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Aerobic exercise for women during pregnancy (Review)

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TABLE OF CONTENTS

HEADER	1
ABSTRACT	1
PLAIN LANGUAGE SUMMARY	2
BACKGROUND	3
OBJECTIVES	3
METHODS	3
RESULTS	5
DISCUSSION	6
AUTHORS' CONCLUSIONS	6
ACKNOWLEDGEMENTS	6
REFERENCES	7
CHARACTERISTICS OF STUDIES	10
DATA AND ANALYSES	23
Analysis 1.1. Comparison 1 Increase in exercise in sedentary women, Outcome 1 Small-for-gestational-age birth.	24
Analysis 1.2. Comparison 1 Increase in exercise in sedentary women, Outcome 2 Preterm birth.	25
Analysis 1.3. Comparison 1 Increase in exercise in sedentary women, Outcome 3 Pre-eclampsia.	25
Analysis 1.4. Comparison 1 Increase in exercise in sedentary women, Outcome 4 Stillbirth.	25
Analysis 1.5. Comparison 1 Increase in exercise in sedentary women, Outcome 5 Neonatal death.	25
Analysis 1.6. Comparison 1 Increase in exercise in sedentary women, Outcome 6 Cesarean section.	26
Analysis 1.7. Comparison 1 Increase in exercise in sedentary women, Outcome 7 Total gestational weight gain (kg).	26
Analysis 1.8. Comparison 1 Increase in exercise in sedentary women, Outcome 8 Change in maternal fat mass (kg).	26
Analysis 1.9. Comparison 1 Increase in exercise in sedentary women, Outcome 9 Change in maternal lean mass (kg).	27
Analysis 1.10. Comparison 1 Increase in exercise in sedentary women, Outcome 10 Birthweight (g).	27
Analysis 1.11. Comparison 1 Increase in exercise in sedentary women, Outcome 11 Birth fat mass (g).	27
Analysis 1.12. Comparison 1 Increase in exercise in sedentary women, Outcome 12 Birth lean mass (g).	27
Analysis 1.13. Comparison 1 Increase in exercise in sedentary women, Outcome 13 Birth % body fat.	28
Analysis 1.14. Comparison 1 Increase in exercise in sedentary women, Outcome 14 Birth length (cm).	28
Analysis 1.15. Comparison 1 Increase in exercise in sedentary women, Outcome 15 Birth head circumference (cm).	28
Analysis 1.16. Comparison 1 Increase in exercise in sedentary women, Outcome 16 Birth ponderal index (g/cm ³ x 100).	29
Analysis 1.17. Comparison 1 Increase in exercise in sedentary women, Outcome 17 Gestational age (wk).	29
Analysis 1.18. Comparison 1 Increase in exercise in sedentary women, Outcome 18 Placental volume at delivery (cm ³).	29
Analysis 1.19. Comparison 1 Increase in exercise in sedentary women, Outcome 19 Mid-trimester placental growth rate (cm ³ /wk).	29
Analysis 1.20. Comparison 1 Increase in exercise in sedentary women, Outcome 20 Placental weight at delivery (g).	30
Analysis 1.21. Comparison 1 Increase in exercise in sedentary women, Outcome 21 Duration of labour, first stage (hr).	30
Analysis 1.22. Comparison 1 Increase in exercise in sedentary women, Outcome 22 Duration of labour, second stage (min).	30
Analysis 1.23. Comparison 1 Increase in exercise in sedentary women, Outcome 23 1-minute Apgar score.	31
Analysis 1.24. Comparison 1 Increase in exercise in sedentary women, Outcome 24 5-minute Apgar score.	31
Analysis 1.25. Comparison 1 Increase in exercise in sedentary women, Outcome 25 Relative heart volume post-delivery (cm ³ /m ²).	31
Analysis 2.1. Comparison 2 Reduction in exercise in physically fit women, Outcome 1 Preterm birth.	32
Analysis 2.2. Comparison 2 Reduction in exercise in physically fit women, Outcome 2 Birthweight (g).	32
Analysis 3.1. Comparison 3 Increase, then reduction in exercise in physically fit women, Outcome 1 Gestational weight gain (kg).	33
Analysis 3.2. Comparison 3 Increase, then reduction in exercise in physically fit women, Outcome 2 Birthweight (g).	33
Analysis 3.3. Comparison 3 Increase, then reduction in exercise in physically fit women, Outcome 3 Birth fat mass (g).	33
Analysis 3.4. Comparison 3 Increase, then reduction in exercise in physically fit women, Outcome 4 Birth lean mass (g).	34
Analysis 3.5. Comparison 3 Increase, then reduction in exercise in physically fit women, Outcome 5 Birth % body fat.	34
Analysis 3.6. Comparison 3 Increase, then reduction in exercise in physically fit women, Outcome 6 Birth length (cm).	34
Analysis 3.7. Comparison 3 Increase, then reduction in exercise in physically fit women, Outcome 7 Birth head circumference (cm).	35

Analysis 3.8. Comparison 3 Increase, then reduction in exercise in physically fit women, Outcome 8 Birth ponderal index (g/cm ³ x 100).	35
Analysis 3.9. Comparison 3 Increase, then reduction in exercise in physically fit women, Outcome 9 Gestational age (wk).	35
Analysis 3.10. Comparison 3 Increase, then reduction in exercise in physically fit women, Outcome 10 Placental volume at delivery (cm ³).	35
Analysis 3.11. Comparison 3 Increase, then reduction in exercise in physically fit women, Outcome 11 Mid-trimester placental growth rate (cm ³ /wk).	36
Analysis 4.1. Comparison 4 Reduction, then increase in exercise in physically fit women, Outcome 1 Gestational weight gain (kg).	37
Analysis 4.2. Comparison 4 Reduction, then increase in exercise in physically fit women, Outcome 2 Birthweight (g).	37
Analysis 4.3. Comparison 4 Reduction, then increase in exercise in physically fit women, Outcome 3 Birth fat mass (g).	37
Analysis 4.4. Comparison 4 Reduction, then increase in exercise in physically fit women, Outcome 4 Birth lean mass (g).	37
Analysis 4.5. Comparison 4 Reduction, then increase in exercise in physically fit women, Outcome 5 Birth % body fat.	38
Analysis 4.6. Comparison 4 Reduction, then increase in exercise in physically fit women, Outcome 6 Birth length (cm).	38
Analysis 4.7. Comparison 4 Reduction, then increase in exercise in physically fit women, Outcome 7 Birth head circumference (cm).	38
Analysis 4.8. Comparison 4 Reduction, then increase in exercise in physically fit women, Outcome 8 Birth ponderal index (g/cm ³ x 100).	38
Analysis 4.9. Comparison 4 Reduction, then increase in exercise in physically fit women, Outcome 9 Gestational age (wk).	39
Analysis 4.10. Comparison 4 Reduction, then increase in exercise in physically fit women, Outcome 10 Placental volume at delivery (cm ³).	39
Analysis 4.11. Comparison 4 Reduction, then increase in exercise in physically fit women, Outcome 11 Mid-trimester placental growth rate (cm ³ /wk).	39
Analysis 5.1. Comparison 5 Increase in exercise in overweight women, Outcome 1 Preterm birth.	40
Analysis 5.2. Comparison 5 Increase in exercise in overweight women, Outcome 2 Birthweight (g).	40
APPENDICES	40
FEEDBACK	41
WHAT'S NEW	41
HISTORY	41
CONTRIBUTIONS OF AUTHORS	42
DECLARATIONS OF INTEREST	42
SOURCES OF SUPPORT	42
INDEX TERMS	42

[Intervention Review]

Aerobic exercise for women during pregnancy

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ABSTRACT

Background

Physiological responses of the fetus (especially increase in heart rate) to single, brief bouts of maternal exercise have been documented frequently. Many pregnant women wish to engage in aerobic exercise during pregnancy, but are concerned about possible adverse effects on the outcome of pregnancy.

Objectives

To assess the effects of advising healthy pregnant women to engage in regular aerobic exercise (at least two to three times per week), or to increase or reduce the intensity, duration, or frequency of such exercise, on physical fitness, the course of labour and delivery, and the outcome of pregnancy.

Search methods

We searched the Cochrane Pregnancy and Childbirth Group's Trials Register (31 August 2009), MEDLINE (1966 to August 2009), EMBASE (1980 to August 2009), Conference Papers Index (earliest to August 2009), contacted researchers in the field and searched reference lists of retrieved articles.

