TITLE

Exercise interventions for weight management during pregnancy and up to one year postpartum among normal weight, overweight and obese women: a systematic review and meta-analysis

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ABSTRACT

Background The prevalence of excessive gestation weight gain, extended postpartum weight retention and pre-gravid obese women is increasing and is associated with numerous adverse health outcomes.

Objective To review the evidence from studies employing exercise-only interventions for weight management among pregnant and postpartum women.

Search strategy Ten databases were searched for randomised controlled trials (RCTs) conducted during pregnancy or within the 12 month following childbirth and published between 1990 and 2013.

Selection criteria There were no restrictions to the type, frequency, duration or intensity of exercise intervention. Interventions not specifically designed to target weight were excluded. The outcomes were a change in body weight (kg) or body mass index (BMI; kg·m^2).

Data collection and analysis All data were continuous and were reported as weighted mean differences (WMD), with 95% confidence intervals (CI). Data were analysed with a fixed-effect model and heterogeneity was determined using the I^2 statistic.

Results Five studies were included in this review. Exercise significantly reduced gestational weight gain (WMD = -2.22kg, CI = -3.14/-1.3, p = < 0.00001) and had no significant effect on postpartum weight loss (WMD = -1.74kg, CI = -3.59/0.10, p = 0.06) or BMI during pregnancy (WMD = -2.8kg·m^2, CI = -5.60/0.00, p = 0.05) or postpartum (WMD = -0.54kg·m^2, CI = -1.17/0.08, p = 0.09).

Conclusions There is currently limited evidence to suggest that exercise can be used to limit maternal gestational weight gain.

Key points

- Excessive gestational weight gain and postpartum weight retention are risk factors for the development of obesity.

- This review examined the effects of exercise only on weight management during pregnancy *and* following childbirth in normal weight, overweight *and* obese women.
- Only five studies met the inclusion criteria and were included in this review.
- There is a need for future studies to perform randomised controlled trails to address this important clinical issue of maternal obesity.

INTRODUCTION

Some weight gain is essential in pregnancy[1] but there are no universal evidence-based recommendations regarding the amount of acceptable gestational weight gain [2]. The American Institute of Medicine[3] guidelines advise under-weight women (pre-pregnancy BMI < 18.5 kg·m^2) to gain 12.5-18.0 kg [28-40 lbs] and normal weight women (pre-pregnancy BMI 18.5-24.9 kg·m^2) to gain 11.5-16.0 kg [25-35 lbs]. Overweight (pre-pregnancy BMI 25-29.9 kg·m^2) and obese (pre-pregnancy BMI ≥ 30 kg·m^2) women are directed to gain 7.0-11.5 kg [15-25 lbs] and 5.0-9.0 kg [11-20 lbs]. Weight gain beyond these recommendations is termed excessive gestational weight gain and has been associated with foetal and maternal complications, such as macrosomia[4] and postpartum weight retention[5-8]. Because of excessive gestational weight gain and postpartum weight retention, pregnancy is a risk factor for the development of obesity[9].

The issues associated with excessive gestational weight gain and postpartum weight retention are augmented by the increasing prevalence of pre-gravid obese females. One in five British[10] and American[3] women are obese at the start of pregnancy; nearly one in every thousand women giving birth in the UK has a BMI greater than 50 kg·m^2[11]. Furthermore, obese women are twice as likely to experience excessive gestational weight gain[12]. Obesity is a risk factor for preeclampsia, diabetes and maternal death[13]. Pre-gravid obesity, also promotes difficulties with foetal monitoring, the need for specialised medical equipment and greater clinical support, problems with anaesthesia and more frequent complications[14]. Long-term postpartum concerns include foetal over-nutrition, an unlikeness to breastfeed and childhood obesity[15].

