PHYSICAL ACTIVITY DURING PREGNANCY AMONG WOMEN WHO ARE OVERWEIGHT OR OBESE

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LIST OF ABBREVIATIONS

BMI: body mass index

CI: confidence interval

GDM: gestational diabetes mellitus

GWG: gestational weight gain

HBM: health belief model

HC: head circumference

IOL: induction of labour

IOM: Institute of Medicine

LGA: large for gestational age

NICU: neonatal intensive care unit

OGTT: oral glucose tolerance test

OR: odds ratio

RCT: randomised controlled trial

RR: risk ratio

SGA: small for gestational age

WHO: World Health Organisation

ABSTRACT

Background

Being overweight or obese during pregnancy and having excessive gestational weight gain increase the risk of many adverse maternal and neonatal health outcomes. Exercise is beneficial during pregnancy. However, physical activity pattern during pregnancy, the effect of exercise on maternal and neonatal health outcomes, and women's perception of making healthy change remains unclear.

Aims

The aims of this thesis were, for women who are overweight or obese during pregnancy, to

- Describe physical activity patterns during pregnancy;
- Evaluate available evidence about antenatal exercise interventions;
- Test the effects of an antenatal exercise intervention in a randomised controlled trial; and
- Explore women's perceptions of making healthy changes during pregnancy.

Methods

To evaluate the above aims, the following methodology was employed:

- A nested prospective cohort study to evaluate physical activity;
- A systematic review and meta analysis using standard Cochrane methodology;
- A randomised controlled trial of an antenatal walking intervention and incorporation of the findings into a meta-analyses of previous literature; and
- A mixed-methods investigation of women's perception of making healthy change during pregnancy.

Results

- In women who were overweight or obese, physical activity declined significantly between early pregnancy and 36 weeks' gestation, before increasing after birth. Physical activity at four months post-partum remained lower than that in early pregnancy. Women with higher BMI had a greater decline in physical activity over pregnancy.
- There was no significant effect of a simple supervised antenatal walking group on gestational weight gain and other clinical maternal and neonatal health outcomes, as confirmed by a meta-analysis of previous trials, despite better physical fitness and activity level represented by higher commuting and leisure activity in late pregnancy.
- A large proportion of women do not consider excessive gestational weight gain to be a concern, with limited awareness of neonatal complications. Women's barriers to making healthy behaviour changes were highly individualised with limited perception of benefits. Furthermore, women were not confident in their ability to make changes.

Conclusions

While providing a walking group is associated with some increase in self reported physical activity, further studies should identify effective strategies to facilitate an increase in leisure activity during pregnancy, overcome perceived barriers, and educate women about both the neonatal health consequences of maternal obesity and health benefits associated with exercise.

DECLARATION

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution to Zhixian Sui and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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AUTHOR'S CONTRIBUTION

I have been responsible for the design and development of the methodological and analytical processes contained within this thesis. Specifically, I performed the data collection and analysis contained in chapters 3, 4, 5, 6 and 7. I personally contacted women and supervised the exercise sessions for the WALK randomised trial, in addition to developing participant information sheets and data collection sheets. I personally conducted the face-to-face interviews with women that form the basis for the mixed-methods study described in chapter 7, in addition to conducting the analysis. Professor Jodie Dodd, and Dr. Rosalie Grivell independently assessed studies for inclusion in the meta-analysis in chapter 3, and I have received statistical support from Dr. Lisa Yelland in the analysis of the WALK randomised trial. Additionally, I have received methodological advice from Professor Jodie Dodd, Professor Deborah Turnbull and Professor Caroline Crowther into aspects of the individual studies. However, the interpretation of the data and any errors in there are my responsibility.

CHAPTER 1. LITERATURE REVIEW

1.1 INTRODUCTION

Obesity is an important contributor to chronic disease. Being overweight or obese during pregnancy contributes to increased risks of many adverse maternal and infant outcomes. Both maternal overweight and obesity, and excessive maternal gestational weight gain have been linked to the subsequent development of childhood and adult obesity.

It is recognised that exercise may bring health benefits during pregnancy, although there is more limited information about the effects of exercise during pregnancy among overweight or obese women. The efficacy and safety of antenatal exercise for overweight or obese women requires further evaluation.

1.2 OVERWEIGHT AND OBESITY

Obesity is a significant contributor to chronic disease worldwide (1). Body size can be assessed using a variety of measures including weight, height, and waist circumference. A widely utilised tool to assess overweight and obesity is Body Mass Index (BMI). The World Health Organisation (WHO) defines normal weight as a BMI of 18.5-24.9 kg/m^2, overweight as a BMI of 25 kg/m^2 to 29.9 kg/m^2, and obesity as a BMI of 30 kg/m^2 or greater (1, 2). Obesity is further sub-categorised into Class I (30-34.9 kg/m^2), II (35-39.9 kg/m^2), and III (40 kg/m^2 or higher). These definitions are reflective of Caucasian populations, while both Indian and Asian populations adopt slightly different cut-off points for overweight and obesity (1, 2).

1.2.1 Prevalence of overweight and obesity

The prevalence of overweight and obesity is escalating world wide. Australian data indicate a 10% increase in the proportion of adults who are overweight or obese between 1990 and 2001 (3), with an estimated 62% of Australian men and 45% of women overweight, and including 16% and 17% respectively, obese (2, 3). It is predicted that by the year 2025, 7.2 million Australians will be obese (3). Worldwide figures are similar. In the United States, 66% of the population is overweight or obese (4). The most recent data from the UK shows similar trends with the prevalence of obesity increasing significantly from 6% to 62% between 1980 and 2008 (5, 6). China's Government National Health Survey also reported an increased prevalence of obesity particularly among upper socioeconomic groups, with estimates that 11.44% of Chinese youth are overweight or obese (7).

1.2.2 Health implications of overweight and obesity

The effects of overweight and obesity on adult health are well documented, being associated with an increased risk of many complications. Overweight or obesity increases the risk of many cardiovascular conditions, the risk of hypertension being five times higher (8), and coronary heart disease 3.6 times higher among obese individuals, compared with those of normal weight (8). Overweight and obesity are also closely associated with risk of type 2 diabetes, the estimated increased risk in obese women being 12.7 times and 5.2 times in obese men (3). Increasing BMI increases the risk of a variety of cancers, with estimates suggesting that 10% of people who die from cancer are obese (8). Obesity places increased mechanical stress on the body, being associated with shortness of breath, sleep apnoea, low back pain (9), and osteoarthritis (3).

In addition to the increased risk of chronic physical ill-health, overweight and obese individuals also report lower quality of life, social stigma, low self-esteem, reduced mobility, and discrimination, representing a significant psychological burden (9, 10), when compared with normal weight individuals. There is also evidence that obesity is associated with risks of anxiety and depression, particularly among women (11-13).

1.3 OBESITY AND WOMEN'S HEALTH

The impact of overweight and obesity in women is greater than in men of similar BMI when examining health, social, economic, and psychological factors. Overweight women report poorer physical health than overweight men (14), being more likely to report diabetes, cardiovascular disease, hypertension, and dyslipidemia. Women with a high BMI are also at increased risk of various cancers including breast, ovarian, and endometrial malignancy (13, 15). For all of these conditions, prevalence increases with increasing BMI (2).

Being overweight or obese may also result in changes in hormone concentrations, adversely effecting reproductive health (8). Obesity increases oestrogen concentration and hence the risk of menstrual dysfunction, polycystic ovarian syndrome, and infertility (14, 16). Both spontaneous rates of conception and outcomes following assisted reproductive techniques are poorer among women of high BMI when compared with women of normal BMI (14, 16). The effect of obesity on risk of early pregnancy loss is less clear, with some studies reporting an increased risk of miscarriage, while others do not (16, 17). It is well documented that even a moderate degree of weight loss can improve menstrual regularity and fertility among women who are overweight or obese(16).

1.4 OBESITY DURING PREGNANCY AND CHILDBIRTH

Overweight and obesity have significant implications during pregnancy and childbirth. In Australia, it was estimated that 34% of pregnant women were overweight or obese in 2002 (18). More recent population data from South Australia indicates that approximately 50% of pregnant women are overweight or obese, including

10% who are severely or morbidly obese (19). Figures from the United States and the U.K. are similar. In the United States, between 1993 and 2003, the prevalence of maternal obesity increased from 13% to 22% (20), while there was a doubling in the UK between 1996 and 2006, with approximately 27.5% of pregnant women overweight, and a further 10.9% obese (21).

There are well documented risks associated with obesity during pregnancy, the risks increasing with increasing maternal BMI (18, 22, 23). Well recognised risks include gestational diabetes, hypertensive conditions (including preeclampsia), and preterm birth (18, 22). There are also considerable risks for the infant, including an increased risk of perinatal death, congenital anomalies, shoulder dystocia, birth injuries, and macrosomia (18, 22, 24, 25). The risks associated with overweight and obesity during pregnancy are summarised in Table 1.1.

Table 1. 1 Risks associated with overweight and obesity during pregnancy

Maternal risks	Pregnancy	- Gestational diabetes - Hypertensive disorders - Difficulty with ultrasound scanning
	Labour and Birth	- Preterm birth (Iatrogenic) - Induction of labour - Caesarean section
	Postpartum	- Infection - Prolonged hospital stay
Infant risks		- Perinatal death - Congenital anomalies - Shoulder dystocia and birth trauma - Macrosomia - Low Apgar score - Hypoglycaemia - Hyperbilirubinemia - NICU admission

1.5 OBESITY AND GESTATIONAL WEIGHT GAIN

There is an extensive literature describing gestational weight gain that has been summarised by the Institute of Medicine (IOM). Average gestational weight gain is widely reported to be between 10-15kg, although this varies considerably, particularly among women who are obese (26, 27).

The Institute of Medicine (IOM) weight gain recommendations were originally released in 1990, and focussed on ensuring women gaining sufficient weight during pregnancy to reduce the risk of small for gestational age infants and maternal preeclampsia (28). While the guidelines re-released in 2009 were essentially unchanged from those published in 1990, there were specific recommendations for weight gain in overweight (6.8-11.4 kg) and obese (5-9 kg) pregnant women (29) as shown in Table 1.2.

Table 1.2 Recommended gestational weight gain – The Institute of Medicine Guidelines 1990 and 2009

	Weight Gain in kg (1990)	Weight Gain in kg (2009)
Normal weight women (BMI 18.5-24.9 kg/m^2)	11.4 – 15.9	11.4 – 15.9
Overweight women (BMI 25.0-29.9 kg/m^2)	6.8 – 11.4	6.8 – 11.4
Obese women (BMI ≥ 30.0 kg/m^2)	At least 6	5 – 9

A literature search was performed to identify evidence focused on evaluating the effect of gestational weight gain in overweight and obese women on pregnancy, birth and infant health outcomes. Relevant English-language journal articles were identified by searching the electronic databases PUBMED and SCOPUS from 1990 through May 2012.

Many large population cohort studies (30-37) were identified describing an association between gestational weight gain and adverse maternal and neonatal outcomes particularly in pregnant women who were overweight or obese. As outlined in Table 1.3, studies from different populations and different countries world wide have consistently identified an increased risk of many adverse maternal health outcomes among pregnant women who are overweight or obese. This is compounded by increased rates of gestational weight gain, including pre-eclampsia and hypertension, gestational diabetes, iatrogenic preterm birth, need for induction of labour, and caesarean birth. Risks for the infant include being large for gestational age and low Apgar score. Longer term health risks include risk of obesity in both childhood and adulthood, although this has remained relatively under-investigated to date.

While excessive gestational weight gain has been associated with an increased risk of adverse maternal and infant health outcomes, weight gain within or below the IOM recommendations has been associated with a reduction in risk of pre-eclampsia and hypertension, gestational diabetes, and infants born large for gestational age. While associated with a reduction in risk of high infant birth weight, inadequate gestational weight gain, and even gestational weight loss, appears to be at the expense of an increase in the risk of small for gestational age infants. This in turn is associated with an increased risk of infant morbidity, and has implications for longer-term health.

When considering outcomes of these cohort studies (30-37), it is possible to only identify the presence of an association between gestational weight gain and health complications. The question of optimal gestational weight gain, particularly for women who are overweight or obese can only be answered adequately by appropriately designed and powered randomised trials.

Table 1.3 Cohort studies describing the association between gestational weight gain and adverse maternal and neonatal health outcomes

Authors	Population	Findings
Bodnar (30) 2010 U.S.A.	47,445 obese pregnant woman	High GWG increased the risk of infants born LGA (OR 1.2-2.1, 95% CI 1.1-2.7) whereas weight loss during pregnancy increased the risk of infant born SGA.
Cedergren (35) 2006 Sweden	245,526 woman	In women of all weight ranges, a positive association was identified between GWG and risk of caesarean birth. Overweight women with excessive GWG had a 2-fold increased risk for preeclampsia and infants born LGA. In obese women, GWG <8kg was associated with a lower risk of preeclampsia (OR 0.51, 95% CI 0.42-0.62), caesarean birth (0.81, 0.73-0.90), instrumental birth (0.75, 0.63-0.88), and infant born LGA (0.66, 0.59-0.75).
Flick (34) 2010 U.S.A.	20,823 obese women	High GWG increased the risk of preeclampsia and caesarean birth (P < 0.001)
Jensen (36) 2005 Denmark	481 obese women	There was a significant positive association between GWG and infant birth weight (P<0.001). High GWG was associated with an increased risk of hypertension (OR 4.8, 95%CI 1.7-13.1), caesarean section (3.5, 1.6-7.8), induction of labour (3.7, 1.7-8.0), and infants born LGA (4.7, 2.0-11.0).

BMI: Body Mass Index; GWG: Gestational Weight Gain; LGA: Large for Gestational Age; SGA: Small for Gestational Age; OR: Odds Ratio; CI: Confidence Interval

Table 1.3 (Cont.)

Authors	Population	Findings
Kiel (33) 2007 U.S.A.	120,251 obese women	Women with gestational weight gain who met the IOM recommendations demonstrated a significantly lower risk of preeclampsia, caesarean delivery, and LGA birth, but a higher risk of SGA birth compared with weight gain below or above the recommendations.
Nohr (37) 2008 Denmark	60,892 women	High BMI and high GWG were associated with higher risk of caesarean birth, postpartum weight retention, and infants born LGA. Low GWG was associated with an increased risk of infants born SGA.
Stuebe (32) 2009 U.S.A.	26,506 mother-daughter pairs	Offspring of women with excessive gestational weight gain were more likely to be obese when they were 18 years old (O.R. 1.81, 95% CI 1.22-2.69) and in adulthood (O.R. 1.74, 95% CI 1.48-2.04)
Vesco (31) 2009 U.S.A.	1,656 women, pre-pregnant BMI >30 kg/m^2	GWG was positively associated with postnatal weight retention (R^2=0.11, P<0.001).

BMI: Body Mass Index; GWG: Gestational Weight Gain; LGA: Large for Gestational Age; SGA: Small for Gestational Age; OR: Odds Ratio

1.6 EXERCISE AND PREGNANCY

While the precise factors contributing to weight gain are complex, it essentially represents an imbalance between energy intake and energy expenditure. The total amount of energy an individual expends on a daily basis is a function of the amount of energy required to maintain basic bodily functions (resting energy expenditure), digest food eaten (thermic effect of food), maintain posture and spontaneous activity, and support voluntary bodily movement (physical activity) (38). Reflecting its voluntary nature, physical activity is the most variable component of total daily energy expenditure. It comprises 20-30 per cent of total energy expenditure in sedentary adults and the proportion is notably higher among active individuals (38). Domains of physical activity include leisure time pursuits (exercise), occupation, transportation, self-care, volunteer work, non-exercise leisure time activities, and domestic-related activity (38). Each of these domains may have a significant influence on energy expended in physical activity and consequently total daily energy expenditure. Until recently only leisure time physical activity has been the focal point for research on energy expenditure in relation to obesity and public health efforts aimed at obesity treatment and prevention (38).

1.6.1 Exercise and maternal and neonatal health outcomes

The beneficial outcomes of being physically active are well recognised, including improving cardiovascular condition and glucose tolerance, building bone and muscle mass, and reducing risks of obesity and its complications (39, 40). A literature review was conducted to evaluate physical activity during pregnancy. The search identified articles published in PUBMED and SCOPUS between 1990 and March 2013.

Studies have investigated the effect of exercise during pregnancy and maternal and neonatal health outcomes. As outlined in Table 1.4, although studies utilised different research designs, a beneficial effect of exercise during pregnancy on maternal and neonatal health outcomes has been consistently identified. In particular, maternal health benefits include reduced risk of gestational diabetes, pre-eclampsia, and operative birth, in addition to improved cardiovascular function, overall fitness, psychological wellbeing and mood stability. Benefits for the infant include reduced risks of prematurity and improved fetal growth, although there is more limited information about longer term health benefits for both women and infants. However, these studies have limitations including the inclusion of women of all BMI categories, failure to control for the effect of maternal BMI, lack of standardisation of methodology relating to assessment of physical activity, in addition to the limitations of specific study designs.

Table 1. 4 Studies describing exercise and maternal and neonatal health outcomes

Authors	Design	Population	Outcomes	Findings
Carmichael (41) 2002 U.S.A.	Case-control	831 women	Neural tube defects	In women who did not use folate supplements, leisure-time physical activity was associated with a 30-50% lower risk of neural tube defects compared with women who were inactive during pregnancy.
Clapp (42) 2000 U.S.A.	Randomised controlled trial	46 women	Antenatal placental growth rate and neonatal and placental morphometric measurements	Exercise was associated with larger infant birth weight ($P = 0.05$) and length ($P = 0.05$), with increased lean body mass ($P = 0.05$). Exercise was also associated with increased placental growth rate ($P = 0.04$) and indexes of placental function ($P < 0.05$).
Dempsey (43) 2004 U.S.A.	Case-control	541 women	Gestational diabetes	Physical activity during the first 20 weeks of pregnancy was associated with a 50% reduction in risk of gestational diabetes (OR 0.40, 95% CI 0.23-0.68)
Dempsey (44) 2004 U.S.A.	Retrospective cohort	909 women	Gestational diabetes	Recreational physical activity before pregnancy was associated with a risk reduction of 56% for gestational diabetes. Physical activity during pregnancy only did not reduce risk of gestational diabetes, although physical activity both before and during pregnancy reduced risk of gestational diabetes compared with inactive women (RR 0.31).

OR: Odds Ratio; CI: Confidence Interval; RR: Relative Risk

Table 1.4 (Cont.)

Authors	Design	Population	Outcomes	Findings
Evenson (45) 2002 U.S.A.	Cohort	1,699 women	Prematurity	Vigorous leisure activity during the first trimester (OR 0.80, 95% CI 0.48-1.35) and second trimester (0.52, 0.24-1.11) had protective effect against preterm birth
Hatch (46) 1998 U.S.A.	Retrospective cohort	557 women	Prematurity	Vigorous leisure-time physical activities were associated with a reduced risk (RR=0.11) of preterm birth.
Latka (47) 1999 U.S.A.	Case-control	346 women	Miscarriage	Leisure-time physical activity during pregnancy was a protective factor against miscarriage (OR=0.6, 95% CI 0.3-0.9)
Lynch (48) 2003 Australia	Prospective cohort	23 women	Cardiovascular function	Exercise was associated with improved aerobic fitness as measured by physical work capacity (P = 0.003), and also decreased maternal heart rate (P = 0.041) and mean fetal heart rates (P = 0.001)

OR: Odds Ratio; CI: Confidence Interval; RR: Relative Risk

Table 1.4 (Cont.)

Authors	Design	Population	Outcomes	Findings
May (49) 2010 U.S.A.	Case-control	61 women	Fetal cardiac autonomic control	At 36 weeks of gestational age, fetal heart rate was significantly lower in the exercise group (P < 0.001). The heart rate variability was also higher in the exercise group.
Melzer (50) 2010 Switzerland	Prospective cohort	71 women	Mode of birth, resting metabolic rate, total energy expenditure, activity-related energy expenditure, maximal oxygen uptake, sleeping heart rate, and movement (accelerometer)	Active women were fitter with lower sleeping heart rate when compared with inactive women. Active women had shorter duration of second stage of labour (P=0.05). Inactive women were at higher risk of operative birth (OR 3.7, 95% CI 0.87-16.08).
Oken (51) 2006 U.S.A.	Retrospective cohort	1805 women	Gestational diabetes or abnormal glucose tolerance during pregnancy	Vigorous physical activity before pregnancy was associated with a 44% reduction in risk of gestational diabetes (OR 0.56, 95% CI 0.33-0.95) and 24% reduction in risk of abnormal glucose tolerance (0.76, 0.57-1.0).
Polman (52) 2007 U.K.	Case-control	66 women	Mood states before and after exercise sessions	Aqua class and gym class, but not parent-craft class, resulted in enhanced mood in women in 2nd and 3rd trimester when compared with the controls (P < 0.01)

OR: Odds Ratio; CI: Confidence Interval

Table 1.4 (Cont.)

