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PREGNANCY/WEIGHT GAIN

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A meta-review of systematic reviews of lifestyle interventions for reducing gestational weight gain in women with overweight or obesity

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Summary

Women with overweight or obesity are twice as likely to gain excessive gestational weight than women of normal weight. Identifying effective interventions to support this group achieve healthy gestational weight gain is important. An overview of systematic reviews regarding the effectiveness of lifestyle interventions on gestational weight gain in women with overweight or obesity was undertaken, including searching eight electronic databases. Quality of included reviews was assessed by two independent researchers. A narrative data synthesis was undertaken, with subgroup and sensitivity analyses by type of intervention and quality of the included reviews. A total of 15 systematic reviews were included within this meta-review. A small reduction in gestational weight gain of between 0.3 and 2.4 kg was noted with lifestyle interventions compared with standard care. There was some evidence that dietary only or physical activity only interventions may reduce the odds of gestational diabetes. No differences were noted in the odds of other maternal or infant health outcomes. Although lifestyle interventions appeared to decrease gestational weight gain, current evidence does not show a clear benefit on maternal and infant outcomes from the small nature of the reduction in gestational weight gain produced by lifestyle interventions in women with overweight or obesity.

KEYWORDS
gestational weight gain, healthy lifestyle, maternal obesity

1 | BACKGROUND

Overweight (body mass index [BMI] ≥ 25 kg/m^2) and obesity (BMI ≥ 30 kg/m^2) are estimated to affect 38% of women globally.[1] Managing the consequences of obesity presents an economic burden to global healthcare services, with overweight- and obesity-related healthcare costs estimated to reach 425 billion U.S. dollars a year across the 52 countries within the Organisation for Economic Co-operation and Development (OECD), European Union, and G20.[2] Data from 37 U.K. maternity units indicate first trimester maternal

Abbreviations: AMSTAR-2, Assessment of Multiple Systematic Reviews v2; BMI, body mass index; CI, confidence interval; DARE, Database of Abstracts of Reviews of Effects; GDM, gestational diabetes mellitus; GWG, gestational weight gain; IOM, Institute of Medicine; LGA, large for gestational age; NICE, National Institute for Health and Care Excellence; RCT, randomized controlled trial; SGA, small for gestational age.

obesity has more than doubled over the last 2 decades,[3] with similar trends also noted elsewhere in the world.[4] Raised BMI is associated with increased short- and long-term adverse outcomes for mothers such as increased risk of maternal mortality, pregnancy induced hypertension, gestational diabetes, primary postpartum hemorrhage, and interventional birth.[5–7] For babies, there are additional risks of stillbirth, large for gestational age, admission to neonatal units, and neonatal mortality.[6–10]

A number of systematic reviews[11,12] have evaluated interventions designed to control weight gain in pregnancy among the general pregnancy population, with various results. Women with overweight or obesity are twice as likely to gain excessive gestational weight than women with a BMI in the normal range,[13] therefore establishing effective interventions for this group is particularly important.

National Institute for Health and Care Excellence (NICE) guidelines[14,15] emphasize the importance of limiting gestational weight gain (GWG) by healthy eating and physical activity. However, they highlight insufficient robust evidence in this area, particularly on ideal GWG or effective strategies to encourage healthy GWG. The Institute of Medicine (IOM) has recommended weight gain ranges according to pre-pregnancy BMI category, including 7–11.5 kg for women with overweight and 5–9 kg for women with obesity.[16] However, their review of the evidence was based on a mixture of study designs including observational projects that were not consistently of a high quality, statistically powered, prospective, controlled trial nature. Limiting GWG in women with overweight or obesity is viewed as important due to the multiple risks associated with excessive weight gain.[17] Pregnant women and their healthcare providers require clear guidance around GWG and appropriate interventions to achieve healthy pregnancy and birth outcomes. Systematic reviews originally evolved within healthcare due to the large volume of primary research making decision making for policy makers and practitioners difficult, especially in the face of contradictory evidence.[18,19] As systematic reviews are increasingly published, clinicians again can be left feeling overwhelmed by the plethora of evidence; therefore, the requirement for overviews of reviews is increasingly recognized, which can compare and contrast current systematic reviews and provide an overall body of available information on a given topic.[18] Given the rising number of systematic reviews in this area, a systematic synthesis of current reviews was deemed imperative to provide an overall body of evidence that evaluates the most appropriate interventions for assisting women with overweight or obesity to avoid excessive GWG.

1.1 | Review question

What is the extent of systematic evidence regarding the effectiveness of lifestyle interventions on GWG in women with overweight or obesity? Lifestyle interventions include dietary interventions, physical activity, or a combination of both.

2 | METHODS

2.1 | Search strategy

The review was undertaken in accordance with the pre-published protocol in PROSPERO CRD42019156883. A systematic search was conducted in CINAHL, MEDLINE, Maternal and Infant Health, PsycInfo, Scopus, Database of Abstracts of Reviews of Effects (DARE), Prospero and the Cochrane Library. The search strategy included search terms and index headings around "pregnancy," "lifestyle interventions," "obesity," and "systematic review." Table S1 provides an example of the full search. References of included systematic reviews and other relevant literature were searched for further relevant citations. Databases were searched from inception. Initial searches were undertaken in December 2019 and updated on April 30, 2020, prior to the final analysis. Studies were limited to those published in the English language.

2.2 | Study selection and data extraction

Studies were screened for inclusion against the following inclusion criteria; systematic reviews that only included randomized controlled trial (RCT) evidence; reviews compared antenatal lifestyle interventions, including dietary, physical activity, or a combination of dietary and physical activity interventions to standard antenatal care; the review focused exclusively on women with overweight and/or obesity or reported this as a subgroup and the review reported our primary outcome of GWG. Interventions exclusively undertaken during the pre-conception or postnatal periods were excluded. Studies were limited to those where the full text version of the review could be obtained, with authors of protocols and conference abstracts contacted regarding full text availability. All citations were screened for inclusion by title and abstract by one reviewer. A random sample of 10% of retrieved citations were screened by a second researcher. Two independent researchers screened the full text of potentially relevant citations, with consensus over inclusion agreed through discussion.

Two researchers used a pre-defined data extraction tool to extract: author, date of publication, type of intervention, number of trials, number of women included, and review outcomes. All RCTs included within the systematic reviews were obtained for clarification of the results, due to discrepancies discovered between the results of included reviews. Authors of the original trials and systematic reviews were contacted where necessary for clarification.

2.3 | Risk of bias assessment

Included systematic reviews were assessed by two researchers for risk of bias using the Assessment of Multiple Systematic Reviews v2 (AMSTAR-2) checklist[20] (Table S2 contains the full checklist). Where

there was disagreement in the scoring, consensus was reached through discussion. To assess confidence in the results, we considered eight AMSTAR-2 domains as critical. These were item 2: review methods established prior to conducting the review; item 4: comprehensive literature search; item 6: data extraction in duplicate; item 9: risk of bias satisfactory assessed; item 11: appropriate methods for statistically combining results; item 12: impact of risk of bias on meta-analysis results considered; item 13: risk of bias considered when interpreting/discussing review results; and item 14: heterogeneity of included studies discussed. An overall rating of confidence in the results of each review, of high, moderate, low, or critically low, was given. This depended on the presence of flaws in the above critical domains or other weakness within the systematic review.

The quality of the primary RCTs, as judged by the authors of the included systematic reviews, was taken into consideration, particularly random sequence generation, allocation concealment, and attrition bias.

2.4 | Outcomes

The primary outcome for this overview of reviews was GWG. Secondary outcomes included adherence to IOM weight gain recommendations[16]; gestational diabetes (GDM), pre-eclampsia, cesarean section, and preterm birth (prior to 37 weeks gestation); birthweight, large for gestational age (LGA), small for gestational age (SGA), macrosomia (birthweight >4000 g), and low birthweight (birthweight <2500 g); changes in dietary intake; and changes in physical activity outcomes.

2.5 | Data synthesis

A meta-synthesis using statistical methods[21] was planned if the percentage of the variability in the effect estimate due to heterogeneity rather than sampling error calculated using I^2 was ≤50%. It is recognized that I^2 values of 50%–90% may represent substantial heterogeneity and values of 75%–100% represents considerable heterogeneity.[22] As heterogeneity between studies was considerable within many included systematic reviews, a formal narrative analysis was undertaken.

Where individual primary studies were incorporated into multiple systematic reviews, the overlap was considered within the analysis. Any meta-analysis only analyzing a subset of RCTs present in another systematic review was excluded from the narrative synthesis.

Effect sizes within individual systematic reviews were converted to weighted mean differences with 95% confidence intervals (CI) for continuous outcomes and to odds ratios and 95% CI for categorical outcomes, to allow comparison between systematic reviews. The overall effect size, the number of studies that informed the outcome, the number of participants, and the percentage of variability in the effect estimate due to heterogeneity within each systematic review were reported.