Large numbers of women gain[3,16] and retain[17] excessive weight during and following pregnancy or start pregnancy already obese[10). Exercise has been promoted as possibly limiting gestational weight gain[18]. Therefore we performed a systematic literature search of RCTs to compare the effects of an exercise intervention with routine care or another intervention on gestational weight gain and postpartum weight retention in (i) normal weight, (ii) overweight and (iii) obese women. The effects of combined diet and exercise interventions were not considered because: the relative contribution of diet or exercise is difficult to quantify, gestation can be an overwhelming time for new mothers[19] and changing both activity and dietary patterns could be difficult, sufficient energy intake and appropriate nutritional constitution is needed for breastfeeding[20] and exercising and dieting are perceived differently by women[21]. We wanted to focus on one aspect of behaviour to provide pragmatic advice for future RCTs and national guidelines. We hypothesised that exercise would be an effective weight management tool in these populations.

METHODS

This report conforms to the PRISMA[22] guidelines for reporting a meta-analysis on intervention studies.

Types of studies

We considered all published randomised controlled trials and quasi-randomised trials, conducted during pregnancy or the postpartum period, comparing an exercise-based weight management intervention with routine care or another type of intervention. In the current study, exercise was defined as: a type of physical activity, consisting of planned, structured, and repetitive bodily movement done to improve or maintain one or more components of physical fitness. Weight management referred to: a set of practices and behaviours that are necessary to keep one's weight at a healthy level (WHO: BMI normal category; 18.50-24.99 $kg \cdot m^2$).

Types of participants

Healthy pregnant and postpartum females were included; postpartum referred to the 12 months following childbirth. In order to be considered healthy, participants had to be free from any pregnancy-related complications (e.g., preeclampsia, hyperemesis gravidarum, gestational diabetes, macrosomia, placenta previa) or other medical conditions (e.g., thyroid disease, high blood pressure, asthma) or not currently taking any medications (e.g., steroids, diuretics, antidepressants) known to affect body weight or exercise performance. Participants included normal weight (BMI 18.50-24.99 $kg{\cdot}m^2$), overweight (BMI > 25 $kg{\cdot}m^2$) and obese women (BMI > 30 $kg{\cdot}m^2$), primigravidas and multigravidas and nulliparous, primiparas and multiparas. Studies on women under 18 years were excluded from our review, in order to prevent any contribution from natural linear growth to body weight. Studies on underweight women (BMI < 18.5 $kg{\cdot}m^2$) and women at risk of giving birth to low birth weight babies (< 2500g) or insufficient gestational weight gain (< 11kg for normal weight women) were also excluded. The combined searches yielded 354 articles. Following phase one, 330 studies were excluded on the basis of being non-randomised, retrospective, duplicates, qualitative or baseline studies. Twenty four full papers (Table 1) were retrieved and following phase two, 19 papers were excluded for: not being specifically designed to influence weight, including non-healthy participants, having combined interventions (i.e., diet and exercise) and being study protocols. Five papers were included in this review (Table 2).

Table 1. Characteristics of excluded studies (ordered by study ID)