Selection criteria

Acceptably controlled trials of prescribed exercise programs in healthy pregnant women.

Data collection and analysis

Both review authors independently assessed trial quality and extracted data. We contacted study authors for additional information.

Main results

We included 14 trials involving 1014 women. The trials were small and not of high methodologic quality. Of the nine trials reporting on physical fitness, six reported significant improvement in physical fitness in the exercise group, although inconsistencies in summary statistics and measures used to assess fitness prevented quantitative pooling of results. Eleven trials reported on pregnancy outcomes. A pooled increased risk of preterm birth (risk ratio 1.82, 95% confidence interval (CI) 0.35 to 9.57) with exercise, albeit statistically non-significant, does not cohere with the absence of effect on mean gestational age (mean difference +0.10, 95% CI -0.11 to +0.30 weeks), while the results bearing on growth of the fetus are inconsistent. One small trial reported that physically fit women who increased the duration of exercise bouts in early pregnancy and then reduced that duration in later pregnancy gave birth to larger infants with larger placentas.

Authors' conclusions

Regular aerobic exercise during pregnancy appears to improve (or maintain) physical fitness. Available data are insufficient to infer important risks or benefits for the mother or infant. Larger and better trials are needed before confident recommendations can be made about the benefits and risk of aerobic exercise in pregnancy.

PLAIN LANGUAGE SUMMARY**Aerobic exercise for women during pregnancy**

Regular aerobic exercise during pregnancy appears to improve physical fitness, but the evidence is insufficient to infer important risks or benefits for the mother or baby.

Aerobic exercise is physical activity that stimulates a person's breathing and blood circulation. The review of 14 trials, involving 1014 pregnant women, found that pregnant women who engage in vigorous exercise at least two to three times per week improve (or maintain) their physical fitness, and there is some evidence that these women have pregnancies of the same duration as those who maintain their usual activities. There is too little evidence from trials to show whether there are other effects on the woman and her baby. The trials reviewed included non-contact exercise such as swimming, static cycling and general floor exercise programs. Most of the trials were small and of insufficient methodologic quality, and larger, better trials are needed before confident recommendations can be made about the benefits and risks of aerobic exercise in pregnancy.

BACKGROUND

Physically demanding work during pregnancy has been associated with an increased risk of preterm birth ([Henriksen 1995](#); [Mamelle 1984](#); [Mozurkewich 2000](#); [Saurel 2004](#)), prolonged labour ([Magann 2002](#)), and reduced fetal growth ([Perkins 2007](#)) in some observational studies. Moreover, numerous reports ([Brenner 1999](#); [Clapp 1993](#); [Hatoum 1997](#); [Pijpers 1984](#); [Veille 1985](#)) have documented fetal physiological responses (especially increase in the fetal heart rate) to single, brief bouts of maternal exercise. The impact of prolonged and repeated aerobic exercise on outcomes of clinical importance for mothers and infants is unknown, however. Two published meta-analyses ([Leet 2003](#); [Lokey 1991](#)) and a narrative review ([Dye 2003](#)) have attempted to summarize the evidence but included observational studies as well as randomized trials. The 2000 Behavioral Risk Factor Surveillance System, a national population health survey in the United States, the most common leisure-time physical activities during pregnancy included walking, swimming, and aerobics ([Evenson 2004](#)). Given the important health benefits of regular physical activity (e.g., reduced blood pressure, improved well-being) for non-pregnant women ([Manson 1999](#)), many pregnant women may wish to continue exercising during pregnancy. Evidence-based recommendations for exercise during pregnancy are therefore important.

OBJECTIVES

To assess the effects of advising healthy pregnant women to engage in regular (at least two to three times per week) aerobic exercise, or to increase or reduce the intensity, duration, or frequency of such exercise, on physical fitness, on the course of labour and delivery, and on the outcome of pregnancy.

METHODS

Criteria for considering studies for this review

Types of studies

All randomized and quasi-randomized trials of prescribed aerobic exercise programmes.

Types of participants

Healthy pregnant women.

Types of interventions

Increase or reduction in regular aerobic exercise. We excluded trials with low frequency or duration of prescribed aerobic exercise (e.g., fewer than two sessions and/or lasting no more than 30 minutes per week), or both.

Types of outcome measures

Outcome measures included: change in level of maternal physical fitness and anthropometric measures; maternal outcomes of pregnancy such as pre-eclampsia, duration of labour, and type of delivery; and fetal and infant outcomes, or both, such as gestational age, birthweight, birth length, stillbirth, preterm birth, and small-for-gestational-age birth.

Search methods for identification of studies

Electronic searches

We searched the Cochrane Pregnancy and Childbirth Group's Trials Register by contacting the Trials Search Co-ordinator (31 August 2009).

The Cochrane Pregnancy and Childbirth Group's Trials Register is maintained by the Trials Search Co-ordinator and contains trials identified from:

1. quarterly searches of the Cochrane Central Register of Controlled Trials (CENTRAL);
2. weekly searches of MEDLINE;
3. handsearches of 30 journals and the proceedings of major conferences;
4. weekly current awareness alerts for a further 44 journals plus monthly BioMed Central email alerts.

Details of the search strategies for CENTRAL and MEDLINE, the list of handsearched journals and conference proceedings, and the list of journals reviewed via the current awareness service can be found in the 'Specialized Register' section within the editorial information about the [Cochrane Pregnancy and Childbirth Group](#).

Trials identified through the searching activities described above are each assigned to a review topic (or topics). The Trials Search Co-ordinator searches the register for each review using the topic list rather than keywords.

In addition, we searched MEDLINE (1966 to August 2009), EMBASE (1980 to August 2009) and Conference Papers Index (earliest to August 2009) using the search strategies detailed in [Appendix 1](#).

Searching other resources

We attempted to contact the authors of all studies identified to obtain additional references and unpublished data. In the case of abstracts only, we attempted to find associated papers, if they existed, in either published or unpublished format. We also searched reference lists of retrieved articles. We did not apply any language restrictions.

Data collection and analysis

For the methods used when assessing the trials identified in the previous version of this review, see [Appendix 2](#).

For this update we used the following methods when assessing the trials identified by the updated search ([Aittasalo 2008](#); [Barakat 2008](#); [Callaway 2008](#); [Granath 2006](#); [Haakstad 2008](#); [Hofman 2005](#); [Hui 2006](#); [Ko 2008](#); [McAuley 2005](#); [McDonald 2001](#); [Memari 2006](#); [Morkved 2007](#); [Oostdam 2009](#); [Quinlivan 2007](#); [Santos 2005](#); [Satyapriya 2009](#); [Yeo 2008](#)) as well as the study that was already awaiting classification ([Lee 1996](#)).

Selection of studies

The two review authors independently assessed for inclusion all the potential studies we identified as a result of the search strategy. We resolved any disagreements through discussion.

Data extraction and management

For eligible studies, the two review authors extracted the data independently by entering them into Review Manager software (RevMan 2008). We resolved discrepancies through discussion and checked all data for accuracy.

When information regarding any of the above was unclear, we attempted to contact authors of the original reports to provide further details.

Assessment of risk of bias in included studies

One of the authors (SW McDonald) assessed risk of bias for each study using the criteria outlined in the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2008); the other author (MS Kramer) then reviewed and approved these assessments.

(1) Sequence generation (checking for possible selection bias)

We describe for each included study the method used to generate the allocation sequence in sufficient detail to allow an assessment of whether it should produce comparable groups.

We assessed the method as:

- adequate (any truly random process, e.g., random number table; computer random number generator);
- inadequate (any non-random process, e.g., odd or even date of birth; hospital or clinic record number); or
- unclear.

(2) Allocation concealment (checking for possible selection bias)

We describe for each included study the method used to conceal the allocation sequence in sufficient detail and determine whether intervention allocation could have been foreseen in advance of, or during recruitment, or changed after assignment.

We assessed the methods as:

- adequate (e.g. telephone or central randomization; consecutively numbered sealed opaque envelopes);
- inadequate (open random allocation; unsealed or non-opaque envelopes, alternation; date of birth);
- unclear.

(3) Blinding (checking for possible performance bias)

We describe for each included study the methods used, if any, to blind study participants and personnel from knowledge of which intervention a participant received. We judged studies at low risk of bias if they were blinded, or if we judged that the lack of blinding could not have affected the results. We assessed blinding separately for different outcomes or classes of outcomes.

We assessed the methods as:

- adequate, inadequate or unclear for participants;
- adequate, inadequate or unclear for personnel;
- adequate, inadequate or unclear for outcome assessors.

