In general, those receiving the NEC intervention gained less weight than those in the comparison groups.

Comments

Risk of bias and quality

Child Health Epidemiology Reference Group adaptation of the Grading of Recommendations, Assessment, Development and Evaluation technique was used.

The overall quality of the body of evidence for an effect of NEC provided during pregnancy was considered to be low for outcomes of anaemia, weight gain and birthweight and low to very low for other primary outcomes. Only 1 of the RCTs clearly specified allocation method and concealment, adjusted for group differences when present at baseline, had an appropriate control group for attribution of effect to NEC, and specified intent to treat analysis. Additionally, for nonrandomised studies, quality was further downgraded for failure to assess and/or adjust for confounding, effect modification, and the sampling design. Several studies had insufficient sample sizes and were not powered to detect differences in the specified outcomes, while others suffered from high and/or differential losses to follow up. Results could not be clearly attributed to NEC in 13 studies due to inappropriate comparison group.

Confounding factors

Specific to GWG: No assessment of baseline differences or adjustment for confounding in 8 studies. Only 1 cluster design study adjusted for sampling strategy.

Limitations (from the authors)

Specific to GWG analysis: 7 studies not randomised. In 1 study, subjects self-selected into group. Five studies had inadequate sample sizes. For RCTs, method of randomisation, sequence generation, allocation concealment, and intent to treat analysis clearly specified in 1 study. Contamination suspected in 3 studies.

AMSTAR2 overall confidence rating

Critically low.

AMSTAR2 additional confidence rating

Critically low.

Jebeile and others (2016)

Title

'A systematic review and meta-analysis of energy intake and weight gain in pregnancy'.

Study design

Systematic review with meta-analysis.

Funding

No external funding.

Declaration of interest

The authors declare they have no conflict of interest.

Methods

Aim

To determine by meta-analysis of relevant studies whether greater increments in energy intake from early to late pregnancy corresponded to higher or excessive GWG.

Search criteria

Search dates

January 1990 to October 2014.

Search design

RCTs and observational, cohort, and longitudinal studies.

Language

English language only.

Population

Pregnant women of any weight status. Women were classed as underweight, normal, overweight and obese category according to the Institute of Medicine (IOM) criteria.

Intervention or exposure and comparators

RCTs aimed to limit GWG via dietary intervention, with a control group who did not receive the intervention. Observational studies reported GWG alongside energy intake in early and late pregnancy.

Primary outcomes

The primary outcomes were as follows:

- difference in energy intake between early and late pregnancy (In relation to energy intake, early and later pregnancy were defined by timepoints (t1 and t2) at least 12 or more weeks apart, where t1 less than 18 weeks and t2 more than 30 weeks gestation (studies reporting data at intervals less than 12 weeks were excluded)
- GWG

Statistical analyses

Random effects model.

Heterogeneity

Not reported.

Publication bias

Funnel plot, Begg and Mazumdar rank correlation, Egger regression.

Sensitivity and meta-regression analyses performed

Not reported.

Included studies**Number of studies**

There were 18 studies which reported GWG and energy intake in early and late gestation (14 observational, 4 RCTs).

Number of participants

Number of participants: n = 2,644.

Age of participants

Mean (SD) 29.6 (1.7) years.

Countries

The included studies were conducted in the following countries:

- observational: USA: 2, Sweden: 2, Italy: 1, Spain: 1, UK: 1, Belgium: 1, Czech Republic: 1, Japan: 1, Mexico: 1, India: 1
- RCTs: Belgium: 1, Finland: 1, Australia: 1, Denmark: 1

Ethnicity of population

Not reported.

BMI category

Mean (SD) 25.3 (4.9) kg/m².

Intervention or exposure

RCTs aimed to limit GWG via dietary intervention, with a control group who did not receive the intervention. Observational studies reported GWG alongside energy intake in early and late pregnancy. Dietary data was collected on average at 12 weeks and 35 weeks gestation. The most frequent dietary collection method was a weighed or estimated food record (n = 18), but 3 studies used a food diary, 2 employed repeat 24-hr recalls and 2 used a diet history.

Main results

Mean reported energy intake in the 18 studies was 8,130 (1,100) kilojoule (kJ) per day and 8,600 (1,230) kJ/day in early and late pregnancy, respectively. The SMD between the 2 was 0.266 (P = 0.016), a difference equivalent to ~475 kJ/day, which did not reach the a priori level of significance (P = 0.01). The mean (SD) GWG was 12.0 (2.8) kg, representing a large statistically significant increase (SMD = 1.306, P < 0.0005). There was no correlation, however, between mean incremental energy intake and GWG (r = 0.321, P = 0.11).

Only 1 study (18 women, BMI 21.7kg/m²) reported a mean increase in energy intake in line with pregnancy guidelines, that is 1,700 kJ/day (GWG 11.4 [3.7] kg). There was no difference in incremental energy intake across BMI groupings. In contrast, GWG differed significantly among the BMI groups, with a downward trend in weight gain as BMI increased. The largest effect was seen in the underweight group (SMD = 1.751.658, P < 0.0005, n = 1), followed by normal weight (SMD = 1.448, P < 0.0005, n = 16) and overweight (SMD = 1.245, P < 0.0005, n = 4). The smallest GWG was seen in the obese women (SMD = 0.0845, P < 0.0005, n = 5), where all interventions were aimed at reducing

GWG. Despite this, the inverse relationship between mean BMI and GWG did not reach statistical significance ($r = -0.363$, $P = 0.068$).