Authors	Design	Population	Outcomes	Findings
Poudevigne & O'connor (53) 2005 U.S.A.	Prospective cohort	24 women	Energy expenditure and psychological wellbeing	Increased fatigue and vigour scores in pregnant women from 12 to 16 weeks and from 32 to 36 weeks gestational age. Above average level of physical activity during the 2nd and 3rd trimesters was associated with mood stability
Stutzman (54) 2010 Canada	Quasi-randomised controlled trial	22 women	Blood pressure, heart rate variability, and baroreflex sensitivity	Exercise lowered resting systolic blood pressure and diastolic blood pressure (P < 0.05).
Sorensen (55) 2003 U.S.A.	Case-control	584 women	Pre-eclampsia	Regular activity during early pregnancy was associated with a 35% reduced risk of pre-eclampsia (OR 0.65, 95% CI 0.43-0.99). This risk was further reduced in women performing vigorous physical activity (0.46, 0.27-0.79).

OR: Odds Ratio; CI: Confidence Interval; RR: Relative Risk

There are two relevant Cochrane systematic reviews relating to exercise in pregnant women (56, 57). Kramer & McDonald (56) evaluated the role of exercise in pregnancy, while Ceysens et al (57) focussed on exercise in women with gestational diabetes. Kramer and McDonald's Cochrane review of exercise for women of all BMI categories during pregnancy included 11 randomised controlled studies involving 1014 women (56), and assessed the effect of aerobic exercise on pregnancy outcomes. Outcome measurements included maternal physical fitness, infant anthropometric measures and adverse maternal and infant birth outcomes. The included RCTs varied considerably in the nature of the intervention provided, the timing and duration of the intervention, as well as assessment of compliance. The sample sizes of the individual studies were relatively small and all were considered to have methodological flaws. While regular exercise was associated with maintained or improved physical fitness (defined as aerobic capacity, cardiopulmonary measures, and physical work capacity), the effect on clinical pregnancy outcomes was uncertain.

Ceysens and colleagues focused on exercise for women with gestational diabetes (57). The authors utilised data from 4 randomised controlled trials, involving a total of 114 pregnant women with gestational diabetes. The exercise programs generally included three 25 to 45-minute sessions per week of approximately six weeks duration. The meta-analysis did not identify a significant effect of exercise on measures of perinatal or maternal morbidity, although the available sample size was well underpowered to be able to detect differences in outcomes of clinical relevance.

1.6.2 Women's exercise pattern during pregnancy

Pregnant women are less active than non-pregnant women (58). The existing literature examining physical activity patterns during pregnancy has focused on women of all BMI categories (59-64), indicating a reduction in activity over the course of pregnancy (58) (Table 1.5). Studies of women of all BMI categories across a range of populations consistently report that physical activity declines from early pregnancy to birth (59-63). In addition, all categories and intensity of activities (household, leisure/exercise, work related, and transportation) declined across pregnancy (59-63).

While there is considerable variation reported in the extent of activity attained by pregnant women, most studies indicate a reduction in activity and exercise as pregnancy progresses. The available literature evaluating physical activity during pregnancy among women who are overweight or obese is more limited and has produced contradictory findings. Some authors report an increase in activity from early to mid pregnancy, followed by a decline in the third trimester (65), while others report a constant reduction in activity across gestation (66) (Table 1.5). Furthermore, there is little information reported in the literature evaluating the relationship between high maternal BMI and activity patterns, in addition to the effect of gestational weight gain.

The precise pattern of physical activity during pregnancy in overweight and obese women has not been described prospectively in a large cohort.

Table 1.5 Studies describing physical activity pattern during pregnancy

Authors	Design	Population	Outcomes	Findings
Women of all weight categories				
Borodulin (67) 2009 U.S.A.	Prospective cohort	471 women	Physical activity	Physical activity declined during pregnancy.
Duncombe (68) 2007 Australia	Cross-sectional	158 women	Time in physical activity	There was a significant reduction in both the prevalence of exercise and the time spent in exercising during pregnancy.
Fell (62) 2009 Canada	Retrospective cohort	1737 women	Physical activity	There was a decline in physical activity in early pregnancy. Obesity was associated with discontinuation of leisure sport activity.
Mottola (61) 2003 Canada	Prospective cohort	529 women	Physical activity	During pregnancy all activities declined, with the exception of walking which increased in the 3rd trimester.

Table 1.5 (Cont.)

Authors	Design	Population	Outcomes	Findings
Schmidt (59) 2006 U.S.A.	Cross-sectional	233 women	Total energy expenditure	No significant difference identified in the median total energy expenditure over 1st, 2nd and 3rd trimester of pregnancy.
Watson (60) 2006 New Zealand	Prospective cohort	197 women	Physical activity	Activity declined throughout pregnancy (P=0.002).
Overweight and obese women				
McParlin (66) 2010 U.K.	Retrospective cohort	55 overweight and obese women	Time in physical activity	There was a significant reduction of physical activity from 1st to 2nd trimester (P=0.018).
Renalt (65) 2010 Denmark	Cross-sectional	163 obese women & 175 overweight women	Physical activity	Obese pregnant women had less step counts when compared with pregnant women of normal weight (P < 0.05). In obese women there was an increase in activity from early to mid pregnancy, followed by a decline in the 3rd trimester.

1.7 CURRENT PHYSICAL ACTIVITY GUIDELINES

Current Australian physical activity guidelines suggest adults, including pregnant women, be active with moderate-intensity exercise for 30 minutes on most days, in the absence of either medical or obstetric complications (69). Both the Royal College (RCOG) and American College of Obstetricians and Gynaecologists recommend that all pregnant women be encouraged to participate in aerobic and strength-conditioning exercise with an aim of maintaining fitness throughout pregnancy (70, 71). While previously inactive women and women with pregnancy complications may benefit from exercise, recommendations suggest evaluation on an individual basis(71). It is important to recognise that these activity guidelines for pregnant women are based on low level evidence, and do not specifically address the issues facing women who are overweight or obese. The best evidence to form the basis of clinical recommendations is provided by systematic review of completed and reported randomised controlled trials. To further confirm guidelines for clinical practice, there is a need to systematically identify and evaluate the currently available literature relating to antenatal exercise interventions specifically targeting pregnant women who are overweight or obese. In addition, it is also necessary to provide high quality evidence to investigate whether providing exercise interventions during pregnancy is effective in limiting gestational weight gain and improving maternal and neonatal health outcomes for overweight and obese women.

There is a need to systematically identify and evaluate the currently available literature relating to antenatal exercise interventions in pregnant women who are overweight or obese. Ideally this information should be obtained from randomised controlled trials.

1.8 WOMEN'S PERCEPTIONS OF ACTIVE LIFESTYLE DURING PREGNANCY

While there are potential opportunities to implement interventions during pregnancy to improve health outcomes, their success requires an understanding of women's attitudes and perceptions, particularly their willingness to make behavioural changes.

While many interventions aim to promote healthy eating and active lifestyle in women who are overweight or obese during pregnancy (23, 72-74), it is consistently reported that adherence to interventions remains problematic. While a previous study has demonstrated that women's attitudes toward weight control interventions during pregnancy are generally positive (75), there is an increasing need to recognise and address individual psychological aspects and the impact they may have on successful behavioural change (76, 77).

A number of studies have investigated women's perceptions of being active during pregnancy and identified a number of enablers and barriers. As outlined in Table 1.6, these studies utilised a variety of tools including self-reported questionnaires, telephone interviews with open-ended questions, focus groups, and semi-structured face-to-face interviews, many utilising mixed-methods to gather both qualitative and quantitative data (78-81). The most notable barriers identified preventing women from being active during pregnancy were pregnancy symptoms, lack of time and child care, and concerns about safety. Conversely, significant enablers included positive psychological feelings, family influence, and receiving advice. However, many of these studies are limited by their small sample size, with involvement of women of all BMI categories with no specific information available for pregnant women who were overweight or obese.

Table 1.6 Studies describing enablers and barriers of active lifestyle during pregnancy

Authors	Design	Population	Findings
Clarke & Gross (78) 2004 U.K.	Interviews & questionnaires	57 pregnant women of all weight ranges	Enablers: receiving advice and education Barriers: concerns about safety, physical limitations, low motivation, and limited facilities or spaces
Cramp & Bray (64) 2009 U.S.A	Questionnaire	309 pre and post-natal women of all weight ranges	Barriers: having other children at home
Duncombe (68) 2006 Australia	Questionnaire	158 pregnant women of all weight ranges	Enablers: feeling of fitness, tone and strength; relieving stress; enjoyment; having a regular routine. Barriers: tiredness, lack of time, dislike exercise, and concern about safety
Evenson (81) 2004 U.S.A.	Short telephone interview	1,535 pregnant women of all weight ranges	Barriers: pregnancy complications and other health problems, personal reasons, social and cognitive reasons, and environmental factors
Foxcroft (82) 2011 Australia	Questionnaire	55 obese pregnancy women	Enablers: Having other children at home, no pregnancy symptoms, lower weight, higher level of education
Hinton & Olson (83) 2001 U.S.A.	Questionnaire	622 pregnant women of all weight ranges	Enablers: higher self-efficacy, lower BMI

Table 1.6 Cont.

Authors	Design	Population	Findings
Pereira (80) 2007 U.S.A.	questionnaire	1,442 pregnant women of all weight ranges	Barriers: work commitment, pregnancy complications, and feelings of depression
Symons Downs & Hausenblas (84) 2004 U.S.A.	Questionnaire	74 post-partum women of all weight ranges	Enablers: feelings that exercise improves mood, increase stamina, staying fit, feeling that weight is under control, and influence from family Barriers: physical limitations and restrictions, tiredness, lack of time, gaining weight, caring for other children, worry about safety, weather, and low motivation
Thornton (85) 2006 U.S.A.	interviews	10 pregnant and post-partum women and 8 family members	Enablers: partner's advice and support, cultural norms, health professional's advice, friends' support and companion, and access to childcare

Overall, there is very little literature describing women's attitudes to diet, activity and weight gain during pregnancy. The extant literature indicates that while women accept the occurrence of weight gain as a 'normal' outcome of pregnancy (86), they report receiving a lack of and often inconsistent information from health professionals about high BMI and associated pregnancy risks (86-88). In contrast, advice from family relating to optimal gestational weight gain was considered to be highly influential (87). Another small-scale qualitative study in Australia reported that most women who were overweight or obese recognised their weight as an issue and believed that health professionals should address their individual needs and expectations (89). To date, there is a lack of information detailing the views of overweight and obese pregnant women in adopting healthy diet and lifestyle.

The perception of making healthy change during pregnancy in overweight and obese women has not been described in a comprehensive manner.

1.7 CURRENT GAPS IN OUR KNOWLEDGE

While there are documented beneficial effects associated with exercise in pregnancy, recommendations to date are based on low quality evidence and do not specifically address exercise in pregnancy for women who are overweight or obese. Furthermore, the change of physical activity pattern remains unclear in women who are overweight or obese, and little is known about their perception of making healthy change during pregnancy. There is a need for:

- A detailed description of physical activity patterns during pregnancy in women who are overweight or obese;

- A comprehensive systematic review of the literature related to exercise interventions for pregnant women who are overweight or obese;
- Randomised trials evaluating exercise interventions for women who are overweight or obese, with a focus on clinical outcomes; and
- An investigation to identify the perception of making healthy change for women who are overweight or obese during pregnancy.

1.8 AIMS OF THESIS

Being overweight or obese during pregnancy is associated with an increased risk of maternal and infant health complications. Available information about interventions to improve health outcomes for these women and their infants is inconclusive. Any health care intervention requires robust evaluation, together with a deep understanding of women's perception of making change. The aims of this thesis are to:

- Conduct a prospective cohort investigation of the change of physical activity during pregnancy in overweight and obese women;
- Conduct a systematic review to evaluate the available literature in exercise interventions for pregnant women who are overweight or obese;
- Conduct a randomised trial of supervised exercise groups to promote physical activity for pregnant women who are overweight or obese; and
- Conduct a mixed-method assessment of the perception of making healthy change during pregnancy in women who are overweight or obese.

CHAPTER 2. METHODS FOR THE LIMIT RANDOMISED TRIAL

The cohort, randomised trial, and mixed-methods study within this thesis are nested within the LIMIT multicentre randomised controlled trial (90), evaluating the effect of limiting weight gain in overweight and obese women during pregnancy on health outcomes. The LIMIT RCT is a large-scale trial, which recruited women from three public maternal hospitals located in the metropolitan area of Adelaide, South Australia (The Women's and Children's Hospital, The Lyell McEwin Hospital, and Flinders Medical Centre). The aim of the study was to assess whether an antenatal dietary and lifestyle intervention aiming to limit gestational weight gain was effective in improving maternal and neonatal health outcomes in overweight and obese women.

The protocol of the LIMIT study has been published previously (90). Specifically, the inclusion criteria were women with a singleton, live pregnancy between 10^{+0} and 20^{+0} weeks gestation, with a BMI ≥ 25 kg/m^2 at the time of their first antenatal visit. Women with a multiple pregnancy, or type 1 or 2 diabetes diagnosed prior to pregnancy were excluded. The primary study outcome was the proportion of infants born large for gestational age.

During recruitment, eligible women were identified and contacted in the antenatal clinic, given written trial information, and counselled by a research officer. Written informed consent was obtained from each woman. Randomisation was performed by telephoning the central randomisation service of the Australian Research Centre for Health of Women and Babies (ARCH), The University of Adelaide. Women were randomised to either the 'Dietary and Lifestyle Advice Group' or the 'Standard Care Group'. Approval to conduct this study and all sub-studies was obtained from the research and ethics committees of all three hospitals.

CHAPTER 3. PHYSICAL ACTIVITY DURING PREGNANCY AND GESTATIONAL WEIGHT GAIN AMONG WOMEN WHO ARE OVERWEIGHT OR OBESE

3.1 ABSTRACT

Objective: Being physically activity is recognised as an important part of a healthy pregnancy. There is contradictory research assessing physical activity patterns during pregnancy and post-partum among women who are overweight or obese. The aim of this study was to evaluate physical activity among overweight and obese women over the course of pregnancy and the initial post-partum period, and to evaluate the effect of body mass index (BMI) and gestational weight gain (GWG) on changes in physical activity.

Methods: 305 overweight or obese pregnant women completed the short questionnaire assessing health enhancing physical activity (SQUASH) at three time points during pregnancy and at 4 months post-partum.

Results: Physical activity declined significantly between early pregnancy and 28 weeks' gestation ($P<0.001$), declined further at 36 weeks' gestation ($P<0.001$), before increasing significantly at 4 months post-partum ($P<0.001$). However, reported activity at 4 months post-partum remained significantly lower than that reported in early pregnancy ($P<0.001$). There was no significant difference either cross-sectionally at each time point or for changes over pregnancy and post-partum for total levels or categories of physical activity for women with different BMI or GWG categories. BMI was the only independent predictor of the change in total physical

activity over the study with women with higher BMI's having larger decline of physical activity (β=0.114, SE=0.750, P=0.032).

Conclusions: Physical activity declines over the course of pregnancy, with a greater decline occurring in women of higher BMI, and remains lower post-partum than in early pregnancy. Future research promoting healthy lifestyle during pregnancy should focus on maintaining physical activity and explore the barriers and enablers for engaging in exercise during pregnancy and the post-partum period.

3.2 INTRODUCTION

Being physically active is recognised as an essential part of a healthy pregnancy and is associated with improved cardiovascular function and physical fitness (56), and reduced risk of adverse maternal outcomes including gestational diabetes, pre-eclampsia, and preterm birth (91). Current physical activity guidelines recommend that women with an uncomplicated pregnancy be active with moderate to intensive exercise for 30 minutes or more on most days of the week (69, 71). Systematic reviews of randomised trials in this field suggest that the benefits of exercise in pregnancy outweigh potential harms such as intrauterine growth restriction (92).

It is estimated that between 34% and 50% of pregnant women in Australia are overweight or obese (18, 19). Both increased maternal body mass index (BMI) on entering pregnancy and high gestational weight gain (GWG), defined by the U.S. Institute of Medicine (IOM) guidelines as greater than 11.4 kg in women who are overweight and 9 kg in women who are obese (29), have been reported to be associated with an increased risk of adverse maternal and neonatal outcomes (93). A recent systematic review indicates that exercise during pregnancy for overweight or obese women is effective in limiting GWG, although the effect on maternal and infant clinical outcomes remains unclear (73, 74). In contrast, it is unclear whether exercise in the post-partum period for overweight or obese women is effective in limiting weight retention (94, 95). This has potential implications for maternal weight management with regards to both limiting obesity at subsequent pregnancies and reducing long-term obesity-associated morbidity and mortality.

The limited existing literature examining changes in total physical activity during pregnancy has focused on women of all BMI categories (59-63), indicating a reduction in activity over the course of pregnancy (58). However, the research evaluating physical activity during pregnancy specifically among women who are overweight or obese is limited to only two papers with relatively small sample sizes and has produced contradictory findings (65, 66). One study reports an increase in activity from early to mid pregnancy, followed by a decline in the third trimester (65), while the second study reports a constant reduction in activity across gestation (66). In addition, there is limited information describing cross-sectional comparisons or changes in physical activity from pregnancy to post-partum in women of different GWG categories with an inverse correlation previously reported between GWG and physical activity (96-99).

Furthermore, the previous research has focused on total physical activity. Examination of the specific subcomponents of physical activity (e.g. leisure time activity, commuting and work activity and household activity) is crucial to allow an understanding of the contribution of different types of physical activity and to aid targeting of future interventions. There is currently no research assessing physical activity categories in women with different BMI or GWG categories either cross-sectionally or over the course of pregnancy and the post-partum period.

The aim of this study was to evaluate changes in physical activity among women who are overweight or obese during pregnancy and the initial post-partum period, and to evaluate the effect of both BMI and GWG on activity levels.

3.3 METHODS

3.3.1 Study population

This prospective cohort study is nested within a randomised trial evaluating the effect of an antenatal intervention to limit weight gain among overweight and obese pregnant women on maternal and infant health outcomes (the LIMIT study) (90). The methodology of the randomised trial has been described in detail previously (90). Women were eligible for inclusion in the current study who were randomised to the control group of the LIMIT trial, received standard antenatal care with no specific encouragement of physical activity during pregnancy, were recruited between September 2009 and August 2011 and who had complete data available for the physical activity questionnaires at all time points (n=305). Specific inclusion criteria were women with a BMI ≥ 25 kg/m^2, and singleton pregnancy, with their first antenatal visit between 10^{+0} and 20^{+0} weeks' gestation. Women with previously diagnosed type 1 or 2 diabetes prior to pregnancy were not eligible. Women were recruited from three public maternity hospitals across the Adelaide metropolitan area, and provided written informed consent to participate. The human research ethics committees of all the participating hospitals approved the study.

3.3.2 Clinical measurements

Baseline demographic information was collected at study entry including age, parity, ethnicity, and postcode of residence. An assessment of socioeconomic disadvantage was calculated using Socioeconomic Indexes for Areas disadvantage score (SEIFA). Height, weight and BMI were measured at study entry and at 36 weeks gestation. Women were categorised as overweight or obese according to the World Health Organisation criteria (overweight 25-29.9 kg/m^2; obese class I 30.0-34.9 kg/m^2; obese class II 35.0-39.9 kg/m^2, and obese class III ≥ 40 kg/m^2) (1). Women's GWG was defined as weight at 36 weeks' minus weight at trial entry and categorised based on BMI category, as below, within, or above the IOM recommendations (overweight 6.8-11.4 kg; obesity 5-9 kg).

3.3.3 Physical activity questionnaire

Women completed the Short Questionnaire to Assess Health-enhancing physical activity (SQUASH) at study entry (1-2 weeks after recruitment), 28 weeks' gestational age, 36 weeks' gestational age, and at four months post-partum. The SQUASH questionnaire was developed by the Dutch National Institute of Public Health and Environment. It has been validated in different populations (100, 101), and is a widely used tool to examine physical activity behaviour (102-105). The questionnaire includes 11 questions relating to the time spent on different types of physical activity, and takes approximately 3-5 minutes to complete (100, 101). Categories of types of activity listed in SQUASH were commuting activity (including walking to and from work and bicycling to and from work), leisure time activity (including walking, bicycling, gardening, odd jobs, sports specified by participants), household activity (including light household work and intense household work), and activity at work (including light work and intense work).

3.3.4 Data analysis

An activity-specific intensity code from the Compendium of Physical Activities (106) was assigned to each reported activity. The Compendium of Physical Activities is a comprehensive list of physical activities with corresponding estimates of intensity in Metabolic Equivalent Task units (METs), where 1 MET is equal to the energy expended during quiet sitting (106). The number of minutes spent in each reported activity recorded in the SQUASH questionnaire was multiplied by its MET intensity and summed to calculate total daily energy expenditure. Since MET is a measure of intensity and rate of physical activity, the concept of MET-minute was used to quantify the total amount of physical activity in a way comparable between individuals and across different types of activities. For example fast walking to and from work for half an hour (a moderate intensity activity of 3.3 METs) accounts for about 100 MET-min and is equivalent to fast bicycling for ten minutes (a vigorous intensive activity of 10 METs). As the SQUASH questionnaire asks women to report their physical activity of an average week in the past months, MET-minutes per week (METs/wk) were calculated as duration (in minutes) x frequency (days per week) x MET intensity.