(4) Incomplete outcome data (checking for possible attrition bias through withdrawals, dropouts, protocol deviations)

We describe for each included study, and for each outcome or class of outcomes, the completeness of data including attrition and exclusions from the analysis. We state whether attrition and exclusions were reported, the numbers included in the analysis at each stage (compared with the total randomized participants), reasons for attrition or exclusion where reported, and whether missing data were balanced across groups or were related to outcomes. Where sufficient information is reported, or can be supplied by the trial authors, we re-include missing data in the analyses which we undertake. We assessed methods as:

- adequate;
- inadequate;
- unclear.

(5) Selective reporting bias

We describe for each included study how we investigated the possibility of selective outcome reporting bias and what we found.

We assessed the methods as:

- adequate (where it is clear that all of the study's pre-specified outcomes and all expected outcomes of interest to the review have been reported);
- inadequate (where not all the study's pre-specified outcomes have been reported; one or more reported primary outcomes were not pre-specified; outcomes of interest are reported incompletely and so cannot be used; study fails to include results of a key outcome that would have been expected to have been reported);
- unclear.

(6) Other sources of bias

We describe for each included study any important concerns we have about other possible sources of bias.

We assessed whether each study was free of other problems that could put it at risk of bias:

- yes;
- no;
- unclear.

(7) Overall risk of bias

We make explicit judgements about whether studies are at high risk of bias, according to the criteria given in the *Handbook* (Higgins 2008). With reference to (1) to (6) above, we assessed the likely magnitude and direction of the bias and whether we consider it is likely to impact on the findings.

Measures of treatment effect

Dichotomous data

For dichotomous data, we present results as summary risk ratio (RR) with 95% confidence intervals (CI).

Continuous data

For continuous data, we use the mean difference if outcomes are measured in the same way between trials.

Unit of analysis issues

All included studies are based on randomization of individual participants.

Dealing with missing data

For included studies, we note levels of attrition.

For all outcomes we have carried out analyses, as far as possible, on an intention-to-treat basis, i.e. we attempt to include all participants randomized to each group in the analyses. The denominator for each outcome in each trial the number randomized minus any participants whose outcomes are known to be missing.

Assessment of heterogeneity

We use the I^2 statistic to measure heterogeneity among the trials in each analysis.

Assessment of reporting biases

Where we suspect reporting bias (see 'Selective reporting bias' above), we have attempted to contact study authors asking them to provide missing outcome data.

Data synthesis

We carry out statistical analysis using the Review Manager software (RevMan 2008). We use fixed-effect inverse variance meta-analysis for combining data where trials are examining the same intervention, and the trials' populations and methods are judged sufficiently similar. We have used random-effects models to pool results when I^2 is greater than 50%.

Subgroup analysis and investigation of heterogeneity

We did not undertake any subgroup analyses.

Sensitivity analysis

We did not undertake any sensitivity analyses.

RESULTS

Description of studies

We identified 30 trials.

Included studies

We included 14 trials (Bell 2000; Carpenter 1990; Clapp 2000; Clapp 2002; Collings 1983; Erkkola 1976; Lee 1996; Marquez 2000; Memari 2006; Prevedel 2003; Santos 2005; Sibley 1981; South-Paul 1988; Wolfe 1999). See Characteristics of included studies.

Excluded studies

We excluded 16 trials (Aittasalo 2008; Asbee 2009; Barakat 2008; Callaway 2008; Granath 2006; Hui 2006; Kihlstrand 1999; Kulpa 1987; Lawani 2003; McAuley 2005; McDonald 2001; Polley 2002; Quinlivan 2007; Satyapriya 2009; Varrassi 1989; Yeo 2008). See Characteristics of excluded studies for details.

Risk of bias in included studies

Overall, the trials are quite small, and none are of high methodologic quality. In most of the trials, the method of treatment allocation was either by alternation or was not described. Most did not specify the number of women originally allocated and the numbers of, and reasons for, losses to follow up. Very few provided data on compliance with the prescribed exercise program, and three excluded non-compliers from the analysis. Those studies excluding non-compliers also excluded women developing obstetric contraindications (e.g., bleeding, intrauterine growth restriction, preterm birth). These exclusions did not appear to have substantially biased the overall results, however. Nor did we identify other sources of bias in any of the included studies that could impact results apart from those already mentioned.

Effects of interventions

Carpenter 1990; Collings 1983; Erkkola 1976; Marquez 2000; Prevedel 2003 and Santos 2005 all reported significant improvement in physical fitness in sedentary women who increased their exercise during pregnancy. South-Paul 1988 reported similar, albeit statistically non-significant, findings, while the even smaller Sibley 1981 trial reported no significant increase in fitness in the exercise group. Inconsistency in the measures used to measure physical fitness across studies (e.g., aerobic capacity, cardiopulmonary measures, or physical work capacity) and the absence of 'change' data made it difficult to statistically combine the results on physical fitness.

Results on pregnancy outcomes in the above trials are limited to Bell 2000; Clapp 2000; Clapp 2002; Collings 1983; Erkkola 1976; Lee 1996; Marquez 2000; Memari 2006; Prevedel 2003 and Santos 2005. As shown by the wide confidence intervals, the small size of these trials permits exclusion of only extremely large effects for most of the reported outcomes. Increasing exercise in sedentary women had no significant effect on mean birthweight (mean difference (MD) +49.49, 95% confidence interval (CI) -27.74 to +126.73 g). The data are somewhat reassuring (albeit based only on two small trials) that increasing exercise in sedentary women does not result in a clinically important shortening of gestation (MD +0.10, 95% CI -0.11 to +0.30 weeks). Despite that result, increasing exercise was associated with a non-significant increase in the risk of preterm birth (risk ratio (RR) 1.82, 95% CI 0.35 to 9.57). No significant effects were observed on mean five-minute Apgar score (MD 0.15, 95% CI -0.10 to 0.39) or on risk of cesarean delivery (RR 0.96, 95% CI 0.60 to 1.53). Data on stillbirth, neonatal death, pre-eclampsia, and cesarean section are limited to one or two trials each, with small sample sizes and hence inconclusive results.

Other than outcomes related to maternal physical fitness, consistency of results across these trials is evaluable for preterm birth, cesarean delivery, gestational (maternal) weight gain, gestational age, birthweight, and five-minute Apgar score, each of which was reported by at least three trials. Within these limits and those imposed by small sample sizes, the results appear reasonably consistent except perhaps for five-minute Apgar score. Because of the small sample sizes and other methodologic limitations of the reported trials, however, heterogeneity is difficult to assess. Despite not contributing quantitative data for pooling, the results by Wolfe 1999 are in line with those already described.

The single trial ([Bell 2000](#)) investigating the effects of reducing high-frequency (at least five times per week) to lower-frequency (no more than three times per week) aerobic exercise is too small to make confident inferences about the benefits or risks of such a reduction.

One small trial ([Clapp 2002](#)) reported that physically fit women who increased the duration of their exercise bouts in early pregnancy, then reduced the duration in later pregnancy ('Hi-Lo' pattern), gave birth to much larger infants (difference in mean birthweight 460.00, 95% CI 251.63 to 668.37 g) with larger placentas than control women who maintained a moderate exercise duration throughout gestation. Women with the opposite pattern ('Lo-Hi') had similar outcomes to those in the control group.

One small trial ([Santos 2005](#)) in overweight women (body mass index 25 to 30 kg/m²) found no significant difference in risk of preterm birth (RR 1.89, 95% CI 0.18 to 19.95) or mean birthweight (MD -5.00, 95% CI -241.27 to +231.27 g) associated with the intervention.

DISCUSSION

Regular exercise during pregnancy appears to improve (or maintain) physical fitness. The available data are insufficient to infer other important risks or benefits for the mother or infant.

AUTHORS' CONCLUSIONS

Implications for practice

Regular exercise during pregnancy appears to improve (or maintain) physical fitness. Unfortunately, the available data are

insufficient to infer important risks or benefits for the mother or infant.

