

# Effects and experiences of exercise during pregnancy

Karolina Petrov Fieril

Department of Health and Rehabilitation  
Institute of Neuroscience and Physiology  
Sahlgrenska Academy at University of Gothenburg



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fieril@hotmail.com

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*What is life? It is the flash of the firefly in the night. It is the breath of a buffalo in the wintertime. It is the little shadow which runs across the grass and loses itself in the sunset.*

Crowfoot (Chief of the Canadian Blackfoot tribe)

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## ABSTRACT

**Background:** Recommendations regarding intensity, duration and type of exercise during pregnancy vary worldwide. Most research on exercise during pregnancy investigates the effects of aerobic exercise while only a few trials have studied the effects of resistance exercise. Obesity is a growing public health problem and little is known about obese pregnant women's experiences of participating in a lifestyle intervention focusing on diet and physical activity. Specifically, in four studies, this thesis aims to: 1) describe experiences of exercise during pregnancy among women engaged in regular resistance training; 2) evaluate the health effects, in healthy pregnant women, of moderate to vigorous-intensity resistance exercise with free weights; 3) investigate and compare blood pressure (BP), heart rate (HR), body temperature and ratings of perceived exertion (RPE) during and after two single sessions of light to moderate continuous exercise, Nordic walking and resistance exercise, in healthy women in the second trimester of pregnancy; and 4) describe the experiences of women with obesity related to participating in a lifestyle intervention, and its experienced impact on health and lifestyle.

**Methods:** A combination of quantitative and qualitative methods was used to elucidate different aspects of interest. Study I was assumed to complement studies II (a randomized controlled trial) and III (a cross over design) by adding a wider variety of viewpoints and experiences of resistance exercise as qualitative studies can. Study IV was considered to complement a range of quantitative studies evaluating the effects of lifestyles interventions in pregnancy.

**Results:** Exercise was perceived to have a positive impact on body and mind and was thus described as generating both immediate and short-term health benefits. The women experienced that exercise led to a sense of control in pregnancy; problems related to pregnancy such as weight gain, poor posture, nausea, fatigue, headache, insomnia and back pain were perceived to be resolved and/or addressed. Performing resistance exercises generated an experience that their body was capable of many types of exercises, and they also found it valuable for acquiring good posture. The women considered that resistance training was a suitable type of exercise during pregnancy (Study I).

The women's functional status deteriorated during the intervention in both the intervention and control groups and pain increased. There were only significant differences between the groups for birthweight. Newborns delivered by women who

underwent resistant exercise during pregnancy were significantly heavier than those born to control women; 3561 ( $\pm$ 452) g versus 3251 ( $\pm$ 437) g ( $p=0.02$ ), a difference that disappeared when adjustment was made for gestational age ( $p=0.059$ ). Both groups showed normal health related quality of life, blood pressure and perinatal data (Study II).

During exercise, there was a significant increase in systolic BP and HR ( $p<.001$ ). Diastolic BP increased, slightly more during aerobic exercise ( $p=.01$ ) than resistance exercise ( $p=.03$ ). Resistance exercise was perceived as more intense than aerobic exercise during 15 minutes ( $p=.02$ ) and 30 minutes ( $p=.001$ ) of exercise. After both types of exercise, BP quickly reverted to normal, although HR was still increased five minutes post-exercise ( $p=.001$ ). There was a moderate but non-significant correlation between HR and RPE during 15 minutes of aerobic exercise, ( $r_s=.43$ ;  $p=.06$ ), but the other correlations were weak ( $r_s<0.2$ ) and non-significant. Orally measured temperature decreased during aerobic exercise ( $p=.008$ ) (Study III).

The essence of the women's experiences of participating in a lifestyle intervention during pregnancy was their expressed need for support to implement new habits, provided by midwives, partners, relatives and friends—as well as by obese pregnant women in the same situation. The midwives' support was experienced as non-judgmental with a balanced outlook on weight. The essential structure of participation can be described with the following constituents: “pregnancy encourages change”; “non-judgmental support”; “from bad habits to conscious choices” and; “barriers to change” (Study IV).