3.3.5 Statistical analyses

The data were analysed using the Statistical Package for the Social Sciences (SPSS, Chicago) software (version 18). Data are presented as mean ± standard deviation (SD). Data was assessed for normality and non-parametric statistical tests were utilised where data was non-normally distributed. Physical activity patterns were analysed using repeated measures analysis of variance (ANOVA) with BMI category and GWG category as between subject factors with post hoc Bonferroni tests. Stepwise multiple logistic regression analysis (for continuous outcomes) was conducted to assess the independent determinants for the change of physical activity during pregnancy and post-partum. A P value of <0.05 was considered statistically significant.

3.4 RESULTS

3.4.1 Participant characteristics

During the study period 305 women randomised to the control group of the LIMIT trial were recruited who completed SQUASH questionnaires at all four time points. The baseline characteristics of women are presented in Table 3.1 and are similar to the reported demographic characteristics of pregnant women in South Australia (107). Approximately 45.6% of the women were categorised as overweight, with 30.2% of women as obesity class I, 15.1% as obesity class II, and 9.1% as obesity class III. The mean gestational age at trial entry was 14.0±2.1 weeks, with 30.1% of women in trimester 1 and 69.9% in trimester 2. With regards to GWG according to the IOM recommendations, fewer obese women had GWG within the IOM recommendations compared with overweight women, with women with BMI 30.0-34.9 kg/m^2 most likely to have GWG above recommended levels (Table 3.2).

Table 3.1 Demographic characteristics of women completed the SQUASH questionnaire

Category	N	%	Mean±S.D.	General population % +
Age: <20	3	0.9	30.4±5.1	4.1
20-30	131	42.9		44.3
30-40	160	52.5		47.8
40+	11	3.8		3.8
Parity: Parity = 0	127	41.6	0.9±0.9	41.5
BMI: Overweight	139	45.6	Overall 31.7±5.5	54.1*
Obesity class I	92	30.2	Overweight 27.3±1.3	25.8
Obesity class II	46	15.1	Obesity 35.3±4.8	12.1
Obesity class III	28	9.1		8.0
Smoker: Yes	30	9.8		15.9
Race: Caucasian	279	91.5		85.0
SEIFA: 1-2 deciles #	71	23.3		20
3-4 deciles	64	21.0		20
5-6 deciles	57	18.8		20
7-8 deciles	61	20.0		20
9-10 deciles	52	17.0		20

Data are presented as mean ±SD or proportions.

+ Source: Pregnancy Outcome in South Australia 2009, Government of South Australia

* % calculated excluded underweight women and women of normal weight

SEIFA. For example, decile 1 contains the bottom 10% of the collection districts and Decile 2 contains the next 10%.

BMI: Body mass index

SEIFA: Socioeconomic indices for areas disadvantage score

Table 3.2 Prevalence of gestational weight gain below, within, or above the IOM guidelines

GWG	Below recommendation (%)	Within recommendation (%)	Above recommendation (%)
Overweight	20.1	38.9	40.0
Obesity	28.9	22.2	48.9
Obesity class I	17.4	21.7	60.9
Obesity class II	37.0	23.9	39.1
Obesity class III	53.6	21.4	25.0

GWG: Gestational weight gain

3.4.2 Physical activity across pregnancy and post-partum

The levels of total physical activity across pregnancy and post-partum are summarised in Table 3.3. There was a significant change over pregnancy and post-partum ($P<0.001$), where physical activity declined significantly between trial entry and 28 weeks' gestation ($P<0.001$), followed by a further decline to 36 weeks' gestation ($P<0.001$). Physical activity then increased significantly at 4 months post-partum ($P<0.001$), however the activity level at 4 months post-partum was significantly lower than that reported at study entry ($P<0.001$).

With regards to different physical activity categories, there was a significant change in all different physical activity categories over pregnancy and post-partum ($P<0.001$) except leisure activity ($P=0.063$). At trial entry, 68.5% women reported still working, declining to 58% at 28 weeks, 40% at 36 weeks, and 16% at 4 months post-partum ($P<0.001$). From trial entry to post-partum, commuting ($P<0.001$) and work activity ($P<0.001$) decreased and were significantly reduced at 4 months post-partum compared with trial entry. All women reported ever engaging in light household activities over pregnancy and post-partum, and 85% in intense household work. Household activities decreased from trial entry to week 28 (P<0.001) and from week 28 to week 36 (P<0.001), followed by an increase after birth (P<0.001). There was an overall increase in household activities over the study duration (P<0.001) and women were involved in significantly more household activity 4 months post-partum compared with trial entry (P<0.001).

The most commonly identified structured activity was walking (either commuting (reported by 23% of all women) or leisure activity (76.4%)) with the most frequently reported leisure walking duration being 60 minutes per week (18%). There were 21.6% of women who reported being engaged in leisure activities other than those listed in the SQUASH questionnaire. The top three most frequently reported leisure activity other than walking (76.4%) and bicycling (4.6 %) were gym aerobic classes (3.9%), netball (3.6%), and yoga (2.3%). While the time spent in leisure activities decreased from trial entry to week 28 (P<0.001) and increased from 36 weeks to 4 months post-partum (P=0.022), there was no significant change in leisure activities over the entire study duration (P=0.063) and no difference in leisure activity at 4 months post-partum compared with trial entry (P=0.150).

Table 3.3 Physical activity (METs/week) in different stages of pregnancy and post-partum (mean ± SD)

Activity category	Trial Entry	28 weeks	36 weeks	Post-partum	P- value Overall effect on time
Total (n=305)	9744.6±6081.0	7026.6±5197.3*	5165.1±4182.6*	7190.2±5266.2*#	<0.001
Commuting	155.5±754.5	112.0±395.1*	47.2±181.3*	33.1±191.7*#	<0.001
Leisure	1194.8±1414.8	1037.5±1810.9*	1043.4±2082.0	1187.8±2702.0*	=0.063
Household	4226.3±5034.7	2905.9±3067.1*	2428.9±2391.3*	5283.1±4083.4*#	<0.001
Work	4116.7±3416.4	2971.1±4225.2*	1645.3±2566.3*	686.1±2023.1*#	<0.001
Weight category	**Trial Entry**	**28 weeks**	**36 weeks**	**Post-partum**	
Overweight (n=139)	10026.0±6610.6	6946.4±4822.5*	5211.2±3765.7*	7298.3±4969.6*#	<0.001
All Obesity (n=166)	9508.7±5608.6	7093.8±5503.2*	5126.5±4512.8*	7099.8±5515.6*#	<0.001
Obesity I (n=92)	10219.1±6460.1	7489.3±6358.8*	5697.6±4600.3*	7316.8±5531.7*#	<0.001
Obesity II (n=46)	8773.9±4476.9	7430.2±4430.3*	4883.0±4926.6*	7285.2±6329.3*#	<0.001
Obesity III (n=28)	8381.4±3770.8	5241.8±3454.8*	3649.6±3033.6*	6246.1±3881.9*#	<0.001
GWG category	**Trial Entry**	**28 weeks**	**36 weeks**	**Post-partum**	
Below (n=76)	9849.5±7704.1	6939.4±4028.6*	5205.6±4050.6*	7314.5±5414.7*#	<0.001
Within (n=91)	10070.3±5909.6	7282.6±6333.3*	5348.4±4092.9*	7479.4±5726.9*#	<0.001
Above (n=138)	9471.7±5144.6	6878.3±4058.0*	5020.2±4451.9*	6931.2±4879.7*#	<0.001

*significantly different compared to the preceding time point p<0.05

#significantly different compared with Trial Entry

METs/week: Metabolic Equivalent Task units in minutes per week

3.4.3 Physical activity across pregnancy and post-partum according to different BMI or GWG categories

With regards to comparing women of different BMI categories, there was no significant difference either cross-sectionally at each time point (P=0.070) or for changes over pregnancy and post-partum (P=0.923) for total levels of physical activity. With regards to different categories of physical activity in women of different BMI categories, there were also no significant differences at each time point (P=0.706 for commuting, P=0.676 for leisure, P=0.254 for household, P=0.510 for work related physical activity). Likewise there were no significant differences for changes over pregnancy and post-partum for all four categories of physical activity (P=0.563 for commuting, P=0.491 for leisure, P=0.882 for household, P=0.577 for work related physical activity). Figure 3.1 demonstrates the METs/week distribution for different physical activity categories, at each time point, and by maternal BMI category.

With regards to comparing women of different GWG categories, there was no significant difference either cross-sectionally at each time point (P=0.957) or for changes over pregnancy and post-partum (P=0.845) for total levels of physical activity. With regards to different categories of physical activity in women of different GWG categories, there was also no significant difference at each time point (P=0.644 for commuting, P=0.393 for leisure, P=0.534 for household, P=0.475 for work related physical activity). Similarly, there were no significant differences for changes over pregnancy and post-partum for all four categories of physical activity (P=0.736 for commuting, P=0.760 for leisure, P=0.854 for household, P=0.618 for work related physical activity). Figure 3.2 reports the effect of GWG on specific categories of physical activity.

Figure 3.1 Mean physical activity in METs/week throughout pregnancy and post-partum for women of different BMI categories

The bar graph demonstrates the METs/week distribution for different physical activity categories, at each time point, and by maternal BMI category (overweight, obesity class I, obesity class II, and obesity class III).

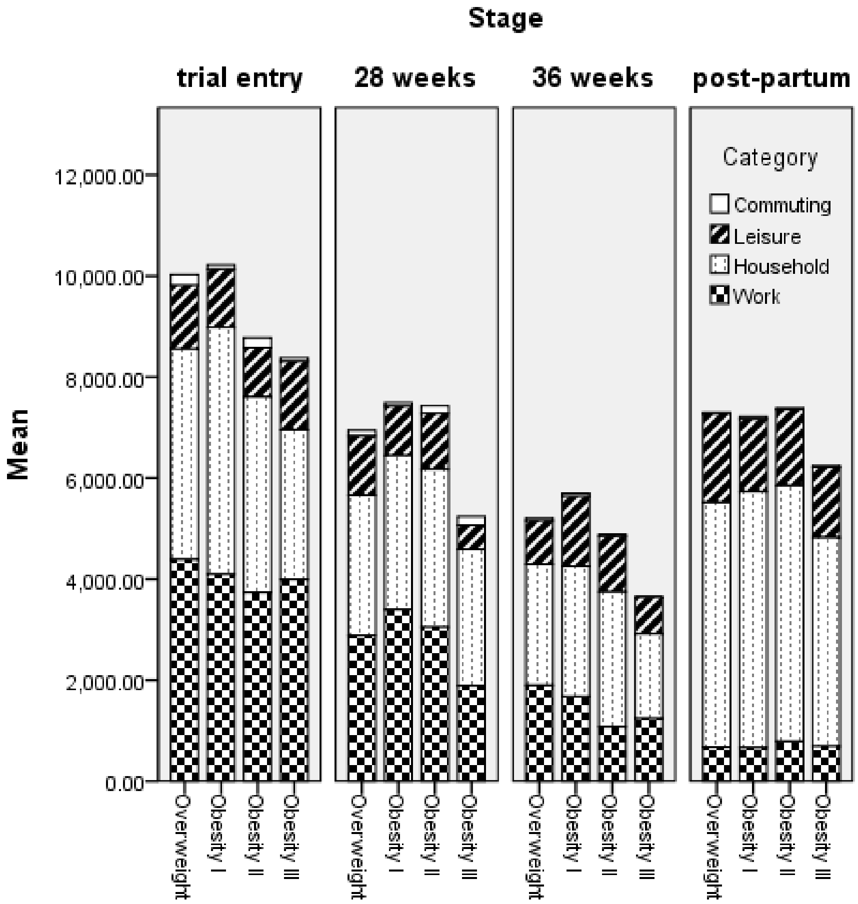
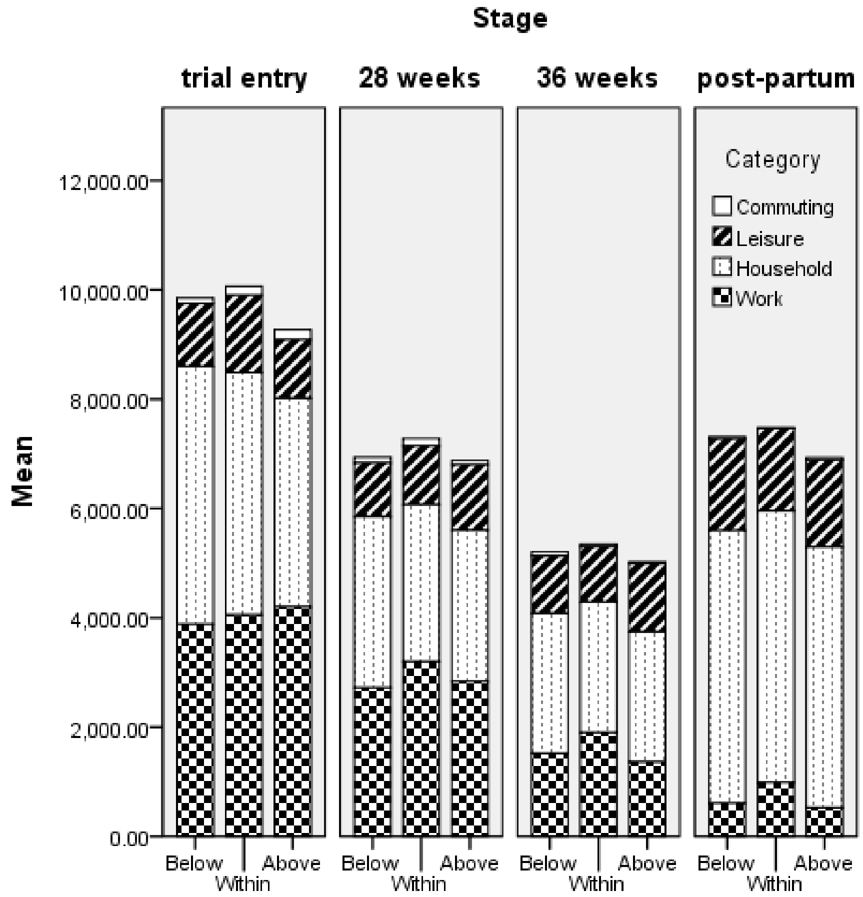


Figure 3.2 Mean physical activity in METs/week throughout pregnancy and post-partum for women of different gestational weight gain categories

The bar graph demonstrates the METs/week distribution for different physical activity categories, at each time point, and by gestational weight gain category (below, within, and above the IOM recommendations).



3.4.4 Determinants of the change of physical activity

A multiple linear regression model was constructed to assess independent predictors of the change in physical activity from trial entry to 4 months post-partum including age, BMI, ethnicity, smoking status, parity, trimester at study entry, breastfeeding status, and SEIFA (for socio-economic disadvantage). The strongest determinant of the change of physical activity during pregnancy and post-partum was maternal BMI (β=0.114, SE=0.750, P=0.032), with women of higher BMI having larger decline of physical activity. Age, ethnicity, smoking status, parity, trimester at study entry, breastfeeding status and socioeconomic status as measured by SEIFA were not independent predictors of physical activity during pregnancy and post-partum. A one unit increase in BMI was associated with a 0.114 increase in the decline in physical activity between trial entry and 4 months post-partum.

3.5 DISCUSSION

This study reports for the first time an examination of physical activity during pregnancy and postpartum in overweight and obese women of different BMI and GWG categories. The aim of this study was to evaluate changes in physical activity among women who are overweight or obese during pregnancy and 4 months post-partum and to assess the effects of BMI and GWG on activity levels. Physical activity declined significantly between early pregnancy and 28 weeks' gestation, with a further decline to 36 weeks' gestation. At 4 months post-partum, physical activity significantly increased but not to the level of that reported at early pregnancy. There was no significant difference between reported physical activity among women with different BMI or GWG categories either cross-sectionally at each time point or over time. Maternal BMI was a significant independent determinant of the change of physical activity during pregnancy and post-partum with women of higher BMI having a larger decline in physical activity from early pregnancy to post-partum.

As previously reported for both overweight and obese women and women of all BMI categories (66, 67), total physical activity decreased across pregnancy and increased in the post-partum period (67). These findings indicated that changes in physical activity were related to a gradual reduction in work activity throughout pregnancy and post-partum. This may be partially explained by a reduction in commuting activities which contributed a relatively small proportion of activity time later in pregnancy and post-partum. In contrast, Renault and colleagues reported an increase in total physical activity between early and mid-gestation in n=163 obese Danish women (65). Furthermore, McParlin and colleagues reported a constant reduction of physical activity during pregnancy in 55 overweight and obese women (66). This is consistent with the current observation that physical activity declined from early pregnancy to 36 weeks gestation in both overweight and obese women. While the methodology of these studies is strengthened by the use of objective measures of physical activity assessment (including accelerometers (66) and pedometers (67)), limitations include the small sample sizes for the studies specifically focusing on overweight and obese women (n=55 (66)) and the lack of an overweight subgroup for Renault et al (65). The findings of the current study also indicate most physical activity during pregnancy consists of household and work related activities, with household activity increasing post-partum. This is consistent with previous research assessing physical activity during pregnancy in women of all BMI categories where household and care-giving activity constituted 24-40% of total energy expenditure as assessed by 24 hour recall across each trimester (59). This highlights the importance of including these activities in an overall assessment of physical activity in women during pregnancy and post-partum.

The findings of this study indicate that despite an increase in physical activity post-partum, at 4 months post-partum total physical activity was significantly reduced compared with early pregnancy levels. This is consistent with previous research that physical activity remains at a low level at 3 months and 12 months post-partum in women of all weight ranges (108). There is only one study examining post-partum physical activity specifically in overweight and obese women which reported a large amount of sedentary activity and a large proportion of women not meeting the physical activity guidelines (109). The results suggest that poor engagement in physical activity post-partum may contribute to post-partum weight retention. This is consistent with Ostbye et al who examined the determinants of post-partum weight loss and reported that a high level of physical activity was a significant predictor of post-partum weight loss in overweight and obese women (110). This is of particular relevance in overweight and obese women who are more likely to have higher weight gain or weight retention 1-2 year post-partum than women of a lower BMI (111). Previous studies have reported that although women thought it was appropriate to exercise at 3 months post-partum, the reasons for poor engagement with physical activity include a lack of time and issues with child care (112, 113). There is no data examining barriers to engaging in physical activity post-partum specifically in overweight and obese women and this warrants further research.

The findings of this study indicate no significant difference in total physical activity or physical activity categories at each time point or over pregnancy and post-partum between overweight and obese women. There is limited research evaluating the determinants of physical activity during pregnancy and the effect of maternal BMI on physical activity remains unclear with some (61, 62, 114) but not all (60, 63, 80, 115) studies reporting an association between increasing BMI and reduced physical exercise. The bulk of the literature focuses on women of all weight ranges with a lack of data investigating the relationship between BMI and total physical activity or physical activity patterns in overweight and obese women. Previous research also identified other determinants of physical activity during pregnancy in women of all weight ranges including higher education and income, no other children at home, being white, and high level of pre-pregnancy physical activity (58). While the current study did not find any association between these factors and changes in physical activity, it is noted that there is no previous research specifically examining the determinants of physical activity in overweight and obese women. While data from a general population indicates that people of higher BMI are generally more likely to be sedentary (116), the current population may comprise a more sedentary population where the effect of BMI is greater than more subtle contributions from other determinants.

The findings of this study indicate no significant difference in total physical activity or physical activity categories at each time point or over pregnancy and post-partum between women of different GWG categories. While previous research in women of all weight ranges has identified an inverse relationship between physical activity and GWG (96-99, 117), the results are not reported based on GWG categories and there is a lack of data assessing an overweight or obese population. It has been previously reported that physical activity and BMI have a minimal effect on GWG when combined with determinants including smoking, parity, age and education (97). A systematic review examining the effect of dietary and lifestyle interventions in pregnancy on maternal weight and obstetric outcomes also confirms that although lifestyle interventions in pregnancy reduce GWG and improve health outcomes, dietary interventions are more effective for weight related and clinical outcomes than exercise interventions (118). Thus, identification of other factors including social demographic features, dietary intake and women's perceptions of diet and exercise during pregnancy may aid in determining the contributing factors to GWG.

The strengths of the current study include the relatively large sample size and prospective assessment of physical activity behaviour across pregnancy and the early postpartum period. However, results are limited by the recognised accuracy and reliability of self-reported questionnaires which are only tools for ranking level of physical activity in a certain population (100). While the use of objective measures such as pedometers and accelerometers provide a more reliable estimate of physical activity, it was not practical to utilise these tools in this study due to the large sample size of the broader LIMIT study. Furthermore, even pedometers cannot provide precise estimates of physical activity (119). The SQUASH questionnaire was utilised in this study as it has been validated in a variety of different populations including overweight and obese individuals (104), is able to rank individuals on level of physical activity (100, 101) and has been previously utilised to detect associations between different types of chronic conditions and physical activity patterns (102, 103, 105). This supports its utility in the current research context which assesses physical activity behaviour patterns rather than precise amounts of energy expenditure. It is also noted that there is a lack of data on post-partum weight and hence it is not possible to consider post-partum weight retention.

Exercise in pregnancy is beneficial for reducing adverse maternal and fetal outcomes such as pre-eclampsia and preterm-birth. Furthermore, exercise in overweight and obese women during pregnancy may be an efficient tool to limit GWG (73, 120), and improve maternal and infant health outcomes (73, 121-123). Future work promoting healthy lifestyles for overweight and obese women during pregnancy should focus on identifying effective approaches to facilitate an increase or maintenance of leisure activity during pregnancy. Furthermore, given the decrease in activity during pregnancy reported in this and other studies, it is crucial to identify the barriers and enablers for engaging in exercise during pregnancy and the post-partum period.