Implications for research

Future trials will require much larger sample sizes to detect potential effects on maternal and infant health. The suggestion that regular exercise may increase the risk of preterm birth (despite its inconsistency with the absence of effect on mean gestational age) requires further study, especially in light of the results of some observational studies of heavy work or prolonged standing ([Henriksen 1995](#); [Mamelle 1984](#)). The report of large increases in birthweight and placental size in physically fit women who prolonged their bouts of exercise in early pregnancy followed by reduction in later pregnancy requires confirmation in larger trials. Besides the traditional focus on fetal growth and gestational duration, future trials should assess the potential impacts on pain and duration of labour and on the risk of cesarean section, as well as possible reduction in risks of pregnancy-induced hypertension and pre-eclampsia ([Weissgerber 2004](#)). Given the differential risks and benefits of weight-bearing versus nonweight-bearing aerobic exercise for women in general and during pregnancy ([Artal 1989](#)), future trials should also compare types of aerobic exercise.

ACKNOWLEDGEMENTS

Edward Plaisance Jr translated [Memari 2006](#) from Persian.

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CHARACTERISTICS OF STUDIES

Characteristics of included studies [ordered by study ID]

Bell 2000

Methods	Randomization by use of a random numbers table and consecutively numbered opaque envelopes.
Participants	61 pregnant women intending to exercise at least 5 times per week throughout pregnancy. All women exercised regularly pre-pregnancy.
Interventions	Experimental: continued strenuous exercise ≥ 5 times per week from 24 weeks. Control: strenuous exercise reduced to ≤ 3 times per week from 24 weeks.
Outcomes	Mean birthweight and preterm birth rate.
Notes	1. Good compliance with interventions. 2. No reported losses or post-randomization exclusions.

Risk of bias

Bias	Authors' judgement	Support for judgement
Adequate sequence generation?	Low risk	Random number table.
Allocation concealment?	Low risk	Consecutively numbered sealed opaque envelopes.
Blinding? All outcomes	High risk	Nature of intervention prevents blinding of participants. No mention of blinding of outcome assessors, but most outcomes are objectively measured, and thus risk of biased measurement is low.
Incomplete outcome data addressed? All outcomes	Low risk	No reported losses or post-randomization exclusions.
Free of selective reporting?	Low risk	
Free of other bias?	Low risk	

Carpenter 1990

Methods	Randomization method not described.
Participants	14 sedentary women at an average of 21 weeks' gestational age.
Interventions	Experimental: 30 minutes of aerobic exercise 4 times per week for 10 weeks.

Aerobic exercise for women during pregnancy (Review)

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Carpenter 1990 (Continued)

Control: no exercise.

Outcomes	Physical fitness; no data reported on pregnancy outcomes.
Notes	1. Number randomized and losses not stated. 2. No information on compliance.

Risk of bias

Bias	Authors' judgement	Support for judgement
Adequate sequence generation?	Unclear risk	Not described.
Allocation concealment?	Unclear risk	Not described.
Blinding? All outcomes	High risk	Nature of intervention prevents blinding of participants. No mention of blinding of outcome assessors, but most outcomes are objectively measured, and thus risk of biased measurement is low.
Incomplete outcome data addressed? All outcomes	Unclear risk	Not described.
Free of selective reporting?	Low risk	
Free of other bias?	Unclear risk	Unable to assess based on information provided.

Clapp 2000

Methods	Randomization "by envelope" not otherwise described.
Participants	50 healthy pregnant women who did not exercise regularly before pregnancy.
Interventions	Experimental: 20 minutes of aerobic exercise 3-5 times per week beginning at 8-9 weeks and continuing until delivery. Control: no aerobic exercise.
Outcomes	Gestational weight gain, mid-trimester placental growth rate, placental volume, birthweight, length, ponderal index, and head circumference, preterm birth, infant lean mass, fat mass, %fat.
Notes	1. 2 non-compliers in experimental group excluded. 2. 2 women with preterm labour (1 in each group) excluded from analyses of outcomes. 3. 0.9 SEM for birthweight in Table I assumed to be .09 pending confirmation from authors.

Risk of bias

Bias	Authors' judgement	Support for judgement
Adequate sequence generation?	Unclear risk	Not described.
Allocation concealment?	Unclear risk	Inadequate information provided.

Clapp 2000 (Continued)

Blinding? All outcomes	High risk	Nature of intervention prevents blinding of participants. Except for placental morphometry, outcome assessors were unblinded, but most other outcomes are objectively measured, and thus risk of biased measurement is low.
Incomplete outcome data addressed? All outcomes	Low risk	Balanced losses. Analyses not ITT, but bias unlikely.
Free of selective reporting?	Low risk	
Free of other bias?	Low risk	Authors state that development of pregnancy complications merited exclusion from data analysis, but only 2 participants excluded for this reason.

Clapp 2002

Methods	Randomization "by envelope" not otherwise described.
Participants	80 healthy, physically fit pregnant women who exercised ≥ 3 times per week before pregnancy.
Interventions	Experimental (2 groups): 60 minutes weight-bearing exercise 5 days per week from 8 to 20 weeks, then reduced to 20 minutes 5 times per week from 24 weeks to delivery ('Hi-Lo' group); opposite pattern ('Lo-Hi' group). Control: intermediate intensity, constant pattern (40 minutes 5 days per week from 8 weeks to delivery).
Outcomes	Gestational weight gain, mid-trimester placental growth rate, placental volume, birthweight, length, ponderal index, and head circumference, preterm birth, infant lean mass, fat mass, % body fat, gestational age.
Notes	1. Good compliance with allocated exercise intervention. 2. 2 women with preterm labour (unclear from which group), 1 with bleeding and IUGR, and 2 with poor compliance not analyzed. 3. Low birthweight SDs.

Risk of bias

Bias	Authors' judgement	Support for judgement
Adequate sequence generation?	Unclear risk	Not described.
Allocation concealment?	Unclear risk	Not described.
Blinding? All outcomes	High risk	Nature of intervention prevents blinding of participants. Except for placental morphometry, outcome assessors were unblinded, but most other outcomes are objectively measured, and thus risk of biased measurement is low.
Incomplete outcome data addressed? All outcomes	Low risk	Post-randomization exclusions symmetrical (1 from each group). Analyses not ITT but bias unlikely.
Free of selective reporting?	Low risk	

Clapp 2002 (Continued)

Free of other bias? Low risk

Collings 1983

Methods	First 5 women selected their own treatment, remainder 'randomized' using unspecified method.
Participants	20 healthy pregnant women in 2nd trimester.
Interventions	Experimental: 3 times per week aerobic exercise (cycle ergometer) for 13 weeks. Control: no regular exercise.
Outcomes	Physical fitness, placental weight, birthweight, birth length, 1- and 5-minute Apgar scores, gestational age, preterm birth, stillbirth, neonatal mortality, low birthweight, small-for-gestational age, pre-eclampsia, gestational weight gain, duration of labour, and cesarean section. Fetal heart rate (acute exercise effect) not reported in review.
Notes	Authors say no losses or non-compliance with intervention.

Risk of bias

Bias	Authors' judgement	Support for judgement
Adequate sequence generation?	Unclear risk	Not described.
Allocation concealment?	High risk	Inadequate; first 5 women selected their own treatment.
Blinding? All outcomes	High risk	Nature of intervention prevents blinding of participants. No mention of blinding of outcome assessors, but most outcomes are objectively measured, and thus risk of biased measurement is low.
Incomplete outcome data addressed? All outcomes	Low risk	No reported losses.
Free of selective reporting?	Low risk	
Free of other bias?	Low risk	

Erkkola 1976

Methods	Allocation by strict alternation in a consecutive series.
Participants	76 healthy primips with singleton fetuses.
Interventions	Experimental: training exercise for 1 hour, 3 times per week starting at 10-14 weeks' gestational age. Control: no instructions for training.
Outcomes	Physical fitness, heart volume, birthweight, gestational age, and pre-eclampsia.
Notes	1. No information on dropouts (44 of 76 original 'randomized') or compliance. 2. Large losses, but symmetric in treatment groups.

Aerobic exercise for women during pregnancy (Review)

Erkkola 1976 (Continued)

3. Infant results and heart volume based on smaller sample size than other outcomes.

Risk of bias

Bias	Authors' judgement	Support for judgement
Adequate sequence generation?	Unclear risk	Not described.
Allocation concealment?	High risk	Inadequate: alternation.
Blinding? All outcomes	High risk	Nature of intervention prevents blinding of participants. No mention of blinding of outcome assessors, but most outcomes are objectively measured, and thus risk of biased measurement is low.
Incomplete outcome data addressed? All outcomes	Low risk	Large but balanced losses. Bias unlikely.
Free of selective reporting?	Low risk	
Free of other bias?	Low risk	

Lee 1996

Methods	Random number table used to allocate treatment, but no apparent method used to conceal allocation from research personnel or consenting participants.
Participants	370 healthy, nonsmoking nulliparae with singleton fetus < 20 weeks of gestation.
Interventions	Intervention: aerobic exercise 1 hour 3 times per week from 20 weeks until delivery. Control: no intervention.
Outcomes	Duration of 2nd stage of labour, birthweight, gestational age, 5-minute Apgar score.
Notes	- Poor compliance with experimental intervention: only 23% attended at least once a week for at least 16 weeks. - Post-randomization exclusion of participants with insulin-dependent gestational diabetes, placental abruption, pregnancy-induced hypertension, placenta previa, IUGR, preterm labour, or breech presentation. - Postnatal questionnaire completed by only 268 participants (72.4% of those included), so data not included in review. 19 of the 370 women delivered at a non-study hospital and were thus lost to follow up.