To detect any evidence of small study effects (where small studies give substantially larger estimates of effect sizes than larger studies), Egger's regression asymmetry test was undertaken for continuous variables and Harbord-Egger's test for categorial variables,[23] for any outcome that included six or more RCTs. A more conservative effect size in the largest study (study with the smallest standard error) than in the random-effects model summary estimate alongside a p value in Egger's test <0.10 was regarded as indicative of small study effects.

To assess whether the observed number of studies with nominally significant results ($p < 0.05$) within a meta-analysis was larger than the expected number, the excess of significance test was undertaken.[24] An excess of significant findings within a meta-analysis can be an indication of publication bias, selective analysis or bias in outcome reporting, resulting in underpowered small studies with spurious significant findings more likely to be published within the field. The expected number of significant studies within a meta-analysis was calculated by summing the statistical power estimates for each study included within a meta-analysis. As the true effect size is not known, the effect size of the study with the smallest standard error was used to calculate the power of each study using Stata 15.1. Excess significance for each meta-analysis was considered if p was <0.10 using the binomial probability test.

A "Summary of Findings" table was produced using the GRADE approach.[25] This considers risk of bias, inconsistency, indirectness, imprecision, small study effects, and reporting bias. An overall grade of high, moderate, low, or very low was assigned to reflect confidence in the evidence for each outcome.

2.6 | Analysis of subgroups

Subgroup and sensitivity analyses were planned "a priori" for different types of interventions: dietary only, physical activity only, or combined lifestyle interventions and for reviews where a rating of high overall confidence in the results was achieved on the AMSTAR-2.

3 | RESULTS

A total of 3416 citations were identified (Figure 1). After removing duplicates, 2512 citations were screened against inclusion criteria. The title and abstract of a subset of 265 citations were double screened, with over 98% agreement. Of the 75 full text articles screened, 16 (covering 15 separate reviews) were included.[12,26–40] Table S3 provides reasons for exclusion at full text.

3.1 | Characteristics of included systematic reviews

Characteristics of the included systematic reviews are given in Table 1. The systematic reviews were published between 2010 and

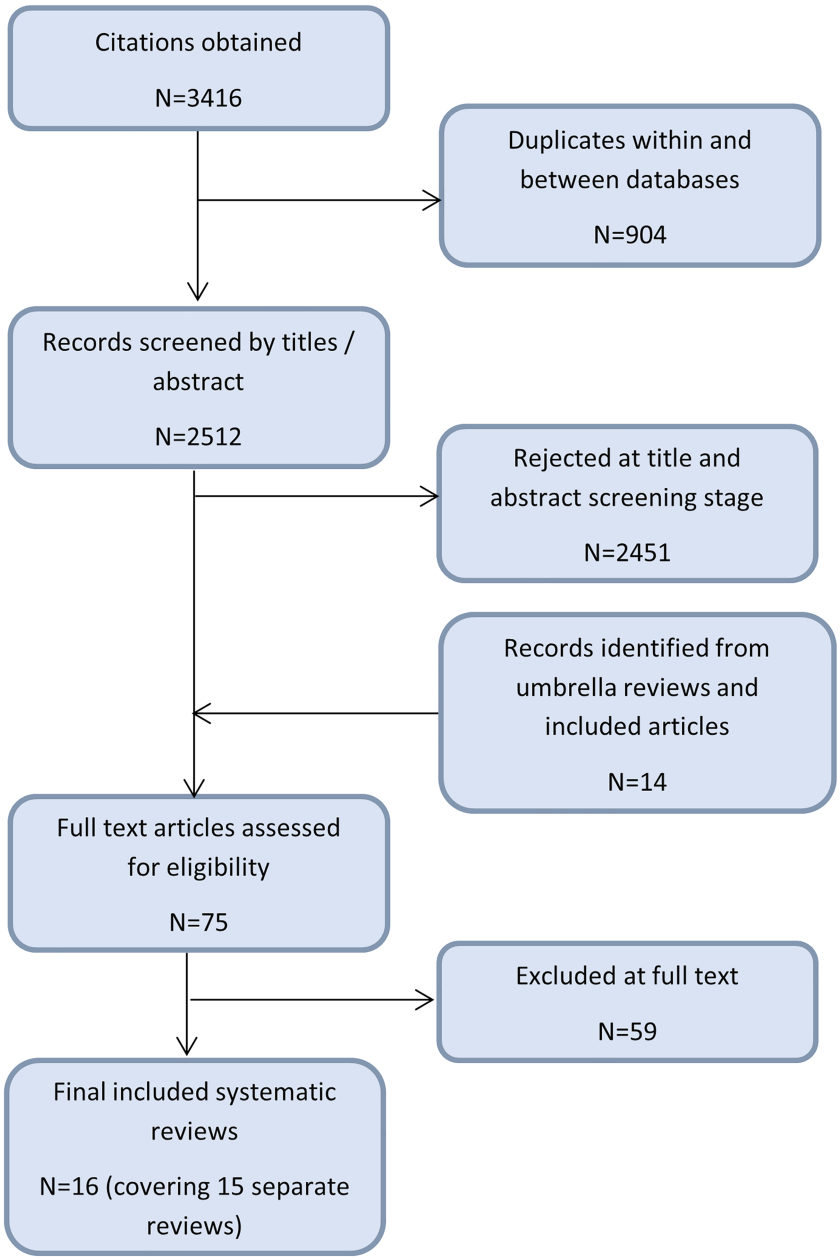

FIGURE 1 Flowchart of study selection

2019, with the latest search within the included reviews run in January 2019.

Two included systematic reviews focused on dietary interventions, one exclusively so[34] and one on dietary interventions that may also include physical activity components.[31] Four reviews focused on physical activity interventions, two exclusively,[29,39] with one of these only looking at supervised physical activity,[39] and two at physical activity interventions that may also include dietary components.[27,30] One review included interventions with both dietary and exercise components,[26] and eight reviews included interventions with any physical activity or dietary lifestyle components,[12,28,32,33,36–37,40] with one looking exclusively at e-based interventions.[33]

All included systematic reviews had "usual or standard care" as the comparator; however the description of what constituted usual care within the studies in many systematic reviews was minimal.

The majority of reviews only included RCTs of women with overweight or obesity prior to pregnancy or when booking for antenatal care.[27–34,36,37,40] The other four reviews incorporated women of all BMIs but providing subgroup analysis for women with overweight or obesity.[12,26,38,39] Three reviews excluded RCTs that exclusively recruited women diagnosed with GDM,[27,31,38] and three reviews only incorporated women with singleton pregnancies.[29–31]

Some reviews included multiple primary outcomes. Primary outcomes included GWG or maternal weight changes,[12,27,29,33,34,36,38,40] GDM,[26,29] LGA or other infant growth outcomes,[12,26,28,39] pre-eclampsia,[32,37] mode of birth,[26] infant mortality/morbidity,[26,38] maternal morbidity,[38] physical activity outcome measures,[30,33] dietary intake,[33,36] and methodological design of the studies.[31]

The systematic reviews incorporated between four[34] and 103 RCTs[38] in total or between two[30] and 32[40] RCTs that reported GWG

TABLE 1 Characteristics of included systematic reviews of randomized controlled trials evaluating the effect of lifestyle interventions on gestational weight gain and other pregnancy and birth outcomes

First author (year)	Primary outcome(s) of the review	Search Strategy	Risk of bias assessment tool Quality of included studies	Number of RCT total [number for overweight/obese subgroup and reporting GWG if different]	Participants [*n* = total number included in review (*o* = total number in GWG outcome for overweight/obese subgroup[a])] Intervention Control	Conclusions of SR
Bain et al. (2015)[26]	GDM, mode of birth, LGA and infant mortality	Four databases including trials register and references searched. Handsearching 30 journals, major conference proceedings, and weekly alerts from 44 journals No language or date restrictions Dates searched: Inception–Feb 2014	Cochrane Collaboration tool for assessing risk of bias Moderate risk of bias across all included trials	13 [3]	*Participants*: All pregnant women excluding pre-existing diabetes [*n* = 4983 (o = 1980)] *Intervention*: Combined diet and exercise interventions *Control*: No interventions (standard care)	Limited evidence for the effect of combined diet and exercise interventions on GDM or other outcomes such as GWG
Choi et al. (2013)[27]	Weight change in pregnancy or postpartum	Four databases and references searched Published in English or Korean Dates searched: Jan 2000–Dec 2011	Cochrane Collaboration tool for assessing risk of bias Risk of bias was judged to be mixed	11 [7]	*Participants*: WWOO [*n* = 1268 (*o* = 721)] *Intervention*: PA or PA plus diet *Control*: Usual care	Supervised PA with dietary advice was most effective for decreasing GWG, especially alongside goal setting
Dodd et al. (2010)[28]	LGA	Four databases including trials register and references searched No date or language restrictions Dates searched: Inception–Jan 2010	Cochrane Collaboration tool for assessing risk of bias Studies judged at mixed risk of bias—from poor to fair	9 [4]	*Participants*: WWOO [*n* = 743 (*o* = 416)] *Intervention*: AN dietary and/or lifestyle interventions *Control*: standard care	Unclear effect of providing AN lifestyle interventions for WWOO
Du et al. (2019)[29]	GWG and risk of GDM	Five databases including trials register searched English language only Dates searched: Inception to April 2018	Cochrane Collaboration tool for assessing risk of bias Risk of bias was judged to be mixed	13 [12]	*Participants*: WWOO (according to author definitions) [*n* = 1439 (o = 1158)] *Intervention*: Physical exercise in AN period (without dietary component) *Control*: Standard AN care or recommended not to undertake exercise	Prenatal exercise reduces GWG and GDM in pregnant WWOO