Study	Reason for exclusion
Barakat, Lucia & Ruiz[23]	The intervention did not intend to manage maternal weight gain during pregnancy or postpartum; rather to examine the effects of a light intensity resistance training programme on the new-born's birth size (i.e. the focus of the intervention was on foetal rather than maternal outcome measures).
Clapp et al.[24]	The intervention did not intend to manage maternal weight gain during pregnancy or postpartum; rather to test the null hypothesis that the volume of exercise at different times during pregnancy has no effect on fetoplacental growth (i.e. the focus of the intervention was on foetal rather than maternal outcome measures).
Davenport et al.[25]	Combined diet and exercise intervention.
Dodd et al.[26]	Study protocol outlining the methodology for the LIMIT randomised controlled trial which aims to limit weight gain in overweight and obese women during pregnancy to improve health outcomes.
Haakstad et al.[27]	Non-intervention study. The purpose of this study was to assess the total physical activity level of pregnant women & to investigate the association between weight gain, physical activity and exercise during pregnancy.
Huang, Yeh & Tsai[28]	Combined diet and exercise intervention.
Hui et al.[29]	Combined diet and exercise intervention (pilot study).
Hui et al.[30]	Combined diet and exercise intervention.
Jackson et al.[31]	Combined diet and exercise intervention.
Kardel & Kase[32]	The intervention was not randomised. In addition, the intervention did not intend to manage maternal weight gain during pregnancy or postpartum; rather to examine the effects of high- and medium-intensity exercise on the foetus and on the onset and length of labour, birth weight and Apgar score in healthy athletes who had performed a high level of exercise before conception (i.e. the focus of the intervention was on foetal rather than maternal outcome measures).
Lewis et al.[33]	The intervention was not randomised and there wasn't a control group.
Lovelady et al.[34]	Combined diet and exercise intervention. In addition, the intervention did not intend to manage maternal weight gain during pregnancy or postpartum; rather to examine the effects of weight loss in overweight, lactating women on the growth of their infants (i.e. the focus of the intervention was on foetal rather than maternal outcome measures).
Lovelady et al.[35]	Combined diet and exercise intervention. In addition, the intervention did not intend to manage maternal weight gain during pregnancy or postpartum; rather to examine the effects of energy restriction and exercise on vitamin B-6 status of women during lactation.
McCrory et al.[36]	Combined diet and exercise intervention. In addition, the intervention did not intend to manage maternal weight gain during pregnancy or postpartum; rather to examine the short-term effects of dieting compared with dieting plus exercise on lactation performance.
Moholdt et al.[37]	Study protocol outlining the methodology for a randomised controlled trial on exercise training in pregnancy for obese women (ETIP study).
Ostbye et al.[38]	Study protocol outlining the rationale, design and baseline characteristics of the active mother's postpartum study (AMP study).
Ostbye et al.[39]	Combined diet and exercise intervention (AMP study).
Phelan et al.[40]	Combined diet and exercise intervention (Fit for Delivery Study).
Sagedal et al.[41]	Study protocol outlining the Fit for Delivery Study; can a lifestyle intervention in pregnancy result in measurable health benefits for mothers and new-borns? A randomised controlled trial.

Table 2. Characteristics of included studies (divided into pregnancy and post-partum studies and ordered by study ID).

	Study & setting	Population	Intervention	Weight change (kg) (mean ± SD)	Adherence rates (%)
Pregnancy studies	Barakat et al.[42] Spain	NW/OW I: n = 34 C = n = 33	**Duration**: 85 training sessions (≈33 wk) **Mode:** toning & light resistance exercises **Frequency**: 35-45 min 3d·wk^{-1} **Intensity**: light-moderate intensity (<70% HRmax) **Delivery mode**: group *C: not stated*	GWG: I: +11.89 ± 3.15 C: +13.90 ± 2.11 p = 0.03	90
	Haakstad & Bo[43] Norway	NW/OW <24 wk P I: n = 14 C: n = 53	**Duration**: 12 wk **Mode:** aerobic dancing (AD) & self-imposed (SI) PA **Frequency**: AD 60 min 2d·wk^{-1} & SI 30 min 5 d·wk-^{1} **Intensity**: moderate 12-14 Borg scale **Delivery mode**: group & individual *C: no change to usual PA patterns*	GWG: C: +13.8 ± 4.0 I: +11.0 ± 2.0 p = 0.01	68
	Nascimento et al.[44] Brazil	OW/O 14-24 wk P I: n = 39 C: n = 41	**Duration**: ≤26 wk **Mode:** strengthening-exercises(SE) & counselling **Frequency**: SE 1d·wk^{-1} & counselling 5 d·wk^{-1} **Intensity**: low-moderate <140 beats per min **Delivery mode**: group & individual *C: Routine prenatal care*	GWG: I: +10.3 ± 5.0 C: +11.5 ± 7.4 NS	60
Post-partum studies:	Bertz et al.[45] Sweden	OW/O (< 35 kg·m^{2}) 8-12 wk PP C: n = 15 D: n = 15 E: n = 16 DE: n = 16	**Duration**: 12 wk **Mode:** exercise - brisk walk **Frequency**: 45 min 4d·wk^{-1} **Intensity**: 60-70% HRmax **Delivery mode**: individual *DE: diet & exercise , C: usual care, D: diet*	WL: C: -0.8 ± 3.0 D: -8.3 ± 4.2 E: -2.4 ± 3.2 DE: -6.9 ± 3.0 E NS	83
	Maturi, Afshary & Abedi[46] Iran	NW/OW 6-24 wk PP I: n = 32 C: n = 34	**Duration**: 12 wk **Mode:** walking **Frequency and intensity:** 10,000 steps per day **Delivery mode**: individual *C: routine PP care*	WL: I: -2.1 ± 8; p = 0.001 C: 0; NS	NR

P = pregnant, PP = postpartum, NW = normal weight, OW = overweight, O = obese, WL = weight loss, C = control, I = intervention, GWG = gestational weight gain, HRmax = maximum heart rate, NS = non-significant, NR = not reported, PA = physical activity.