Risk of bias

Bias	Authors' judgement	Support for judgement
Adequate sequence generation?	Low risk	Random number table.
Allocation concealment?	High risk	Author correspondence notes inadequate concealment.

Lee 1996 (Continued)

Blinding? All outcomes	High risk	Nature of intervention prevents blinding of participants. No mention of blinding of outcome assessors, but most outcomes are objectively measured, and thus risk of biased measurement is low.
Incomplete outcome data addressed? All outcomes	High risk	Post-randomization exclusions not compared by group, and the exclusion factors could have been (although probably were not) caused or prevented by the intervention. Study is included, but with caveats about possible bias.
Free of selective reporting?	High risk	Published manuscript reports on only a subset of outcomes that were originally obtained. Study is included with caveats about this possible bias.
Free of other bias?	Low risk	Apart from caveats mentioned above, other biases unlikely.

Marquez 2000

Methods	Allocation method not described, yet appears to be quasi-randomization.
Participants	20 sedentary primigravidae in second trimester of pregnancy.
Interventions	Experimental: aerobic exercise 1 hour 3 times per week for 15 weeks. Control: no aerobic exercise during pregnancy.
Outcomes	Physical fitness, gestational weight gain, birthweight, 5-minute Apgar score, cesarean section, and body image.
Notes	1. 10% and 40% drop-out rates from experimental and control groups, respectively. 2. No compliance issues; no post-randomization exclusions. 3. SD birthweight in experimental group (275 g) very low - error?

Risk of bias

Bias	Authors' judgement	Support for judgement
Adequate sequence generation?	High risk	Alternate allocation.
Allocation concealment?	High risk	Alternate allocation.
Blinding? All outcomes	High risk	Nature of intervention prevents blinding of participants. No mention of blinding of outcome assessors, but most outcomes are objectively measured, and thus risk of biased measurement is low.
Incomplete outcome data addressed? All outcomes	Low risk	Despite unbalanced losses, bias unlikely.
Free of selective reporting?	Low risk	
Free of other bias?	Low risk	

Memari 2006

Methods	Randomization method not described.
Participants	80 healthy but sedentary women from Tehran (Iran) in their second pregnancy recruited at 18 weeks of gestation.
Interventions	Experimental: aerobic exercise 15-30 minutes per day, 3 days per week, for 8 weeks Control: no intervention.
Outcomes	Gestational age, birthweight, 5-minute Apgar score
Notes	1. No mention of number of women recruited, randomized, or lost to follow up. 2. No data provided on compliance with experimental intervention. 3. No data on differences achieved (if any) in physical fitness.

Risk of bias

Bias	Authors' judgement	Support for judgement
Adequate sequence generation?	Unclear risk	Not described.
Allocation concealment?	Unclear risk	Not described.
Blinding? All outcomes	High risk	Nature of intervention prevents blinding of participants. No mention of blinding of outcome assessors, but most outcomes are objectively measured, and thus risk of biased measurement is low.
Incomplete outcome data addressed? All outcomes	Unclear risk	Translated notes report no withdrawals or losses; no information on post-randomization exclusions.
Free of selective reporting?	Low risk	
Free of other bias?	Low risk	

Prevedel 2003

Methods	Randomization method not described.
Participants	60 healthy primips at 16 weeks.
Interventions	Experimental: hydrotherapy program 1 hour 3 times per week throughout 2nd half of pregnancy Control: not offered hydrotherapy program.
Outcomes	Physical fitness, gestational weight gain, lean mass, fat mass,%fat, birthweight, gestational age, preterm birth, perinatal death, SGA.
Notes	19 women were lost to follow up, non-compliant, or excluded for obstetric/medical reasons (no breakdown for type of loss).

Risk of bias

Bias	Authors' judgement	Support for judgement

Prevedel 2003 (Continued)

Adequate sequence generation?	Unclear risk	Not described.
Allocation concealment?	Unclear risk	Not described.
Blinding? All outcomes	High risk	Nature of intervention prevents blinding of participants. No mention of blinding of outcome assessors, but most outcomes are objectively measured, and thus risk of biased measurement is low.
Incomplete outcome data addressed? All outcomes	Low risk	Balanced overall losses, although no breakdown provided about type of loss by group. Bias unlikely.
Free of selective reporting?	Low risk	
Free of other bias?	Low risk	

Santos 2005

Methods	Randomization via "blocked sequence" (not further specified) generated from a random number table, using numbered opaque envelopes.
Participants	92 overweight (pre-pregnancy BMI 25-30 kg/m ²) but otherwise healthy women < 20 weeks of gestation.
Interventions	Experimental: supervised aerobic exercise sessions for 60 minutes per day, 3 times per week, for 12 weeks. Control: weekly relaxation and stretching sessions (no aerobic or weight-resistance exercise during sessions).
Outcomes	Physical fitness, preterm birth, mean birthweight, gestational diabetes, gestational hypertension/pre-eclampsia, cesarean delivery.
Notes	1. Of the 92 women randomized, 9 and 11 dropped out or did not perform fitness testing in the experimental and control groups, respectively. 2. Compliance with session attendance low in both groups (40% and 50% in the E and C groups, respectively). 3. No quantitative data presented for gestational diabetes, gestational hypertension/pre-eclampsia, or cesarean delivery.

Risk of bias

Bias	Authors' judgement	Support for judgement
Adequate sequence generation?	Low risk	Random number table.
Allocation concealment?	Low risk	Numbered opaque envelopes.
Blinding? All outcomes	Unclear risk	Nature of intervention prevents blinding of participants. Outcome assessor for main outcomes blinded to treatment allocation. Low risk of bias.
Incomplete outcome data addressed?	Low risk	Balanced losses. Bias unlikely.

Santos 2005 (Continued)

All outcomes

Free of selective reporting?	Low risk
Free of other bias?	Low risk

Sibley 1981

Methods	Randomization method not described.
Participants	13 healthy women age 18-35 years and 13-26 weeks' gestational age.
Interventions	Experimental: aerobic (swimming) exercise for 1 hour, 3 times per week for 10 weeks. Control: normal activity without aerobic exercise.
Outcomes	Physical fitness; no data reported on pregnancy outcomes. Fetal heart rate before and after exercise (acute exercise effect) not included in review.
Notes	1. Number of women originally allocated not mentioned. 2. No data on compliance, yet authors note that the intervention was personalized and that all subjects at the end remained healthy, reported an increased sense of well-being, appropriate weight gain, etc. from which good compliance is inferred.

Risk of bias

Bias	Authors' judgement	Support for judgement
Adequate sequence generation?	Unclear risk	Not described. Authors report that participants were randomly assigned to 1 of 2 groups but also describe the design as quasi-experimental.
Allocation concealment?	Unclear risk	Not described.
Blinding? All outcomes	High risk	Nature of intervention prevents blinding of participants. No mention of blinding of outcome assessors, but most outcomes are objectively measured, and thus risk of biased measurement is low.
Incomplete outcome data addressed? All outcomes	Low risk	No losses reported.
Free of selective reporting?	Low risk	
Free of other bias?	Low risk	

South-Paul 1988

Methods	Randomization method not described.
Participants	23 untrained healthy women (primips and multips) age 19-35 years at beginning of the 2nd trimester.
Interventions	Experimental: progressive aerobic exercise (cycle ergometer) 1 hour 3 times per week.

South-Paul 1988 (Continued)

Control: usual physical activity without supervised exercise.

Outcomes	Physical fitness, respiratory fitness; no data reported on pregnancy outcomes.
Notes	1. Large, asymmetric losses across treatment groups, but bias unlikely. 2. No data on compliance.