**Conclusion:** Among healthy women who exercise regularly, from walks to moderate-to-strenuous exercise, regular moderate intensity resistance exercise appears to be appropriate during the second trimester of pregnancy. Pregnant women who perform this type of exercise considered it as suitable. Aerobic and resistance exercise corresponding to 13–14 on the Borg RPE-scale seems to be safe with regard to blood pressure and heart rate responses in second trimester healthy pregnancies. In order to implement new habits, participants of a lifestyle intervention express a need for support, given with a non-judgmental attitude and a balanced outlook on weight. For controlling gestational weight gain, lifestyle interventions focusing on healthy eating patterns are probably of major importance.

**Keywords:** pregnancy, resistance exercise, aerobic exercise, physical activity, obesity, blood pressure, heart rate, qualitative content analysis, phenomenology, women's health

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# SAMMANFATTNING PÅ SVENSKA

Träningsrekommendationerna för gravida kvinnor skiljer sig åt i världen beträffande intensitet, duration och träningsform. De flesta studier har undersökt effekten av konditionsträning. Endast ett fåtal studier har undersökt styrketräningens effekt på den gravida kvinnan. Muskulär uthållighetsträning är en form av styrketräning som innebär många repetitioner med lägre motstånd. Fetma är ett växande problem i världen och lite kunskap finns om hur gravida kvinnor med fetma upplever ett deltagande i en livsstilsintervention.

Syftet med denna avhandling var att i fyra studier undersöka 1) upplevelsen av att träna under graviditeten hos kvinnor som tränade regelbunden muskulär uthållighetsträning; 2) att utvärdera hälsoeffekter av att träna regelbunden medelhård till hård muskulär uthållighetsträning hos friska gravida kvinnor; 3) att undersöka och jämföra blodtryck, hjärtfrekvens, kroppstemperatur och upplevd ansträngningsgrad under och efter ett styrketräningsspass och ett konditionsspass (stavgång) på friska gravida kvinnor; samt 4) beskriva gravida kvinnor med fetma upplevelse av att delta i en livsstilsintervention med kost och fysisk aktivitet.

I avhandlingen har olika metodologiska ansatser använts. En kombination av kvalitativa och kvantitativa metoder har belyst olika aspekter av träning under graviditeten. Studie I kompletterade Studie II (en randomiserad kontrollerad studie) och Studie III (cross over design) då den kvalitativa ansatsen ansågs kunna ge en mer beskrivande bild av hur styrketräningen upplevdes från ett ”inifrånperspektiv”. Studie IV ansågs komplettera de kvantitativa studier som finns och som utvärderar effekten av livsstilsinterventioner under graviditeten.

Resultaten från studierna i denna avhandling kan sammanfattas enligt följande: träning under graviditet upplevdes påverka både fysiskt och psykiskt välbefinnande. Kvinnorna upplevde att träningen ledde till en känsla av att hantera graviditeten lättare och graviditetsrelaterade komplikationer såsom viktuppgång, dålig hållning, trötthet, smärta och sömnproblem upplevdes minska. Styrketräningen upplevdes av dessa kvinnor som en lämplig träningsform att utöva under graviditeten (Studie I).

I den randomiserade kontrollerade studien förelåg inga skillnader mellan interventionsgruppen och kontrollgruppen avseende flertalet av de undersökta parametrarna. Funktionen försämrades under interventionen hos både

interventionsgrupp och kontrollgrupp, även smärta ökade i båda grupperna. Signifikanta skillnader mellan grupperna uppmättes endast avseende födelsevikt, där nyfödda till kvinnor som hade styrketränat var signifikant tyngre än de som var födda av kvinnor i kontrollgruppen ( $p=0,02$ ). Denna skillnad försvann dock då justering för gestationsålder gjordes ( $p=0,059$ ). Båda grupperna uppvisade normal livskvalitet, blodtryck och förlossningsutfall (Studie II).

Studie III visade att under ett styrke- eller konditionsträningspass ökar det systoliska blodtrycket och hjärtfrekvensen ( $p<,001$ ). Det diastoliska blodtrycket ökar också, något mer under konditionsträning ( $p=,01$ ) i jämförelse med styrketräning ( $p=,03$ ). Styrketräningen upplevdes mer intensiv än konditionsträningen. Efter båda träningsformerna återgick blodtrycket snabbt till utgångsvärdet, medan hjärtfrekvensen var fortsatt förhöjt fem minuter efter träningspasset ( $p=,001$ ). Det var en icke signifikant korrelation mellan hjärtfrekvens och upplevd ansträngning vid 15 minuters konditionsträning ( $r_s=,43$ ;  $p=,06$ ), medan de andra korrelationerna var svaga och icke-signifikanta ( $r_s<0,2$ ) (Studie III).