CHAPTER 4. ANTENATAL EXERCISE TO IMPROVE OUTCOMES IN WOMEN WHO ARE OVERWEIGHT OR OBESE: A SYSTEMATIC REVIEW

4.1 ABSTRACT

Objective: Women who are overweight or obese during pregnancy are at increased risk of a number of adverse pregnancy outcomes. The aim of this study was to systematically review the literature to assess the benefits and harms of an exercise intervention for pregnant women who are overweight or obese.

Methods: A literature search of PUBMED, SCOPUS, the Cochrane Controlled Trials Register (CENTRAL), and the Australian and International Clinical Trials Registers, and an additional hand search through bibliographies of various publications was performed. There were no date or language restrictions.
Selection criteria: Randomised controlled trials comparing supervised antenatal exercise intervention with routine standard antenatal care in women who were overweight or obese during pregnancy were included. The primary outcome was maternal gestational weight gain. The quality of each study was assessed utilising standard Cochrane Systematic Review methodology.

Results: Six randomised controlled trials and one quasi-randomised trial involving a total of 276 women who were overweight or obese during pregnancy, were identified and included. Provision of a supervised antenatal

exercise intervention was associated with lower gestational weight gain (5 trials, 216 participants, mean difference of -0.36 kg, 95% CI: -0.64 to -0.09kg) when compared with standard antenatal care.

Conclusions: A monitored physical activity intervention appears to be successful in limiting gestational weight gain, however the effect on maternal and infant health is less certain.

4.2 INTRODUCTION

Obesity is a significant contributor to chronic disease (1). Current estimates suggest that 64.1% of U.S. women have a BMI ≥ 25kg/m^2 with 35.5% obese (BMI ≥ 30.0 kg/m^2) (4). A national survey indicates that overweight and obesity affect nearly half of U.S. women of reproductive age, with 24.5% being overweight and 23% obese (124).

Overweight and obesity is associated with a number of well documented health complications during pregnancy and childbirth, including preeclampsia, gestational diabetes, caesarean section, and infection (25, 36, 125). Women who are overweight or obese utilise greater healthcare resources during pregnancy(126), spending on average 4.8 days longer in hospital during childbirth, at a cost 5 times greater than women of normal BMI(5). Infants born to women who are overweight or obese are at increased risk of perinatal death, congenital anomalies (24, 25), and macrosomia (18, 22).

Being physically active during pregnancy is thought to be beneficial, particularly for women who are overweight or obese (39, 40). The Royal College of Obstetricians and Gynaecologists (RCOG) guidelines for exercise in pregnancy suggests, while all women be encouraged to exercise during pregnancy, previously inactive women should commence with a 15 minute continuous exercise routine three times a week, increasing gradually thereafter (127). However, these recommendations are based on limited evidence on strength conditioning, weight training, and stretching exercises (127). Importantly, the guidelines do not specifically address the issue of exercise recommendations for pregnant women who are overweight or obese. The aim of this review was to systematically identify and evaluate the currently available literature relating to antenatal exercise interventions specifically targeting pregnant women who are overweight or obese.

4.3 METHODS

4.3.1 Study inclusion and exclusion criteria

Standard Cochrane methodology was adopted for this systematic review (128). All published randomised and quasi randomised controlled trials in which a monitored lifestyle/exercise/physical activity intervention was provided to pregnant women who were overweight or obese were considered for inclusion. The comparison involved provision of routine antenatal care without specific encouragement to increase physical activity. Trials were excluded where the intervention involved consultation/education alone or where study information was available in abstract form only.

4.3.2 Types of participants

Women were defined as overweight if their BMI was between 25.0-29.9 kg/m^2, and obese if their BMI was ≥30 kg/m^2. Subgroup analysis was performed according to BMI category at trial entry (overweight versus obese).

4.3.3 Outcomes of the review

The primary outcome was maternal gestational weight gain. The secondary outcomes included hypertension, pre-eclampsia or eclampsia, gestational diabetes, infection, need for induction of labour, caesarean section, and postpartum haemorrhage requiring blood transfusion for the women, and the risk of large for gestational age infant (LGA) (defined as birth weight >90th centile for gestational age or > 4,000 gm), preterm birth before 37 weeks gestation, perinatal death (stillbirth and neonatal death), congenital anomalies, macrosomia, small for gestational age infant (defined as birth weight <10th centile for gestational age), Apgar score less than 7 at 5 minutes, hypoglycaemia requiring intravenous treatment, hyperbilirubinaemia requiring treatment, admission to neonatal intensive care unit, and birth trauma for the infant. Childhood outcomes of relevance related to body size (including height, weight, BMI) and body composition. The outcome definitions were those used by individual trial authors.

4.3.4 Search methods

PUBMED, SCOPUS, the Cochrane Controlled Trials Register (CENTRAL), and the Australian and International Clinical Trials Registers were searched. References of all published review articles identified and included studies were searched to identify other eligible studies. No language or date restriction was imposed. A search strategy was developed for PUBMED and adapted for other databases, using the search terms as detailed in APPENDIX I.

4.3.5 Data collection and analysis

Abstracts identified by the search strategy were assessed (Sui Z, Dodd J and Grivell R) and categorised as relevant, not relevant or possibly relevant. All relevant and possibly relevant trials were then reviewed in their entirety. Disagreement was resolved by consensus. Titles and abstracts of all studies identified in the search were scanned and full papers of any studies that were associated with maternal obesity were retained for further independent evaluation by three reviewers. There was no blinding of authorship.

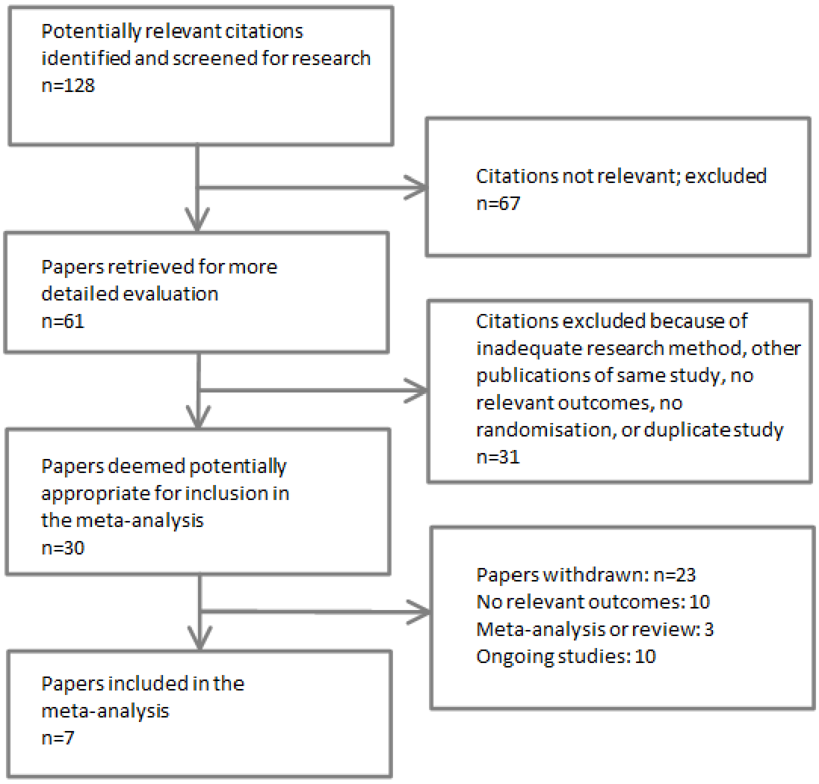
The validity of each study was assessed using criteria outlined in the Cochrane Handbook for Systematic Reviews of Interventions (128). Assessment of quality included five categories of bias: selection, performance, attrition, detection and reporting. This involved analysis based on a Yes (low risk of bias), No (high risk of bias), and Unclear (either lack of information or uncertainty over the potential bias) marking of the five categories of bias. Studies were then evaluated overall as Low, High, or Unclear risk of bias, in combination with consideration of study design, size, and the potential impact of the identified weaknesses.

Continuous and dichotomous variables were analysed with Review Manager 5 software (Cochrane IMS, www.cc-ims.net/revman), with calculation of Risk Ratios (RR) with 95% Confidence Intervals (CI). The fixed effect inverse variance meta-analysis was chosen for combining data where trials were examining the same intervention, and the trial populations and methods were judged to be sufficiently similar. If substantial heterogeneity (defined as I^2 >50%) was identified within the fixed-effect meta-analysis, a repeated analysis using a random effects model was used, and the reasons for the heterogeneity explored. All included trials were included in the initial analyses, and sensitivity analyses were subsequently carried out to explore the effect of trial quality.

4.4 RESULTS

The search identified 128 records following deduplication, with 67 excluded based on the titles and abstracts. A total of 61 records were screened, of which 54 were excluded (Figure 4.1) including 10 ongoing randomised trials. Seven studies were eligible and included in the review. All included manuscripts were published between 2004 and 2011 and included participants from Europe, Australia, North America, and South America.

Figure 4. 1 Systematic review study selection process



4.4.1 Description of the included studies

Six randomised and one quasi-randomised controlled trials were included, (54, 121-123, 129-131) involving 276 women who were overweight or obese during pregnancy. Four studies compared an antenatal exercise intervention with standard antenatal care (involving no intervention) (54, 123, 129, 130). Women in the control group in the Santos trial received an additional once per week relaxation session (129) while women in the control group in the Brankston trial and Nascimento trial received dietary advice only (122, 131). The studies by Barakat (121), Brankston (122), and Stutzman (54) recruited women of all BMI categories, with variable reporting of outcomes for women who were overweight or obese. The trials by Ong (123) and Callaway (130) recruited obese women only. The trial by Nascimento recruited both overweight and obese women (131). Six trials recruited overweight/obese but otherwise healthy women in the first or second trimester of pregnancy (54, 121, 123, 129-131), while women in the trial by Brankston were recruited in their third trimester following a diagnosis of gestational diabetes(122).

4.4.2 Methodological quality

The generation of the randomisation sequence utilising random number table was reported by six trials (121, 123, 129-131). The study by Stutzman was considered to be quasi-randomised as treatment allocation was done by coin toss. Allocation concealment was adequate, utilising sealed opaque sequentially numbered envelopes in four trials (121, 122, 129, 131), but was unclear in the remaining three. Blinding of participants and caregivers was specified in the study by Barakat (121), being unclear in the remainder (54, 122, 123, 129-131). Losses to follow-up were greater than 20% of the original randomised cohort for the trial by Santos (129). For further details of the characteristics of the included studies, see Table 4.1

Table 4.1 Characteristics of included studies in the systematic review

Author and Setting	Population	Intervention	Outcomes	Quality
Barakat Spain and Sweden 2009	Inclusion: 12-13 weeks pregnant; 25-35 years old; sedentary; singleton; all BMI categories Exclusion: multiple pregnancy; high risk of preterm delivery Sample size: 160 randomised, 142 analysed; 40 overweight or obese	Experiment (n=23): light resistance and toning exercise (35-40 min per session) 3 times per week, last for 26 weeks Control. (n=17): routine hospital care	birth weight; birth length; Apgar score; GWG	Randomisation: random number table Allocation concealment: opaque envelopes Blinding: researchers blind to randomisation process Losses to follow-up: 11%
Brankston Canada 2004	Inclusion: 26-32 weeks pregnant; 20-40 years old; BMI≤40; diagnosis GDM; not involved in regular exercise program Exclusion: multiple pregnancy Sample size: 38 randomised, 32 analysed	Experimental (n=16): 3 sessions of a circuit of 8 exercises repeated until felt "somewhat hard". Control (n=16): asked not to start a specific exercise program. Women in both groups were given dietary advice.	use of insulin therapy	Randomisation: random number table Allocation concealment: opaque envelopes Blinding: not stated Losses to follow-up: 15%
Callaway Australia 2010	Inclusion: 12 weeks pregnant; singleton; BMI≥30 Exclusion: multiple pregnancy Sample size: 50 randomised	Experimental (n=25): closely monitored individualised exercise plan in order to achieve an energy expenditure of 900 kcal/wk Control (n=25): routine hospital care	energy expenditure; fasting insulin; fasting glucose	Randomisation: random number table Allocation concealment: not stated Blinding: not stated Losses to follow-up: -

Table 4.1 Characteristics of included studies (Cont.)

Author and Setting	Population	Intervention	Outcomes	Quality
Nascimento Brazil 2011	Inclusion: 14-24 weeks pregnant; BMI ≥ 26; age ≥ 18 Exclusion: multiple pregnancy; conditions contraindicate exercise	Experimental: weekly general stretching and muscle strengthen exercise (40 min per session) Control: routine hospital care	GWG; caesarean rate; birth weight; gestational age; Apgar score; LGA; quality of life	Randomisation: random number table Allocation concealment: opaque envelop Blinding: not stated Losses to follow-up: 2.4%
Ong Australia 2009	Inclusion: 18 weeks singleton pregnant; sedentary; BMI≥30 Exclusion: multiple pregnancy; diabetes or cardiovascular disease Sample size: 12 randomised	Experimental: stationary cycling (35-50 min per session) 4 times per week for 10 weeks Control: routine hospital care	OGTT; GWG; fitness level	Randomisation: random number table Allocation concealment: not stated Blinding: not stated Losses to follow-up: -
Santos Brazil 2005	Inclusion: <20 weeks pregnant; >20 years old; BMI 26-31 Exclusion: multiple pregnancy; hypertension; diabetes; preterm labour; thyroid disease Sample size: 92 randomised, 72 analysed	Intervention (n=37): supervised resistance, stretching, and relaxation exercise of 60 minutes, 3 times per week Control (n=35): once-weekly relaxation session and focus group discussion.	sub maximal exercise capacity (oxygen uptake); respiratory exchange ratio; carbon dioxide output; GWG; heart rate at the anaerobic threshold; Apgar score; low birth weight	Randomisation: random number table Allocation concealment: opaque envelopes Blinding: not stated Losses to follow-up: 22%

Table 4.1 Characteristics of included studies (Cont.)

Author and Setting	Population	Intervention	Outcomes	Quality
Stutzman Canada 2010	Inclusion: 20 weeks pregnant; sedentary; singleton; all BMI categories Exclusion: hypertension; diabetes; smoking during pregnancy; alcohol or drug dependence Sample size: 22 randomised, 12 overweight or obese	Experimental: low intensity walking (0.6-3km/walk) 5 times per week for 16 weeks Control: routine hospital care	Blood pressure; Maternal Baroreflex Sensitivity; GWG	Randomisation: coin toss Allocation concealment: not stated Blinding: not stated Losses to follow-up: 12%

4.4.3 Excluded studies

One study was excluded, as women of all BMI categories were recruited, with no specific reporting of outcomes for women who were overweight or obese (42). Four studies were excluded as the study designs were inadequate (a single armed intervention study, a case-control study, and a cohort study) (132-134). Six studies were excluded as the lifestyle intervention involved consultation, education, and encouragement only, rather than actual physical activity (135-140). One study was excluded as the exercise was only a component of the dietary/lifestyle intervention and there was no report of independent effect of the exercise component (141). For further details of the excluded studies, see Table 3.2. Three papers were excluded as they were reviews or meta-analyses (142-144).

Table 4.2 Excluded studies

Author	Setting		Reason for exclusion
Mottola	Canada	2010	Single armed intervention study, no control
Guelinckx	Belgium	2009	Exercise intervention involved education alone
Asbee	USA	2009	Exercise intervention involved education alone
Kinnunen en	Finland	2008	Exercise intervention involved education alone
Kuhlmann	USA	2008	Review
Davenport	Canada	2008	Case-control study
Artal	Canada	2007	Exercise intervention involved education alone
Polley	USA	2002	Exercise intervention involved education alone
Gray-Donald	Canada	2000	Cohort intervention
Davies	USA	2010	Review
Schmitt	Germany	2007	Review

Lindholm	Sweden	2010	Single armed intervention study, no control
Clapp	USA	2000	No information for overweight group
Phelan	USA	2011	Exercise intervention involved education and encouragement alone
Vinter	Denmark	2011	No report of the effect of exercise as an independent component

4.4.4 Antenatal lifestyle (exercise) intervention for women who are overweight or obese

All seven included trials evaluated the effect of a lifestyle (exercise) intervention (54, 121-123, 129-131). Two studies focused on resistance training (121, 122), while the remainder focused on aerobic exercise including stationary cycling (123), aerobic classes (129), walking (54), stretching and strengthening physiotherapy (131), and an individualised energy expenditure plan (130).

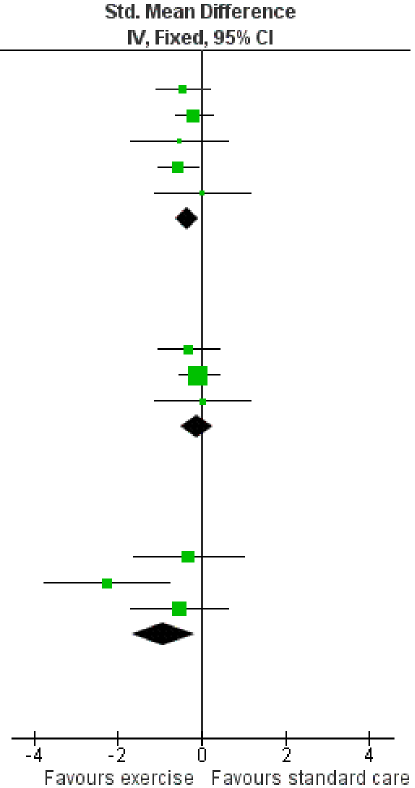
4.4.5 Effect of the intervention

For the primary outcome, gestational weight gain, five trials reported outcome data (54, 121, 123, 129, 131).

Women who were provided with a supervised exercise program gained significantly less weight during pregnancy, when compared with women who did not (5 studies, 216 women, Standard Mean Difference -0.36; 95% Confidence Interval -0.64 to -0.09). There was no significant differential effect based on maternal BMI at trial entry. The results are summarised in Figure 4.2.

Figure 4.2 Analysis of gestational weight gain (kg): exercise intervention versus standard care

	Exercise intervention			Standard care				Std. Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Fixed, 95% CI**
1.1.1 Gestational Weight Gain Among Both Overweight and Obese Women								
Barakat 2009	9.92	4.6	23	11.84	3.4	17	18.1%	-0.45 [-1.09, 0.18]
Nascimento 2011	10.3	5	39	11.5	7.4	41	37.9%	-0.19 [-0.63, 0.25]
Ong 2009	3.7	3.4	6	5.2	1.3	6	5.4%	-0.54 [-1.70, 0.62]
Santos 2005	5.7	1.2	37	6.3	0.9	35	32.9%	-0.56 [-1.03, -0.09]
Stutzman 2010 (1)	14.02	2.89	6	13.99	0.58	6	5.7%	0.01 [-1.12, 1.14]
Subtotal (95% CI)			**111**			**105**	**100.0%**	**-0.36 [-0.64, -0.09]**
Heterogeneity: Chi² = 1.86, df = 4 (P = 0.76); I² = 0%								
Test for overall effect: Z = 2.65 (P = 0.008)								
1.1.2 Gestational Weight Gain Among Overweight Women (BMI 25.0 - 29.9 kg/m2)								
Barakat 2009	10.9	4.9	14	12.3	3.9	14	26.3%	-0.31 [-1.05, 0.44]
Nascimento 2011	10.4	5.6	30	10.9	7.6	36	62.3%	-0.07 [-0.56, 0.41]
Stutzman 2010	14.02	2.89	6	13.99	0.58	6	11.4%	0.01 [-1.12, 1.14]
Subtotal (95% CI)			**50**			**56**	**100.0%**	**-0.12 [-0.51, 0.26]**
Heterogeneity: Chi² = 0.33, df = 2 (P = 0.85); I² = 0%								
Test for overall effect: Z = 0.64 (P = 0.52)								
1.1.3 Gestational Weight Gain Among Obese Women (BMI 30 kg/m2 or greater)								
Barakat 2009	8.4	4.14	9	9.7	1.2	3	32.5%	-0.32 [-1.64, 1.00]
Nascimento 2011	10	1.7	9	16.4	3.9	5	25.9%	-2.27 [-3.74, -0.79]
Ong 2009	3.7	3.4	6	5.2	1.3	6	41.7%	-0.54 [-1.70, 0.62]
Subtotal (95% CI)			**24**			**14**	**100.0%**	**-0.91 [-1.66, -0.16]**
Heterogeneity: Chi² = 4.41, df = 2 (P = 0.11); I² = 55%								
Test for overall effect: Z = 2.39 (P = 0.02)								



(1) quasi-randomised trial

While the trial by Brankston (122) indicated a reduction in insulin use among women with insulin dependent gestational diabetes who received the exercise intervention, no data were reported. Three studies reported neonatal outcomes including birth weight, gestational age, and Apgar scores (121, 129, 131). The Barakat trial did not report separate neonatal outcomes for overweight and obese women and hence cannot be compared (121). While both the Santos trial and the Nascimento trial found no significant difference in neonatal outcomes between the treatment groups, it was not possible to combine the outcomes in a formal meta-analysis due to reporting differences (129, 131). While the majority of trials assessed glucose tolerance (122, 123, 130) and cardio respiratory measures of exercise tolerance (54, 129), suggesting a benefit through exercise training, there was limited reporting of the pre-specified secondary maternal and neonatal health outcomes.