Comments

Risk of bias and quality

Evidence analysis manual: steps in the academy: evidence analysis process was used.

Of the 18 studies that met inclusion criteria, 2 obtained a positive quality rating and 16 were neutral.

Confounding factors

Stratified by developed and developing countries, BMI (under-weight, normal, overweight, and obese), study design (observational and RCT).

Limitations (from the authors)

The authors noted the following limitations:

- most studies were observational in nature and therefore susceptible to the effects of bias and confounding, as well as the potential for measurement error and under or over reporting of dietary intake
- only articles published after 1990 were included because they were deemed more applicable to current context of high prevalence of overweight and obesity at the time of conception

AMSTAR2 overall confidence rating

Critically low.

AMSTAR2 additional confidence rating

Critically low.

Lamminpää and others (2018)

Title

‘A systematic review of dietary interventions for gestational weight gain and gestational diabetes in overweight and obese pregnant women’.

Study design

Systematic review.

Funding

Finnish Foundation for Nurse Education and the Finnish Cultural Foundation for RL as research grants.

Declaration of interest

All authors declare that they have no conflict of interest.

Methods

Aim

To review studies that reported results related to the efficacy of dietary interventions on GWG or the prevention of GDM in overweight and obese women.

Search criteria

Search dates

2000 to March 2016.

Search design

12 randomised controlled trials and 3 controlled trials.

Language

English language only.

Population

Overweight (BMI ≥ 25) or obese (BMI ≥ 30) pregnant women. Mostly, the overweight and obese pregnant women were recruited to the intervention before the 20th gestational week (n = 10 studies) or during the 1st trimester of pregnancy (n = 5 studies).

Intervention or exposure and comparators

Dietary intervention or an intervention including a dietary component compared with a control group.

Primary outcomes

The primary outcomes were:

- GWG
- GDM

Statistical analyses

Not applicable.

Included studies

Number of studies

There were 15 studies, of which:

- 3 trials reported on diet-only interventions
- 2 trials reported on diet and PA interventions separately
- 10 trials reported on diet and PA interventions combined

Number of participants

The number of participants were as follows:

- n = 3,411 (15 studies)
- n = 379 (3 studies)

Age of participants

Not reported.

Countries

The included studies were conducted in the following countries:

- Australia (20% n=3)
- USA (20% n=3)
- Denmark (20% n=3)

- UK (n=2)
- Belgium (n=2)
- Italy (n=1)
- Sweden (n=1)

Ethnicity of population

Not reported.

BMI category

BMI category was 25kg/m² or higher.

Intervention or exposure

Dietary intervention compared with a control group.

Six studies used food records or diaries as the dietary assessment method; 2 studies used a food frequency questionnaire (FFQ); and 2 studies used 24-hour recall. Two studies used logs for the women to report their food consumption, and an audit of items consumed was used in 1 study.

Eight studies included a specified diet with limited amounts of allowed nutrients or energy in the dietary intervention. The remaining 7 studies used a strategy including dietary advice or counselling related to healthy eating and a healthy diet during pregnancy mostly based on the National Nutritional Recommendations.

The counselling was provided by a nutritionist or a dietitian in most of the studies.

The counselling was provided individually in 7 studies, in groups in 3 studies and both individually and in groups in 3 studies. In 2 studies, the mode of delivering advice was not clearly described. In addition to the individual or group sessions providing dietary advice or the counselling, some of the studies reported giving written material for the women to support the process, containing information related to healthy food, nutrition and benefits to avoiding excessive weight gain.

Main results

There were 3 studies with dietary interventions or interventions with a dietary component that were effective without physical activity. The effective interventions consisted of an

inclusion of a dietitian or a nutritionist, but the interventions mainly delivered by a midwife or a lifestyle or health coach had impacts on the outcomes.

In the 5 studies reporting no significant differences between the intervention and control groups, the study designs were similar to those in which the intervention was found to be effective. Two of the non-effective interventions did not include a specified diet, but dietary advice was included, and 2 studies did not include physical activity.

One study reported that the interventions were effective with overweight women but not obese women and another study reported the opposite results. Other studies did not report any significant differences when participants were stratified by BMI category as overweight vs. obese women.

Comments

Risk of bias and quality

Agency for Healthcare Research and Quality (AHRQ) Methods Reference Guide for Effectiveness and Comparative Effectiveness Reviews quality assessment tool was used. AHRQ was generally good, and there were no differences in the efficacy of the interventions in relation to the assessed quality of the study regardless of whether it was graded as A or B.

Confounding factors

Not reported.

Limitations (from the authors)

The authors noted the following limitations:

- the exclusion of studies written in languages other than English, which may cause a minor publication bias
- the exclusion of pilot studies may have slightly reduced the number of studies included in this review; however, this exclusion is related to the quality of the review
- the search did not encompass grey literature (for example theses, conference proceedings and so on), which may cause some bias in the results of this review
- in the search and the selection of the articles for this review the behaviour change technique taxonomy was not used to help in categorising the interventions or components used in the studies, which could have provided clearer results in this

review. Instead, each study was carefully screened to determine the type and components of the dietary intervention used

AMSTAR 2 overall confidence rating

Critically low.