(Continues)

TABLE 1 (Continued)

First author (year)	Primary outcome(s) of the review	Search Strategy	Risk of bias assessment tool Quality of included studies	Number of RCT total [number for overweight/obese subgroup and reporting GWG if different]	Participants [*n* = total number included in review (*o* = total number in GWG outcome for overweight/obese subgroup[a])] Intervention Control	Conclusions of SR
Flannery et al. (2019)[30]	Change in physical activity level. The review also identified which BCTs were most frequently used	Eight databases and references searched English language only Studies excluded if only in the grey literature or no discernible BCT within the intervention Dates searched: Inception–Jan 2019	Cochrane Collaboration risk of bias assessment tool Overall high risk of bias	19 [3]	*Participants*: WWOO with singleton pregnancy [*n* = 5181 in largest meta-analysis (*o* = NR)] *Intervention*: At least one intervention component aimed at maintaining or increasing PA levels *Control*: Comparison interventions or usual care	PA interventions slightly increase PA in WWOO, however many studies were high risk of bias
Flynn et al. (2016)[31]	Methodological design of interventions	12 databases including trials registers and references searched English language only Dates searched: 1990–March 2015	Cochrane Collaboration tool to assess risk of bias Most studies mixed or low risk of bias, 2 studies high risk of bias	13	*Participants*: WWOO (including BMI ≥ 23 kg/m^2 if high risk ethnicity), excluding multiple pregnancies, or receiving interventions to treat GDM [*n* = 4276 (*o* = NR)] *Intervention*: Dietary or dietary and PA interventions *Control*: Standard AN care	There is considerable methodological variability in design, assessment, and outcomes evaluated in dietary interventions to control GWG in WWOO
Ho et al. (2012)[32]	Pre-eclampsia	Six databases including trials register and references searched. English language only Dates searched: 1970–May 2011	CASP RCT checklist and a modified version of the SIGN 50 checklist Two studies high quality, one low quality, and the others of mixed quality	6	*Participants*: WWOO (BMI ≥ 26 kg/m^2) [*n* = 867 (*o* = NR)] *Intervention*: AN weight management interventions (dietary, exercise, behavioral, or awareness-based interventions) *Control*: Routine care	No evidence that AN weight management interventions effectively reduce pre-eclampsia in WWOO
International Weight Management in	GWG and composite maternal and fetal/	Six databases including trials register and	Cochrane risk of bias tool	103 eligible studies of which 33 had	*Participants*: Pregnant women of normal	Diet and lifestyle interventions in

(Continues)

TABLE 1 (Continued)

First author (year)	Primary outcome(s) of the review	Search Strategy	Risk of bias assessment tool Quality of included studies	Number of RCT total [number for overweight/obese subgroup and reporting GWG if different]	Participants [*n* = total number included in review (*o* = total number in GWG outcome for overweight/obese subgroup[a])] Intervention Control	Conclusions of SR
Pregnancy Collaborative Group (2017)[38] Rogozińska et al. (2017)[35]	neonatal outcomes in subgroups of women (e.g., according to BMI, age, parity, ethnicity, and pre-existing medical conditions)	internet, and references searched. Contacted experts in the field No language restrictions Dates searched: 1990–Feb 2017	Mixed quality of studies	Individual Participant Data for GWG outcome [31]	BMI, or WWOO [*n* = 9320 with individual participant data for GWG outcome (*o* = 5909)] *Intervention*: Diet and/or PA interventions in pregnancy *Control*: Routine AN care	pregnancy reduce GWG in women with normal, overweight or obese BMI status
Lau et al (2017)[33]	GWG, postnatal weight change, moderate and vigorous PA and calorie intake	Seven databases, trial registries and references searched English Language only Dates searched: Inception–July 2016	Cochrane risk of bias tool Moderate to high risk of bias within included studies	14 [7]	*Participants*: WWOO [n=3169 (o=1636)] *Intervention*: E-based lifestyle interventions with at least one dietary, PA or weight management intervention *Control*: minimal intervention or usual care	E-based interventions limited GWG – especially e-based interventions with additional contact in person/by phone/ both. However considerable intervention variability
Quinlivan et al. (2011)[34]	GWG	Two databases including trial register and references searched No date or language restrictions Dates searched: Inception–March 2011	Not reported	4	*Participants*: WWOO [*n* = 537 (*o* = 537)] *Intervention*: Dietary interventions *Control*: standard care	AN dietary interventions can reduced GWG in pregnant WWOO without effecting newborn weight
Shieh et al. (2018)[36]	GWG and calorie/ macronutrient intake	Five databases and references searched English language only Dates searched: Inception–June 2016	Risk of bias based on Cochrane risk of bias tool Two studies were low risk, 19 moderate, and two high risk of bias	23 [21 compared to routine care not different intervention type]	*Participants*: WWOO [*n* = 7056 (*o* = 6473)] *Intervention*: Healthy eating and/or PA interventions *Control*: usual care	Healthy eating interventions with/or without PA are effective at limiting GWG, especially when including clear goal setting
Syngelaki et al. (2019)[37]	Pre-eclampsia and hypertensive disorders	Five databases including trials register and references searched No language restrictions	Cochrane handbook used to assess risk of bias Risk of bias was judged to be mixed	23 [18]	*Participants*: WWOO [*n* = 7236 (*o* = 5117] *Intervention*: Diet and/or exercise	Diet and exercise are effective at reducing GWG in WWOO, but do not reduce the risk

(Continues)

TABLE 1 (Continued)

First author (year)	Primary outcome(s) of the review	Search Strategy	Risk of bias assessment tool Quality of included studies	Number of RCT total [number for overweight/obese subgroup and reporting GWG if different]	Participants [*n* = total number included in review (*o* = total number in GWG outcome for overweight/obese subgroup[a])] Intervention Control	Conclusions of SR
		Dates searched: Inception–November 2017			*Control*: "expectant management"	of pre-eclampsia or hypertensive disorders
Thangaratinam et al. (2012)[12]	Weight related changes for mother and infant	13 databases including trial registers searched No language restrictions Dates searched: Inception to Jan 2012	Examines: allocation concealment, sequence generation, blinding, incomplete outcome data, selective reporting and other potential biases Studies were of mixed quality	44 [11]	*Participants*: Women with normal BMI or WWOO [*n* = 7278 (*o* = 2149)] *Intervention*: Any dietary or lifestyle intervention with potential to influence maternal or fetal weight or pregnancy outcomes *Control*: Only described as "control"	Dietary and lifestyle interventions can improve pregnancy outcomes and reduce GWG, with dietary interventions most effective for women of all BMIs
Wiebe et al. (2015)[39]	Neonatal size at birth (birthweight, small at birth and large at birth)	Six databases including trials register and references searched No language restrictions Dates searched: Inception–Jan 2015	Jadad Scale (and allocation concealment as recommended by Cochrane Collaboration) Studies were at moderate to high risk of bias	28 [3]	*Participants*: Women of all BMIs [*n* = 5322 (*o* = 439)] *Intervention*: Supervised prenatal exercise (minimum of one exercise session with study personnel every 2 weeks throughout intervention) *Control*: standard care	Additional research in WWOO is warranted
Yeo et al (2017)[40]	GWG	Three databases and references searched Restricted to the last 10 years Dates searched: January 2005–June 2016	Consolidated Standards of Reporting Trials statement and Cochrane Collaboration tool for assessing risk of bias Studies were of mixed risk of bias	32	*Participants*: WWOO [*n* = 5869 (*o* = 5418)] *Intervention*: Lifestyle interventions targeting GWG initiated prior to the 3rd trimester *Control*: Only described as "control"	WWOO have greater success meeting GWG targets when prenatal care providers deliver nutrition or PA counsel

Abbreviations: AN, antenatal; BCT, behavior change techniques; BMI, body mass index; GDM, gestational diabetes; GWG, gestational weight gain; LGA, large for gestational age; NR, not reported; PA, physical activity; WWOO, women with overweight or obesity.

[a]Overweight taken as BMI = 25.0–29.9 kg/m^2 and obesity as BMI ≥ 30 kg/m^2 unless otherwise stated.

in women with overweight and/or obesity. Between 416[28] and 6473[36] participants with overweight or obesity and for whom GWG was reported were included within the reviews. The individual studies reporting outcomes were not clearly identified within the analysis in one review.[38] A total of 56 different trials reporting outcomes in women with overweight or obesity were included within the other systematic reviews. The vast majority of these were undertaken in very high human development countries[41]: 17 in the United States, 12 in Australia, three in Canada and Demark, two in Belgium, Ireland, Italy, the Netherlands, Spain, and the United Kingdom, and one in Finland, New Zealand, and Norway. One further study was undertaken across different European countries. Just five studies were undertaken in high human development countries: two in Brazil, one in China, one in Egypt, and one in Colombia and none in medium or low human development countries.