4.5 DISCUSSION

The results of this systematic review indicate that for women who are overweight or obese, provision of a supervised antenatal exercise intervention appears to be beneficial in limiting weight gain during pregnancy. Although the interventions in these studies are very diverse including walking, cycling, and resistance training, and vary in both the timing of initiation, the direction and magnitude of treatment effect was similar across trials. Importantly, the effect of an antenatal exercise intervention on other maternal and infant health outcomes remains unclear, with the included studies primarily reporting outcomes reflecting exercise tolerance, and cardiovascular and metabolic changes.

The beneficial outcomes of being physically active are well recognised, including improving cardio-vascular condition and glucose tolerance, building bone and muscle mass, and reducing risks of obesity and its complications (39, 40). Exercise in pregnancy has been reported to improve maternal health outcomes through a reduction in risk of preterm birth and labour complications (42, 45). For the infant, moderate intensity exercise during pregnancy has been associated with a reduction in fat mass at birth and in childhood (42, 145). Current guidelines from the RCOG and other national organizations encourage women to incorporate exercise into pregnancy to minimize their risk of developing complications (127).

The findings of this meta-analysis are in agreement with previously reported systematic reviews in women of all BMI categories. Streuling (74) conducted a meta-analysis of diet and physical activity intervention involving women of all BMI categories, and included four randomised controlled trials and five non-randomised studies. Women participating in exercise interventions gained significantly less weight during pregnancy (standardized mean difference of -0.22 kg; 95% C.I.: -0.38,-0.05 kg) compared with women who did not receive the intervention.

Kramer and McDonald's Cochrane review of exercise for women of all BMI categories during pregnancy included 11 randomised trials involving 1014 women (56). Outcome measurements included a change in degree of maternal physical fitness, anthropometric measures and adverse maternal and infant birth outcomes. The included RCTs varied considerably in the nature of the intervention provided, the timing and duration of the intervention, as well as assessment of compliance. The sample sizes of the individual studies were relatively small and all had methodological flaws. While regular exercise was associated with maintained or improved physical fitness (defined as aerobic capacity, cardiopulmonary measures, and physical work capacity), the effect on clinical pregnancy outcomes was considered uncertain. Ceysen's review utilised data from four randomised trials evaluating the effect of exercise programs, involving 114 pregnant women with gestational diabetes (57). This study found no significant effect of exercise on health outcomes for pregnant women with gestational diabetes.

Based on the results of this review, current evidence indicates that provision of a supervised antenatal exercise intervention may help in limiting gestational weight gain in women who are overweight or obese. However, there remains a lack of high quality research evidence to assess the impact on maternal and infant health, and there is currently insufficient information on which to base recommendations for clinical care. Clearly, adequately powered, well designed randomised trials are required to evaluate the effect of exercise during pregnancy for women who are overweight or obese on relevant clinical outcomes. Issues that require attention include the optimal intensity of the exercise, as well as acceptability to women.

CHAPTER 5. WALKING TO LIMIT WEIGHT GAIN AND KEEP FIT DURING PREGNANCY: THE WALK RANDOMISED TRIAL

5.1 ABSTRACT

Objectives: Obesity is a significant global health problem, with the proportion of women entering pregnancy with a body mass index (BMI) greater than or equal to 25 kg/m^2 approaching 50%. The aim of this nested randomised trial was to investigate whether providing access to a simple walking intervention during pregnancy is effective in limiting gestational weight gain and improving maternal and neonatal health outcomes for overweight and obese women.

Methods: Women were eligible if they had a singleton pregnancy between 10^{+0}-20^{+0} weeks gestation and a BMI ≥ 25kg/m^2 at the first antenatal visit. Participants randomised to the intervention group were provided access to supervised group walking sessions. Both the intervention and control group received written and verbal information detailing the benefits of exercise in pregnancy and encouraging an active lifestyle. The primary outcome was gestational weight gain.

Results: A total of 582 women were randomly allocated to either the walking (n=287) or information group (n=295). Both intention-to-treat and per-protocol analyses showed no significant difference between groups in gestational weight gain or secondary maternal and neonatal health outcomes.

Women in the walking group maintained better fitness as higher levels of commuting ($P=0.02$) and leisure activity ($P<0.01$) in late pregnancy than women in the information group.

Conclusions: Access to supervised walking group sessions during pregnancy had limited impact on maternal and neonatal health. Future research should focus on developing individualised strategies during pregnancy to promote a healthy lifestyle, and increase physical activity.

5.2 INTRODUCTION

Obesity is a significant contributor to disease worldwide (1). Overweight (defined as a Body Mass Index (BMI) of 25- 29.9 kg/m^2) or obesity (defined as a BMI of ≥30 kg/m^2) during pregnancy is associated with a well documented increased risk in a range of adverse health outcomes for both women and infants, including gestational diabetes, hypertension, caesarean birth, macrosomia, and perinatal mortality (93, 146). Data from the United States indicate that approximately 50% of women enter pregnancy with a BMI greater than 25 kg/m^2, consistent with figures from both the United Kingdom and Australia (18, 107, 124, 146).

Exercise during pregnancy is considered beneficial, improving maternal wellbeing and cardiovascular performance (39, 40). More specifically, exercise in pregnancy has been associated with a reduction in the risk of gestational diabetes (43, 51), pre-eclampsia (55), and operative birth (147). The American College of Obstetricians and Gynaecologists (ACOG) has advocated that all pregnant women without contraindications to exercise be active and participate in mild-to-moderate exercise for at least 30 minutes on most days of the week (71). However, the recommendations for women who have been previously inactive or who have pregnancy complications are less clear-cut, requiring individual consideration (71). ACOG recommend that pregnant women who are overweight or obese should be encouraged to follow an exercise program in order to optimize health outcomes for both the woman and her infant (146).

Despite the proposed benefits of exercise in pregnancy, physical activity has been reported to decline over the course of pregnancy, particularly among women who are overweight or obese (58, 148), with a large proportion of women not attaining the recommended amount of exercise. While systematic reviews have indicated that an exercise intervention appears effective in limiting gestational weight gain in overweight and obese women (74, 149), the effects on maternal and infant health outcomes remain uncertain (149). Additionally, the existing randomised trials have varied in both the nature and intensity of the intervention provided (74, 149). The aim of this nested randomised trial was to investigate whether providing access to a simple walking intervention during pregnancy was effective in limiting gestational weight gain and improving maternal and neonatal health outcomes for overweight and obese women.

5.3 METHODS

This randomised trial was nested within a multi-centre randomised controlled trial evaluating the effect of an antenatal dietary and lifestyle intervention in pregnancy for women who were overweight or obese on maternal and infant health outcomes (the LIMIT trial). The methods of the LIMIT trial have been described in detail previously (90). Briefly, women with a booking BMI $\geq$25kg/m^2 at their first antenatal visit between 10+0 and 20+0 weeks' gestation, and a singleton pregnancy were eligible to participate. Women with previously diagnosed type 1 or 2 diabetes, or a multiple pregnancy were excluded. Women were recruited from three public metropolitan maternity hospitals across Adelaide, South Australia, following informed consent, and ethics approval from each site.

5.3.1 The WALK randomised trial

Women randomised to the Intervention group of the LIMIT randomised trial between January 2010 and September 2011 underwent further randomisation to receive either written and verbal information about exercise only (Information group), or to additionally be invited to participate in a targeted, supervised walking group (Walking group).

5.3.2 Randomisation and allocation concealment

The randomisation schedule was computer generated, used balanced variable blocks, and was prepared by a researcher not involved in recruitment or clinical care. Women were allocated to their treatment group by using the central telephone randomisation service, with stratification for maternal BMI at trial entry (BMI 25.0-29.9 kg/m^2 versus $\geq$30 kg/m^2) and parity (parity 0 versus $\geq$1).

5.3.3 Information group

Women randomised to the Information Group received the standard intervention for the LIMIT trial, which included written and verbal information detailing the benefits of exercise in pregnancy, and advice to exercise regularly and adopt a more active lifestyle. This information was reinforced during the face to face (at 20 and 28 weeks gestation) and telephone contact women had with research staff during pregnancy.

5.3.4 Walking group

Women randomised to the Walking Group received written and verbal information as described above, and were additionally invited to participate in a simple group walking activity. As discussed in Chapter 1, physical activity is essential for a healthy pregnancy. The walking group was designed to enable women to increase their level of physical activity through a simple form of exercise that could in future be performed without supervision, and that did not present a health risk to the pregnant woman or her unborn infant. Exercise was performed by women under the guidance of a trained researcher. Women were encouraged to participate three times per week and to attend with a support person. There were three outdoor walking locations across a range of suburbs within the Adelaide metropolitan area, and two indoor shopping centre walking locations. Indoor treadmill walking at no cost was provided as an alternative when the weather was not suitable for outdoor walking. Each walking session was designed to cover a distance of approximately 4.2 km and was of 40 minutes duration (including 5 minutes general stretching and warming up, followed by 5 minutes cooling down time at the end of each session). The intensity of walking was moderate, consistent with exercise recommendations in pregnancy (150). The intensity of walking was monitored by the researcher using the speaking test where it was ensured that participants were able to maintain a conversation using complete sentences without having to breathe too hard. During the walking session, women were provided with the opportunity to discuss the importance and effects of physical activity during pregnancy, including the optimal amount and intensity of home exercise.

5.3.5 Baseline variables

Baseline demographic and clinical information was obtained at trial entry including age, ethnicity, height, weight, BMI, parity, socio-economic status utilising the Socio-Economic Index For Areas disadvantage score (SEIFA) (SEIFA quintile one representing the greatest social disadvantage) (151), and smoking status.

5.3.6 Study outcomes

The primary study outcome was gestational weight gain, defined as the difference in maternal weight measured at 36 weeks' gestation and booking antenatal visit. Average weekly gestational weight gain was also calculated as gestational weight gain divided by the time between weight measurements in weeks.

Secondary study outcomes included:

1) Maternal health outcomes (including hypertension and pre-eclampsia (according to recognised Australasian Society for the Study of Hypertension in Pregnancy criteria) (152); maternal gestational diabetes (defined as a positive oral glucose tolerance test with fasting blood glucose level ≥ 5.5 mmol/L, or 2 hour blood glucose level ≥ 7.8 mmol/L); gestational age at birth; mode of birth; and post-partum haemorrhage (defined as blood loss ≥ 600 ml)).

2) Neonatal health outcomes (including birth weight; birth length; birth head circumference; birth weight ≥ 4.0 kg; birth weight ≤ 2.5 kg; Apgar score <7 at 5 minutes; admission to neonatal intensive care unit; and perinatal death (defined as either a stillbirth (intrauterine fetal death after 20

weeks' gestation and prior to birth), or neonatal death (death of a live born infant prior to 28 days of life))).

3) Physical fitness and activity (assessed by self completion of the Short Questionnaire to Assess Health-enhancing physical activity (SQUASH)) (101) at both trial entry and 36 weeks gestation. Types of activity evaluated included commuting activity (for example walking and bicycling to and from work); leisure time activity (for example walking, bicycling, gardening, other activities, and sports specified by participants); household activity (light or intense household work); and activity at work (light or intense work). Reported physical activity was converted to Metabolic Equivalent Task units (METs) (106), where 1 MET is equal to the energy expended during quiet sitting. The number of minutes spent in each reported activity was multiplied by its MET intensity and summed to calculate total weekly energy expenditure.

5.3.7 Sample size calculation

It was anticipated that recruitment of at least 230 women in each group, would provide 90% power to detect a difference in gestational weight gain between the two groups of 0.75 kg, assuming a standard deviation of 1.1kg (two-tailed alpha=0.05). These figures were conservatively based on those reported previously (153).

5.3.8 Statistical analysis

The analyses utilised intention-to-treat principles, supplemented by a per-protocol analysis (defined as women who participated in the walking group at least once). Binary outcomes were analysed using log binomial regression, with treatment effects expressed as relative risks (RR), or Fisher's exact tests. Continuous outcomes were analysed using linear regression, with treatment effects expressed as differences in means. Both unadjusted and adjusted analyses were performed, adjusted analyses presented with adjustment for the stratification variables as detailed above. Outcomes derived from birth weight were additionally adjusted for maternal age, socio-economic status, and maternal smoking status. Statistical significance was considered as P value <0.05 (two-sided) with no adjustment for multiple comparisons. All analyses were performed using SAS v9.3 (Cary, NC, USA) or SPSS v18 (Chicago, USA).

5.4 RESULTS

During the study period, 582 eligible women were randomised to the LIMIT intervention group, of whom 295 were further randomised to the Information Group, and 287 to the Walking Group. Outcome data were available for 294 women and infants in the Information Group (one woman suffered miscarriage), and 286 women and infants in the Walking Group (one women withdrew her consent to utilise data (Figure 4.1).

Of the women randomised to the Walking Group, 190 (66%) women subsequently declined to participate when contacted despite their initial consent, 57 (20%) women booked but subsequently did not attend a walking session, and 40 (14%) women attended at least one session. The median number of sessions attended was 2 (interquartile range 1-7). In women who participated in the Walking Group, no serious adverse effects of exercise (including syncope, chest pain, shortness of breath, vaginal bleeding or miscarriage) were identified. At trial entry, baseline variables were comparable between the two treatment groups (Table 4.1).

Figure 5. 3 Flow chart of participants in the WALK RCT

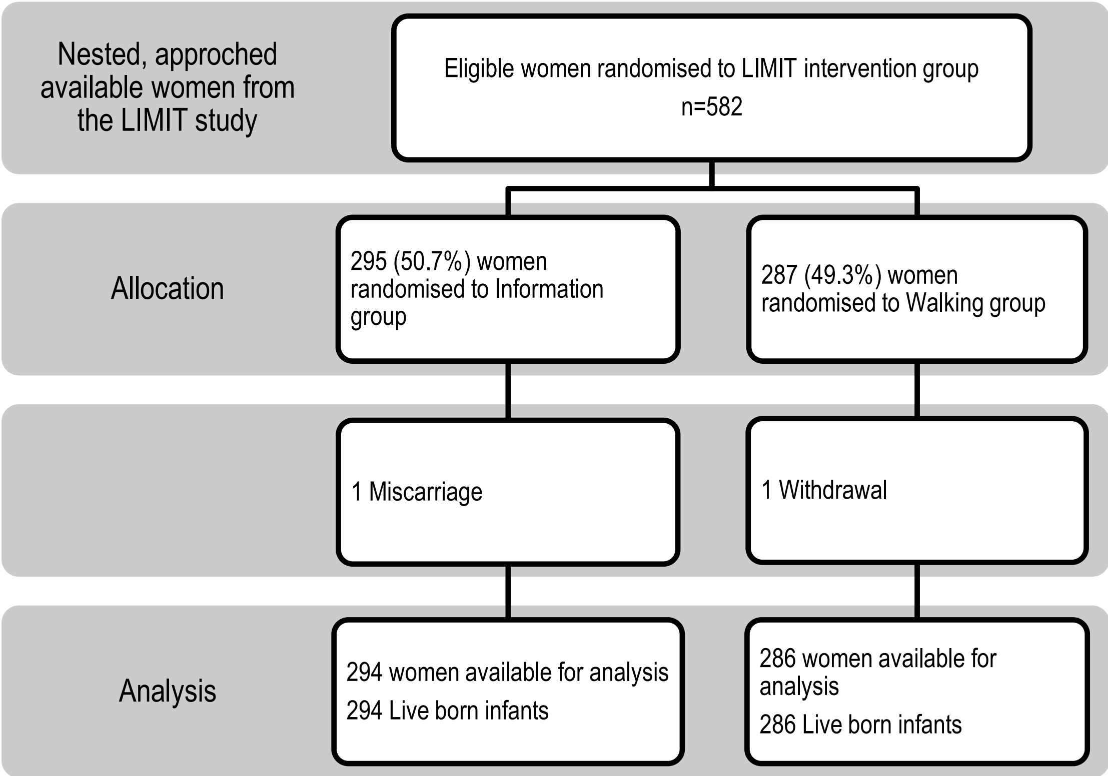


Table 5.3 Demographic characteristics of women in the WALK RCT

Characteristic	*Information group*	*Walking group*
	n=294*	n=286*
Maternal Age (Years): Mean (SD)	29.4 (5.7)	29.0 (5.2)
Gestational Age at Entry (Weeks): Median (IQ range)	14.4 (12.0-17.9)	14.1 (12.1-17.0)
Body Mass Index (kg/m2): Median (IQ range)	30.8 (27.9-36.0)	31.2 (28.1-35.2)
Body Mass Index Category: N (%)		
. BMI 25.0-29.9	127 (43.2)	125 (43.7)
. BMI 30.0-34.9	83 (28.2)	86 (30.1)
. BMI 35.0-39.9	53 (18.0)	48 (16.8)
. BMI >=40.0	31 (10.5)	27 (9.4)
Weight (kg): Mean (SD)	88.6 (17.1)	88.3 (17.4)
Race: N (%)		
. Caucasian	263 (89.5)	263 (92.0)
. Asian	7 (2.4)	6 (2.1)
. Indian	13 (4.4)	8 (2.8)
. Other	11 (3.7)	9 (3.1)
Smoker: N (%)	35 (11.9)	40 (14.0)
Nulliparous: N (%)	124 (42.2)	117 (40.9)
Index of Socio-economic Disadvantage: N (%)		
. Unknown	1 (0.3)	0 (0.0)
. Quintile 1(Most disadvantaged)	93 (31.6)	89 (31.1)
. Quintile 2	69 (23.5)	70 (24.5)
. Quintile 3	50 (17.0)	45 (15.7)
. Quintile 4	39 (13.3)	32 (11.2)
. Quintile 5 (Least disadvantaged)	42 (14.3)	50 (17.5)

* Excludes one woman from the Walking group who withdrew and one woman from the Information group who suffered a miscarriage prior to 20 weeks gestation.

5.4.1 Gestational weight gain

There was no statistically significant difference identified in gestational weight gain for women in the Information Group or Walking Group, utilising both intention to treat principles (9.46±6.04kg Information Group versus 9.38±5.80kg Walking Group; adjusted difference in means -0.02; 95% Confidence Intervals (CI) -1.00 to 0.96; P=0.97) and per protocol analysis (9.46±6.04kg Information Group versus 9.35±5.71kg Walking Group; adjusted difference in means -0.01; 95% CI -1.98 to 1.97; P=0.99) (Tables 4.2 and 4.3). Similarly, no statistically significant differences were identified between groups in women's average weekly gestational weight gain.

5.4.2 Maternal and neonatal health outcomes

There were no statistically significant differences identified for any maternal and infant health outcomes, utilising both intention to treat and per protocol analyses (Table 4.2 and 4.3). The mean birth weight of infants born to women in the Information Group did not differ significantly from infants born to women in the Walking Group either in the intention to treat (3486.51 ±536.66 g Information group versus 3486.39 ±518.59 kg Walking group; adjusted difference in means -1.33; 95% CI -87.60 to 84.94; P=0.98) or per protocol analysis (4386.51 ±536.66 kg Information group versus 3560.28 ±445.02 kg Walking group; adjusted difference in means 57.89; 95% CI -119.04 to 234.82; P=0.52) (Table 4.2 and 4.3).