Gravida kvinnor med fetma uttryckte ett behov av stöd för att implementera nya kost- och motionsvanor. Stödet kom från barnmorska, partner, släktingar och vänner eller från andra gravida kvinnor som var i samma situation. Barnmorskornas icke-dömande stöd liksom att barnmorskan hade ett lagom fokus på kvinnans vikt var av avgörande betydelse för att fullfölja interventionen (Studie IV).

Slutsatserna i denna avhandling är att hos friska gravida kvinnor tycks regelbunden muskulär uthållighetsträning vara en lämplig träningsform under graviditetens andra trimester. Konditions- och styrketräning ger normala blodtryck- och hjärtfrekvenssvar vid träning på en ansträngningsnivå motsvarande ”något ansträngande” eller 13–14 på Borgs upplevda ansträngningsskala.

För att implementera nya kost- och motionsvanor under graviditeten, behöver gravida kvinnor med fetma ett icke-dömande stöd med ett balanserat fokus på vikten. Livsstilsinterventioner som fokusera på hälsosamma kostmönster har troligtvis störst betydelse på viktuppgång under graviditeten.

# LIST OF PAPERS

This thesis is based on the following studies, referred to in the text by their Roman numerals. The papers are reprinted with permission from the publishers.

- I. Petrov Fieril Karolina, Larsson Maria EH, Glantz Anna, Fagevik Olsén Monika. Experiences of regular resistance training during pregnancy: a qualitative study. *Phys Ther.* 2014 Aug; 94(8):1135–43.
- II. Petrov Fieril Karolina, Glantz Anna, Fagevik Olsén Monika. The efficacy of moderate-to-vigorous resistance exercise during pregnancy: a randomized controlled trial. *Acta Obstet Gyecol Scand.* 2015 Jan; 94(1):35–42.
- III. Petrov Fieril Karolina, Glantz Anna, Fagevik Olsén Monika. Exercise in pregnancy: hemodynamic responses during a single session of aerobic exercise and resistance exercise. In manuscript.
- IV. Petrov Fieril Karolina, Fagevik Olsén Monika, Glantz Anna, Premberg Åsa. Experiences of a lifestyle intervention in obese pregnant women—a qualitative study. In manuscript.

Studies III and IV, may not be the final versions before publication.

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# ABBREVIATIONS

BMI	Body mass index
BP	Blood pressure
bpm	Beats per minute
DRI	Disability Rating Index
GDM	Gestational diabetes mellitus
GWG	Gestational weight gain
HR	Heart rate
HRQoL	Health Related Quality of Life
IPAQ	International Physical Activity Questionnaire
kg	Kilogram
PGP	Pregnancy-related pelvic girdle pain
PLBP	Pregnancy-related low back pain
RM	Repetition maximum
RPE	Rating of Perceived Exertion
RCT	Randomized controlled trial

## DEFINITIONS IN SHORT

Exercise	A planned, structured, and repetitive subset of physical activity that improves or maintains physical fitness, overall health or well-being as an intended intermediate or final objective (Caspersen, 1985).
Obesity	A BMI of $\geq 30$ kg/m <sup>2</sup> (WHO, 2012).
Physical activity	Any bodily movement produced by skeletal muscles that requires energy expenditure (Caspersen, 1985).
Resistance exercise	Exercises to increase muscle strength and endurance. It consists of repetitive exercises with weights, weight machines, or resistance bands (American College of Sports, 2009).

## INTRODUCTION

Physical activity and exercise are important components of a healthy lifestyle. According to the World Confederation for Physical Therapy (1) physiotherapy provides services that enable people to develop, maintain and restore maximum movement and functional ability through life. Adjusted physical activity and exercise constitute the core in physical therapy and are implemented in many patient categories. Pregnancy is a normal process although it entails considerable changes and may restrict the capacity to be physically active. Nevertheless, women also wish to be physically active during pregnancy (2).