The RCTs within the included systematic reviews incorporated a diverse range of interventions. Many RCTs included more than one dietary component. These included calorie restriction, with some personalizing targets according to pre-pregnancy weight but others providing uniform advice; macronutrient goals; replacing carbohydrates with lower glycemic foods; reducing fat or cholesterol intake; increasing beneficial food intake such as fruit, vegetables, fiber, fish, and vegetable oils; providing meal plans and/or recipes; portion size advice; information on how to check nutrition labels; eating out options; limiting or swapping high energy snacks for healthy alternatives; eating a Mediterranean style diet; advice on adjusting dietary intake to activity levels and dietary supplements of vitamins and trace elements. Some interventions were delivered through written information but most involved counselling sessions, either individually or as a group. Counselling could be provided by dieticians, nutritionists, health coaches, or other healthcare professionals, through between one and 16 sessions, lasting from 5 min to 2 h. Many interventions encouraged women to set goals to change their diet or provided logs to self-monitor diet.

Physical activity interventions were similarly diverse. Physical activity was either supervised or unsupervised, with some interventions combining the two. Supervised sessions included aerobic training, such as dance, treadmill walking or stationary cycling, or resistance training such as pelvic floor or large muscle training or a combination of both aerobic and resistance training. Some interventions determined exercise intensity through heart rate monitoring, while others used self-perceived exertion. Structured programs varied from once a month to five times a week throughout pregnancy in sessions lasting up to 60 min, with an estimated 85 sessions in one RCT. Unsupervised physical activity interventions included being encouraged to "be active," for example, walking more by not driving short distances; discussions around increasing physical activity; individual exercise plans with time and/or frequency goals; providing an exercise DVD or video; step count monitors; provision of treadmills or home cycles or 6 months free gym membership. Some women were given logs to self-monitor physical activity and some interventions used social learning theory to promote change. Physical activity interventions were delivered through written information; face-to-face contact either individually or in a group; telephone contact; or e-based contact such as websites, applications, texts, email, Facebook groups, or support forums. Contact was daily in some studies, for example, via text messages.

Combined interventions incorporated aspects from both diet and physical activity. Of the 33 RCTs deemed within the systematic reviews to have incorporated combined interventions, eight focused mainly on diet and six mainly on physical activity with the others having an equal emphasis. Weight management was reported as an element of 18 interventions. Self-monitoring of weight gain was the exclusive focus of one RCT and an aspect incorporated into three further RCTs. Provider monitoring and feedback around GWG was a feature of a further four RCTs. Relatively few trials incorporated psychosocial factors as part of their intervention, with one RCT each incorporating stress management, anxiety management, or management of emotional binge eating. A further five RCTs were reported to use other behavioral strategies, for example, identification of barriers, problem solving, using social support, or increasing self-efficacy.

3.2 | Methodological quality of systematic reviews

Table 2 provides AMSTAR-2 quality assessment scores. Four reviews[27,28,34,36] did not explicitly report that review methods were established prior to conducting the review, and a further five[12,31,32,39,40] only partially reported elements of their protocol or the protocol was not reported to be registered. One review[33] was noted to have unjustified protocol violations, as several included trials incorporated women without overweight or obesity, so was also considered to have a critical flaw within this domain.

Only three reviews[12,31,38] were judged to have undertaken a fully comprehensive literature search. All of the other reviews partially met the criteria due to none reporting consulting with experts in the field; some also did not report searching trial registries[27,30,36,40] or searching references of included studies or other relevant literature.[29] Two reviews[34,37] did not report undertaking data extraction in duplicate.

All reviews that included meta-analysis justified its use and undertook appropriate methods. All but one review[34] reported adequately assessing the risk of bias within included studies. However, of those that undertook meta-analysis, seven reviews[27–29,34,36,37,40] did not report assessing the impact of risk of bias within the included studies on the results of the meta-analysis, for example, through sensitivity analysis. Furthermore, five reviews[27,32,34,36,37] did not discuss the likely impact of risk of bias within included studies when interpreting or discussing the reviews' results. Only one review[34] was judged to provide inadequate exploration, explanation, and discussion around heterogeneity.

Overall confidence in the results of the review was rated as high for three reviews,[26,30,31] moderate for three reviews,[12,38,39] low for four reviews,[29,32,33,40] and critically low for five reviews.[27,28,34,36,37]

TABLE 2 AMSTAR-2 checklist assessment for each included systematic review

Item study	1	2[a]	3	4[a]	5	6[a]	7	8	9[a]	10	11[a]	12[a]	13[a]	14[a]	15	16	Overall confidence in the results of the review
Bain et al. (2015)[26]	✓	✓	X	/	✓	✓	✓	✓	✓	X	✓	✓	✓	✓	✓	✓	High
Choi et al. (2013)[27]	✓	X	✓	/	✓	✓	✓	✓	✓	X	✓	X	X	✓	✓	✓	Critically low
Dodd et al. (2010)[28]	✓	X	X	/	✓	✓	X	✓	✓	X	✓	X	✓	✓	X	✓	Critically low
Du et al. (2019)[29]	✓	✓	X	/	✓	✓	/	✓	✓	X	✓	X	✓	✓	X	X	Low
Flannery et al. (2019)[30]	✓	✓	X	/	✓	✓	/	✓	✓	X	✓	✓	✓	✓	✓	✓	High
Flynn et al. (2016)[31]	✓	/	X	✓	✓	✓	/	✓	✓	X	NA	NA	✓	✓	NA	✓	High
Ho et al. (2012)[32]	✓	/	✓	/	NR	✓	/	✓	✓	X	NA	NA	X	✓	NA	✓	Low
I-WIP (2017)[38]	✓	✓	✓	✓	✓	✓	/	/	✓	X	✓	✓	✓	✓	✓	✓	Moderate
Lau et al. (2017)[33]	✓	X	X	/	✓	✓	/	✓	✓	X	✓	✓	✓	✓	✓	✓	Low
Quinlivan et al. (2011)[34]	✓	X	X	/	✓	NR	X	/	X	X	✓	X	X	X	✓	✓	Critically low
Shieh et al. (2018)[36]	✓	X	✓	/	✓	✓	/	/	✓	X	✓	X	X	✓	X	✓	Critically low
Syngelaki et al. (2019)[37]	✓	✓	X	/	✓	NR	X	/	✓	X	✓	X	X	✓	✓	✓	Critically low
Thangaratinam et al. (2012)[12]	✓	/	X	✓	✓	✓	/	/	✓	X	✓	✓	✓	✓	✓	✓	Moderate
Wiebe et al. (2015)[39]	✓	/	X	/	✓	✓	/	✓	✓	X	✓	✓	✓	✓	X	✓	Moderate
Yeo et al. (2017)[40]	✓	/	X	/	✓	✓	/	/	✓	X	✓	X	✓	✓	✓	✓	Low

Abbreviations: X, not met; /, partial yes; ✓, full yes; i-WIP, International Weight Management in Pregnancy Collaborative Group; NA, no meta-analysis; NR, not reported.

Note: Item 1: research question; item 2: protocol development; item 3: included study design explained, item 4: comprehensive literature search; item 5: study selection in duplicate; item 6: data extraction in duplicate; item 7: list of excluded studies; item8: included study description; item 9: risk of bias assessment; item 10: sources of funding of included studies; item 11: appropriate methods for statistically combining results; item 12: risk of bias impact on meta-analysis considered; item 13: risk of bias considered when interpreting/discussing results; item 14: heterogeneity of included studies discussed; item 15: publication bias assessment; item 16: author conflict of interest.

[a]Domains considered as critical.

3.3 | Risk of bias assessed within the reviews

As well as the quality of the systematic reviews, it is important to consider risk of bias within the included RCTs. Ten reviews assessed risk of bias using the Cochrane Collaboration risk of bias assessment tool, with a further review combining this with the Consolidating Standards of Reporting Trials statement.[40] Another review[12] did not report using a specific tool but assessed the same areas of bias as the Cochrane Collaboration risk of bias tool. One review[32] used the CASP RCT checklist, one the Jadad Scale,[39] and one review did not report undertaking any risk of bias assessment.[34] Most reviews judged their included studies to be of mixed quality, with one[30] judging them to be at high risk of bias.

Three reviews did not provide the scores attributed to individual studies.[12,37,39] However, scores for nine of the studies included in one of these reviews[12] were obtained from the full health technology review report by the same authors.[42] Individual risk of bias scores could not therefore be obtained for only one of the 56 included RCTs.[43] Where an RCT was incorporated into multiple reviews, the risk of bias judgements could vary widely. On overall risk of bias for each domain was therefore given according to the criteria in Table S4. Figure 2 provides the overall ratings for individual RCTs included in the reviews.