Types of interventions

All interventions involving exercise, which aimed to manage maternal weight during and following pregnancy, such as training programmes and counselling, were considered. There were no restrictions to the type, frequency, duration, intensity or mode of exercise intervention. Interventions in any setting were considered, although the intervention must have been introduced during or following pregnancy. We compared one intervention with no intervention (i.e., control group or routine care) or one intervention with another intervention (i.e., dietary intervention). Interventions not specifically designed to target or affect weight were excluded. Interventions involving mothers of young children were excluded when the postpartum period was not specified.

Types of outcome measures

The primary outcome was a change in body weight (kg), defined as body weight post-intervention minus pre-intervention body weight; a positive change implies gestational weight gain in the pregnancy studies and negative change implies weight loss in the postpartum studies. In addition, we considered changes in BMI (kg·m^2), defined as BMI post-intervention minus pre-intervention BMI; a positive change implies gestational weight gain in the pregnancy studies and a negative change implies weight loss in the postpartum studies.

Search strategy

We searched the following databases: Cochrane Central Register of Controlled Trials (CENTRAL), the Cumulative Index of Nursing and Allied Health (CINAHL), PubMed, MEDLINE, OVID, Springer Link, ScienceDirect, Oxford Journal, BioMed Central and Web of Science to identify relevant articles. The last search was conducted in September 2013. We used search terms such as “exercise”, “physical activity”, “pregnancy”, “pregnant women”, “weight”, “weight loss”, “weight management”, “postpartum”, “obesity” and “overweight” as MeSH headings, subject headings or titles. We applied a date restriction of 1990 to coincide with the publication of the landmark guidelines by the Institute of Medicine (IOM) on weight gain during pregnancy[47]. In addition, we restricted the search to papers published in English, using human participants.

We excluded all review papers and considered only original data. We did not include abstracts from conference proceedings. We contacted the authors of studies to obtain further information where relevant. All searches followed the same strategy (Figure 1); the title and abstract of every hit generated from the search terms was reviewed against the inclusion/exclusion criteria. Studies which had questionable suitability were included at this stage (phase one) and the final decision was reached at the next phase. In phase two, the full article was retrieved and again assessed against the eligibility criteria.

Selection of studies and data extraction

Three investigators (KES, CTB, CS) independently assessed the eligibility for inclusion for each study that was identified through the search strategy (both phases). We resolved any disagreement through discussion. Data extraction was carried out by one reviewer (KES) and all relevant information was extricated using a standardised data extraction form (Table 2).

Quality assessment

Studies were assessed, by one reviewer (KES) and double-checked by another (CTB), using the Cochrane Collaboration's tool for assessing risk of bias in randomised trials (Table 3; adapted from Higgins[48]), which assesses data quality based on five criteria: randomisation, allocation concealment, double blinding, follow-up and overall bias. Each criteria was allocated a grade of either A, B, C or D; A – stated or adequate or low risk, B - unclear or not stated or moderate risk, C –inadequate or not used or high risk, D (allocation concealment only) – not used. In addition, the strength of the evidence provided by studies was reviewed, by KES and CTB, using the criteria outlined in the Consolidated Standards of reporting Trials[49,50] (CONSORT) statement (Table 4). Items 3b, 6b, 7b, 11b, 12b and 18 were removed as they were not applicable to any of the studies. Neither set of criteria were used to exclude any study that did not meet their standards or requirements. The differences between the reviewers were resolved by discussion until a consensus was reached.

Table 3. Cochrane Collaboration’s tool for assessing risk of bias (adapted from Higgins[48]).