Table 5.4 Outcomes by treatment group utilising intention-to-treat analysis

Outcome	*Information Group*	*Walking Group*	*Treatment Effect*	*P-value*
Total Gestational Weight Gain (kg)*	9.46 (6.04)	9.38 (5.80)	-0.02 (-1.00, 0.96)	0.97
Average Weekly Gestational Weight Gain (kg)*	0.46 (0.30)	0.44 (0.28)	-0.01 (-0.06, 0.04)	0.67
Hypertension ^	28/285 (9.82%)	26/282 (9.22%)	0.97 (0.59, 1.59)	0.90
Pre-Eclampsia or Eclampsia ^	17/285 (5.96%)	15/282 (5.32%)	0.85 (0.43, 1.69)	0.65
Gestational Diabetes ^	37/280 (13.21%)	38/278 (13.67%)	1.05 (0.70, 1.59)	0.81
GA at birth (Weeks)*	39.41 (1.45)	39.38 (1.52)	-0.03 (-0.27, 0.22)	0.83
Caesarean Delivery ^	96/284 (33.80%)	103/282 (36.52%)	1.05 (0.85, 1.31)	0.63
Postpartum Haemorrhage ≥600 mls ^	54/274 (19.71%)	60/273 (21.98%)	1.09 (0.79, 1.51)	0.61
Birth Weight (g)*	3486.51 (536.66)	3486.39 (518.59)	-1.33 (-87.60, 84.94)	0.98
Birth Length (cm)*	49.88 (2.27)	49.82 (2.22)	-0.05 (-0.42, 0.33)	0.81
Birth Head Circumference (cm)*	34.85 (1.49)	34.86 (1.47)	-0.01 (-0.25, 0.24)	0.96
Apgar Score ≤ 7 at 5 Minutes ^	6/283 (2.12%)	4/281 (1.42%)	N/A	N/A
Birth Weight ≥ 4.0kg ^	47/284 (16.55%)	44/282 (15.60%)	0.94 (0.65, 1.37)	0.75
Birth Weight ≤ 2.5 kg ^	13/284 (4.58%)	9/282 (3.19%)	N/A	N/A
Admission to NICU ^	7/284 (2.46%)	5/282 (1.77%)	N/A	N/A

* reported as Mean (SD); treatment effect is adjusted difference in means ^ reported as n/N (%); treatment effect is adjusted relative risks

Table 5.5 Outcomes by treatment group utilising per-protocol analysis

Outcome	*Information Group*	*Walking Group*	*Treatment Effect*	*P-value*
Total Gestational Weight Gain (kg)*	9.46 (6.04)	9.35 (5.71)	-0.01 (-1.98, 1.97)	0.99
Average Weekly Gestational Weight Gain (kg)*	0.46 (0.30)	0.43 (0.28)	-0.02 (-0.12, 0.08)	0.65
Hypertension ^	28/285 (9.82%)	2/39 (5.13%)	N/A	N/A
Pre-Eclampsia or Eclampsia ^	17/285 (5.96%)	1/39 (2.56%)	N/A	N/A
Gestational Diabetes ^	37/280 (13.21%)	5/38 (13.16%)	1.06 (0.45, 2.53)	0.89
GA at birth (Weeks)*	39.41 (1.45)	39.38 (1.32)	-0.04 (-0.52, 0.44)	0.87
Caesarean Delivery ^	96/284 (33.80%)	11/39 (28.21%)	1.02 (0.60, 1.72)	0.95
Postpartum Haemorrhage ≥600 mls ^	54/274 (19.71%)	7/39 (17.95%)	0.86 (0.40, 1.86)	0.70
Birth Weight (g)*	3486.51 (536.66)	3560.28 (445.02)	57.89 (-119.04, 234.82)	0.52
Birth Length (cm)*	49.88 (2.27)	50.27 (2.02)	0.36 (-0.40, 1.12)	0.36
Birth Head Circumference (cm)*	34.85 (1.49)	35.17 (1.29)	0.25 (-0.24, 0.74)	0.32
Apgar Score ≤ 7 at 5 Minutes ^	6/283 (2.12%)	1/39 (2.56%)	N/A	N/A
Birth Weight ≥ 4.0kg ^	47/284 (16.55%)	7/39 (17.95%)	1.00 (0.50, 2.03)	0.99
Birth Weight ≤ 2.5 kg ^	13/284 (4.58%)	0/39 (0.00%)	N/A	N/A
Admission to NICU ^	7/284 (2.46%)	0/39 (0.00%)	N/A	N/A

* reported as Mean (SD); treatment effect is adjusted difference in means ^ reported as n/N (%); treatment effect is adjusted relative risks

5.4.3 Physical fitness and activity

Categories of physical fitness and activity did not differ between the groups at the time of trial entry (Table 4.4). At 36 weeks gestation, women in both the Information and Walking Groups had significantly reduced their total physical activity (Reduction 1585.24±332.42 METs, P<0.001 Information Group versus 1510.11±246.20 METs, P<0.001 Walking Group). While for women in the Walking Group, this reflected a significant reduction in work related physical activity (Reduction 2680.06±187.15 METs, P<0.001), for women in the Information Group, the reduction reflected a decline in both leisure activity (Reduction 149.92±91.15 METs, P<0.001) and work related physical activity (Reduction 1255.67±183.17 METs, P<0.001). At 36 weeks gestation, women in the Walking Group reported significantly more commuting and leisure activity when compared with women in the Information Group in both the intention-to-treat (Commuting activity difference in means 46.97±350.76 METs, P=0.02, and leisure activity 248.32±353.04 METs, P<0.001) and per-protocol analysis (Commuting activity difference in means 76.03±372.64 METs, P<0.001, and leisure activity 27.67±388.29 METs, P=0.04).

A total of 37 women (12.9%) in the Walking Group reported participating in additional exercise groups (e.g. yoga) other than the intervention, which did not differ significantly from that reported by women in the Information group (32 women; 10.9%; relative risk 1.03; 95% C.I. 0.84-1.64; P=0.80).

Table 5.6 Physical activity in METs

			Intention-To-Treat			Per-Protocol		
METs		***Information Group Mean (SD)***	***Walking Group Mean (SD)***	***Difference in Means (95% CI)***	***P-value***	***Walking Group Mean (SD)***	***Difference in Means (95% CI)***	***P-value***
Trial Entry	Commuting	61.59(183.16)	82.42(183.31)	0.66(274.05)	0.97	31.59(71.23)	-69.75(208.61)	0.44
	Leisure	1165.50(1726.34)	1246.08(1270.83)	134.43(795.15)	0.24	1100.50(936.49)	-16.52(1848.12)	0.96
	Housework	3887.65(3683.60)	3016.07(1789.49)	-743.13(1465.96)	0.37	2704.14(1423.98)	-501.54(2004.26)	0.13
	Work	3862.83(3032.12)	4124.67(2064.83)	-302.12(3562.56)	0.24	4334.43(2133.48)	706.10(4085.87)	0.38
	Total	8977.58(4613.79)	7491.91(3061.33)	-1625.79(5411.82)	0.64	6870.32(3281.44)	-1715.41(5590.14)	0.63
36 Weeks Gestation	Commuting	51.55(145.09)	106.77(314.15)	46.97(350.76)	0.02	114.60(360.39)	76.03(372.64)	<0.01
	Leisure	1015.57(977.59)	1268.02(859.83)	248.32(353.04)	<0.01	1023.83(746.44)	27.67(388.29)	0.04
	Housework	3718.04(1359.20)	3149.97(1610.68)	-336.37(370.92)	0.12	3134.90(1932.76)	-473.48(2693.83)	0.28
	Work	2607.17(2578.29)	1457.03(1818.32)	-1529.21(3017.05)	0.64	1436.06(1856.53)	-1470.50(3046.57)	0.95
	Total	7392.33(4007.40)	5981.80(2502.37)	-1598.78(4425.83)	0.24	5699.38(2555.30)	-948.65(4137.41)	0.16
Change^	Commuting	10.05(183.90)	-24.35(343.52)	-	-	-83.01(327.93)	-	-
	Leisure	149.92(91.15)*	-21.9 (98.25)	-	-	86.67(195.55)	-	-
	Housework	169.61(257.04)	-133.91(149.59)	-	-	-430.76(310.37)	-	-
	Work	1255.67(183.17)*	2680.06(187.15)*	-	-	3206.60(935.08)*	-	-
	Total	1585.24(332.42)*	1510.11(246.20)*	-	-	1170.94(473.17)*	-	-

^ METs at trial entry – METs at 36 weeks gestation

* Significant difference between trial entry and 36 weeks gestation P<0.001

5.5 DISCUSSION

This randomised trial demonstrated that provision of an antenatal walking intervention was not effective in limiting gestational weight gain, or improving maternal and neonatal health outcomes in pregnant women who were overweight or obese. However, women who were invited to participate in the walking intervention maintained improved fitness, with greater commuting and leisure activity in late pregnancy, compared with women who received information only.

Strengths of this randomised trial include its robust methodology and a sample size adequate to evaluate maternal and perinatal health outcomes. When compared with similar intervention trials identified in Chapter 4, the current study has a larger sample size, and is therefore powered to evaluate clinically relevant maternal and neonatal health outcomes. The walking group intervention was chosen to reflect a low cost form of exercise that women could, in future, perform at minimal cost and inconvenience, and without the need for specialised instruction or supervision. This is in contrast to other interventions identified in the previous meta-analysis, which were reliant upon expensive equipment (e.g. stationary bicycle) or skilled health professionals (e.g. physiotherapists) to deliver the intervention, thereby limiting the capacity for the exercise program to be maintained outside of a research environment.

Despite initial consent to participate, only 14% of women randomised to the supervised walking sessions attended. The randomised trials identified and reported in the meta-analysis did not provide detailed information about adherence to the specific physical activity regimens. However, several exercise studies have been identified involving pregnant women from a range of BMI categories, in which women who were overweight or obese had documented lower rates of compliance compared with women of normal BMI, and are consistent with the reported rate of adherence in this presented study (65, 137, 154, 155).

Together, these findings indicate the very real difficulty in increasing physical activity levels in pregnant women, particularly among women who are overweight or obese. A systematic review of interventions promoting healthy eating and physical activity during pregnancy to limit gestational weight gain indicate that dietary interventions were more effective than physical activity interventions, generating the greatest reduction in maternal gestational weight gain (Diet: mean difference 3.84 kg, 95% C.I. 2.45-5.22 kg, $P<0.001$, $I^2=92\%$; Physical activity: mean difference 0.72 kg, 95% C.I. 0.25-1.20 kg, $P=0.003$, $I^2=30\%$), although there was evidence of considerable heterogeneity (118).

Qualitative studies (88, 156) indicate that pregnant women generally consider healthy eating to be of greater health importance than physical activity, with many women not considering excessive weight gain to be problematic. Additionally, a variety of barriers have been identified within this thesis, that appear to be highly individualised in preventing women from increasing their physical activity during pregnancy (156) (see Chapter 7). Furthermore, a significant proportion of women (42%) did not consider excessive gestational weight gain to be of concern during pregnancy, and were not knowledgeable of the potential maternal and neonatal health risks related overweight or obesity during pregnancy (156). Further research to identify strategies to promote individualised care therefore remains a priority (157).

A potential limitation of this presented trial is assessment of physical activity reliant on women's self report via questionnaire completion. Self reported physical activity is widely recognised to consistently over-report activity when compared with more objective measures, including data obtained via pedometers or accelerometer (66, 67). However, questionnaire assessment does allow conduct of a between group comparison as detailed in this trial, and was considered both more cost efficient and practical, considering the scale of the study. Furthermore, pedometers and accelerometers are not without limitations. These tools do not measure the intensity, duration, or frequency of different categories of different physical activities and hence cannot provide a description of how women distribute their daily activity as detailed in this presented study. In addition, pedometers and accelerometers may underestimate the number of steps taken during higher intensity activities, and demonstrate consistent errors during slow walking or low intensity activity (66, 67).

Qualitative investigations have indicated that many women reduce their leisure activity during pregnancy because of safety concerns for their unborn child (58, 156). The findings of this presented trial did not identify the walking intervention to be associated with any increase risk of harms, either for the woman or her infant. However it is important that health promotion messages target this mismatch, and highlight the benefits and safety of exercise in pregnancy.

This present trial did not find the provision of access to an antenatal walking group for women who are overweight or obese to be associated with limiting gestational weight gain, or improving maternal and infant health outcomes. While the benefits of exercise in improving pregnancy health are well recognised (39, 40), the challenge remains in developing effective individualised intervention strategies to enable women who are overweight or obese to increase their physical activity during pregnancy.

CHAPTER 6. ANTENATAL EXERCISE TO IMPROVE OUTCOMES IN WOMEN WHO ARE OVERWEIGHT OR OBESE: AN UPDATED META-ANALYSIS

6.1 ABSTRACT

Objective: Women who are overweight or obese during pregnancy are at increased risk of a number of adverse pregnancy outcomes. The aims of this study are to incorporate the information generated from the WALK randomised controlled trial into the currently available published literature, and to update the meta-analysis of gestational weight gain of the systematic review described in Chapter 4.

Methods: A literature search of PUBMED, SCOPUS, the Cochrane Controlled Trials Register (CENTRAL), and the Australian and International Clinical Trials Registers, and an additional hand search through bibliographies of various publications was performed. There were no date or language restrictions.

Selection criteria: Randomised controlled trials comparing supervised antenatal exercise intervention with routine standard antenatal care in women who were overweight or obese during pregnancy were included. The primary outcome was maternal gestational weight gain. The quality of each study was assessed utilising standard Cochrane Systematic Review methodology.

Results: Six randomised controlled trials and one quasi-randomised trial involving a total of 899 women who were overweight or obese during pregnancy, were identified and included. Provision of a supervised antenatal exercise intervention was not associated with a difference in gestational weight gain (mean difference of -0.08 kg, 95% CI: -0.21 to 0.05kg, p=0.24) when compared with standard antenatal care.

Conclusions: A monitored physical activity intervention does not limit gestational weight gain.

6.2 INTRODUCTION

Being physically active during pregnancy is thought to be beneficial, particularly for women who are overweight or obese (39, 40). As indicated in Chapter 4, there is a lack of well-powered randomised controlled trials that provide evidence relating to antenatal exercise interventions specifically targeting pregnant women who are overweight or obese. The aims were to incorporate the information generated from the WALK randomised controlled trial (Chapter 5) into the currently available published literature, and to update the gestational weight gain meta-analysis described in Chapter 4.

6.3 METHODS

The methods of the systematic review have been described previously in Chapter 4. The current randomised controlled trial conforms with the stated inclusion criteria and will be included in an updated meta-analysis.

6.4 RESULTS

The characteristics of the identified randomised controlled trials published before 2012 are described in Chapter 4. The characteristics of the trial published after January 2012 and the current WALK randomised trial are described in detail in Chapter 5 and summarised below in Table 6.1.

Table 6.7 Characteristics of the current identified randomised trials

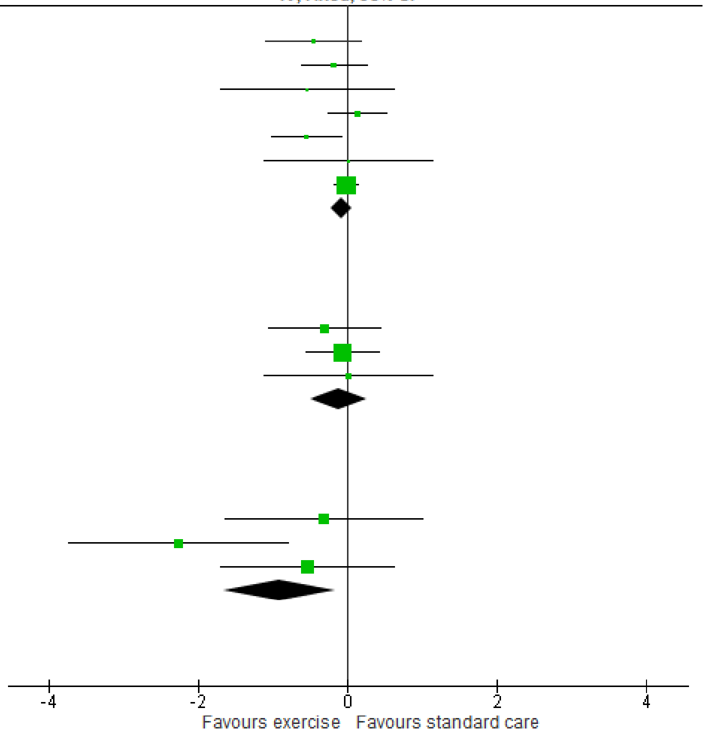
Author and Setting	Population	Intervention	Outcomes	Quality
Oostdam Netherland	Inclusion: pregnant; BMI ≥ 25; at high risk of gestational diabetes Exclusion: 20+ weeks gestation; diagnosed gestational diabetes Sample size: 101 randomised	Experimental: aerobic and strength training 2 times per week for remaining pregnancy Control: routine hospital care	Fasting blood glucose; fasting insulin and HbA1c; weight; BMI; daily physical activity; birth weight; fetal growth	Randomisation: random number table Allocation concealment: not stated Blinding: not blinded Losses to follow-up: 18%
Sui Australia (WALK)	Inclusion: singleton pregnancy 10-20 wks gestation, BMI ≥ 25; Exclusion: diagnosed gestational diabetes Sample size: 582	Experimental: walking group 3 times per week for remainder of pregnancy Control: written and verbal information about the benefits of exercise in pregnancy	Gestational weight gain; maternal and neonatal health outcomes	Randomisation: random number table Allocation concealment: not concealed Blinding: not blinded Losses to follow-up: < 1%

Review of the electronic searching after December 2011 indicated that one published study fulfilled the selection criteria and was included (154). Together with the WALK randomised controlled trial, the meta-analysis involved 899 women who were overweight or obese during pregnancy. The meta-analysis of results indicated that provision of a supervised exercise program for pregnant women who were overweight or obese had no significant effect on gestational weight gain, when compared with women who received routine antenatal care only (899 women; standard mean difference -0.08 kg; 95% CI -0.21 to 0.05; P=0.24). The results are summarised in Figure 6.1. While the majority of trials assessed glucose tolerance (122, 123, 130, 154) and cardio respiratory measures of exercise tolerance (54, 129), suggesting a benefit through exercise training, there was limited reporting of the pre-specified secondary maternal and neonatal health outcomes, the majority of outcomes reported in the WALK randomised trial only.

Figure 6.1 Analyse of gestational weight gain: exercise intervention versus standard care (the updated meta-analysis)

	Exercise intervention			Standard care				Std. Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Fixed, 95% CI**
1.1.1 Gestational Weight Gain Among Both Overweight and Obese Women								
Barakat 2009	9.92	4.6	23	11.84	3.4	17	4.3%	-0.45 [-1.09, 0.18]
Nascimento 2011	10.3	5	39	11.5	7.4	41	8.9%	-0.19 [-0.63, 0.25]
Ong 2009	3.7	3.4	6	5.2	1.3	6	1.3%	-0.54 [-1.70, 0.62]
Oostdam 2012	6.2	5	49	5.6	3.5	52	11.3%	0.14 [-0.25, 0.53]
Santos 2005	5.7	1.2	37	6.3	0.9	35	7.7%	-0.56 [-1.03, -0.09]
Stutzman 2010 (1)	14.02	2.89	6	13.99	0.58	6	1.3%	0.01 [-1.12, 1.14]
Sui 2012	9.38	5.8	287	9.46	6.04	295	65.2%	-0.01 [-0.18, 0.15]
Subtotal (95% CI)			**447**			**452**	**100.0%**	**-0.08 [-0.21, 0.05]**
Heterogeneity: Chi² = 7.97, df = 6 (P = 0.24); I² = 25%								
Test for overall effect: Z = 1.18 (P = 0.24)								
1.1.2 Gestational Weight Gain Among Overweight Women (BMI 25.0 - 29.9 kg/m2)								
Barakat 2009	10.9	4.9	14	12.3	3.9	14	26.3%	-0.31 [-1.05, 0.44]
Nascimento 2011	10.4	5.6	30	10.9	7.6	36	62.3%	-0.07 [-0.56, 0.41]
Stutzman 2010	14.02	2.89	6	13.99	0.58	6	11.4%	0.01 [-1.12, 1.14]
Subtotal (95% CI)			**50**			**56**	**100.0%**	**-0.12 [-0.51, 0.26]**
Heterogeneity: Chi² = 0.33, df = 2 (P = 0.85); I² = 0%								
Test for overall effect: Z = 0.64 (P = 0.52)								
1.1.3 Gestational Weight Gain Among Obese Women (BMI 30 kg/m2 or greater)								
Barakat 2009	8.4	4.14	9	9.7	1.2	3	32.5%	-0.32 [-1.64, 1.00]
Nascimento 2011	10	1.7	9	16.4	3.9	5	25.9%	-2.27 [-3.74, -0.79]
Ong 2009	3.7	3.4	6	5.2	1.3	6	41.7%	-0.54 [-1.70, 0.62]
Subtotal (95% CI)			**24**			**14**	**100.0%**	**-0.91 [-1.66, -0.16]**
Heterogeneity: Chi² = 4.41, df = 2 (P = 0.11); I² = 55%								
Test for overall effect: Z = 2.39 (P = 0.02)								

Std. Mean Difference
IV, Fixed, 95% CI



(1) quasi-randomised trial

6.5 DISCUSSION

This updated meta-analysis included six randomised controlled trials and one quasi randomised controlled trial comparing antenatal exercise intervention with routine hospital care, and involves 899 women who were overweight or obese during pregnancy. The finding of the WALK randomised controlled trial weighed largest and is consistent in direction with most of the other reported studies, including the trials involved women of all weight ranges (54, 121, 123). However, because of the differences in magnitude of treatment effect in the trials, the meta-analysis indicates that provision of an antenatal exercise intervention was not effective in limiting gestational weight gain. It was not possible to conclude the effect of antenatal exercise intervention on other maternal and neonatal health outcomes as a result of lack of report.

This meta-analysis collates information from the WALK trial and other previously published studies that addressed similar research question, allowing information to be assimilated and increasing the statistical power and available sample size. It allows assessment of consistency and applicability of to be made in the area of research.

The included trials adapted very different exercise interventions and targeted a large variety of different maternal and neonatal health outcomes. Hence, there is not enough evidence to construct meta-analysis on other clinically relevant health outcomes as listed in the above chapters. Despite the two additional trials, as discussed in Chapter 4, there remains a lack of research evidence to assess the impact of additional antenatal exercise on maternal and infant health, the majority of outcomes reported in only one trial to date. While the effect of exercise intervention on gestational weight gain among obese women appeared to be significant in the meta-analysis, the result needs to be interpret with caution as reported in only very small sample size.

CHAPTER 7. PERCEPTION OF MAKING HEALTHY CHANGE DURING PREGNANCY IN WOMEN WHO ARE OVERWEIGHT OR OBESE: A MIXED-METHODS STUDY

7.1 ABSTRACT

Objective: Overweight and obesity during pregnancy is associated with risk of a range of adverse health outcomes. While intervention studies aim to promote behavioural change, little is known about the underlying psychological mechanisms facilitating and hindering change. The aim of this study was to evaluate overweight and obese women's perceptions of making behaviour change during pregnancy.