Out of 55 RCTs with reported risk assessment scores, the judgement of low risk of bias was made for random sequence generation in 40, allocation concealment in 22, attrition bias in

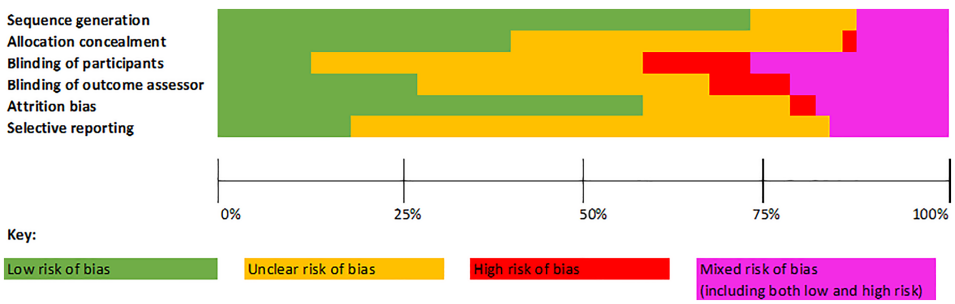

FIGURE 2 Combined risk of bias from the different systematic reviews across the 55 included RCTs

32, and selective reporting in only 10 included studies. Due to the nature of the intervention, blinding of participants was deemed not possible or inadequate across the majority of the reviews. Blinding of assessors was judged to be low risk of bias in just 15 RCTs. Other bias was reported to be high for four RCTs. This was due to baseline imbalances for one RCT within Ho et al.,[32] but no explicit reason was given for the other three judgements by review authors.

3.3.1 | Publication and excess of significance biases

Publication bias was considered by eight of the included reviews, two visually inspected for funnel plot asymmetry,[26,37] and the rest assessed funnel plot asymmetry alongside statistical tests, for example, Begg's, Egger's, and Peter's tests.[12,27,30,34,38,40] When assessing small study effects further within this overview of reviews, for meta-analyses with six or more included RCTs, statistical evidence ($p < 0.10$) suggested potential publication bias in four out of eight reviews within the GWG outcome,[29,36,38,40] one review reporting birthweight,[12] and both reviews with more than six RCTs reporting LGA.[12,29] Once considering this alongside a more conservative effect size in the largest study than the random-effects model summary estimate, concerns regarding small study effects only remained within two reviews[36,40] for the GWG outcome (Table S5).

When the overall effect size was assumed to be equal to the effect of the largest study, two meta-analyses had evidence of an excess of statistically significant studies ($p < 0.10$) for the GWG outcome[33,37] (Table S5). No evidence of excess of significant studies was observed within any other meta-analysis included within the reviews. Excess of significant findings alongside small study effects can provide evidence of selective reporting biases; however, no meta-analysis included in this overview indicated both small study effects and excess of significance. Small study effects and excess significance were however not calculated for outcomes reported narratively within reviews[30–32] and could not be calculated within one review[38] due to lack of clarity over included trials for each outcome.

3.4 | Synthesis of findings

3.4.1 | Gestational weight gain

All 15 systematic reviews included the outcome of GWG. Of these three[26,28,34] only included a subset of studies incorporated into a newer systematic review, so were excluded from the data synthesis for this outcome. Three further reviews[27,32,39] did not include any unique studies; however, all of their studies were not included as a subset within another systematic review, so remained within the data synthesis. It was not possible to evaluate the studies included within one review[38] as individual participant data were utilized. The other included systematic reviews incorporated 49 different RCTs, and 10,291 participants contributed to the analyses.

Three reviews provided a narrative synthesis of the results.[30–32] One review[30] reported GWG to be lower in the intervention than control groups in three of their included studies, of which one was noted to not exclusively recruit participants with overweight or obesity. Furthermore, it was unclear how many of their included studies reported this outcome but did not find a reduction in GWG. GWG was reported to be significantly lower in two of the six included studies within another review with narrative results[32] and nine of the 13 studies included within the other.[31] In this final review,[31] GWG was not significantly lower in the intervention group in the RCT that was not reported within other systematic reviews. A graphical representation of the results of the nine systematic reviews that undertook a meta-analysis can be seen in Figure 3, with full results provided in Table S5. Lifestyle interventions significantly reduced GWG in all but one included meta-analysis. The weighted mean difference in weight gain between control and intervention groups varied from −2.41 to −0.3 kg. The

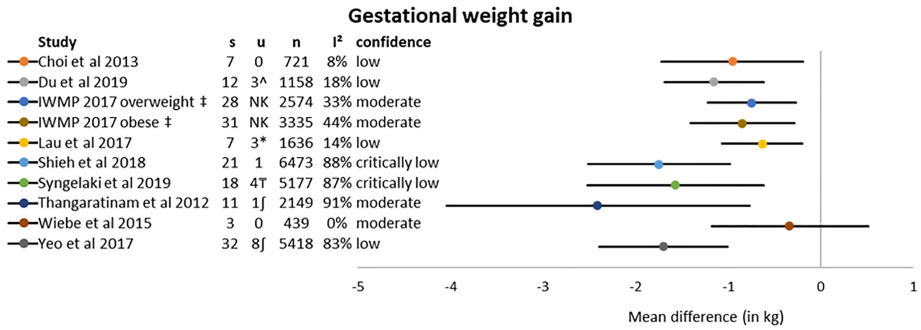

FIGURE 3 Graphical representation of gestational weight gain meta-analysis results. *s* = number of included studies, *u* = number of unique studies, *n* = number of participants, I^2 = percentage of variability in the effect estimate due to heterogeneity, confidence = AMSTAR-2 confidence in the results of the review. ^compares different arms in Renault et al.[44] to other reviews. ‡ adjusted for baseline weight and clustering effect. * this review was noted to include two RCTs that incorporated women of normal BMI, despite review inclusion criteria being exclusively women with overweight/obesity. compares different arms in Bogarts et al.[45] to other reviews. ∫ this review was noted to include 1 RCT in their overweight/obese meta-analysis that did not exclusively recruit participants with overweight/obesity

percentage of variability in the effect estimate due to heterogeneity was considerable within four included systematic reviews. Confidence in the findings of the systematic reviews was rated as low or critically low in seven included systematic reviews, moderate in three systematic reviews and high in two reviews that reported this outcome narratively.

Only one review considered adherence to IOM GWG guidelines.[38] Adherence to IOM guidelines was given as overall proportions rather than according to group allocation within trials. Within the overweight subgroup, 19% had GWG below recommendations, 29% within recommendations, and 51% over recommendations (n = 1245). Within the obese subgroup, 26% had a GWG below recommendations, 30% within recommendations, and 44% over recommendations (n = 1562).

3.4.2 | Dietary intake assessments

Three included reviews assessed changes in dietary intake.[32,33,36] Two reviews reported calorie intake.[33,36] Of the five included RCTs, four reported some reduction in calorie intake in the intervention group; however, they measured change in calorie intake at different time points including at 27–28 weeks, 32 and 36 weeks, over all three trimesters, and from study enrolment to 36 weeks. Neither of the two studies that assessed calorie intake at 15–18 weeks' gestation found differences at this timepoint.

Four out of five RCTs incorporated into two separate reviews[31,33] reported decreased energy intake from saturated fat in the intervention group. Six studies across two reviews[31,33] assessed intake of fruit and vegetables. Intake increased in both the intervention and control groups in one study and increased only in the intervention groups in the other five studies; however, one of these studies was noted not to have exclusively recruited women with a raised BMI. One review[31] also reported that sugar/fizzy drink consumption decreased in two studies and protein intake increased in two studies. In the two studies that assessed dietary fiber intake within that review,[31] one found increased consumption with the intervention, while the other found no difference.

3.4.3 | Physical activity assessments

Two included reviews assessed changes in physical activity.[30,33] One review[30] found no differences in step count between intervention and control groups in two included studies. Similarly, the other review[33] that included three studies found no differences in step count; however, out of these three studies it was noted that one recruited postnatal women and two studies did not exclusively recruit women with a raised BMI. One review[30] reported meta-analyses showing compared with the control group, intervention groups had increased metabolic equivalent (minutes/week) across eight studies and increased amount of oxygen used during exercise (VO_2 max) across two studies.

One review[33] reported no differences in the number of moderate to vigorous physical activity minutes per week between intervention and control groups when using either self-reported or an objective measure, SenseWear. However, the study using SenseWear technology was noted to include women with a BMI in the normal range not just those with overweight or obesity. Self-reported exercise was not significantly different between intervention and control groups in one review including four studies,[33] but was increased in another review[30] incorporating two studies. Both reviews however were noted to include studies for this outcome despite them not exclusively incorporating women with overweight or obesity.