Study	**Selection bias**		**Performance/detection bias**	**Attrition/reporting bias**				**Bias**
	Randomised	**Allocation concealment**	**Blinding**	**Follow-up**	**AR**	**R**	**DS**	**Quality**
Barakat et al.[42]	A	B	B	A	Y	Y	F	moderate
Bertz et al.[45]	A	B	B	A	Y	Y	F	moderate
Haakstad & Bo[43]	A	B	A	C	Y	Y	P	high
Maturi, Afshary & Abedi[46]	A	B	B	A	Y	N	P	moderate
Nascimento et al.[44]	A	A	B	A	Y	Y	F	moderate

AR = attrition rates, R = reasons for drop-outs, Y = reported, N = not reported, DS = data set, F = full, P = partial.

Table 4. CONSORT 2010 checklist of information to include when reporting a randomised trial (adapted from Schulz et al.[50]).

Study	1a	1b	2a	2b	3a	4a	4b	5	6a	7a	8a	8b	9	10	11a	12a	13a	13b	14a	14b	15	16	17a	17b	19	20	21	22	23	24	25
Barakat	+	+	+	+	-	+	+	+	+	+	+	-	-	-	NA	+	+	+	-	-	+	+	-	-	-	+	+	+	-	-	+
Bertz	-	+	+	-	+	+	+	+	+	+	+	+	-	-	NA	+	+	+	+	-	+	+	-	-	-	+	+	+	+	-	+
Haakstad	+	+	+	+	-	+	+	+	+	+	+	+	-	+	+	+	+	+	+	-	+	+	-	-	-	+	+	+	+	-	-
Maturi	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	-	-	-	+	+	+	+	-	+
Nascimento	+	+	+	-	-	+	+	+	+	+	+	-	+	-	NA	+	+	+	+	-	+	+	-	-	-	+	+	+	+	+	+

+ = stated, - = not stated, NA = not applicable.

Data analysis

When data were available, sufficiently similar and of sufficient quality, statistical analyses was performed using Review Manager - software 5.2 (RevMan, 2012). All data were continuous and were therefore expressed as weighted mean differences, with 95% confidence intervals, between the baseline and post-intervention values. All data were analysed with a fixed-effect model and heterogeneity was determined using the I^2 statistic. Due to the limited number of eligible studies we were unable to use funnel plots as a simple graphical test to assess for evidence of publication bias[51].

RESULTS

Interventions

All included studies were published between January 2011 and July 2012. Three studies were conducted in Europe[42,43,45], one in South America[44] and one in the Middle East[46]. Three of the studies used normal and overweight women[42,43,46] and two used overweight and obese women[45,44]. Nascimento et al.[44] analysed their data as both combined, overweight and obese, and separate, overweight or obese, groups; the combined results from both groups were considered in this review. In the pregnancy studies, participants were recruited between six[42] and 24[43,44] weeks' gestation and the interventions lasted between 12[43] and 33[42,44] weeks. In the postpartum studies[45,46], participants were typically between 6 and 24 weeks postpartum, were a mixture of normal and overweight[46] or overweight and obese[45] and intended to breastfeed. Both interventions lasted 12 weeks. All studies used singleton pregnancies and only one trial exclusively used nulliparous women[43]. Baseline physical activity levels ranged from unspecified[42,45], to those who did not participate in structured exercise of more than 60 minutes once a week but performed more than 120 minutes of brisk walking per week in the 6 months prior to the study[43], to women who did not exercise "regularly"[44] and to participants who were classed as either physically inactive or low physical activity by the International Physical Activity Questionnaire[46].

The pregnancy-related studies all had exercise interventions with similar characteristics; duration 45 - 60 minutes, frequency 3 – 5 times per week and moderate intensity (<70% heart rate maximum; <140 beats per minute; 12-14 on the 6-20 Borg Scale). Interventions were predominately aerobic -exercise based, with some resistance exercises (e.g., bicep curls, arm side lifts, knee extensions) included. All interventions were performed in supervised classes. Two studies[43,44] had additional at-home components that required participants to perform self-imposed, moderate-intensity, physical activity. Both of the postpartum interventions involved a progressive walking programme, although there were differences in how these were conducted. Bertz et al.[45] required participants to complete 45 minutes of brisk walking 4 times a week at 60-70% heart rate maximum and Maturi, Afshary and Abedi[46] asked participants to achieve 10,000 steps per day.