Methods: Beliefs were explored through self-administered questionnaires (n=464) and semi-structured face-to-face interviews (n=26). Questions were designed according to the Health Belief Model. A triangulation protocol was followed to combine quantitative and qualitative data.

Results: A total of 269 women (58%) indicated that high gestational weight gain is a concern, with 348 (75%) indicating excessive weight gain to be associated with complications during pregnancy or child birth. Women were aware of maternal complications associated with high gestational weight gain, but had more limited awareness of neonatal complications. While most women indicated in questionnaires that healthy eating and physical activity were associated with improved health during pregnancy, they were unable to identify specific benefits at interview. Barriers to making healthy behaviour changes were highly individualised, the main

barrier being lack of time. While the majority (91%) of women indicated that they would make behaviour changes if the change made them feel better, only half felt confident in their ability to do so.

Conclusions: Interventions for overweight and obese pregnant women should incorporate education about neonatal health consequences and benefits of healthy behaviour change in addition to incorporating strategies to enhance self-efficacy.

7.2 INTRODUCTION

Approximately 50% of women in the U.S.(124), Australia (18, 107), and the UK(70) have a Body Mass Index (BMI) ≥25 kg/m^2. There are well documented risks associated with high BMI during pregnancy and childbirth (125, 158, 159), with the risk of complications increasing with increasing maternal BMI (93). A number of systematic reviews have focused on the effects of both dietary (23, 72) and exercise (73, 74) based interventions on maternal gestational weight gain among overweight and obese women. While such interventions appear effective in limiting gestational weight gain, the impact on other relevant maternal and neonatal health outcomes remains unclear (23, 73), and adherence to healthy eating and physical activity recommendations remain problematic. Although a previous study has demonstrated that women's attitude toward weight control interventions during pregnancy are generally positive (75), there is an increasing need to identify and address individual psychological aspects and the impact they may have on successful behavioural change (76, 77).

Overall, there is very little research describing women's attitudes to diet, activity and weight gain during pregnancy. The extant literature indicates that women accept the occurrence of weight gain as a 'normal' outcome of pregnancy (86), and they report receiving little and often inconsistent information from health professionals about high BMI and excessive weight gain and associated pregnancy risks (86, 87). In contrast, advice from family relating to optimal gestational weight gain was considered to be highly influential (87). Another small-scale qualitative study in Australia reported that most women who were overweight or obese prior to pregnancy recognised their weight as an issue and believed that health professionals should address their individual needs and expectations (89).

The aim of the current study was to describe, using a mixed methods approach, overweight and obese pregnant women's views about making healthy behavioural changes during pregnancy. To date, there are no reported studies that have utilised this approach to converge quantitative and qualitative data, an approach ideally suited to addressing complex questions from a number of perspectives thus enhancing validity (160, 161).

7.3 METHODS

7.3.1 Theoretical Framework

The study is framed by the Health Belief Model (HBM) (including the theory of Self-Efficacy) (162), and utilises an approach of examining hypothetical pathways between intention to change behaviour and actual behaviour change (Table 5.1). According to the HBM, individuals will make healthy changes if they believe that their health is at risk, in this study due to overweight or obesity, and have awareness of potential consequences. The benefits of making healthy change must outweigh encountered barriers, with cues to action and adequate self-efficacy leading to behaviour change. The HBM has been previously tested in a variety of populations for weight management (162, 163).

Table 7.1 Content of the questionnaire in the mixed-methods study

Themes of HBM	Questions
Perceived susceptibility	Possible risks associated with being overweight in pregnancy
Perceived severity	Possible consequences of weight gain in pregnancy
Perceived benefits – diet	Why some women choose to adopt a healthy diet during pregnancy
Perceived benefits – physical activity	Why some women choose to be physically active during pregnancy
Perceived barriers – diet	Why women may not eat a healthy diet during pregnancy
Perceived barriers – physical activity	Why women may not exercise during pregnancy
Cues to action	Things that may prompt a woman to make changes to her diet or lifestyle during pregnancy
Self-efficacy	How confident you feel you are in being able to make changes to your diet and physical activity

7.3.2 Participants

This mixed-method study is nested within a randomised trial evaluating the effect of an antenatal intervention to limit weight gain among overweight and obese pregnant women on maternal and infant health outcomes (the LIMIT study) (90). Participants in this study were recruited between October 2010 and January 2012. Recruitment to the LIMIT study occurred in three public maternity hospitals across the South Australian metropolitan area. The inclusion criteria were a measured BMI ≥25 kg/m^2 at first antenatal visit between 10 and 20 weeks' gestation, and a singleton pregnancy. Women with type 1 or 2 diabetes diagnosed prior to pregnancy or multiple pregnancy were excluded. Women provided written informed consent to participate, and ethics approval was obtained from each hospital. Baseline demographic information was collected at the time of study entry.

7.3.3 Quantitative component

A self-administered questionnaire was distributed to participants at study entry. Women were provided with instructions on the completion of the questionnaires, and were provided with a reply paid envelope. Follow-up contact was made by telephone if questionnaires were not returned within two weeks. The questions were developed based on an extensive review of the published literature and validated questionnaires (164-167), and were cross-checked by psychological experts for completeness of relevant themes and usability prior to dissemination. The questionnaire took approximately 10 minutes to complete and contained eight questions designed according to the Health Belief Model. Women were asked to respond whether the provided statements to the related questions were Not at all true for me, Not true for me, Undecided, True for me, or Very true for me. Cronbach's alpha was calculated to test reliability for all themes. Stepwise multiple logistic regression analysis (for continuous outcomes) was conducted to assess whether BMI, parity, and age were independent determinants for the questionnaire answers. A P value of < 0.05 was set to be significant. The data were analysed using the Statistical Package for the Social Sciences (SPSS, Chicago) software (version 18).

7.3.4 Qualitative component

Qualitative data were obtained via semi-structured interviews from April 2011 to August 2011. The interviewer was a female health science researcher with trained interviewing skills and knowledge of pregnancy health. The interviewer had no previous connection with any participant. A purposive sampling frame was applied (168) with participants being chosen from women recruited to the LIMIT study based on a selection matrix of randomization group (control versus intervention), BMI category (BMI<30 kg/m^2 and ≥30 kg/m^2), and parity

(Parity 0 and 1+). Women were then approached and the purpose and methods of the interview were explained. Women who agreed undertook a face-to-face interview at 28 weeks of gestation. The interviews, lasting 20 to 30 minutes, took place at the time of the women's oral glucose tolerance test, in a private hospital clinic room.

The interview explored women's general attitude to diet and exercise in pregnancy, investigated how women adopted healthy changes during pregnancy according to the HBM theory, and identified new issues regarding diet, exercise, pregnancy, and weight. Open-ended questions were posed to stimulate discussion and included probes to address the different dimensions. Non-sensitive and broader questions were asked first in order to build rapport with participants. Narrow and sensitive questions were asked later when the participants were comfortable, and questions to identify new themes were asked last. The researcher took notes during the interviews to record significant facial and bodily expression of the interviewees, ensuring a deeper access to meaning. The interview procedure was piloted with an eligible woman and a psychological professional for feedback and corrections.

The concept of data saturation was adopted to determine the number of interviews needed so that data collection was viewed as being complete when no new insights were being gained (169). Determination of data saturation was made in discussion between the authors.

The audio recording of the interviews was fully transcribed verbatim with each interview transcription addressed with a unique identifier (e.g. In01). Interviews were analysed using the framework analytical approach (170), a deductive approach for analysing qualitative data obtained with pre-selected aims and objectives (171). The computer software program NVivo9 (QSR International Pty Ltd.) was used to store and manage the data. Following transcription, each transcript was read several times, with every few lines then coded in ways that described the issues emerging from the data. These issues were then grouped together into themes according to the Health Belief Model. Codes that could not be categorized according to the HBM were grouped as new issues arising from the interview. During the data analysis process, regular discussion between authors assisted in elucidating areas of potential bias, minimizing discrepancies and overstatements, and drawing the main themes.

7.3.5 Mixed-methods data interpretation

The study used a mixed-methods sequential explanatory design. Quantitative data were collected at study entry (10 – 20 gestational weeks) and qualitative data were collected at 28 weeks gestation. Quantitative and qualitative data were collected and analysed separately for each component to produce two sets of findings, and then combined and compared according to a triangulation protocol (160, 161). Under each theme of the HBM, the proportion of agreement from the questionnaires and interview codes were analysed together to identify agreement, partial agreement, silence, and dissonance. Agreement was identified if the two sets of data agreed with each other. Partial agreement was identified where one set of data covered the theme whereas the theme was absent from the other set of data. Silence was identified where the theme was largely absent from both sets of data. Dissonance was identified where there was a disagreement between the two sets of data. A convergence assessment was then performed to provide an overall assessment.

7.4 RESULTS

7.4.1 Questionnaire findings

All available women approached (n= 464) completed the questionnaire. Demographic features are shown in Table 5.2 indicating that participants were representative of the general pregnant population in South Australia. A Cronbach's alpha of 0.88 among questionnaire items was obtained indicating good internal consistency. Women's BMI, parity and age were not determinants for their answers to the questionnaire

(P>0.05). Women appeared to perceive excessive weight gain as making them susceptible to a range of negative outcomes (Table 5.3). Similarly, excessive gestational weight gain was viewed to be a severe health issue, with only 14(3%) women responding that 'nothing will happen'. In contrast however, only 201 (43%) women viewed weight gain as affecting the baby's future weight. While women perceived numerous benefits to healthy eating, only 201 (43%) viewed this as being associated with fewer pregnancy complications. Similarly, physical activity was perceived as being associated with numerous benefits, the most notable being improving health and wellbeing.

Women identified numerous barriers associated with healthy eating and physical activity, the most common being time constraints. Interestingly, only 130 (28%) women identified doctor's advice as a useful cue to action with the majority of women reporting being influenced by factors associated with their health and their baby's health. Responses to items related to self-efficacy varied, but in five out of ten items measuring self-efficacy, women indicated that they were less confident to engage in healthy behaviours.

Table 7.2 Demographic characteristics of participants in the mixed-methods study

	Quantitative		Qualitative		General pregnancy population in South Australia [a]
	N = 464	%	N = 26	%	%
Age: <20	4	0.9	1	3.8	4.1
20-30	199	42.9	10	38.5	44.3
30-40	244	52.5	14	53.8	47.8
40+	17	3.7	1	3.8	3.8
Parity: P0	193	41.6	12	46.2	41.5
P1-2	251	54.1	12	46.2	49.9
P3+	20	4.3	2	7.6	8.5
BMI:					
Overweight	212	45.6	14	53.8	54.1 [b]
Obesity class I	140	30.2	4	15.4	25.8
class II	70	15.1	5	19.3	12.1
class III	42	9.1	3	11.5	8.0
Smoker: Yes	45	9.8	4	15.4	15.9
No	409	88.2	22	84.6	82.6
unknown	9	2.0	0	0	1.5
Race:					
Caucasian	425	91.5	23	88.5	85.0
Asian	21	4.6	3	11.5	8.1
African	3	0.7	0	0	-
Aboriginal	6	1.3	0	0	3.1
Others	9	1.9	0	0	3.8

BMI, Body Mass Index

a. Source: Pregnancy Outcome in South Australia 2009, Government of South Australia

b. % calculated excluded underweight women and women of normal weight

Table 7.3 Questionnaire findings (n=464) in the mixed-methods study

Themes	True/ Very True %	Undecided %	Not at All True/ Not True %
Perceived susceptibility – Excess GWG			
It is a concern	58	14	28
May cause complications during pregnancy and childbirth	75	19	6
May affect baby's health	74	20	6
May affect on women's health after birth	82	14	4
Perceived severity – Excess GWG			
Nothing will happen	3	27	71
May affect maternal health	75	17	8
May affect baby's health	60	29	12
May cause weight retentions	84	9	7
Baby may have weight problem in future	43	43	14
Perceived benefits-healthy eating			
Improve baby's health	94	5	1
Improve women's health	94	5	1
A choice I want to make	93	5	3
Feel good	91	7	2
Important in life	90	3	3
Cooking for the family makes me feel good	84	11	5
Enjoy cooking and eating healthy meals	80	14	6
Feel better about the way I look	73	16	11
Less pregnancy complications	43	37	19
Relieve pressure from others	24	14	63

Table 7.3 Questionnaire findings (n=464) (Cont.)

Themes	True/ Very True %	Undecided %	Not at All True/ Not True %
Perceived benefits – Physical activity			
Improve my health	92	8	1
Feel good	92	7	2
Feel better about the way I look	88	9	2
A choice I want to make	87	10	2
Important in life	86	12	2
Improve baby's health	83	15	1
Exercise with family feels good	78	15	7
Enjoy exercise	72	19	10
Less pregnancy complications	70	19	10
Relieve pressure from others	23	15	63
Perceived barriers – Healthy eating			
No time	39	17	44
Too tired	24	18	58
Too expensive	23	9	68
Don't like it	19	13	67
No support	18	14	68
Don't know how	8	11	81
Perceived barriers – Physical activity			
No time	32	12	56
No where safe	30	8	61
Bad weather	27	15	58
No support	26	17	57
Conscious about my appearance	25	17	57
Too expensive	13	11	76

Table 7.3 Questionnaire findings (n=464) (Cont.)

Themes	True/ Very True %	Undecided %	Not at All True/ Not True %
Cues to action			
Diet and exercise made me feel better	91	4	5
Family and friend encouragement	90	7	3
Baby complications	88	6	6
Good for baby	86	11	3
If I were to develop complications	77	13	10
More information	62	19	19
Someone else's good story	57	22	21
Doctors asks me to	28	13	59
Self-efficacy			
I'm able to prepare healthy food	90	6	4
I could avoid eating takeaways even on Busy days	88	8	5
Diet is under control	57	21	23
I'm able to eat healthily even on busy days	56	20	24
I'm able to buy healthy food	54	17	29
I'm able to exercise even on busy days	50	24	26
Exercise is under control	48	20	32
I plan to eat healthily	74	21	6
I plan to be physically active	75	16	10

7.4.2 Interview findings

Interview findings are reported here according to the order of appearance of themes in the questionnaire. All women approached agreed to participate the interview with 26 face-to-face interviews conducted. Findings in general confirmed the findings from the questionnaire across the themes of the HBM. Women who responded in a manner consistent with perceiving themselves as susceptible (11/26 interviews, including six overweight women and five obese women) were often quite certain when asked whether they considered gestational weight gain as an issue:

> Absolutely. I've been warned that it is a serious factor because I was overweight beforehand. It may have implications when I give birth to my little one. I've been warned by the midwife that I've been overweight and it's so important that I should try to keep healthy. (In09, obese)

Women who did not consider gestational weight gain a concern, (7/26 interviews, including four overweight women and three obese women) did not deny the issue directly but rather referred to it as someone else's problem or not a problem during pregnancy:

> Not to me, I don't think…but that can be, for someone, I'm sure of it. Yes, it is for some big people out there and they can't be healthy. (In07, overweight)
>
> Not during pregnancy. No. After, or before, yes. (In08, obese)

The interviews also indicated that women were aware that excessive weight gain might cause adverse maternal and neonatal health outcomes (10/26 interviews, including five overweight women and 5 obese women):

> Oh! Not good for your baby. Not good for you...probably difficult labour. (In03, overweight)

The interviews were silent with respect to the relationship between excessive weight gain and long-term health outcomes after birth.

Regarding severity, most respondents (20/26 interviews, including 11 overweight women and 9 obese women) indicated an awareness of adverse maternal health consequences and many were able to provide details:

> The preeclampsia, not having a normal delivery, caesarean, wound infection, diabetes...yes...it's not really very good. (In03, overweight)

The interviews also confirmed that women were concerned about weight retention (11/26 interviews, including six overweight women and five obese women):

> You worry about getting it off after… not losing it at the end. (In02, obese)

There was an absence of expression with none of the women being in a position to describe specific neonatal consequences of overweight and obesity during pregnancy, either in the short or long-term.

The interviews identified body image as a major concern raised by eight women (seven overweight women and one obese woman), for example:

> Just the physical appearance. If they feel uncomfortable with their body, and if they can't love themselves, how can anyone else love them? I think that's the biggest concern. (In08, obese)

Only six interviews reflected perceived benefits (three overweight women and three obese women). The interviews indicated that women recognised the benefits of healthy eating and lifestyle to maternal and neonatal health although this was expressed in general terms rather than through descriptions of related health conditions:

> (If I eat healthily and be more active) I'll be healthy and I'll make the baby healthy. (In24, obese)

The interviews also indicated that 'to feel good' was perceived as a major benefit from healthy eating and physical activity (three interviews, including two overweight women and one obese woman):

> Exercise makes me feel better…The head space. You just feel good. Your blood got pumping… the smooth mood... (In21, overweight)

There was absence of expression identified in the interviews with respect to women's awareness of long-term maternal health benefits (two interviews, including one overweight woman and one obese woman):

> …long term, my own health as well. I'm quite aware of that… I don't want to die or have any lifestyle problem. I want to see my children grow up. (In17, overweight)

Women reported a much wider range of barriers in the interviews than was identified from the questionnaires, including: time; being busy caring for other children; cost; not liking cooking/exercise; external environmental factors; personal health conditions and pregnancy complications; lack of knowledge and family support; mood; tiredness; and concern about safety of the baby. All interviewees supplied information about barriers they encountered in much more detail than perceived benefits. The barriers were also highly individualised to the woman's personal situation rather than being only generalised statements:

> …in between working, and picking up from child care, and cooking tea (dinner), that's not much time left in the day. (In02, obese)
>
> …at work it (healthy eating) is really hard because the kind of food they serve there is (not healthy)... (In13, obese)
>
> …and I worry if I do some heavy exercise I may lose it (the baby)... It is IVF. I've tried to get pregnant for 10 years…so I'll just put the exercise aside and wait until I have the baby. (In15, overweight)

The most frequently reported cue to action was concern about the baby's health (9/26 interviews, including four overweight women and five obese women):

The baby's health is the first consideration of all mothers…and if you are eating healthily and doing more exercise the baby will be healthy and the labour process can be easy. (In26, overweight)

Other prompts for healthy change that agreed with the questionnaire responses included encouragement from family; greater health information; willingness to improve maternal health conditions; and previous experience in relation to self and others. Silence was identified with only one interview indicating a desire to look good as an important motivator for healthy changes:

I think most women want to remain healthy and fit, and look good during pregnancy. (In07, overweight)

Regarding self-efficacy, interview data confirmed that 12 women (seven overweight women and five obese women) expressed confidence about healthy changes. Typical expressions about confidence to change included:

(I'm) confident enough. I've done a lot of changes. (In03, overweight)

I think it depends...I don't know at the moment. (In17, overweight)

During the interviews, the researcher probed to explore whether women found either diet or exercise change more difficult, with change in exercise referred to more frequently as harder to change than diet (eight vs. one interview):

Maybe changing diet is easy, but exercise, it depends on the person. (In10, obese)

The interviews also identified a range of highly individualised new themes not reflected in the HBM theory. Each of these tended to be reported by only one or two women. The new themes reported here represent themes that emerged across several interviews. Firstly, women thought having a healthy diet/exercise routine prior to conception was very important for keeping up healthy eating and exercise during pregnancy (three interviews, including two overweight women and one obese woman):

> If I've already got an exercise routine, then stick with it… and just, if you are eating healthy, keep up with that. (In14, obese)

Women also requested more support from health professionals (seven interviews, including two overweight women and five obese women). In particular, they requested more health education prior to conception, to be weighed more often during pregnancy, and more creative exercise opportunities and healthy eating instructions:

> They don't want to frighten you. They tried to be nice but it's so unhelpful…I think it might be good just to get weighed every now and again (In01, overweight)
>
> Maybe there needs to be more help from the hospital...like freebies and gyms, vouchers…they need to make some attractive activities rather than just educate people...(In11, obese)

7.4.3 Convergence assessment

The comparisons between the quantitative and qualitative data were reviewed together for overall assessment of the level of convergence (Table 5.4). In all themes of the HBM, the two sets of data in general agreed with each other. Silence codes were identified mainly from the themes of perceived susceptibility, severity, benefits, and self-efficacy, as meaning and prominence were shown in the quantitative data but specific examples were not complete in the qualitative data. No evidence of dissonance was observed.

Table 7.4 Convergence assessment

Themes	Convergence			
	Agree	Partial agree	Silence	Dissonance
Perceived susceptibility		✓		
Perceived severity		✓		
Perceived benefits		✓		
Perceived barriers	✓			
Cues to action	✓			
Self-efficacy		✓		

7.5 DISCUSSION

This study examined the views of overweight and obese women about making healthy diet and lifestyle changes during pregnancy. The mixed-method data approach indicated that excess gestational weight gain was a concern for only half of the women involved in the study. Although many women realised that being overweight or obese during pregnancy and excessive gestational weight gain were associated with adverse maternal health outcomes, knowledge of neonatal outcomes was less evident. Similarly, while agreeing that healthy eating and physical activity might improve maternal and neonatal health, the majority of women were unable to describe these benefits in detail, with fewer women identifying physical activity during pregnancy as beneficial for baby's health. A variety of barriers were identified to making behaviour changes, with many barriers being highly individualised. Concern about maternal and neonatal health was a much stronger motivator compared with the advice from health professionals. While many women planned to make healthy changes during pregnancy, approximately half were confident in their ability to do so.