Historically, in the Western world, exercise and sport have been considered inappropriate for women during pregnancy. Recommendations have largely reflected the social and cultural norms of the times, rather than scientific evaluations (3) and medical, moral and esthetic arguments have been raised against sport for females in general (4). In the early 20<sup>th</sup> century, it was believed that sports activities would damage the uterus and breasts and endanger the ability to bear children. Vigorous exercise was considered to lead to infertility, disease and weakness, although gentle, moderate physical exercise during certain times in a woman's life could be valuable (5). It was considered unhealthy for women to overstrain their bodies and if they participated in a sports activity at all, they should behave in "a ladylike manner". Women were not allowed to participate in some sports that were considered too demanding or rough (5).

During the 1950s and 1960s in Sweden, simultaneously with increasing demands for women's rights, sports organizations and the government contributed to the spread of sports participation, not only amongst young men but in wider society, including women (5).

Accordingly, recommendations for exercise during pregnancy have changed over the years and also vary between countries (6). During the last decades, physical exercise recommendations during pregnancy have become more proactive and current guidelines in nine countries in the Western world are essentially based on evidence or expert consensus (6).

Most research investigates the effects of aerobic exercise (6-9). Only a few trials have studied the effect of resistance exercise on maternal (10-13) and fetal outcomes (14-16).

The research underlying this thesis was conducted in order to understand more about exercise in pregnancy, especially resistance exercise, and to gain knowledge concerning experiences of gestational weight gain (GWG) control in women with obesity.

## Exercise in pregnancy

### Recommendations

Exercise is commonly defined as a planned, structured, and repetitive subset of physical activity that improves or maintains physical fitness, overall health or well-being as an intended intermediate or final objective (17).

As mentioned above, recommendations concerning exercise during pregnancy in national guidelines vary, a variation that highlights the need for an updated international guideline (6).

Aerobic activities are generally regarded as acceptable in national guidelines, and thus recommended during pregnancy, while strength training is recommended in half of the national guidelines (6).

When it comes to exercise intensity, the recommendations are diverse. Different guidelines and studies recommend a heart rate (HR) of 125–155 beats per minute (bpm), depending on age (18) (Table 1) or an upper range of 60–90% of the maximal HR (6).

*Table 1. Recommended heart rate during exercise (Exercise in pregnancy and the postpartum period, 2003).*

Age (years)	Heart rate (beats per minute)
< 20	140–155
20–29	135–150
30–39	130–145
> 40	125–140

Furthermore, a level corresponding to 12–14 on the Borg Ratings of Perceived Exertion (RPE) Scale level 6–20 (19) (Table 2), just below or above “somewhat hard”, is recommended in the British, Norwegian, and Canadian national guidelines (6). However, “fairly light” intensity, level 11, is recommended for continuous exercise in the Japanese national guideline (6). It is unclear how RPE and HR correspond during exercise in pregnancy.

*Table 2. The Borg Rating of Perceived Exertion Scale (Borg, 1970). In some guidelines, pregnant women are recommended a level corresponding to 11–14.*

6	No exertion at all
7	Extremely light
8	
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard (heavy)
16	
19	Extremely hard
20	Maximal exertion

Strenuous exercise is recommended in the Danish and one of the American guidelines, for women who have engaged in it already or prior to pregnancy while the Spanish national guideline recommends no more than 15 minutes of vigorous exercise (6). Recommendations concerning exercise frequency and duration are also diverse in the national guidelines, ranging from 15–30 minutes two–three times per week up to 60 minutes or more two–three times per week. Avoiding sedentary behavior is generally recommended (6).

A majority of guidelines warn against exercise in the supine position, due to the risk of decreased cardiac output and orthostatic hypotension, since the enlarged uterus can obstruct venous return from the vena cava. Notably, most guidelines also suggest that pregnant women should contact their health care providers before starting or continuing an exercise program (6). Some guidelines also advise against motionless standing during exercise, due to its

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association with decreased cardiac output. Several guidelines warn against exercising in humid or hot weather, and two out of the eleven reviewed national guidelines caution against excessive body heat during exercise (6). Avoiding heavy lifting particularly maximal isometric muscle contractions, is recommended due to the cardiovascular responses and added pressure on the musculoskeletal system (8).