Risk of bias

Bias	Authors' judgement	Support for judgement
Adequate sequence generation?	Unclear risk	Not described.
Allocation concealment?	Unclear risk	Not described.
Blinding? All outcomes	High risk	Nature of intervention prevents blinding of participants. No mention of blinding of outcome assessors, but most outcomes are objectively measured, and thus risk of biased measurement is low.
Incomplete outcome data addressed? All outcomes	Low risk	Asymmetric losses but unlikely to affect results.
Free of selective reporting?	Low risk	
Free of other bias?	Low risk	

Wolfe 1999

Methods	Randomization method not described.
Participants	55 healthy, previously sedentary pregnant women at beginning of second trimester.
Interventions	Experimental: aerobic conditioning (stair stepping) 30 minutes 3 times per week plus light muscular conditioning during second and third trimesters. Control: light muscular conditioning only.
Outcomes	Physical fitness; infant birthweight, length, body circumferences, limb lengths, adiposity.
Notes	1. Published abstract only; no information on losses, post-randomization exclusions, or compliance. 2. No reported quantitative outcomes to enter in the meta-analysis.

Risk of bias

Bias	Authors' judgement	Support for judgement
Adequate sequence generation?	Unclear risk	Not described.
Allocation concealment?	Unclear risk	Not described.

Wolfe 1999 (Continued)

Blinding? All outcomes	High risk	Nature of intervention prevents blinding of participants. No mention of blinding of outcome assessors, but most outcomes are objectively measured, and thus risk of biased measurement is low.
Incomplete outcome data addressed? All outcomes	Unclear risk	No information on losses of any type.
Free of selective reporting?	Unclear risk	Information insufficient to assess.
Free of other bias?	Unclear risk	Information insufficient to assess.

BMI: body mass index

ITT: intention to treat

IUGR: intrauterine growth restriction

SD: standard deviation

SEM: standard error of the mean

SGA: small-for-gestational age

Characteristics of excluded studies [ordered by study ID]

Study	Reason for exclusion
Aittasalo 2008	Allocation was not randomly allocated but was self-selected by clinics. In addition, no outcome data reported.
Asbee 2009	Intervention included both dietary and exercise recommendations, making it difficult to separate the 2 components.
Barakat 2008	Intervention not aerobic: described as "very light resistance and toning exercises."
Callaway 2008	Feasibility/pilot study only. Intervention judged infeasible, no data reported on outcomes.
Granath 2006	Both intervention and control groups included exercise component (water vs land-based exercise program), and both groups exercised only once per week.
Hui 2006	Intervention included both diet and exercise components. Moreover, the exercise program consisted of only 1 supervised group exercise session per week and a recommendation for home-based exercise.
Kihlstrand 1999	Exercise intervention was only 30 minutes per week.
Kulpa 1987	Ambiguous methodology (e.g., exercise intervention and participant allocation ill-defined).
Lawani 2003	Allocation to the groups was neither randomized nor quasi-randomized.
McAuley 2005	Nearly half of randomized women dropped out "for medical reasons or poor compliance".
McDonald 2001	No mention of randomization or other method of allocation, no data reported on control (no exercise) group.
Polley 2002	Intervention included both dietary and exercise recommendations, making it difficult to separate the 2 components. Also, the 'modest' exercise recommendation resulted in similar exercise levels

Study	Reason for exclusion
	post-intervention in the 2 comparison groups, raising concerns about compliance and potency of intervention.
Quinlivan 2007	Intervention includes both dietary and exercise recommendations, making it difficult to separate the 2 components.
Satyapriya 2009	Intervention based on yoga and "deep relaxation" (i.e., not aerobic).
Varrassi 1989	Ambiguous methodology (e.g., exercise intervention and participant allocation ill-defined).
Yeo 2008	Intervention intensity too low (walking program in which women reached their target heart rate only 35% of the time at 18 weeks and 17% at the end of pregnancy).

RCT: randomized controlled trial

vs: versus

Characteristics of ongoing studies *[ordered by study ID]*

[Haakstad 2008](#)

Trial name or title	Haakstad 2008.
Methods	RCT.
Participants	100 sedentary primiparous women < 24 weeks' gestation.
Interventions	Supervised aerobic exercise for 60 minutes at least 2 times per week, for 12-16 weeks.
Outcomes	Gestational weight gain, physical fitness, birthweight, duration of labour, delivery complications.
Starting date	November 2007.
Contact information	Lene Haakstad, Norwegian School of Sport Science, Oslo.
Notes	

[Hofman 2005](#)

Trial name or title	Hopkins 2005.
Methods	RCT.
Participants	120 healthy nulliparous pregnant women with singleton gestation < 20 weeks' gestation.
Interventions	Moderate aerobic exercise for 40 minutes, 5 times per week until term.
Outcomes	Maternal insulin sensitivity at 20 and 35 weeks, newborn size and body composition.
Starting date	December 2004.
Contact information	Sarah Hopkins, Liggins Institute, U of Auckland, NZ.
Notes	

Aerobic exercise for women during pregnancy (Review)

Ko 2008

Trial name or title	Ko 2008.
Methods	RCT.
Participants	Healthy pregnant women 18-45 years of age and ≤ 13 weeks of gestation.
Interventions	Advice to increase vigorous physical activity.
Outcomes	Central adiposity measured 6-8 weeks postpartum; maternal leptin, glucose, insulin, and cholesterol; fetal and neonatal adiposity.
Starting date	October 2007.
Contact information	Cynthia Ko, U of Washington.
Notes	

Morkved 2007

Trial name or title	Morkved 2007.
Methods	RCT.
Participants	Healthy pregnant ≥ 18 years with singleton gestation at 18 weeks.
Interventions	"Regular exercise."
Outcomes	Gestational diabetes, low back and pelvic girdle pain, maternal weight gain, labour and delivery, fetal macrosomia.
Starting date	May 2007.
Contact information	Siv Morkved, Dept of Community Medicine and General Practice, Norwegian University of Science and Technology, Trondheim.
Notes	Vague description of intervention.

Oostdam 2009

Trial name or title	Oostdam 2009.
Methods	RCT.
Participants	Pregnant women > 18 years of age and at increased risk for gestational diabetes, recruited 14-20 weeks' gestation.
Interventions	Supervised aerobic exercise for 60 minutes, 2 days per week.
Outcomes	Maternal fasting glucose and insulin, maternal lipids and HbA1c, gestational weight gain, birth-weight.

Aerobic exercise for women during pregnancy (Review)

Oostdam 2009 (Continued)

Starting date	Not stated.
Contact information	Nicolette Oostdam, Dept of Public and Occupational Health, VU University Medical Centre, Amsterdam.
Notes	Publication includes study rationale and protocol, but no results.

RCT: randomized controlled trial

DATA AND ANALYSES
Comparison 1. Increase in exercise in sedentary women

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Small-for-gestational-age birth	2	61	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
2 Preterm birth	3	111	Risk Ratio (M-H, Fixed, 95% CI)	1.82 [0.35, 9.57]
3 Pre-eclampsia	2	82	Risk Ratio (M-H, Fixed, 95% CI)	1.17 [0.44, 3.08]
4 Stillbirth	1	20	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
5 Neonatal death	2	61	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
6 Cesarean section	3	386	Risk Ratio (M-H, Fixed, 95% CI)	0.96 [0.60, 1.53]
7 Total gestational weight gain (kg)	4	122	Mean Difference (IV, Fixed, 95% CI)	0.79 [-0.73, 2.31]
8 Change in maternal fat mass (kg)	1	41	Mean Difference (IV, Fixed, 95% CI)	-1.51 [-3.06, 0.04]
9 Change in maternal lean mass (kg)	1	41	Mean Difference (IV, Fixed, 95% CI)	1.59 [0.38, 2.80]
10 Birthweight (g)	6	556	Mean Difference (IV, Fixed, 95% CI)	49.49 [-27.74, 126.73]
11 Birth fat mass (g)	1	46	Mean Difference (IV, Fixed, 95% CI)	30.0 [-82.72, 142.72]
12 Birth lean mass (g)	1	46	Mean Difference (IV, Fixed, 95% CI)	19.0 [-161.21, 199.21]
13 Birth % body fat	1	46	Mean Difference (IV, Fixed, 95% CI)	0.30 [-1.78, 2.38]
14 Birth length (cm)	2	64	Mean Difference (IV, Fixed, 95% CI)	1.27 [0.48, 2.07]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
15 Birth head circumference (cm)	1	46	Mean Difference (IV, Fixed, 95% CI)	0.40 [-0.43, 1.23]
16 Birth ponderal index (g/cm3 x 100)	1	46	Mean Difference (IV, Fixed, 95% CI)	0.04 [-0.07, 0.15]
17 Gestational age (wk)	4	495	Mean Difference (IV, Fixed, 95% CI)	0.10 [-0.11, 0.30]
18 Placental volume at delivery (cm3)	1	46	Mean Difference (IV, Fixed, 95% CI)	48.00 [3.30, 92.70]
19 Mid-trimester placental growth rate (cm3/wk)	1	46	Mean Difference (IV, Fixed, 95% CI)	5.0 [4.07, 5.93]
20 Placental weight at delivery (g)	1	16	Mean Difference (IV, Fixed, 95% CI)	14.30 [-118.70, 147.30]
21 Duration of labour, first stage (hr)	1	18	Mean Difference (IV, Fixed, 95% CI)	2.00 [-1.15, 5.15]
22 Duration of labour, second stage (min)	2	316	Mean Difference (IV, Fixed, 95% CI)	-5.72 [-15.22, 3.78]
23 1-minute Apgar score	1	20	Mean Difference (IV, Fixed, 95% CI)	1.0 [-1.37, 3.37]
24 5-minute Apgar score	4	462	Mean Difference (IV, Random, 95% CI)	0.15 [-0.10, 0.39]
25 Relative heart volume post-delivery (cm3/m2)	1	44	Mean Difference (IV, Fixed, 95% CI)	39.0 [1.78, 76.22]