Most studies involved two comparisons; exercise versus usual care (control). Bertz et al.[45] had four comparison groups; control, diet, exercise and diet plus exercise. However, as the purpose of this review was to investigate the effect of exercise on weight management, only the exercise and control data were considered. Discrete measures, such as fat, lean and muscle mass[45], waist and hip circumference[46], weekly weight gain[47] and number of women who exceeded the IOM guidelines for weight gain[46], were not included in the analysis. Haakstad and Bo[43] analysed their data by intention to treat (ITT), per protocol and attendance at 24 exercise sessions. The results from the attendance at 24 exercise sessions are presented in this review. Characteristics of the included studies are described in Table 2.

Methodological quality

Methodological quality varied considerably across the trials (Table 3). Group sample size after attrition ranged from 14[43] to 39[44] in the pregnancy trials and 16[45] to 32[46] in the postpartum studies. Each of the included studies had performed a power calculation (accepted level 70-85% power) to determine sample size; Barakat et al.[42] recruited 67 out of a predicted 80, Haakstad et al.[43] recruited 67 out of a predicted 100, Nascimento et al.[44] recruited 80 out of a predicted 82, Bertz et al.[45] recruited 31 out of a predicted 34 and

Maturi, Afshary & Abedi[46] recruited 66 out of a predicted 70. In Haakstad and Bo's trial[43] only 14 out a predicted 50 participants were recruited and completed 24 of the exercise sessions.

According to the criteria outlined in the Cochrane's tool for assessing risk of bias[48], all trials were classed as randomised, however only Nascimento et al.[44] clearly reported the method used for allocation concealment. Haakstad and Bo[43] were the only study to conduct an assessor-blinded protocol. All studies reported attrition rates and all but one reported the reasons for drop-outs[46]. Haakstad and Bo[43] lost more than 20% in the follow-up period, which meant that the reporting bias (completeness of follow-up) was ranked as inadequate. Most of the studies reported full data sets with the exception of Haakstad and Bo[43], who did not report baseline physical activity data and interview data. All of the studies scored moderate on overall bias, except for Haakstad and Bo[43] who were classified as high risk of quality bias (Table 3).

None of the included papers stated that they had used the CONSORT checklist[49,50]. Barakat et al.[42] fulfilled 19 out of 30 criteria (63%), Bertz et al.[45] fulfilled 21 out of 30 criteria (70%), Haakstad et al.[43] fulfilled 22 out of 31 criteria (71%), Maturi, Afshary & Abedi[46] fulfilled 24 out of 31 criteria (77%) and Nascimento et al.[44] fulfilled 22 out of 30 criteria (73%). None of the trials reported why the trial ended or was stopped (item 14b), the estimated effect size and its precision (such as 95% confidence interval) for each primary and secondary outcome or the absolute and relative effect sizes for binary outcomes (items 17a and b) or all important harms or unintended effects in each group (item 19). Only one study[44] reported where the full trial protocol can be accessed (item 24) (Table 4).

Outcomes

Table 5 shows the comparison between exercise and usual care (control) for the outcome measures. Exercise resulted in a significant reduction in gestational weight gain during pregnancy (WMD = -2.2 kg, CI = -3.14/-1.30, $p < 0.00001$). That is, women who took part in an exercise intervention gained about 2.2 kg less weight during pregnancy, when compared with women receiving usual care. No heterogeneity was shown in these data. Only one pregnancy trial contributed data for the comparison between pre and post intervention BMI[44]; the data showed a tendency towards a reduction in BMI (WMD = -2.8 kg·m^2, CI = -5.6/0.00, p = 0.05). Due to the limited number of studies reporting BMI data, heterogeneity could not be calculated (Figure 2).

Exercise did not cause a significant reduction in gestational weight retention or BMI, although the effect size showed a trend towards a reduction in both (WMD weight = -1.74 kg, CI = -3.59/0.10, p = 0.06 and WMD BMI = -0.54 kg·m^2, CI = -1.17/0.08, p = 0.09). That is, women who took part in a postpartum exercise programme lost more weight (about 1.74 kg), than women in the control group. No heterogeneity was shown in these data (Figure 2).

Table 5. Comparison between exercise and usual care for the outcome measures.