In summary, there is consensus that exercise during pregnancy is beneficial, but national guidelines vary with regard to intensity, duration and type.

## **Exercise patterns and experiences of exercise**

Most women in the Western world do not follow current recommendations (20) and decrease their exercise level instead during pregnancy (21, 22). Research shows that only one-fourth to one-sixth of pregnant women follow the national exercise recommendations (21). Primiparity, higher education, older age, body mass index (BMI) <30 and non-smoking are strong predictors of regular exercise (21, 22, 24). The proportion of competitive and moderate to heavy exercise decreases over the trimesters (25) and pre-pregnancy exercise is the strongest predictor of regular exercise at late gestational ages (25, 26). Bicycling, swimming and low-impact activities, including walking, are the most common types of exercise during pregnancy (24).

One systematic review concluded that there is a lack of knowledge about the efficacy of interventions to promote exercise during pregnancy (20). One strategy might be increased information on exercise guidelines; Davari Tanha et al. (27) recently showed that when pregnant women studied a national exercise guideline, they significantly increased their exercise rate ( $p=0.001$ ) and decreased their anxiety ( $p=0.001$ ) concerning exercise.

Anxiety and lack of knowledge are strong barriers to exercise in pregnancy (28, 29), as are pregnancy-related discomfort and complications (28-31) and lack of social support (28-30, 32).

Contrary to what might be expected, only a few studies have examined experiences of exercise and physical activity during pregnancy. A Danish qualitative study found that women experienced feelings of happiness and physical wellbeing during exercise, as well as perceiving a balance between worry and a sense of security (31).

## **A brief overview of physiological changes in pregnancy**

To be able to put exercise during pregnancy in context, it is important to have knowledge about the normal physiological changes that occur in pregnancy as: hormonal changes, increase of total blood volume and cardiac output with a significant redistribution of blood-flow to the uterus, fetal growth, increased body weight and adaptive changes in posture (33).

Progesterone reduces smooth muscle tone, e.g. urethral tone (which may result in stress incontinence), reduced peristaltic activity (food may remain longer in the stomach), increased water absorption in the colon (leading to constipation tendency) and reduced vascular wall smooth muscle tone (leading to blood vessel dilatation and mild hypotension). Relaxing gradually breaks down collagen and replaces it with a modified form with higher water content in pelvic joints, cervix and joint capsules, generating greater pliability and extensibility. Relaxing also affects relaxation of the pelvic floor muscles (33). Overall, hormonal changes increase joint laxity and can lead to increased risk of injury (6) and pain (34).

Blood volume increases by 40% or more in order to handle the increasing requirements of the uterus/placenta and the increased body weight. Plasma volume increases more than red cell volume and the hemoglobin level consequently falls to about 80%, one cause of tiredness in pregnancy. The heart increases in size, causing stroke volume to rise, and cardiac output increases by 30–50% (33). Additionally, there is a progressive minor increase in resting HR and a reduction in maximal HR throughout pregnancy (35).

The fetal growth results in consequent enlargement and displacement of the uterus. As pregnancy progress the uterus dramatically increases in size. The changing center of gravity is due to the distending abdomen and lumbar and thoracic curves are increased in most women. Muscle fibers permit stretching and collagen structures (e.g. linea alba and the aponeurosis) also seem to undergo hormonally mediated changes (33).

During pregnancy, a normal weight gain of 11–15 kg is expected, but will vary according to pre-pregnancy weight, height and BMI (33). If a woman's BMI is high, she will be encouraged to aim for a lower gain, since high GWG is a poor indicator of fetal well-being (33). The recommendations for GWG aim to optimize maternal and fetal outcomes and should be considered models rather than specific individual requirements. For women of normal BMI, a GWG of 11–16 kg is recommended (36).

## **Potential benefits of exercise...**

Maintaining a physically active lifestyle is associated with many benefits, including lower risk of cardiovascular disease, diabetes, hypertension, some type of cancer and depression (37). However, only a few reviews investigating these effects during pregnancy have been published.