3.4.4 | Maternal morbidity

Seven of the included systematic reviews reported the outcome of gestational diabetes (see Figure 4). One meta-analysis with low confidence in the findings[29] found physical activity interventions reduced the risk of GDM, and a second meta-analysis with moderate confidence in the findings[12] found dietary interventions reduced the risk of GDM. One review[30] reported narratively that GDM reduced in two included studies; however, it was not clear how many of their included studies reported this outcome but did not find a reduction in GDM; furthermore, one of the trials that reported a reduction in GDM with physical activity was noted to not exclusively recruit participants with overweight or obesity. None of the meta-analyses reporting any lifestyle intervention (dietary and/or physical activity) found a difference in risk of GDM between intervention and control groups.

For the outcome of pre-eclampsia, two systematic reviews only included a subgroup of trials included in a subsequent review,[28,33] so were not included in the analysis for this outcome. The remaining five meta-analyses found no evidence that lifestyle interventions impacted on the risk of pre-eclampsia for women with overweight or obesity. The review undertaking narrative analysis found none of their included studies reduced pre-eclampsia.

There was no evidence of an impact of lifestyle interventions in women with overweight or obesity on the incidence of cesarean section or preterm delivery.

3.4.5 | Infant outcomes

Eight systematic reviews included the outcome of birthweight. Of these three[26,28,34] only included a subset of studies incorporated into a newer systematic review, so were excluded from the data synthesis for this outcome.

A graphical representation of the results of the four systematic reviews that undertook a meta-analysis can be seen in Figure 5. Lifestyle interventions had no significant impact on birthweight. The weighted mean difference in birthweight between control and intervention groups varied from −40 to 10 g. The percentage of variability in the effect estimate due to heterogeneity was likely to be unimportant (0%–27%) within the included meta-analyses.

One review[31] also provided a narrative synthesis of results. They reported no difference between lifestyle intervention and control groups within 11 included studies and a significant increase in birthweight with lifestyle interventions in the remaining two studies.

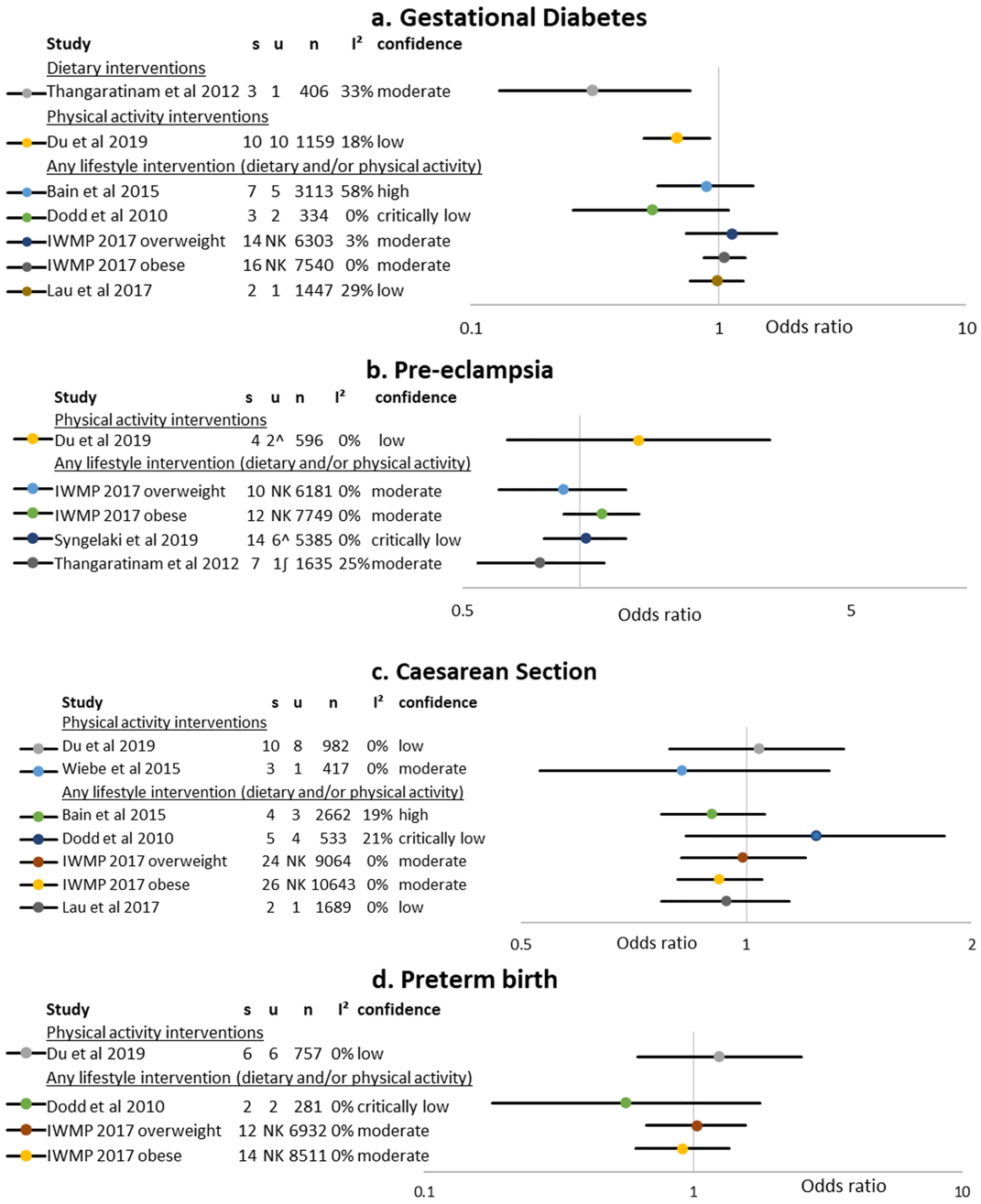

FIGURE 4 Graphical representation of other maternal outcomes (odds ratios with 95% confidence intervals) within included systematic reviews. *s* = number of included studies, *u* = number of unique studies, *n* = number of participants, I^2 = percentage of variability in the effect estimate due to heterogeneity, confidence = AMSTAR-2 confidence in the results of the review. ^Systematic reviews compared different arms of Renault et al.[44] within their meta-analyses, so taken as non-overlapping study. ∫ this review was noted to include one RCT in their overweight/obese meta-analysis that did not exclusively recruit participants with overweight/obesity

One of the included studies that showed a lack of significance was noted to actually report LGA and macrosomia, not birthweight. Confidence in the results of the systematic reviews was judged to be low within two meta-analyses, moderate within the other two meta-analyses, and high in the review reporting narrative results.

There was no evidence of an impact of lifestyle interventions in women with overweight or obesity on the incidence of macrosomia, LGA, low birthweight, or SGA (Figure 5).

3.5 | Subgroup and sensitivity analyses

3.5.1 | Subgroup analysis

Subgroup analysis by type of intervention, dietary only, physical activity only, or combined interventions incorporating both physical activity and dietary components was undertaken for the primary outcome GWG. Full results are given in Table S6. Physical activity