AMSTAR 2 additional confidence rating

Low.

Ota and others (2015)

Title

‘Antenatal dietary education and supplementation to increase energy and protein intake’.

Study design

Systematic review with meta-analysis.

Funding

National Institute for Health Research through Cochrane Infrastructure funding to Cochrane Pregnancy and Childbirth.

Declaration of interest

None known.

Methods

Aim

To assess the effects of education during pregnancy to increase energy and protein intake, or of actual energy and protein supplementation, on energy and protein intake, and the effect on maternal and infant health outcomes.

Search criteria

Search dates

Inception to 31 January 2015.

Search design

RCTs with randomisation at either the individual or cluster level. Quasi-randomised trials and cross-over trials not included.

Language

No language restrictions.

Population

All pregnant women with no systemic illness. Seven trials were conducted in an economically disadvantaged area including under-nourished populations; the other 10 trials included well-nourished populations.

Intervention or exposure and comparators

For assessing dietary education to increase energy and protein intake, RCTs of such education were included, whether administered on a one-to-one basis or to groups of women. For assessing dietary supplementation: RCTs of energy and protein supplementation, with or without placebo.

Primary outcomes

The primary outcomes were as follows:

- perinatal mortality (defined by trialists)
- stillbirth (death after 20 weeks' gestation and before birth)
- neonatal death (death of a live infant within the first 28 days of life)

Secondary outcomes**Maternal outcomes**

Pre-eclampsia (defined by trialists), energy intake (kilocalorie (kcal) per day), protein intake (g per day), GWG (kg), duration of labour (hours), mode of birth, number of antenatal hospital admissions, exclusive breastfeeding at 6 months (defined by trialists).

Fetal or infant outcomes

Birthweight (g), small-for-gestational weight (defined by trialists), low birthweight (less than 2500g), macrosomia (birthweight more than 4kg and birth injury), birth length (cm), birth head circumference (cm), neurological development, preterm birth (prior to 37 weeks' gestation), respiratory distress syndrome, admission to neonatal intensive care unit, chronic lung disease, periventricular leukomalacia, intraventricular haemorrhage,

necrotising enterocolitis, retinopathy of prematurity, child growth (weight, height, head circumference, BMI).

Child outcomes

Child growth (weight, height, head circumference, BMI) and neurological development.

Statistical analyses

Fixed effects model.

Heterogeneity

Tau², I² and Chi² statistics. Heterogeneity was regarded as substantial if the I² was greater than 30% and either the Tau² was greater than zero, or there was a low P value (less than 0.10) in the Chi² test for heterogeneity.

Publication bias

Funnel plots where there were more than 10 studies. If asymmetry was suggested by a visual assessment, exploratory analyses were performed to investigate this.

Sensitivity and meta-regression analyses performed

Sensitivity analyses were carried out to explore the effects of fixed-effect or random-effects analyses for outcomes with statistical heterogeneity.

Included studies

Number of studies

There were 17 studies, of which 2 reported on GWG with nutritional education during pregnancy versus no nutritional education, and 9 reported on GWG with balanced protein and energy supplementation versus control or no intervention in pregnancy.

Number of participants

The number of participants were as follows:

- n = 9,030 (17 studies)
- n = 233 (2 studies)
- n = 2,391 (9 studies)

Age of participants

Not reported.

Countries

Seven trials were from high-income countries such as the USA and UK, and 10 trials from low- and middle-income countries such as Gambia, Taiwan, India, Burkina Faso, Greece, Indonesia, Colombia, South Africa, Ghana and Bangladesh.

Ethnicity of population

Not reported.

BMI category

Not reported.

Intervention or exposure

Specific nutritional education to increase dietary energy and protein intake versus no nutritional education or a different form of consultation.

Balanced energy and protein supplementation versus no 'balanced energy and protein' supplementation or placebo. The types of supplements included those that were 'balanced' energy and protein supplements (that is an energy supplement in which less than 25% of the energy is from protein).

High-protein supplements versus low- or no protein supplements (that is an energy supplement in which more than 25% of the energy is from protein).

Iso-caloric protein supplements versus the protein replacing an equal quantity of non-protein energy (that is a supplement in which the protein content is 'balanced', and provides less than 25% of total energy content, but the protein replaced an equal quantity of non-protein energy in the control group).

Main results

The results of total GWG for nutritional education during pregnancy versus no nutritional education (2 studies) were inconsistent and showed higher heterogeneity ($I^2 = 63\%$) – MD (random effects): -0.41 (95% CI -4.41 to 3.59). Heterogeneity: $\text{Tau}^2 = 5.93$; $\text{Chi}^2 = 2.72$, $df = 1$ ($P=0.1$); $I^2 = 63.27\%$. Test for overall effect: $Z = 0.2$ ($P = 0.84$).