Outcome	No of studies	No of comparison groups	No of participants	Statistical method	Effect size (95% CI)	I^2
Weight gain (kg)	3	6	214	Mean difference (IV, Fixed, 95% CI)	-2.22 (-3.14, -1.30)	0%
BMI gain (kg·m^2)	1	2	80	Mean difference (IV, Fixed, 95% CI)	-2.8 (-5.60, 0.00)	NA
Weight loss (kg)	2	6	128	Mean difference (IV, Fixed, 95% CI)	-1.74 (-3.59, 0.10)	0%
BMI loss (kg·m^2)	2	6	128	Mean difference (IV, Fixed, 95% CI)	-0.54 (-1.17, 0.08)	0%

NA = not applicable

DISCUSSION

Main findings

In this systematic review, exercising during pregnancy resulted in a significant reduction in gestational weight gain (-2.22 kg, p< 0.00001). The studies included in the meta-analysis contained women of all BMI status; two of the three studies studied normal and overweight women[42,43] and Nascimento et al.[44] studied overweight and obese women. The overweight and obese women in that trial were the only participants who did not reduce gestational weight gain when compared to usual care. However, the women in this study reported the lowest adherence rates to the exercise protocol. Note that exercise interventions did not significantly increase weight loss during the postpartum period[45,46].

Strengths and limitations

The strength of this systematic review with meta-analysis is the number and diversity of databases used during the search strategy, which was more than any other equivalent review[52-57]. Moreover our review is comprehensive and covers a range of BMI status, from normal weight to obese, during pregnancy and the postpartum period, unlike previous reviews that focused on one BMI classification during either pregnancy or postpartum[52-57]. Importantly, the current review focused solely on the exercise paradigm and only included studies designed to affect weight management, thus reducing the likely of Type II errors. Some women will choose to change both diet and activity patterns to influence weight management; this review is limited to providing evidence for exercise interventions only.

Interpretation

We compared our findings to the results of other reviews and meta-analyses with a similar research question. Streuling et al.[52] showed that physical activity resulted in a significant reduction in gestational weight gain (WMD = -0.61 kg, 95% CI = -1.17/-0.06) in a meta-analysis of 12 randomised controlled trials of normal weight, overweight and obese women. Sui et al.[53] reviewed five studies involving overweight or obese women and showed that supervised antenatal exercise interventions were associated with lower gestational weight gain (mean difference of −0.36 kg, 95% CI −0.64 to −0.09 kg) when compared with standard antenatal care. Similarly, Choi et al.[54] showed that gestational weight gain was lower following a supervised physical activity intervention (WMD = -1.74 kg, 95% CI = --3.66/+0.19, p = 0.077), with two studies included in the analyses. In contrast, Muktabhant et al.[55] performed a Cochrane Review on interventions for preventing excessive weight gain during pregnancy. These authors concluded that there was not enough evidence to recommend any intervention, including exercise, for preventing excessive gestational weight gain. In 2013, Furber et al.[56] could not find any studies which met the inclusion criteria for their Cochrane Review on antenatal interventions, including exercise, for reducing weight in obese pregnant women. The disparity in results between reviews is entirely attributable to differences in inclusion criteria and, as such, it is impossible to demonstrate reproducible findings. In this systematic review, we adopted the procedures stipulated for a Cochrane review, in addition to following the PRISMA statement. Moreover, we determined the effect size using a meta-analytical approach. We examined the efficacy of exercise as a weight management tool during pregnancy and following childbirth in normal weight, overweight and obese women, thus making this review very comprehensive.

It is difficult to identify the most appropriate exercise programme for the management of gestational weight gain, as all of the studies included in this review differed in terms of exercise modality, duration and frequency; though all studies consistently used a moderate intensity activity. In terms of pragmatic advice, this suggests that most forms of moderate intensity exercise will have a positive effect on gestational weight gain and should be encouraged. Our findings indicate a mean difference of -2.2 kg as a result of exercising during pregnancy, although it is hard to quantify what constitutes a meaningful reduction in gestational weight gain since this will depend upon pre-pregnancy weight and the rate of gestational weight gain; the pregnancy studies included in this review used non-homogenous groups and did not always track the time course of gestational weight gain. Future studies may benefit from tracking percentage weight changes throughout the intervention period. However, due to the numerous adverse maternal and foetal outcomes associated with excessive gestational weight gain and the fact that less than one in three women gains within the IOM recommendations[3], it is clear that any reduction in gestational weight gain will be beneficial at a population level; with the exception of underweight women.