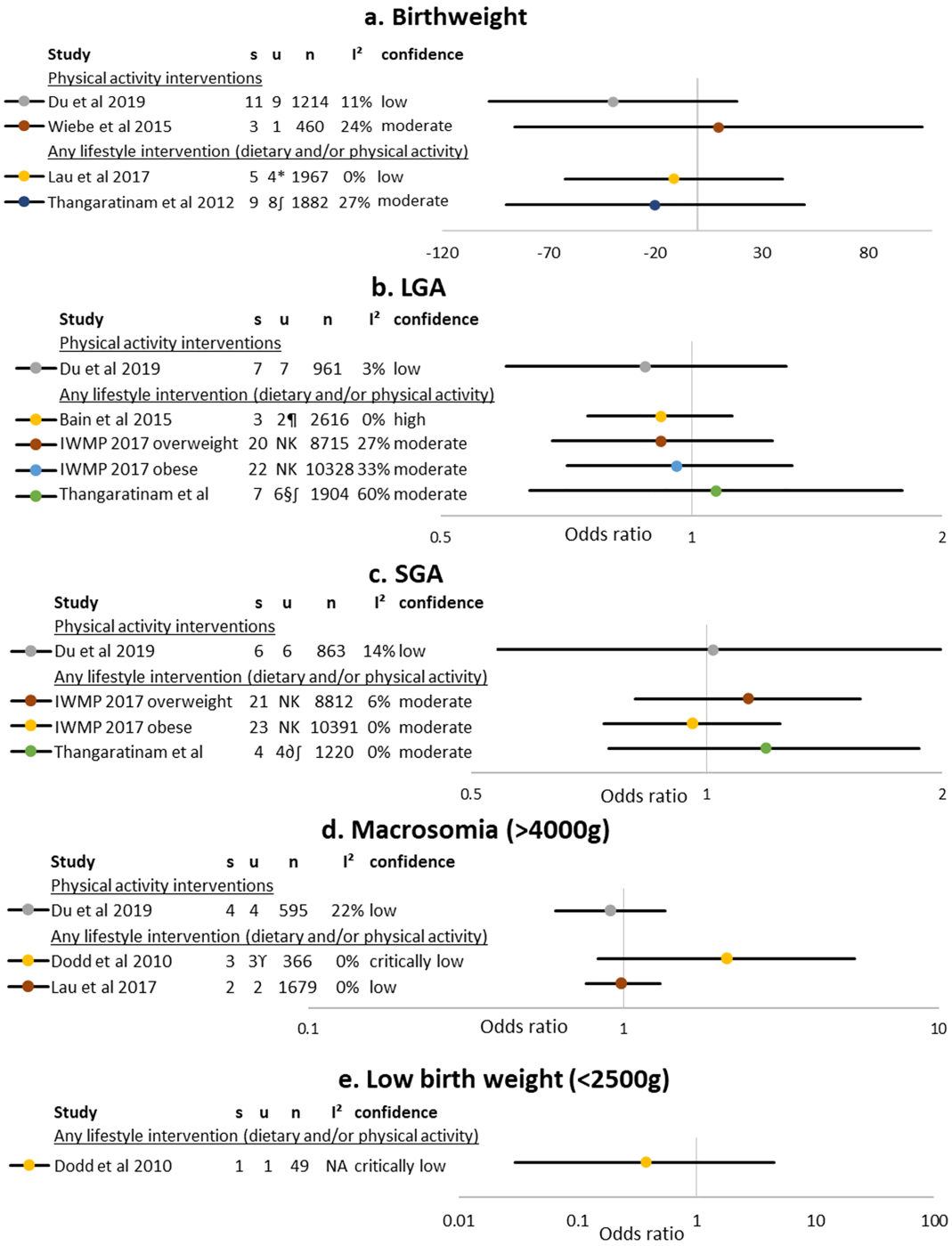

FIGURE 5 Graphical representation of birthweight and birthweight related outcomes within meta-analysis results within included systematic reviews. *s* = number of included studies, *u* = number of unique studies, *n* = number of participants, I^2 = percentage of variability in the effect estimate due to heterogeneity, confidence = AMSTAR-2 confidence in the results of the review. * this review was noted to include two RCTs that incorporated women of normal BMI, despite review inclusion criteria being exclusively women with overweight/obesity. ʃ this review was noted to include one RCT in their overweight/obese meta-analysis that did not exclusively recruit participants with overweight/obesity. ¶ one trial reported birthweight >4000 g not LGA. § Three included trials report birthweight >4000 g and one trial reported birthweight >4500 g rather than LGA. ∂ Three of the included trials report birthweight <2500 g not SGA. ϒ One trial reported birthweight >4500 g not >4000 g

only and combined interventions had varied results, with some reviews finding GWG to significantly decrease with the intervention compared with the control and other reviews not. Only for dietary interventions did the reviews unanimously find GWG to decrease in the intervention groups. These results should however be treated with caution, as it was noted there was a lack of consistency between the reviews over which subgroup an individual study belonged to, for example, some reviews would attribute an RCT to physical

intervention only, but others would attribute it to a combined intervention.

3.5.2 | Sensitivity analysis on AMSTAR quality

Overall confidence in the findings of the reviews was only judged to be high in three reviews.[26,30,31] All of these evaluated the impact of diet and/or physical activity interventions. The impact of lifestyle interventions on GWG was unclear within these reviews. In the two reviews[30,31] reporting narrative results GWG was reduced in some but not all included studies and in the review incorporating meta-analysis[26] GWG was not significantly lowered 0.28 kg (95% CI −1.13, 1.69, three studies, 1980 participants, I^2 = 43%).

3.6 | Strength of evidence

The strength of the evidence for each outcome was summarized using the GRADE approach. The overall certainty of evidence for each outcome, alongside reasons for downgrading the evidence, is recorded in Table 3. The strength of the evidence was judged to be low for pre-eclampsia, cesarean section and birthweight and very low for all other outcomes.

4 | DISCUSSION

A small reduction in GWG of between 0.3 and 2.4 kg with lifestyle interventions compared with standard care was noted within the included systematic reviews. However, overall certainty of this evidence is very low. This was due to concerns over risk of bias within both the included trials and the included systematic reviews, substantial heterogeneity within the included reviews, and potential small study effects within two reviews that were among those incorporating the largest number of trials. The small reduction in GWG is in line with the findings of a meta-analysis from a consortium of seven centers that undertook collaborative randomized trials of lifestyle interventions in women with overweight or obesity[46] and with a previous overview that found GWG was reduced with diet and physical activity interventions by between 0.7 and 1.8 kg for women of all BMI classes and by between 0.63 and 0.91 kg in a subgroup of women with overweight or obesity.[47] Our finding also agrees with the results of a recent RCT that was not within the included systematic reviews, which showed a small reduction in GWG but no impact on pregnancy and infant outcomes with partial meal replacement and encouragement to achieve 10,000 steps per day.[48] Due to the lack of reporting within the current systematic reviews, it was not possible to determine if this small reduction in gestational weight gain had any impact on the proportion of women with GWG within IOM recommendations. Further research is also required around the impact of this reduced GWG on weight retention postpartum, as weight gain during pregnancy is a well-recognized contributor to increasing maternal BMI over the childbearing years.[49]

Excess GWG has been associated with increased adverse pregnancy outcomes in observational studies.[50,51] Although GWG was significantly different in the meta-analyses undertaken within the majority of reviews, the small nature of the reduction did not appear to have a clear impact upon maternal and infant outcomes for women with overweight or obesity. For some outcomes, such as low birthweight, preterm birth, and pre-eclampsia with low incidences, this may be due to a lack of power within the current evidence; however, for other outcomes such as GDM, macrosomia, SGA, LGA, and cesarean section, at least some of the trials included within the meta-analyses were adequately powered to detect reductions in these outcomes. The lack of benefit on pregnancy or infant outcomes from lifestyle interventions noted within this overview of reviews was in line with a previous meta-analysis of intervention trials undertaken across a consortium.[46] Within this overview, only for the outcome of GDM was there evidence that dietary only interventions or physical activity only interventions may reduce the odds of GDM with the intervention compared with control. The lack of reduction in the incidence of macrosomia with lifestyle interventions within this overview contrasts with a previous overview of reviews that found a reduced incidence of macrosomia within a subgroup of women with overweight or obesity[47]; however, this current overview contains more systematic reviews incorporating a wider range of trials that the previous overview.

While no clear positive clinical outcomes have been demonstrated from undertaking lifestyle interventions during pregnancy within the subgroup of women with overweight or obesity, there was also no evidence of any adverse outcomes from restricting diet or undertaking physical activity, with SGA, low birthweight, and preterm delivery all showing no differences between those in the intervention and control groups.

A recent systematic review of six studies that incorporated cost estimates found lifestyle interventions aimed at limiting GWG were mainly not cost effective.[52] This was largely due to the lack of benefit across a range of clinical outcomes, which some studies may have been underpowered to detect. The analysis was also limited by the lack of studies reporting cost-effectiveness.[52] Furthermore, neither this overview of reviews nor the cost effective analysis could consider the impact of reduced GWG or improved maternal nutrient intake and exercise participation on important longer term benefits such as postpartum weight retention, maternal BMI at the start of a subsequent pregnancy, maternal psychosocial well-being, and long-term infant health due to lack of current evidence.

The impact of maternal diet during pregnancy on the long-term well-being of the infant is increasingly recognized, as the role of fetal-programming through epigenetics is increasingly understood.[53,54] The Mediterranean diet is considered one of the healthiest dietary patterns within the general population.[54] Limited studies within pregnant populations suggest that adherence to a Mediterranean style diet may reduce long term metabolic ill health in the offspring.[54] Furthermore, a recent trial of a low glycemic diet in women of all BMIs showed differential methylation in infants within the intervention and control groups.[55] Our understanding of the impact of maternal diet on human

TABLE 3 Summary of findings table for lifestyle interventions compared with standard care in pregnancy for women with overweight or obesity

Certainty assessment							Summary of findings
Systematic reviews reporting outcome	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Publication bias**	**Overall certainty of evidence**	**Impact**
Gestational weight gain							
9	Serious[a]	Serious[b]	Not serious	Not serious	Strongly suspected[c]	⨁◯◯◯ VERY LOW	Small reduction in gestational weight gain suggested, of between 0.3 and 2.4 kg with lifestyle interventions compared with standard care
Gestational diabetes (GDM)							
7	Serious[a]	Serious[d]	Not serious	Serious[e]	None	⨁◯◯◯ VERY LOW	Reduced odds of GDM were suggested in one systematic review of dietary only interventions and one systematic review of physical activity only interventions. There was no consistent reduction in GDM observed in women undertaking any lifestyle interventions (diet and/or physical activity) compared to standard care
Pre-eclampsia							
4	Serious[a]	Not serious	Not serious	Serious[e]	None	⨁⨁◯◯ LOW	No clear effect on the odds of pre-eclampsia in women undertaking lifestyle interventions compared to standard care
Cesarean section							
6	Serious[a]	Not serious	Not serious	Serious[e]	None	⨁⨁◯◯ LOW	No clear effect on the odds of cesarean delivery in women undertaking lifestyle interventions compared with standard care
Preterm delivery							
3	Serious[a]	Not serious	Not serious	Serious[e]	Other bias[f]	⨁◯◯◯ VERY LOW	No clear effect on the odds of preterm delivery in women undertaking lifestyle interventions compared with standard care
Birthweight							
4	Serious[a]	Not serious	Not serious	Serious[e]	None	⨁⨁◯◯ LOW	No clear effect on birthweight in infants of women undertaking lifestyle interventions compared with standard care
Macrosomia							
4	Serious[a]	Not serious	Not serious	Serious[e]	Other bias[f]	⨁◯◯◯ VERY LOW	No clear effect on the odds of macrosomia in infants of women undertaking lifestyle interventions compared with standard care
Low birthweight							
1	Serious[g]	Not serious	Not serious	Very serious[h]	Other bias[f]	⨁◯◯◯ VERY LOW	No clear effect on the odds of low birthweight infants in women undertaking lifestyle interventions compared with standard care