Balanced protein and energy supplementation versus control or no intervention in pregnancy led to no significant difference in weekly GWG (g/week) (MD: 18.63, 95% CI -

1.81 to 39.07). Heterogeneity: $\text{Tau}^2 = 441.14$; $\text{Chi}^2 = 18.41$, $\text{df} = 8$ ($P = 0.02$); $I^2 = 56.54\%$. Test for overall effect: $Z = 1.79$ ($P = 0.07$).

Comments

Risk of bias and quality

The Cochrane risk of bias tool and the GRADE approach were used.

Studies reporting on GWG after nutritional education during pregnancy were graded as very low quality (wide CI crossing the line of no effect, one study with design limitations, statistical heterogeneity ($I^2 > 60\%$)).

Studies reporting on GWG after balanced protein and energy supplementation were graded as very low quality (most studies contributing data had design limitations, wide CI crossing the line of no effect, statistical heterogeneity ($I^2 = 57\%$)).

The overall risk of bias was unclear.

Confounding factors

Group (cluster) randomisation of study subjects was taken into account. Preference was given to cluster adjusted values provided by the study. If study results were not adjusted for cluster randomisation, models were adjusted by using an estimate of the intra-cluster correlation co-efficient reported in the literature.

Limitations (from the authors)

Although the authors' views varied, it was decided to accept the final conclusions after extensive discussion and reaching a consensus. Carrying out reviews, however, may require a number of subjective judgements, and it is possible that a different review team may have reached different decisions regarding the assessments of eligibility and risks of bias.

AMSTAR 2 overall confidence rating

Moderate.

AMSTAR 2 additional confidence rating

Moderate.

Pari-Keener and others (2020)

Title

‘Maternal and infant health outcomes associated with medical nutrition therapy by registered dietitian nutritionists in pregnant women with malnutrition: an evidence analysis center systematic review’.

Study design

Systematic review.

Funding

Academy of Nutrition and Dietetics and the Women’s Health Dietetic Practice Group.

Declaration of interest

No potential conflict of interest was reported by the authors.

Methods

Aim

To evaluate maternal and infant outcomes affected by medical nutrition therapy with a registered dietitian nutritionists (RDNs) among pregnant women with malnutrition.

Search criteria

Search dates

2000 to 2014.

Search design

RCTs or clinical controlled studies.

Language

English.

Population

Pregnant women with malnutrition. Mean maternal age between 15 and 55 years of age (non- adolescent or older women).

Intervention or exposure and comparators

Medical nutrition therapy delivered by a RDN in pregnant women compared with a control group which ranged from standard pre-natal care to medical records of women who completed groups sessions.

Primary outcomes

The primary outcomes were as follows:

- GWG
- markers of glycaemic control (that is glucose, oral glucose tolerance test, insulin use)
- maternal complications (that is GDM, hypertensive disorders of pregnancy such as preeclampsia or eclampsia, hypertension, caesarean section, birth weight in grams, birth weight in clinical categories, preterm delivery and gestational age)
- infant illnesses or complications (that is perinatal mortality, neonatal intensive care unit admissions, congenital malformations rate)

Statistical analyses

Not applicable.

Included studies**Number of studies**

There were 5 studies, of which 4 reported on the effects of medical nutrition therapy on GWG.

Number of participants

The number of participants were as follows:

- n = 2,959 (5 studies)
- n = 2,765 (4 studies)

Age of participants

Not reported.

Countries

The included studies were conducted in the following countries:

- USA: 2
- Australia: 1
- Denmark: 1

Ethnicity of population

Not reported.

BMI category

Mixed.

Intervention or exposure

Medical nutrition therapy (MNT) delivered by a registered RDN. Interventions all included dietary advice provided by an RDN but the nature of the interventions varied widely including providing standardised dietary and physical activity recommendations, 2 sessions with an RDN plus telephone calls by trained people, intensive MNT, individualised plans plus group therapy, and physical activity plus low-fat Mediterranean diet instructions.

Main results

There was consistent evidence in 3 studies that medical nutrition therapy provided by a RDN can help lower maternal GWG in women of mixed BMI status or overweight or obese, although 1 study found no significant difference in GWG between the intervention and control groups among pregnant women who were overweight or obese.

Comments

Risk of bias and quality

Quality Criteria Checklist was used.

The overall strength of the available evidence was scored as grade I (good or strong) for GWG.

Confounding factors

Not reported.

Limitations (from the authors)

The authors noted the following limitations:

- this review consisted of only 6 controlled trials on the effects on medical nutrition therapy by a RDN in studies over an almost 2-decade period, 2000-2019. Although the majority of studies were graded as positive quality, this number limits the ability to translate findings to clinical and policy guidelines
- heterogeneity in the populations assessed, types of interventions, and inconsistency in outcomes examined further limited the results of this review
- subjects included those with mixed BMI status, overweight or obese, with diabetes mellitus or GDM
- although the aim was to include all studies which incorporated medical nutrition therapy for malnutrition during pregnancy, no studies of undernourished pregnant women were identified, as these were more likely to be included as part of supplementation trials and not medical nutrition therapy
- although the studies included in this review were conducted in multiple global regions, the training and educational requirements for the RDN credential may vary widely and hence, may have contributed to variation in study results

AMSTAR2 overall confidence rating

Critically low.

AMSTAR2 additional confidence rating

Critically low.