Pregnancy-related low back pain (PLBP) and pregnancy-related pelvic girdle pain (PGP) are common. In a Cochrane report 26 RCTs evaluating interventions for preventing and treating PGP and back pain in pregnancy were reviewed. The authors concluded that more than two-thirds of pregnant women reported back pain and almost one-fifth had PGP (34). Another review of PGP and PLBP concluded that physical fitness exercises before pregnancy reduce the risk of developing PLBP and that exercise during pregnancy is beneficial for PLBP. However, the role of exercise in alleviating PGP is unclear (38).

The prevalence of prenatal depression is 10–13% of pregnancies (39). There is some evidence that exercise may be effective in treating, and perhaps also preventing, depressive symptoms during pregnancy (40, 41).

Pregnancy-induced hypertension is a potentially serious complication for both mother and fetus. Hypertensive disorders affect up to 8% of all gestations and remain a major cause of maternal and neonatal mortality and morbidity worldwide (42). The effect of exercise on hypertensive disorders during pregnancy is unclear (43).

Gestational diabetes mellitus (GDM) affects around 5% of pregnant women. As pregnancy progresses, the demand for insulin production increases. For some women, this increased insulin demand is not met, leading to poor glycemic control and GDM. After delivery, most of these women revert to normal glucose metabolism, although they are at increased risk of developing type 2 diabetes, as are their offspring (44). In a recent review, Russo et al. (45) concluded that physical activity in pregnancy provides a slight protective effect against the development of GDM.

In another recent review (46), including 14 RCTs, the effects of exercise interventions on neonatal outcomes were analyzed. Exercise was associated with a significant but small reduction in birth weight ( $p=0.04$ ) and increased Apgar scores at 1 minute ( $p=0.048$ ). There were no significant differences in Apgar score at 5 minutes or gestational age at birth. When it comes to mode of delivery, one meta-analysis on the effects of exercise during pregnancy on mode of delivery concluded that regular exercise during pregnancy

moderately increases the chance of normal delivery in healthy pregnancy (47) and reduces the risk of caesarean delivery (48).

### **...and potential risks**

There seem to be no reviews looking at risks related to exercise in pregnancy. However, there is one cohort study, with both prospective and retrospective variables, that found a stepwise increased relationship between exercise and miscarriage; the risk of miscarriage increased with the amount of exercise. Vigorous-intensity exercise also increased this risk. No association was, however, found between exercise and miscarriage after 18 weeks of gestation (49).

### **Hemodynamic changes during and after exercise**

Although some studies have been carried out, maternal blood pressure (BP) and HR responses to a single session of submaximal exercise have not been sufficiently studied, especially when it comes to resistance exercise (13). Three studies have been found in which this have been studied. Bgeginski et al. (13) recently concluded that BP response to resistance exercise is unaffected by pregnancy and showed that BP remained within safe limits during exercise. Amorim et al. (50) concluded that maternal BP levels were slightly increased during aerobic exercise, followed by a substantial hypotensive effect hours after the exercise session. Finkelstein et al. (51) showed that there was no difference in cardiovascular response between pregnant and non-pregnant women during land or water exercise, although BP response was lower when exercising in water. More studies are therefore needed to elucidate the relation between BP and exercise in pregnant women.

When it comes to fetal responses during and after maternal resistance exercise, Bgeginski et al. recently demonstrated normal fetal HR (14), while a review concluded that the normal response to sustained submaximal exercise is an increase in fetal baseline HR (35). Responses to prolonged (>30 min) submaximal exercise at late gestational ages include a moderate reduction in maternal blood glucose concentration, which may transiently reduce glucose availability for the fetus (35).

### **Resistance exercise in general and during pregnancy**

As late as in 1990, the American College of Sports Medicine for the first time recommended resistance exercise as part of the recommended guidelines for

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exercise and rehabilitation in healthy adults (52). Resistance exercise, consisting of repetitive exercises with weights, weight machines or resistance bands, acts to increase muscle strength and endurance (53, 54). The body itself can also serve as a resistance e.g. in push-ups. Resistance exercise leads to increased strength and insulin sensitivity, increased submaximal and maximal endurance, increased basal metabolism, lean body mass and bone mineral density and decreased resting diastolic BP in healthy adults (55). Resting HR and systolic BP remain unaffected (55). Table 3 shows different types of resistance exercise (56).