Analysis 1.1. Comparison 1 Increase in exercise in sedentary women, Outcome 1 Small-for-gestational-age birth.

Study or subgroup	Treatment n/N	Control n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Collings 1983	0/12	0/8			Not estimable
Prevedel 2003	0/22	0/19			Not estimable
Total (95% CI)	34	27			Not estimable
Total events: 0 (Treatment), 0 (Control)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
			0.1 0.2 0.5 1 2 5 10		

Analysis 1.2. Comparison 1 Increase in exercise in sedentary women, Outcome 2 Preterm birth.

Analysis 1.3. Comparison 1 Increase in exercise in sedentary women, Outcome 3 Pre-eclampsia.

Analysis 1.4. Comparison 1 Increase in exercise in sedentary women, Outcome 4 Stillbirth.

Analysis 1.5. Comparison 1 Increase in exercise in sedentary women, Outcome 5 Neonatal death.

Analysis 1.6. Comparison 1 Increase in exercise in sedentary women, Outcome 6 Cesarean section.

Analysis 1.7. Comparison 1 Increase in exercise in sedentary women, Outcome 7 Total gestational weight gain (kg).

Analysis 1.8. Comparison 1 Increase in exercise in sedentary women, Outcome 8 Change in maternal fat mass (kg).

Analysis 1.9. Comparison 1 Increase in exercise in sedentary women, Outcome 9 Change in maternal lean mass (kg).

Analysis 1.10. Comparison 1 Increase in exercise in sedentary women, Outcome 10 Birthweight (g).

Analysis 1.11. Comparison 1 Increase in exercise in sedentary women, Outcome 11 Birth fat mass (g).

Analysis 1.12. Comparison 1 Increase in exercise in sedentary women, Outcome 12 Birth lean mass (g).

Analysis 1.13. Comparison 1 Increase in exercise in sedentary women, Outcome 13 Birth % body fat.

Analysis 1.14. Comparison 1 Increase in exercise in sedentary women, Outcome 14 Birth length (cm).

Analysis 1.15. Comparison 1 Increase in exercise in sedentary women, Outcome 15 Birth head circumference (cm).

Analysis 1.16. Comparison 1 Increase in exercise in sedentary women, Outcome 16 Birth ponderal index (g/cm³ x 100).

Analysis 1.17. Comparison 1 Increase in exercise in sedentary women, Outcome 17 Gestational age (wk).

Analysis 1.18. Comparison 1 Increase in exercise in sedentary women, Outcome 18 Placental volume at delivery (cm³).

Analysis 1.19. Comparison 1 Increase in exercise in sedentary women, Outcome 19 Mid-trimester placental growth rate (cm³/wk).

Analysis 1.20. Comparison 1 Increase in exercise in sedentary women, Outcome 20 Placental weight at delivery (g).

Analysis 1.21. Comparison 1 Increase in exercise in sedentary women, Outcome 21 Duration of labour, first stage (hr).

Analysis 1.22. Comparison 1 Increase in exercise in sedentary women, Outcome 22 Duration of labour, second stage (min).

Analysis 1.23. Comparison 1 Increase in exercise in sedentary women, Outcome 23 1-minute Apgar score.

Analysis 1.24. Comparison 1 Increase in exercise in sedentary women, Outcome 24 5-minute Apgar score.

Analysis 1.25. Comparison 1 Increase in exercise in sedentary women, Outcome 25 Relative heart volume post-delivery (cm3/m2).

Comparison 2. Reduction in exercise in physically fit women

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Preterm birth	1	61	Risk Ratio (M-H, Fixed, 95% CI)	1.18 [0.08, 17.99]
2 Birthweight (g)	1	61	Mean Difference (IV, Fixed, 95% CI)	-135.0 [-368.66, 98.66]

Analysis 2.1. Comparison 2 Reduction in exercise in physically fit women, Outcome 1 Preterm birth.

Analysis 2.2. Comparison 2 Reduction in exercise in physically fit women, Outcome 2 Birthweight (g).

Comparison 3. Increase, then reduction in exercise in physically fit women

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Gestational weight gain (kg)	1	49	Mean Difference (IV, Fixed, 95% CI)	0.90 [-1.59, 3.39]
2 Birthweight (g)	1	49	Mean Difference (IV, Fixed, 95% CI)	460.0 [251.63, 668.37]
3 Birth fat mass (g)	1	49	Mean Difference (IV, Fixed, 95% CI)	210.0 [148.02, 271.98]
4 Birth lean mass (g)	1	49	Mean Difference (IV, Fixed, 95% CI)	260.0 [79.28, 440.72]
5 Birth % body fat	1	49	Mean Difference (IV, Fixed, 95% CI)	4.20 [2.71, 5.69]
6 Birth length (cm)	1	49	Mean Difference (IV, Fixed, 95% CI)	1.40 [0.69, 2.11]
7 Birth head circumference (cm)	1	49	Mean Difference (IV, Fixed, 95% CI)	0.5 [-0.21, 1.21]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
8 Birth ponderal index (g/cm ³ x 100)	1	49	Mean Difference (IV, Fixed, 95% CI)	0.14 [0.03, 0.25]
9 Gestational age (wk)	1	49	Mean Difference (IV, Fixed, 95% CI)	0.43 [-0.36, 1.22]
10 Placental volume at delivery (cm ³)	1	49	Mean Difference (IV, Fixed, 95% CI)	65.0 [-5.26, 135.26]
11 Mid-trimester placental growth rate (cm ³ /wk)	1	49	Mean Difference (IV, Fixed, 95% CI)	1.0 [-4.54, 6.54]

Analysis 3.1. Comparison 3 Increase, then reduction in exercise in physically fit women, Outcome 1 Gestational weight gain (kg).

Analysis 3.2. Comparison 3 Increase, then reduction in exercise in physically fit women, Outcome 2 Birthweight (g).

Analysis 3.3. Comparison 3 Increase, then reduction in exercise in physically fit women, Outcome 3 Birth fat mass (g).

Analysis 3.4. Comparison 3 Increase, then reduction in exercise in physically fit women, Outcome 4 Birth lean mass (g).

Analysis 3.5. Comparison 3 Increase, then reduction in exercise in physically fit women, Outcome 5 Birth % body fat.

Analysis 3.6. Comparison 3 Increase, then reduction in exercise in physically fit women, Outcome 6 Birth length (cm).

Analysis 3.7. Comparison 3 Increase, then reduction in exercise in physically fit women, Outcome 7 Birth head circumference (cm).

Analysis 3.8. Comparison 3 Increase, then reduction in exercise in physically fit women, Outcome 8 Birth ponderal index (g/cm³ x 100).

Analysis 3.9. Comparison 3 Increase, then reduction in exercise in physically fit women, Outcome 9 Gestational age (wk).

Analysis 3.10. Comparison 3 Increase, then reduction in exercise in physically fit women, Outcome 10 Placental volume at delivery (cm³).

Analysis 3.11. Comparison 3 Increase, then reduction in exercise in physically fit women, Outcome 11 Mid-trimester placental growth rate (cm³/wk).