Quinlivan and others (2011)

Title

‘Antenatal dietary interventions in obese pregnant women to restrict gestational weight gain to institute of medicine recommendations’.

Study design

Systematic review with meta-analysis.

Funding

Not reported.

Declaration of interest

The authors did not report any potential conflicts of interest.

Methods

Aim

To estimate whether antenatal dietary interventions restrict maternal weight gain in obese pregnant women without compromising newborn birth weight.

Search criteria

Search dates

Not reported to March 2011.

Search design

RCTs.

Language

No language restrictions were places on the search.

Population

Pregnant women who were overweight (BMI ≥ 25) or obese (BMI ≥ 30) at booking.

Intervention or exposure and comparators

Antenatal dietary interventions compared with a control group who did not receive the intervention.

Primary outcome

The primary outcome was GWG (total GWG calculated as the difference between the body weight at the time of enrolment and the weight just before delivery).

Secondary outcome

The secondary outcome was birth weight of newborn.

Statistical analyses

Random effects model.

Heterogeneity

Maximum likelihood estimator method.

Publication bias

Funnel plot using the fill and trim method. Begg's rank correlation method and Eggar regression method.

Sensitivity and meta-regression analyses performed

Pooled treatment estimates were calculated after removal of one trial each time from the list of trials.

Included studies**Number of studies**

There were 4 studies.

Number of participants

n = 537.

Age of participants

Not reported.

Countries

The included studies were conducted in the following countries:

- Denmark: 1
- USA: 1
- Belgium: 1
- Australia: 1

Ethnicity of population

Not reported.

BMI category

BMI category was 25kg/m² or higher.

Intervention or exposure

Antenatal dietary interventions compared with a control group who did not receive the intervention.

Main results

The results suggested that there was a significant pooled treatment effect ($z = 11.58$, $P < 0.001$) with a WMD of -6.5kg (95% CI -7.6 to -5.4kg) using weights in proportion to the inverse of variance. These results suggested that dietary intervention programs, on the whole, were significantly effective in reducing the total GWG by approximately 6.5kg. This meant that weight gain in pregnancy matched the IOM recommendations. Results obtained from the model diagnostics using both the Begg's and Eggar regression methods suggested no significant publication bias ($t = 0.68$, $P = 0.565$).

Comments**Risk of bias and quality**

Not reported

Confounding factors

It was noted that 2 of the 4 studies did not adjust for any variables, whilst one adjusted for: maternal age, parity, body weight, and height, and the other adjusted for: age, pregravid BMI, parity, race, social isolation, and gestational age.

Limitations (from the authors)

Not reported.

AMSTAR2 overall confidence rating

Critically low.

AMSTAR2 additional confidence rating

Critically low.

Shieh and others (2018)

Title

'Intervention strategies for preventing excessive GWG: systematic review and meta-analysis'.

Study design

Systematic review with meta-analysis.

Funding

Indiana University School of Nursing Center for Enhancing Quality of Life for Chronic Disease and release time support by the IUPUI Office of the Executive Vice Chancellor and Chief Academic Officer.

Declaration of interest

That authors have no conflict of interest to declare.

Methods

Aim

To analyse (1) healthy eating and physical activity strategies, particularly relevant to calorie intake and calories from macronutrients and (2) effects of healthy eating and/or physical activity on GWG.

Search criteria

Search dates

Not reported to 30 June 2016.

Search design

RCTs.

Language

English.

Population

Healthy overweight and/or obese pregnant adult women (in all RCTs, participants were enrolled by 28 weeks of gestation).

Intervention or exposure and comparators

Exercise, diet or both as the intervention with RCT design.

Primary outcomes

The primary outcome was GWG.

Statistical analyses

Random effects model.

Heterogeneity

I^2 statistic was calculated. An I^2 greater than 50% was considered high heterogeneity.

Publication bias

Not reported.

Sensitivity and meta-regression analyses performed

Not reported.

Included studies**Number of studies**

There were 23 studies, of which 4 were healthy eating only RCTs included in the meta-analysis.

Number of participants

n = 6,920 (21 studies in meta-analysis).

Age of participants

Not reported.

Countries

The included studies were conducted in the following countries:

- Brazil: 1

- Australia: 1
- USA: 1
- Denmark: 1

Ethnicity of population

Not reported.

BMI category

BMI category was 25kg/m² or higher.

Intervention or exposure

Healthy eating only RCTs.

Main results

Four healthy eating only RCTs demonstrated a significant reduction in GWG among women receiving the intervention as compared to women receiving no intervention (mean weight difference: -5.77kg, 95% CI: -9.34 to -2.21, $p = 0.002$). Heterogeneity, however, was high ($I^2 = 97\%$). Of the 4 healthy eating RCTs, 3 showed significant outcomes on GWG reduction. Quinlivan and others also included weighing pregnant women in each parental visit which was not routinely done in the country where the study was conducted and integrated their intervention in prenatal care. They found that women in the intervention group decreased carbonated drinks and juices and consumption of fast food. Thornton and others and Wolff and others included daily calories and macronutrient goals in their trials. Thornton and others found that women who adhered to the nutrition protocol had lower GWG than those who had poor compliance. Women receiving healthy eating intervention conducted by Wolff and others demonstrated a significantly lower fat intake than women in the control group.