*Table 3. Overview of types of resistance exercise (Resistance Training for Health and Fitness, American College of Sports Medicine, 2013). RM= Repetition Maximum*

	Muscular strength	Muscular power	Muscular hypertrophy	Muscular endurance
Load (% of 1 RM)	60–100	0–60	70–100	< 70
Repetitions per set	1–12	3–6	1–12	10–25
Sets per session	1–6	1–3	1–6	2–4
Rest between sets (minutes)	1–3	1–3	1–3	30 seconds–1 minute

## Effects of resistance exercise in pregnancy

Despite the fact that approximately 5–10% of women engage in resistance exercise during pregnancy (57), it has been the object of limited research (6, 8). Table 4 shows an overview of resistance exercise interventions during pregnancy, of which only a few are randomized controlled trials (RCT). These studies examined the efficacy and safety of resistance exercise during pregnancy (15, 16) and its effects on glycemic control in women with GDM (10). The results indicate that resistance exercise is effective in improving glycemic control in this group (10). No adverse impact on the newborn infant was found (16).

Recently, in a retrospective survey, White et al. (57) found that rates of hypertensive disorders and GDM were lower if women did resistance and aerobic exercise during pregnancy, in comparison with aerobic exercise or no exercise. They concluded that aerobic exercise and resistance training for muscular endurance for 30 minutes three days per week throughout gestation is safe.

Since there are potential health-related benefits of resistance exercise during pregnancy, more studies are needed to clarify safety levels in terms of volume and intensity (6).

Table 4. Overview of resistance exercise RCTs in pregnancy.

<b>Author</b> (reference no)	<b>Intervention</b>	<b>Results</b>
Brankston GN et al. (12)	32 pregnant women with GDM. Diet group, n=16. Diet plus resistance exercise, n=16.	Overweight women had a lower incidence of insulin use in the diet plus resistance exercise group.
Barakat R et al. (15)	160 sedentary pregnant women. Light resistance and toning exercises, n= 80. Control group, n =80.	No differences in maternal or newborn characteristics.
Barakat R et al. (16)	160 sedentary pregnant women. Light resistance, n= 80. Control group, n =80.	The percentage of women who had normal, instrumental or cesarean delivery was similar. The mean dilation, expulsion and childbirth time did not differ between groups.
De Barros MC et al. (10)	64 patients with GDM. Resistance exercise, n=32. Control group, n=32.	A reduction in the number of patients who required insulin.
O'Connor PJ et al. (11)	32 pregnant women at increased risk of back pain. Resistance exercise for 12 weeks.	Increased in external load in leg press, leg curl, lat pull down, lumbar extension and leg extension.

## Obesity in pregnancy

Overweight and obesity are growing public health problems and globally represent leading risks for death (58). Today, more than 10% of the world's adult population is obese (58). It is well known that maternal obesity is associated with adverse maternal and neonatal outcomes, including GDM, hypertension, preeclampsia, cesarean delivery, large for gestational age and postpartum weight retention (59-64), and that these risks increase with the

degree of obesity (62). For example, overweight and obese women have a 17% risk of GDM, compared to 1–3% among normal-weight women (62).

Obese women are recommended a GWG of 5–9 kg (36). However, Campbell et al (65) report that 20–40% of obese pregnant women exceed this recommendation. Excessive GWG predicts long-term obesity in both the mother (66) and the child (60, 67). Currently, there is limited evidence to suggest that exercise alone can be used to limit maternal GWG (68).

## **Interventions and experiences of a lifestyle program**

Many weight management strategies have been developed especially for pregnant women. Most of these interventions focus on dietary changes, sometimes combined with increasing physical activity (65). In a review, Campbell et al (65) conclude that there is a lack of sufficient evidence to indicate which interventions are effective in reducing GWG, although Thangaratinam et al (69) conclude that weight control interventions do reduce GWG and that dietary interventions are most effective. Despite the growing attention to GWG control, there are few studies investigating women's perspectives on such interventions during pregnancy. In previous studies, obese pregnant women participating in a lifestyle intervention programs have reported that the most positive experiences were the availability of social support, regular weight monitoring, motivational interviews conducted by midwives, group discussions and the advice-based approach (70, 71).