Only one of the studies included in this review suggested a possible mechanism for the biological benefits of attenuated gestational weight gain due to exercise. Barakat et al.[42] proposed that excessive maternal weight gain is associated with negative alterations to the pelvic floor muscles. Their data supported this tenant, showing that women who exercised had less weight gain and a small improvement in type I lacerations. Consequently, they recommended that future studies should include general strengthening exercises in addition to those that stimulate the pelvic floor.

Our meta-analysis showed that exercise intervention had no significant effect on postpartum weight loss (WMD = -1.74 kg, CI = -3.59/0.10, p = 0.06) or BMI (WMD = -0.54 kg·m^2, CI = -1.17/0.08, p = 0.09). All studies used overweight females; one used normal and overweight females[46] and one used overweight and obese females[48]. Amorim Adegboye, Linne & Lourenco[57] also showed that exercise alone was not sufficient to significantly reduce postpartum weight retention in one trial (MD = 0.00 kg, 95% CI = -8.36/8.36). Interestingly, Choi et al.[54] did not identify any exercise-only, postpartum interventions in their review that were not combined with a dietary intervention. Moreover, there was no randomised control trial that had tracked weight gain and retention from pregnancy through the postpartum period in the same participants. No other review has considered both weight gain and retention in one article.

Both of the postpartum trials included in this review used a 12 week, progressive walking protocol. Surprisingly, the duration and intensity of the intervention used by Bertz et al.[45] was less than and equal to those in the pregnancy trials. In the trial of Bertz et al.[45] the women were mostly unsupervised and were asked to monitor their activities using self-reported diaries. However, following the intervention, despite undertaking a walking intervention, the number of steps per day or total energy expenditure was not significantly increased (p = 0.948 and p = 0.090). This may suggest that there were compliancy issues (the authors reported 83% adherence with the walking programme, which was supplied by the participants) or that the prescribed intervention was not of sufficient duration, frequency or intensity to illicit a meaningful response. Maturi, Afshary & Abedi[46] used pedometers and calendars to measure the number of free-living steps per day, which has been established as a valid and reliable method for measuring steps in adult populations[58]. They showed a significant reduction in a number of anthropometric measures (weight, BMI, and waist and hip circumference), as well as a shift from moderate to vigorous intensity activity and an increase in energy expenditure per week in the intervention group when compared to the control group. Concomitantly, food intake did not differ between groups either pre or post intervention. While the duration of this trial was equivalent to that of Bertz et al.[45], the exercise intensity was greater and participants' habitual energy expenditure was also increased. This may account for the differences between findings.

CONCLUSIONS

Exercise during pregnancy significantly reduced gestational weight gain but did not significantly enhance weight loss in the postpartum period. The exercises performed during pregnancy were both aerobic and resistance based, whereas following childbirth the interventions were walking based. Due to inconsistencies in the research design of the studies analysed and the limited number of papers included in this review, it is very difficult to conclude the most appropriate or effective exercise programme for either pregnant or postpartum women, but it is likely that for pregnant women at least the intervention should include aerobic, toning and strengthening exercises. There is a need for additional RCTs that conform to known standards for methodological quality (e.g., CONSORT) and bias prevention (e.g., Cochrane) to accurately determine the efficacy of exercise interventions as a weight management tool both during pregnancy and the postpartum period. The duration, intensity and frequency of exercise intervention, required to cause long-term phenotypic changes, needs to be determined. The results from these studies are needed to inform national guidelines and practices in these high-risk populations.

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DISCLOSURE OF INTERESTS

None of the authors had any conflicts of interest.

CONTRIBUTORSHIP

All authors (KES, CTB and CS) contributed to, and were responsible, for the conception and design of the study, data acquisition, analysis and interpretation. All authors (KES, CTB and CS) were involved in drafting and editing the article and will have the final approval of the version to be published.

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