Healthy eating daily calories: 5 RCTs identified: 2 out of the 5 cover diet interventions only.

Healthy eating daily macronutrients: 6 RCTs identified: 3 out of the 6 cover diet interventions only.

Comments

Risk of bias and quality

Cochrane risk of bias tool was used.

Sixteen RCTs were rated as adequate for concealment of allocation and completeness of follow-up. Eight RCTs were adequate for blinding and for non-selective reporting. Twenty RCTs presented no other bias relevant to group differences in baseline. Overall, 19 RCTs were rated as having moderate risk for reporting bias, 2 were rated as low risk and 2 were rated as high risk. The 4 healthy eating only trials were all rated as moderate risk.

Confounding factors

One of the 4 relevant studies adjusted daily calorie need based on body weight: 18 to 24 kcal/kg/day or $\geq 2,000$ kcal/day.

One of the 4 relevant studies adjusted calories by physical activity and gestational weeks.

Limitations (from the authors)

The authors noted the following limitations:

- the review did not include pregnant women with under-weight or normal-weight, and therefore strategies for GWG management found in the current review may not be applicable to these women
- only 10 RCTs provided last weight measure at delivery. Variation in total GWG among RCTs therefore is related to gestational weeks when the last body weight was assessed. GWG in this review may not reflect the GWG for the whole pregnancy

AMSTAR2 overall confidence rating

Critically low.

AMSTAR2 additional confidence rating

Critically low.

Streuling and others (2011)

Title

‘Weight gain and dietary intake during pregnancy in industrialized countries - a systematic review of observational studies’.

Study design

Systematic review.

Funding

German Federal Ministry of education and research.

Declaration of interest

None of the authors had a conflict of interest.

Methods

Aim

To gain more evidence on whether diets with lower caloric or protein content or other diets might be associated with lower GWG.

Search criteria

Search dates

Not reported to November 2009.

Search design

Observational studies published in population-based or hospital-based cohorts in industrialised countries.

Language

English or German.

Population

Healthy women having singleton pregnancies.

Intervention or exposure and comparators

Studies reporting associations between diet and GWG.

Primary outcomes

The primary outcomes were as follows:

- association between energy intake and GWG
- association between GWG and: protein intake, animal lipids, energy density, number of different food servings per day, carbohydrates intake and vegetarian diet

Statistical analyses

Not applicable

Included studies**Number of studies**

There were 12 studies.

Number of participants

n = 6,649 (12 studies).

Age of participants

Not reported.

Countries

The included studies were conducted in the following countries:

- USA: 9
- Germany: 1
- Sweden: 1
- Iceland: 1

Ethnicity of population

Not reported.

BMI category

Not reported.

Intervention or exposure

Studies reporting associations between diet and GWG. The majority of studies defined GWG as the difference between the maternal weight at her last visit to the prenatal care centre and (mostly self-reported) pre-pregnancy weight. Four studies assessed dietary habits by semi-quantitative FFQs, also asking for information on portion size, 2 used food records and 5 relied on recall methods. One study used dietary records and recall methods. Nutritional intake was assessed at least once or repeatedly at different points in

time and assessed food intake over time periods of different length. Some studies assessed intake of specific nutrients, for example protein, fat and carbohydrates or the intake of individual foods or food groups. Except for 2 studies, food consumption was directly converted into some measure of energy intake.

Main results

Significantly ($P < 0.05$) positive associations between energy intake and GWG were reported in 5 studies, 3 of them adjusted for confounders, whereas in 3 others (2 adjusted) no significant association was found. All 3 studies which assessed protein intake reported positive associations with GWG - in 2 of them (1 with adjustment), these associations were significant. Further significant associations of GWG were reported with respect to animal lipids, energy density, number of different food servings per day - all of them associated with higher GWG; carbohydrates and vegetarian diet - both associated with lower GWG; with all but 1 of these studies having adjusted for confounders.

Comments

Risk of bias and quality

Not reported.

Confounding factors

Six studies adjusted for confounders, whereas the other 6 did not.

Limitations (from the authors)

The authors noted the following limitations:

- unfortunately, the studies identified varied considerably with respect to dietary assessment and definition of GWG, so that it wasn't possible to provide a summary effect estimate
- publication bias also could not be assessed, since conventional approaches like funnel plots require comparable measures for the strength of the association

AMSTAR2 overall confidence rating

Critically low.

AMSTAR2 additional confidence rating

Critically low.

Syngelaki and others (2019)

Title

‘Diet and exercise for preeclampsia prevention in overweight and obese pregnant women: systematic review and meta-analysis’.

Study design

Systematic review with meta-analysis.

Funding

Fetal Medicine Foundation (Charity No: 1037116).

Declaration of interest

The authors report no conflict of interest.

Methods

Aim

To investigate the effect of diet and/or exercise in overweight or obese pregnant women on the risk of preeclampsia.

Search criteria

Search dates

Inception to November 2017.

Search design

RCTs.

Language

No language restrictions.

Population

Overweight or obese pregnant women.

Intervention or exposure and comparators

Dietary or exercise interventions with RCT design.

Diet alone, exercise alone or a combination of diet and exercise.