Comparison 4. Reduction, then increase in exercise in physically fit women

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Gestational weight gain (kg)	1	50	Mean Difference (IV, Fixed, 95% CI)	-2.60 [-4.96, -0.24]
2 Birthweight (g)	1	50	Mean Difference (IV, Fixed, 95% CI)	-100.0 [-308.39, 108.39]
3 Birth fat mass (g)	1	50	Mean Difference (IV, Fixed, 95% CI)	20.0 [-7.72, 47.72]
4 Birth lean mass (g)	1	50	Mean Difference (IV, Fixed, 95% CI)	-100.00 [-280.74, 80.74]
5 Birth % body fat	1	50	Mean Difference (IV, Fixed, 95% CI)	0.60 [-0.38, 1.58]
6 Birth length (cm)	1	50	Mean Difference (IV, Fixed, 95% CI)	-0.10 [-0.93, 0.73]
7 Birth head circumference (cm)	1	50	Mean Difference (IV, Fixed, 95% CI)	-0.20 [-0.91, 0.51]
8 Birth ponderal index (g/cm ³ x 100)	1	50	Mean Difference (IV, Fixed, 95% CI)	-0.07 [-0.17, 0.03]
9 Gestational age (wk)	1	50	Mean Difference (IV, Fixed, 95% CI)	-0.14 [-0.77, 0.49]
10 Placental volume at delivery (cm ³)	1	50	Mean Difference (IV, Fixed, 95% CI)	-33.0 [-73.36, 7.36]
11 Mid-trimester placental growth rate (cm ³ /wk)	1	50	Mean Difference (IV, Fixed, 95% CI)	-1.00 [-7.38, 1.38]

Analysis 4.1. Comparison 4 Reduction, then increase in exercise in physically fit women, Outcome 1 Gestational weight gain (kg).

Analysis 4.2. Comparison 4 Reduction, then increase in exercise in physically fit women, Outcome 2 Birthweight (g).

Analysis 4.3. Comparison 4 Reduction, then increase in exercise in physically fit women, Outcome 3 Birth fat mass (g).

Analysis 4.4. Comparison 4 Reduction, then increase in exercise in physically fit women, Outcome 4 Birth lean mass (g).

Analysis 4.5. Comparison 4 Reduction, then increase in exercise in physically fit women, Outcome 5 Birth % body fat.

Analysis 4.6. Comparison 4 Reduction, then increase in exercise in physically fit women, Outcome 6 Birth length (cm).

Analysis 4.7. Comparison 4 Reduction, then increase in exercise in physically fit women, Outcome 7 Birth head circumference (cm).

Analysis 4.8. Comparison 4 Reduction, then increase in exercise in physically fit women, Outcome 8 Birth ponderal index (g/cm3 x 100).

Analysis 4.9. Comparison 4 Reduction, then increase in exercise in physically fit women, Outcome 9 Gestational age (wk).

Analysis 4.10. Comparison 4 Reduction, then increase in exercise in physically fit women, Outcome 10 Placental volume at delivery (cm3).

Analysis 4.11. Comparison 4 Reduction, then increase in exercise in physically fit women, Outcome 11 Mid-trimester placental growth rate (cm3/wk).

Comparison 5. Increase in exercise in overweight women

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Preterm birth	1	72	Risk Ratio (M-H, Fixed, 95% CI)	1.89 [0.18, 19.95]
2 Birthweight (g)	1	72	Mean Difference (IV, Fixed, 95% CI)	-5.0 [-241.27, 231.27]

Analysis 5.1. Comparison 5 Increase in exercise in overweight women, Outcome 1 Preterm birth.

Analysis 5.2. Comparison 5 Increase in exercise in overweight women, Outcome 2 Birthweight (g).

APPENDICES

Appendix 1. Search strategies

Authors searched the following:

MEDLINE (1966 to August 2009)

1. exp *Pregnancy/ or exp *PREGNANT WOMEN/ or exp Pregnancy Complications/
2. exp EXERCISE THERAPY/ or exp *EXERCISE/ or exp EXERCISE TEST/ or exp EXERCISE TOLERANCE/
3. 1 and 2
4. random\$.mp.
5. 3 and 4

EMBASE (1980 to August 2009)

1. exp *Pregnancy/ or exp *PREGNANT WOMAN/
2. exp ISOKINETIC EXERCISE/ or exp *EXERCISE/ or exp EXERCISE TOLERANCE/ or exp STATIC EXERCISE/ or TREADMILL EXERCISE/
3. 1 and 2
4. controlled.mp.
5. 3 and 4

Conference Papers Index (to August 2009)

(pregnant or pregnancy) and (exercise or aerobic)

Appendix 2. Methods used to assess trials included in previous versions of this review

The following methods were used to assess [Bell 2000](#); [Carpenter 1990](#); [Clapp 2000](#); [Clapp 2002](#); [Collings 1983](#); [Erkkola 1976](#); [Marquez 2000](#); [Prevedel 2003](#); [Sibley 1981](#); [South-Paul 1988](#); [Wolfe 1999](#).

Both review authors independently evaluated trials under consideration for methodological quality and appropriateness for inclusion without consideration of their results. Any disagreement was resolved through discussion.

We assessed the validity of each study using criteria outlined in the Cochrane Reviewers' Handbook ([Alderson 2004](#)). We operationalized selection bias using quality scores for allocation concealment: adequate (A), unclear (B), or inadequate (C). We assessed attrition bias in terms of percentage loss of participants (dropouts, withdrawals) and whether the losses were asymmetric, that is, different in the randomized groups. Attempts were made to contact study authors to provide missing data.

Both review authors independently extracted study data. RevMan5 was used for data entry and meta-analysis; reported effect measures are relative risks and their 95% confidence intervals (CIs) for dichotomous outcomes and weighted mean differences and their 95% CIs for continuous outcomes. We report outcomes within data type (dichotomous versus continuous), with dichotomous outcomes presented first. Results are reported for three different comparisons, based on the types of participants and specific nature of the trial interventions: (1) increase in exercise among sedentary pregnant women; (2) initial increase followed by reduction in exercise among fit pregnant women; and (3) initial reduction followed by increase in exercise among fit pregnant women.

All analyses were based on the principle of intention to treat, whether or not the original studies presented their results as such.

FEEDBACK

Vlassov, 15 March 2008

Summary

The Abstract for this review is misleading. It comments that 11 studies are included, and then states that five reported increased physical fitness. No data are presented and it is unclear why the authors conclude that aerobic exercise increases physical fitness.

Reply

In the Abstract, we clearly indicate that the measures of physical fitness were highly heterogeneous, and thus data presentation would require separate tables for all measures in all studies reporting on fitness.

Contributors

Summary of feedback from Vasiliy Vlassov, March 2008.

WHAT'S NEW

Date	Event	Description
23 December 2009	New search has been performed	Search updated: 18 new reports added.

HISTORY

Protocol first published: Issue 3, 1996

Review first published: Issue 3, 1996

Date	Event	Description
25 June 2008	Feedback has been incorporated	Feedback from Vasiliy Vlassov added.
23 June 2008	Amended	Converted to new review format.
30 April 2006	New citation required and minor changes	New author.

Date	Event	Description
30 June 2005	New search has been performed	Search updated. New studies were added to the Background and Implications for research sections, expanding these sections; one new trial was added (Wolfe 1999) and one trial, previously included, was removed pending clarification of further information received from the authors of the trial (Lee 1996a); one study which was included only as an abstract in a previous review is now included as a published article, adding more outcomes; new comparisons were added; general updates and modifications were made; despite all this, our conclusions remain unchanged.

CONTRIBUTIONS OF AUTHORS

Michael Kramer prepared the first draft and the 2002 and 2009 updates of this review. Sheila McDonald developed the 2005 update with mentoring and input from Michael Kramer; she also completed the [Risk of bias in included studies](#) and collaborated in all other aspects of the 2009 update.

DECLARATIONS OF INTEREST

We certify that we have no affiliations with or involvement in any organization or entity with a direct financial interest in the subject matter of the review or our criticisms (e.g., employment, consultancies, stock ownership, honoraria, expert testimony).

SOURCES OF SUPPORT

Internal sources

- McGill University, Canada.

External sources

- Canadian Institutes of Health Research, Canada.

INDEX TERMS

Medical Subject Headings (MeSH)

Exercise [*physiology]; Physical Fitness; Pregnancy [*physiology]; Pregnancy Outcome; Randomized Controlled Trials as Topic

MeSH check words

Female; Humans