(Continues)

TABLE 3 (Continued)

Certainty assessment							Summary of findings
Systematic reviews reporting outcome	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Overall certainty of evidence	Impact
Large for gestational age							
4	Serious[a]	Serious[d]	Not serious	Serious[e]	Other bias[f]	⨁◯◯◯ VERY LOW	No clear effect on the odds of infants large for gestational age in women undertaking lifestyle interventions compared with standard care
Small for gestational age							
3	Serious[a]	Not serious	Not serious	Serious[e]	Other bias[f]	⨁◯◯◯ VERY LOW	No clear effect on the odds of infants small for gestational age in women undertaking lifestyle interventions compared with standard care

[a]Downgraded (−1) for risk of bias due to concerns over bias within the included randomized controlled trials with less than half being judged to be low risk of bias across all three areas of random sequence generation, allocation concealment and attrition bias and due to low or critically low confidence in the findings of the majority of included systematic reviews.
[b]Downgraded (−1) for inconsistency due to substantial unexplained statistical and procedural heterogeneity within many included systematic reviews.
[c]Downgraded (−1) for publication bias due to small study effects noted within several systematic reviews with the highest number of included randomized controlled trials.
[d]Downgraded (−1) for inconsistency due to statistical and procedural heterogeneity between studies within some included reviews.
[e]Downgraded (−1) for imprecision due to uncertainty over the true effect size within the different included systematic reviews.
[f]Downgraded (−1) due to suspected poor reporting of outcome within included systematic reviews despite the outcome itself being reported in many included randomized controlled trials.
[g]Downgraded (−1) for risk of bias due to concerns over bias within the included randomized controlled trial and within the included systematic review.
[h]Downgraded (−2) for very serious concerns around imprecision due to single study, small sample size, with few events.

fetal development and on the long-term health outcomes for infants are only just beginning to develop. Further exploration is required to increase our understanding of the specific nutritional components that are important in pregnancy, to both maximize pregnancy outcomes and long-term infant health.

Historically, pregnancy has been viewed as a "teachable moment" for women due to their motivation, related to the developing fetus's health, and the frequent contact with health professionals providing an opportune time to deliver health promotion.[56] However, this overview of reviews has been unable to demonstrate a clear clinical benefit of lifestyle interventions during pregnancy for women with a raised BMI. This may in part be due to the short time scale of pregnancy in which to change habits and also due to competing demands on a woman's attention including financial, emotional, and other health promotional activities.[57] It is suggested that targeting interventions to the pre-conception period could have more impact, as women have more time to be exposed to healthy lifestyle advice and to assimilate positive behavior change.[57,58] There are currently very limited lifestyle intervention studies during the preconceptual period around nutrition.[59] This is despite NICE guidance highlighting the importance of the pre-conceptual period for informing women with a raised BMI about losing weight prior to pregnancy.[14] In part, this may be due to the perception that undertaking pre-conception studies is difficult due to the number of unplanned pregnancies. A recent survey of women at antenatal clinics in a region within England has however suggested that just 5.5% of pregnancies not ending in induced abortion were unplanned.[60] Given the importance of the preconceptual and early pregnancy periods and their impact on fetal-programming, it is an urgent area of further investigation.

There was insufficient evidence to confirm the most effective type of lifestyle intervention in women with overweight or obesity during pregnancy, with all types of intervention: dietary only, physical activity only, and combined interventions having an impact on GWG within some of the included reviews. It was also difficult to identify the characteristics of interventions that have the potential to impact most upon GWG and clinical outcomes, due to the pronounced methodological and statistical heterogeneity between interventions within each review. Interventions could vary from providing women with additional information to in-depth dietary and physical activity support. A previous meta-analysis of lifestyle interventions for women across all BMI categories found that physical activity interventions that combined both individual and group elements were more effective at reducing GWG than individual or group interventions in isolation.[61] However, none of the other study characteristics investigated including gestation at which the intervention commenced, intensity of the intervention in terms of length of time, frequency, or duration of the intervention or the type of diet advised predicted the success of the lifestyle intervention.[61] This current lack of clarity regarding effective interventions during pregnancy appears to carry over into practice, with a recent study of providers and commissioners[62] highlighting provider's desire for clearer guidance on which to base their practice. This current overview illustrates how much our understanding of effective interventions still needs to advance. Michie et al.[63] have developed a taxonomy of behavior change techniques that allows the active behavior change components of interventions to be more clearly identified. Determining which behavior change techniques are effective, as well as the required frequency of an intervention requires further investigation within the subpopulation of pregnant women with overweight or obesity. Indeed, the identification of effective components of lifestyle interventions that promote dietary improvements during pregnancy and optimize gestational weight gain has been identified as a key research priority by the Health in Preconception, Pregnancy, and Postpartum Global Alliance.[64]

4.1 | Limitations of the review

A strength of this review was limiting the evidence base to RCTs to minimize heterogeneity in study design and to ensure comparability. The review searched multiple databases with no date restrictions to provide a comprehensive overview of current evidence. Rigorous quality appraisal by two reviewers was also undertaken using the AMSTAR-2 tool.

The limitations within this review were the diverse nature of the included lifestyle interventions preventing understanding of effective components of interventions. There is also inconsistency in end points for GWG within included trials and therefore within the systematic reviews. GWG from pre-pregnancy to delivery is used to assess IOM adherence; however, multiple other time points were used within the included trials. One review[40] describes these clearly with "initial" weight taken as pre-pregnancy, early pregnancy, or trial entry, which extended up to 28 weeks within one study. "End" weights were from 24 weeks' gestation up to delivery. The inclusion of few studies undertaken within low income countries within the included systematic reviews is recognized as a further limitation, despite the increased incidence of obesity globally.

It is recognized that there was an updated version of one included review.[26] However, the more recent update[65] no longer included an overweight/obese subgroup for the outcome of GWG, so was not eligible for inclusion. The decision was therefore made to retain the older review[26] within this overview.

This overview is also limited by the limitations within the included reviews including the quality of their searches, extraction, and reporting. Areas of weakness identified included, for example, combining LGA and macrosomia outcomes, including studies within their overweight and/or obese subgroups that were not exclusively women with a raised BMI, for example, including women of normal weight,[66–68] those with previous GDM as well as those with a raised BMI[69] and women with raised blood glucose levels.[70] Others too have noted the inclusion of apparently ineligible trials within systematic reviews.[71] Furthermore, several errors in data extraction within included reviews were noted such as extracting standard error rather than standard deviation. It is felt that going back to the original study results within this overview and correcting or highlighting the areas of inconsistency has mitigated these limitations in part.

4.2 | Implications for research

Further trials are required to identify the most effective components of interventions, as well as the required frequency and level of supervision within an intervention. Exploration of the impact of specific nutrients in pregnancy also need further exploration in both pregnant women as a whole and within the subgroup of women with overweight or obesity. To reduce some heterogeneity between studies, a universal definition for the measurement of GWG would be beneficial. Consideration should also be given to exploring lifestyle interventions in the prenatal period given the current lack of benefit on maternal and infant outcomes from lifestyle interventions during pregnancy.

Care is required when compiling an overview of reviews to prevent perpetuation of errors that are present within included systematic reviews.

5 | CONCLUSION

Lifestyle interventions appear to have a small effect in reducing GWG in women with overweight or obesity. Heterogeneity between studies within most of the included reviews meant it was not possible to identify the most effective interventions within this group of women. Current evidence does not show a clear benefit on maternal and infant outcomes from the small nature of the reduction in GWG produced by lifestyle interventions in women with overweight or obesity.

ETHICAL APPROVAL

Ethical approvals were not required to undertake this overview of reviews.

ACKNOWLEDGEMENT

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CONFLICT OF INTEREST

No known conflicts of interests to declare.

AUTHOR CONTRIBUTIONS

F.F. was primary responsible for the development of the research question, study design and protocol, assessing articles for inclusion, undertaking quality appraisal and extraction of data of included studies, analysis, and writing the main body of the manuscript and also agreed final manuscript for submission. H.S. was responsible for advisory role in research question and protocol development, assessed full text articles for inclusion, undertaking quality appraisal of included studies, cross-checked all extracted data, and revised manuscript, also agreed final manuscript for submission.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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