Primary outcomes

The primary outcome was preeclampsia.

Secondary outcomes

The secondary outcome was hypertensive disorders of pregnancy.

Authors also examined the primary and secondary outcomes in relation to GWG.

Statistical analyses

Random effects model.

Heterogeneity

Higgin's I^2 and considered high if over 50%.

Publication bias

Funnel plots.

Sensitivity and meta-regression analyses performed

Subgroup analyses were performed to evaluate the effect of the type of intervention: diet only, exercise only or diet and exercise together. Meta regression weighted by the size of the studies was performed to evaluate the association of GWG and the risk of preeclampsia and hypertensive disorder.

Included studies**Number of studies**

There were 23 studies, of which 14 assessed GWG in response to diet interventions.

Number of participants

The number of participants were as follows:

- $n = 7,236$ (23 studies)
- $n = 4,927$ (14 studies)

Age of participants

Not reported.

Countries

The included studies were conducted in the following countries:

- USA: 6
- Australia: 2
- Italy: 2
- Belgium: 2
- UK: 1
- Denmark: 1

Ethnicity of population

Not reported.

BMI category

BMI category was 25kg/m² or higher.

Intervention or exposure

Effects of dietary interventions on gestational weight.

Main results

Forest plot of GWG, comparison between intervention vs control groups, diet only subgroup: MD: -1.56 (95% CI: -2.14 to -0.99). Test for overall effect: $Z = 5.36$ ($p < 0.00001$); Heterogeneity: $I^2 = 91\%$.

Comments

Risk of bias and quality

PRISMA tool and Cochrane risk of bias tool were used.

Most studies were considered to be at low risk of bias for random sequence allocation and incomplete outcome data but at high risk for blinding of participant and personnel.

Analysis of the funnel plots suggests the possibility of publication bias or low methodological quality of smaller studies because small asymmetry of the right.

Confounding factors

Not reported.

Limitations (from the authors)

The authors noted the following limitations:

- the definition of the intervention varied across the trials and a pragmatic approach was taken of accepting the definition used in each study
- only 1 of the included trials was powered to examine the effect of diet and/or exercise in reducing the risk of preeclampsia; in all other trials preeclampsia was a secondary rather than primary outcome
- an essential element in randomised trials is the adherence to the study intervention and unlike interventions such as supervised exercise, interventions focused on diet cannot provide information to allow assessment of the influence of adherence on the potential beneficial effect of diet on pregnancy outcome. Similarly, the extent to which stricter diets can affect pregnancy outcome remains unclear

AMSTAR 2 overall confidence rating

Critically low.

AMSTAR 2 additional confidence rating

Critically low.

United States Department of Agriculture 2020 Dietary Guidelines Advisory Committee: Pregnancy and Lactation Subcommittee

Title

‘Frequency of eating during pregnancy and gestational weight gain: a systematic review’.

Study design

Systematic review without meta-analysis.

Funding

United States Department of Agriculture, Food and Nutrition Service, Center for Nutrition Policy and Promotion, Alexandria, VA.

Declaration of interest

Members of the 2020 Committee were appointed as SGEs. SGEs are selected based on recognised expertise or expert knowledge relevant to the Committee. In contrast, none of the members was appointed as Representative Members, who are individuals appointed for the purpose of presenting the points of view of outside interest groups or stakeholders.

USDA ethics officials conducted an annual review of each Committee member's OGE Form 450 to manage potential conflicts of interest throughout the proceedings. USDA ethics officials provided ethics training on 2 occasions to members of the 2020 Committee.

The approaches the Committee used to examine the evidence - systematic reviews, data analyses, and food pattern modelling - are rigorous, objective, and protocol driven, and are designed to minimise bias. Protocols for each question being addressed were developed before examining any evidence and were presented at the Committee's meetings and posted to DietaryGuidelines.gov, providing transparency to the public throughout the Committee's deliberations.

The review of evidence was not based on any one member's expertise, nor were the final decisions for the scientific evaluation reached on an individual-by-individual basis. The Committee's review of the evidence was completed in a collaborative manner. The Committee came to its conclusions and advice to USDA and HHS together.

Methods

Aim

To investigate the relationship between the frequency of eating during pregnancy and GWG.

Search criteria

Search dates

January 2000 to 17 September 2019.

Search design

Randomised controlled trials (RCTs), non-randomised controlled trials, prospective and retrospective cohort studies, and nested case-control studies.

Language

English.

Population

Pregnant women who were generally healthy.

Intervention or exposure and comparators

Frequency of eating (number of daily eating occurrences).

Comparator: different number of daily eating occasions.

Primary outcomes

The primary outcomes were as follows:

- change in maternal body weight from baseline (before or during pregnancy) to a later time point during pregnancy and/or right before delivery
- maternal body weight gain in relationship to weight gain recommendations, based on pre-pregnancy BMI

Statistical analyses

Not applicable (no evidence identified).

Publication bias

Not applicable (no evidence identified).

Sensitivity and meta-regression analyses performed

Not applicable (no evidence identified).

Included studies**Number of studies**

Not applicable (no evidence identified).

Number of participants

Not applicable (no evidence identified).

Age of participants

Not applicable (no evidence identified).

Countries

Not applicable (no evidence identified).