New information was also identified, indicating that women thought healthy routines formed prior to pregnancy were important. Interestingly, although women believed they did not receive enough information from health professionals, only one quarter reported that they would respond to such advice. Indeed, this finding may underline the low levels of adherence to antenatal diet and exercise interventions that have been described in similar populations.

The results in this presented study are consistent with a previous systematic review of maternity experiences amongst obese pregnant women (86), which demonstrated acceptance and inevitability of weight gain in pregnancy, while reporting a variety of barriers to healthy behaviour change. This systematic review included six studies from the UK and Sweden which provided qualitative information. While many of these studies identified receiving less personalised care for women who were overweight or obese during pregnancy, this was not reported by women in this study. This may possibly reflect an increasing acceptance of obesity among health care professionals in Australia.

Two small studies were identified describing overweight and obese women's attitudes to diet, activity and weight gain during pregnancy (87). In one of these including 13 Hispanic women in the U.S. who were overweight or obese, women reported negative attitudes towards large gestational weight gain (87). In addition, women reported receiving inconsistent information from health professionals about optimal gestational weight gain, and relied heavily on advice from their families (87). This study did not aim for data saturation in the focus groups, and as the ethnicity of the interviewees was primarily Hispanic, the generalisability of findings is limited. However, this study has similarly identified the limited influence of health professionals in effecting behaviour change in women who are overweight or obese. In contrast, Mills and colleagues interviewed 14 pregnant women in Australia who were obese and reported that while most women recognised their weight to be an issue, they believed that health professionals should address their individual needs and expectations (89). It was also reflected in the interviews in the present study that women were willing to be weighed more during pregnancy. Currently there is no formal guideline in South Australia about antenatal weighing and recording of weight after the first antenatal visit.

To date, this study is the only mixed-method investigation of views about making healthy change in overweight and obese pregnant women. The adoption of a mixed-method design combines the strengths of both quantitative and qualitative research and the corroboration of findings from the two sets of data provide stronger evidence of the validity of the findings. Other strengths of this present study are the high response rates to the questionnaires and the comparability of participants to the general South Australia pregnancy population. A limitation is that this present study considered overweight and obese women together and aimed for data saturation across these two groups. At the same time however, the step wise logistic regression indicates that BMI did not correlate with the questionnaire responses. In addition, another limitation of this present study is that it did not provide separate analysis for 'being overweight or obese' and 'having excess gestational weight gain'. It is recognised that both issues (degree of overweight/obesity and gestational weight gain) are important and could have differential effects on women's responses.

The findings suggest that future work promoting healthy eating and active lifestyles for pregnant women who are overweight or obese should incorporate increased education about neonatal health consequences and maternal health benefits. It is also important to incorporate individualised strategies for enhancing self-efficacy. Finally, this presented study exposes many concepts requiring more in-depth investigation, including the role of health professionals in information provision and the potential for education prior to conception in overweight and obese women.

CHAPTER 8. CONCLUSIONS

8.1 PATTERNS OF PHYSICAL ACTIVITY

In pregnant women who are overweight or obese, physical activity declines from early pregnancy up until birth. At four months post-partum, although physical activity was found to have increased, it did not return to patterns reported in early pregnancy. While changes in physical activity were not identified to be related to maternal BMI or gestational weight gain, increasing maternal BMI was associated with a greater decline in activity over pregnancy and the post-partum period.

In pregnant women who are overweight or obese, physical activity declines from early pregnancy up until birth.

With regards to different categories of physical activity, work and commuting activities declined from early pregnancy to four months post-partum. Household activities declined from early pregnancy up until birth, then increased after birth, and remained significantly higher post-partum compared with early pregnancy. Leisure activity did not change across pregnancy and post-partum.

Across pregnancy and post-partum, work related and commuting activities declined, whereas household activities increased.

8.2 WALK RANDOMISED TRIAL

Provision of a simple low cost antenatal walking group intervention was not effective in limiting gestational weight gain or improving clinical maternal and neonatal health outcomes in pregnant women who were overweight or obese. Despite this, antenatal walking and exercise support was associated with women reporting higher levels of commuting and leisure activity in late pregnancy. While low adherence, as a common finding in intervention studies in overweight and obese individuals, limited the findings, it represents a realistic picture in that more individualised care and strategies should be considered for future research investigating promotion of active lifestyle during pregnancy.

A supervised antenatal walking intervention is effective in maintaining commuting and leisure activity in women who are overweight or obese, but was not effective in limiting gestational weight gain.

8.3 SYSTEMATIC REVIEW AND META-ANALYSIS OF EVIDENCE

Provision of antenatal exercise intervention is not effective in limiting gestational weight gain in women who are overweight or obese during pregnancy. There are few randomised controlled trials that have examined antenatal exercise/lifestyle interventions, and have included a variety of different physical activities and intensities. The available evidence is limited by small sample sizes and lack of consistent reporting of clinically relevant outcomes. The effect of a supervised antenatal exercise/lifestyle intervention on maternal and neonatal health outcomes is unclear.

Further randomised controlled trials are required to study the effect of antenatal exercise interventions on clinical maternal and neonatal outcomes.

8.4 WOMEN'S PERCEPTION OF MAKING HEALTHY CHANGE IN PREGNANCY

Approximately half of overweight or obese women assessed did not consider excessive gestational weight gain to be of concern during pregnancy. Although many women were aware that being overweight or obese during pregnancy and having excessive gestational weight gain were associated with adverse maternal health outcomes, knowledge of neonatal outcomes was less evident. A wide variety of barriers were identified by women to making healthy behaviour change during pregnancy, although the majority were unable to describe in detail the benefits of making healthy changes. The strongest motivator of making healthy change reported by women was their concern about maternal and neonatal health outcomes. While many women have plans to make healthy changes during pregnancy, only half of them were confident in their ability to do so. Having a healthy routine before conception, positive influences from their family, and health professionals who address their needs and expectations on an individualised base were reported by women to be effective strategies of making healthy behaviour changes during pregnancy.

Approximately half of overweight or obese women assessed did not consider excessive gestational weight gain to be concern during pregnancy.

Future work promoting healthy behaviour change during pregnancy in women who are overweight or obese should incorporate the involvement of family members and increased education about both neonatal health consequences and maternal health benefits.

8.5 OVERALL CONCLUSIONS

Being physically active is crucial for a healthy pregnancy, especially in overweight and obese women. This thesis discussed physical activity during pregnancy from a variety of perspectives and was able to cover a broad range of questions by using a variety of research methods. It provides a comprehensive explanation about the change of physical activity during pregnancy, whether extra antenatal physical activity is beneficial, and women's perception of making healthy change during pregnancy. A key strength of this thesis is the opportunity to address the issue with a large sample of women who were overweight or obese, a limitation of previous work.

The results of this thesis are limited as the observational work was conducted in the context of the LIMIT trial which involved strategies about healthy eating and active lifestyle promotion. It is acknowledged that making lifestyle changes during pregnancy could be physically and mentally challenging as shown by the low adherence to intervention studies.

Although previous studies and this thesis do not provide evidence for the precise amounts and types of physical activity that should be suggested to pregnant women who are overweight or obese, the high prevalence of overweight and obesity among women of childbearing age worldwide, and therefore the high risk of adverse maternal and neonatal health outcomes, calls for further research to evaluate individualised interventions.

Implications for clinical practice:

Health professionals should understand the highly individualised barriers toward making healthy change and being active during pregnancy. Women require information about safe exercise during pregnancy, in addition to the risk of adverse health outcomes associated with overweight or obesity during pregnancy. Wherever possible, health professionals should consider the involvement of a woman's family and friends in this process. Future interventions promoting healthy lifestyle during pregnancy for overweight and obese women should incorporate education about neonatal health consequences as well as the benefits of healthy behaviour change, in addition to incorporating strategies to enhance self-efficacy.

Implications for further research:

Further research is required to identify effective and individualised strategies to increase physical activity among women who are overweight or obese during pregnancy.

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APPENDIX I. SEARCH TERMS FOR META-ANALYSIS

Keywords and strategy:

1. “Exercise” / all subheadings
2. “lifestyle” / all subheadings
3. “Physical activity” / all subheadings
4. “Pregnancy” / all subheadings

5. “Perinatal” / all subheadings
6. “overweight” / all subheadings
7. “obesity” / all subheadings
8. #1 or #2 or #3
9. #4 or #5
10. #6 or #7
11. #8 and #9 and #10
12. “Controlled-clinical-trials” / all subheadings
13. “Randomised-Controlled-Trials” / all subheadings
14. #12 or #13
15. #11 and #14

APPENDIX II. THE SQUASH QUESTIONNAIRE

Think about an average week in the past months.
Please indicate how many days per week you performed the following activities,
how much time on average you were engaged in this, and how strenuous this activity was for you?

1. COMMUTING ACTIVITIES

* *How do you travel from home to WORK or your PLACE of STUDY?*
* *include travel to work and home again [ie, ROUND TRIP]*
* *include travel TO/FROM PUBLIC TRANSPORT*
* *If you walk your children to/from school, please include this in Question 2.*

	Days per WEEK	average time EACH DAY (please circle)	Effort (please circle one)
Walking to and from work or place of study	☐ days	☐ hours OR minutes	slow / moderate / fast
Bicycling to and from work or place of study	☐ days	☐ hours OR minutes	slow / moderate / fast
Not applicable	☐		

2. LEISURE TIME ACTIVITIES (NOT including work / home duties.)

* *Write down the average number of days in recent weeks and the average time per day - if you do something every two weeks, record it for the actual time, but as 1/2 day per week*
* *If you walk your children to/from school, please record it here.*

	Days per WEEK	average time EACH DAY (please circle)	Effort (please circle one)
Walking	☐ days	☐ hours OR minutes	slow / moderate / fast
Bicycling	☐ days	☐ hours OR minutes	slow / moderate / fast
Gardening	☐ days	☐ hours OR minutes	slow / moderate / fast
Odd jobs	☐ days	☐ hours OR minutes	slow / moderate / fast
Sport - please specify			
1.________________	☐ days	☐ hours OR minutes	slow / moderate / fast
2.________________	☐ days	☐ hours OR minutes	slow / moderate / fast
3.________________	☐ days	☐ hours OR minutes	slow / moderate / fast
4.________________	☐ days	☐ hours OR minutes	slow / moderate / fast

P.T.O.

3. HOUSEHOLD ACTIVITIES

** Record here everything you have done regularly AT HOME in the past few months.*

	Days per WEEK	average time EACH DAY (please circle)
Light household work (cooking, washing dishes, ironing, childcare)	☐ days	☐ hours OR minutes
Intense household work (scrubbing floor, walking with heavy shopping bags)	☐ days	☐ hours OR minutes

4. ACTIVITY AT WORK OR PLACE OF STUDY

** What was a typical day at your PLACE OF WORK or STUDY away from home in recent months?*
** If you do a variety of things at work, split up the days as appropriate:*
eg; you work 3 days/week for 7.5 hours spend 4 hours mostly at a desk, and the rest very active, then record this as Light work 3 days / 4 hours; Intense work 3 days / 3.5 hours
** If you go for a walk in your lunch break, record this in Question 2*

	Days per WEEK	average time EACH DAY (please circle)
Light work (sitting/standing with some walking, eg a desk job)	☐ days	☐ hours OR minute
Intense work (regularly lifting heavy objects at work)	☐ days	☐ hours OR minute
Not applicable	☐	

Thank You for Completing this Questionnaire

APPENDIX III. THE PERCEPTION OF MAKING HEALTHY CHANGE QUESTIONNAIRE

Name: ....

Address: ....

Study number: ....

Date you completed this questionnaire:............/.........../.............

1. **Below are some statements about possible risks associated with being overweight in pregnancy.** "How true are these statements for you?"	Not at all true for me	Not true for me	Undecided	True for me	Very true for me
Weight gain is not a concern in pregnancy, as all pregnant women gain weight	☐	☐	☐	☐	☐
A woman's weight and weight gain during pregnancy may affect the health of their baby	☐	☐	☐	☐	☐
A woman's weight and weight gain may lead to complications during pregnancy and childbirth	☐	☐	☐	☐	☐
A woman's weight and weight gain during pregnancy may affect their health after birth	☐	☐	☐	☐	☐

2. **Below are some statements about possible consequences of weight gain in pregnancy.** "How true are these statements for you?"	Not at all true for me	Not true for me	Undecided	True for me	Very true for me
Nothing will happen to either the woman or her baby	☐	☐	☐	☐	☐
The woman may develop some complications during pregnancy or birth	☐	☐	☐	☐	☐
The baby may develop some complications during pregnancy or after birth	☐	☐	☐	☐	☐
The woman may have difficulty losing weight after birth	☐	☐	☐	☐	☐
The baby may go on to develop weight problems as a child	☐	☐	☐	☐	☐

3. **Below are some statements about why some women choose to adopt a healthy diet during** "A reason to eat a healthy diet during pregnancy is because..."	Not at all true for me	Not true for me	Undecided	True for me	Very true for me
I believe that it is very important for many aspects of my life	☐	☐	☐	☐	☐
It is an important choice I really want to make	☐	☐	☐	☐	☐
I feel pressure from others to do so	☐	☐	☐	☐	☐
I want others to approve of me	☐	☐	☐	☐	☐
A healthy diet improves my health during pregnancy	☐	☐	☐	☐	☐
A healthy diet improves my baby's health	☐	☐	☐	☐	☐
Preparing healthy meals makes me feel good about myself	☐	☐	☐	☐	☐
Preparing healthy meals for my family makes me feel good about myself	☐	☐	☐	☐	☐
I enjoy preparing and eating healthy meals	☐	☐	☐	☐	☐
When I eat healthy food I feel better about myself	☐	☐	☐	☐	☐
When I eat healthy food I feel better about the way I look	☐	☐	☐	☐	☐
I enjoy preparing healthy food with my partner / family	☐	☐	☐	☐	☐

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	Not applicable	Not at all true for me	Not true for me	Undecided	True for me	Very true for me
I enjoy preparing healthy food with my children	☐	☐	☐	☐	☐	☐
When I eat a healthy diet I feel less tired and have more energy		☐	☐	☐	☐	☐
When I eat a healthy diet I experience less back ache / muscle cramps / constipation		☐	☐	☐	☐	☐
When I eat a healthy diet I can concentrate better on tasks		☐	☐	☐	☐	☐
I enjoy shopping to buy healthy food		☐	☐	☐	☐	☐

4. **Below are some statements about why some women choose to be physically active during pregnancy.**

"A reason to be physically active during pregnancy is because…"

	Not applicable	Not at all true for me	Not true for me	Undecided	True for me	Very true for me
I believe that it is very important for many aspects of my life		☐	☐	☐	☐	☐
It is an important choice I really want to make		☐	☐	☐	☐	☐
I feel pressure from others to do so		☐	☐	☐	☐	☐
I want others to approve of me		☐	☐	☐	☐	☐
Exercise improves my health during pregnancy		☐	☐	☐	☐	☐
Exercise improves my baby's health		☐	☐	☐	☐	☐
Exercising makes me feel good about myself		☐	☐	☐	☐	☐
Exercising with my family makes me feel good about myself		☐	☐	☐	☐	☐
I enjoy being physically active		☐	☐	☐	☐	☐
Nothing will happen to either the woman or her baby		☐	☐	☐	☐	☐
When I exercise I feel better about myself		☐	☐	☐	☐	☐
When I exercise I feel better about the way I look		☐	☐	☐	☐	☐
I enjoy exercising with my partner / family		☐	☐	☐	☐	☐
I enjoy exercising with my children	☐	☐	☐	☐	☐	☐
When I exercise I feel less tired and have more energy		☐	☐	☐	☐	☐
When I exercise I experience less back ache / muscle cramps / constipation		☐	☐	☐	☐	☐
When I exercise I can concentrate better on tasks		☐	☐	☐	☐	☐
It is refreshing to be outside to exercise		☐	☐	☐	☐	☐
When I exercise I meet other people in my community		☐	☐	☐	☐	☐
Exercise is time that I can put aside for myself		☐	☐	☐	☐	☐

5. **Below are some statements about why women may not eat a healthy diet during pregnancy.**	Not at all true for me	Not true for me	Undecided	True for me	Very true for me
I do not have time to prepare and eat healthy meals	☐	☐	☐	☐	☐
I am too busy doing other things for my children / family / partner to eat healthy	☐	☐	☐	☐	☐
There is no-one to help me prepare healthy meals	☐	☐	☐	☐	☐
Healthy food is too expensive	☐	☐	☐	☐	☐
I am too tired to prepare healthy meals	☐	☐	☐	☐	☐
I am too busy to prepare and eat healthy meals	☐	☐	☐	☐	☐
I do not like healthy food	☐	☐	☐	☐	☐
My children / partner / family do not like healthy food	☐	☐	☐	☐	☐
I do not know what healthy food to buy when I am shopping	☐	☐	☐	☐	☐

6. **Below are some statements about why women may not exercise during pregnancy.**	Not at all true for me	Not true for me	Undecided	True for me	Very true for me
I do not have time to exercise	☐	☐	☐	☐	☐
I am too busy doing other things for my children / family / partner to exercise	☐	☐	☐	☐	☐
There is no-one who I can exercise with	☐	☐	☐	☐	☐
There is nowhere safe nearby where I can exercise	☐	☐	☐	☐	☐
I have complications with my pregnancy that prevent me from exercising	☐	☐	☐	☐	☐
I am too tired to exercise	☐	☐	☐	☐	☐
I am too busy to exercise	☐	☐	☐	☐	☐
The weather prevents me from exercising	☐	☐	☐	☐	☐
I am too self conscious about my appearance to exercise	☐	☐	☐	☐	☐
I would like to exercise but it is too expensive (eg swimming, gym)	☐	☐	☐	☐	☐

7. **Below are some statements about things that may prompt a woman to make changes to her diet or lifestyle during pregnancy.**

"I would make changes to my diet and lifestyle if…"	Not at all true for me	Not true for me	Undecided	True for me	Very true for me
My doctor or midwife asks me to	☐	☐	☐	☐	☐
I were to develop complications during my pregnancy	☐	☐	☐	☐	☐
My baby were to develop complications during my pregnancy	☐	☐	☐	☐	☐
A healthy diet and exercise changes made me feel better	☐	☐	☐	☐	☐
A healthy diet and exercise changes were good for my baby	☐	☐	☐	☐	☐
My family or friends encouraged me to eat a healthy diet and exercise more	☐	☐	☐	☐	☐
I received more information about a healthy diet and exercise in pregnancy	☐	☐	☐	☐	☐
I knew someone else whose pregnancy was improved through a healthy diet and exercise	☐	☐	☐	☐	☐

8. **Below are some statements about how confident you feel you are in being able to make changes to your diet and physical activity.**	Not at all true for me	Not true for me	Undecided	True for me	Very true for me
I am able to be physically active every day for 30minutes, even on days when I am very busy, or when friends/family ask time of me	☐	☐	☐	☐	☐
Being physically active every day for 30 minutes, is completely under my control	☐	☐	☐	☐	☐
I am able to eat 5 serves of vegetables and 2 serves of fruit, even on days when I am very busy, or when friends/family ask time of me	☐	☐	☐	☐	☐
I am able to buy healthy food for my family	☐	☐	☐	☐	☐
I am able to prepare healthy food for my family	☐	☐	☐	☐	☐
I am capable of not eating fast food or take-away, even on days when I am very busy, or when friends/family ask time of me	☐	☐	☐	☐	☐
Eating healthy is completely under my control	☐	☐	☐	☐	☐
I plan to be physically active every day for 30 minutes	☐	☐	☐	☐	☐
I plan to eat a healthy diet, including 5 serves of vegetables and 2 serves of fruit	☐	☐	☐	☐	☐

How often have you gone on a diet (limited the amount you have eaten) in order to lose weight in the past year?

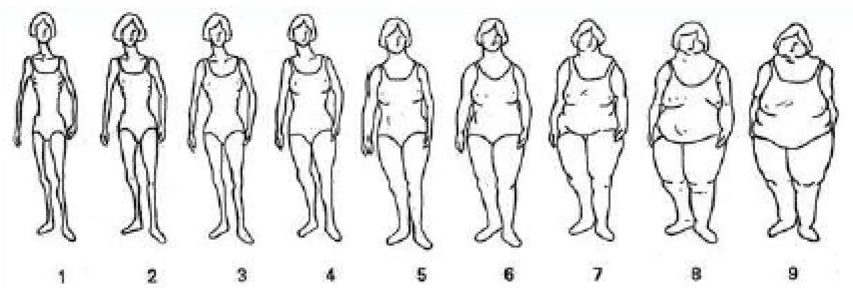
Never / 1-4times / 5-10 times / more than 10 times / constantly dieting

In the past month, how satisfied have you felt about (choose 1 only)

Your weight Markedly satisfied / Moderately satisfied / Slightly satisfied / Not at all satisfied

Your body shape Markedly satisfied / Moderately satisfied / Slightly satisfied / Not at all satisfied

Below are some figures depicting different body sizes. (Bulik et al 2001)



Please indicate the figure that you think most closely represents your body size (choose 1 only)

Figure number _______

Please indicate the figure that most closely represents your ideal body size (choose 1 only)

Figure number _______