Ethnicity of population

Not applicable (no evidence identified).

BMI category

Not applicable (no evidence identified).

Intervention or exposure

Not applicable (no evidence identified).

Main results

Not applicable (no evidence identified).

Comments**Risk of bias and quality**

Not applicable (no evidence identified).

Confounding factors

Not applicable (no evidence identified).

Limitations (from the authors)

Not applicable (no evidence identified).

AMSTAR2 overall confidence rating

High.

AMSTAR 2 additional confidence rating

High.

Zhang and others (2018)

Title

‘Effects of low-glycemic-index diets in pregnancy on maternal and newborn outcomes in pregnant women: a meta-analysis of randomized controlled trials’.

Study design

Systematic review with meta-analysis.

Funding

Not reported.

Declaration of interest

Irma Silva-Zolezzi is employee of Nestlé Research Center, Lausanne. Gerard Vinyes Parés and Yi Wang are employees of Nestlé Research Center Beijing. The authors state that there is no conflict of interest.

Methods**Aim**

To examine the effects of low-GI diets on maternal and newborn outcomes.

Search criteria**Search dates**

Not reported to January 2016.

Search design

RCTs.

Language

English language.

Population

Pregnant women (18 years or above, with a singleton pregnancy) regardless of their health status.

Intervention or exposure and comparators

Intervention (more than 4 weeks) was low-GI diet with dietary GI level and control or comparison group. The dietary GI ranged from 47 to 71 (median 50.4) in the intervention groups and from 48.6 to 84 (median 57.7) in the control groups. Dietary intervention was initially conducted from 12.9 to 30.1 weeks of gestation, and 5 trials continued the intervention until delivery. Nine trials measured the dietary intake by using 3-day diet records, and other 2 used 24 hour dietary recalls. Most participants in the control group received healthy eating diet advice.

Primary outcomes**Maternal outcomes included the following**

GWG, fasting blood glucose, 2-h postprandial glucose, glycated Hb A1c (HbA1c), gestational age at delivery, proportion of pregnant women who use insulin, and proportion of caesarean delivery.

Newborn outcomes included the following

Birth weight, ponderal index, head circumference, body length, abdominal circumference, proportion of large for gestational age (LGA; birth weight more than 90th centile), small for gestational age (birth weight less than 10th centile), macrosomia (birth weight more than 4kg), prematurity, birth centile, and birthweight centile.

Statistical analyses

A random-effects model was used when $P < 0.10$ at the Q test; otherwise, a fixed-effects model was applied.

Heterogeneity

Cochran's Q test at the $P < 0.10$ level of significance, and I^2 statistic.

Publication bias

Begg's funnel plots and the Egger's regression test.

Sensitivity and meta-regression analyses performed

Subgroup analyses using stratified outcomes from ≥ 8 trials. Sensitivity analysis by omitting one trial in each turn.

Included studies

Number of studies

There were 11 studies, of which 9 reported GWG.

Number of participants

The number of participants were as follows:

- n = 1,985 (11 studies)
- n = 1,840 (9 studies)

Age of participants

Mean age ranged from 29.9 to 34.7 years (11 studies).

Countries

The included studies were conducted in the following countries:

- Australia: 5
- USA: 2
- China: 1
- Ireland: 1

Ethnicity of population

Not reported.

BMI category

Mean BMI ranged from 21.5 to 32.4kg/m² (11 studies).

Intervention or exposure

Interventions were low-GI diets.

Main results

Low-GI diets produced somewhat lower GWG (WMD = -0.69kg, 95 % CI: -1.74, 0.36, n = 9) than control diets without significant difference. $I^2 = 53.8\%$ ($p=0.027$). In subgroup

analyses the significant decrease in GWG by low-GI diets was observed when the analysis was limited to trials with a GI difference ≥ 7 . When the study of Moses and others was excluded, reduced GWG became significant (WMD = -0.99kg, 95 % CI: -1.95, -0.03) without heterogeneity across the studies ($P = 0.122$, $I^2 = 38.6\%$).

Comments

Risk of bias and quality

Jadad score was used. The Jadad scores ranged from 1 to 4.

No publication bias was found for GWG as assessed by Begg's funnel plot and Egger's test.

Confounding factors

Not reported.

Limitations (from the authors)

The authors noted the following limitations:

- considerable heterogeneity across studies
- most included RCTs used an open-label design. As such, blinding of the treatment to the participants or investigator is difficult, perhaps impossible, because of the nature of dietary intervention or advice design
- regarding intervention, these RCTs differed in values of dietary GI and sometimes in co-interventions. For example, all participants in the Clapp study participated in an exercise program before and after pregnancy, which may reinforce the effect of the dietary intervention. On the other hand, 3 studies declared that low-GI diets for intervention were supported or supplied by relevant companies
- different criteria for screening and diagnosis of GDM, start of counselling in first or second trimester, and frequency of counselling that varied from twice only to weekly during pregnancy
- the SDs of the net changes were not available in some trials. SDs were derived from the standard errors, median and interquartile ranges, or standard deviations for the initial and final values. These methods employed may not be ideal and result in some inaccuracies

AMSTAR2 overall confidence rating

Critically low.

AMSTAR2 additional confidence rating

Critically low.