## **Summary**

In summary, there is a variation in exercise recommendations during pregnancy worldwide, and the guidelines vary with regard to intensity, duration and type of exercise. Most research on exercise during pregnancy investigates the effects of aerobic exercise. Only a few trials have studied the effects, immediate and longer-term, of resistance exercise on maternal and fetal outcomes. Obesity is a growing public health problem and little is known about obese pregnant women's experiences of participating in a lifestyle intervention focusing on diet and physical activity.

## AIM

The aims of this thesis were to examine the effect and experiences of exercise, especially resistance exercise, during pregnancy, as well as to investigate the experiences of women with obesity, related to participating in a lifestyle intervention in pregnancy, with a focus on healthy exercise and diet.

The thesis comprises four papers reporting on studies with the following specific aims:

- Study I: to describe experiences of exercise during pregnancy among women who engaged in regular resistance training
- Study II: to evaluate the health effect, in healthy pregnant women, of moderate-to vigorous-intensity resistance exercise with free weights, with regard to quality of life, pain location, physical strength, GWG, BP, functional status, activity level and childbirth outcomes
- Study III: 1) to investigate and compare BP, HR, body temperature and RPE during and after two single sessions of light to moderate continuous exercise (Nordic walking and resistance exercise respectively) in healthy pregnant women at gestational week 21
- 2) to examine whether RPE correlates to HR during light-to moderate-intensity exercise
- Study IV: to describe the experiences of women with obesity related to participating in a lifestyle intervention, and its experienced impact on health and lifestyle

## MATERIALS AND METHODS

### Design

The research questions and aims of the four studies included in this thesis required multiple methodological approaches. A combination of quantitative and qualitative methods was used to elucidate different aspects of interest. Study I was assumed to complement Studies II and III by adding the wider variety of viewpoints and experiences of resistance exercise as quantitative studies can. Study IV was considered to complement a range of quantitative studies evaluating the effects of lifestyle interventions in pregnancy. Table 5 shows an overview of the research designs.

*Table 5. Research design, overview.*

<b>Study</b>	<b>I</b>	<b>II</b>	<b>III</b>	<b>IV</b>
<b>Design</b>	Explorative descriptive	Randomized controlled trial	Cross-over	Explorative, descriptive
<b>Setting</b>	Two prenatal clinics in Gothenburg Sweden	Two prenatal clinics in Gothenburg Sweden	Four prenatal clinics in Gothenburg, Sweden	Two prenatal clinics in Gothenburg, Sweden
<b>Partici-pants</b>	Seventeen healthy pregnant women doing resistance exercise on a regular basis	92 healthy pregnant women	20 healthy pregnant women	Eleven women who participated in a lifestyle intervention project targeting pregnant women with BMI $\geq 30$
<b>Data collec-tion</b>	Semi-structured individual	Questionnaire, test, medical record	Test	Semi-structured individual

	interviews			interviews
<b>Analysis</b>	Qualitative content analysis	Descriptive statistics, non-parametric & parametric statistics (Student's t-test, Mann-Whitney U-test)	Descriptive statistics, nonparametric & parametric statistics (paired t test, Wilcoxon signed rank test, Spearman's correlation)	Phenomenological lifeworld approach

### Setting

The setting for this thesis was the Primary Care District of Gothenburg, with 530,000 inhabitants (the second largest city in Sweden). To be eligible for the studies, participants had to be aged over 18 and be registered at a prenatal clinic in Gothenburg. Ninety-nine percent of Swedish women attend combined midwifery and obstetric care offered by the public health care system (72). Studies I and II included two prenatal clinics in the center of Gothenburg. Study III included four prenatal clinics in the center of Gothenburg. To be eligible for Study IV the potential participants had to be participating in a lifestyle intervention and registered at one (out of two) specified prenatal clinics in Gothenburg.

### Participants

Study I included 17 pregnant women, 12 of whom were recruited from Study II (see flow chart Figure 1). Another five women who also engaged in regular resistance exercise at fitness centers on their own participated. The inclusion criteria were: ongoing regular, highly repetitive resistance exercise; ability to speak Swedish and healthy pregnancy.

For Study II, 92 pregnant women were recruited, see flow chart Figure 1. The inclusion criteria were: < 14 gestational weeks and healthy singleton pregnancy.

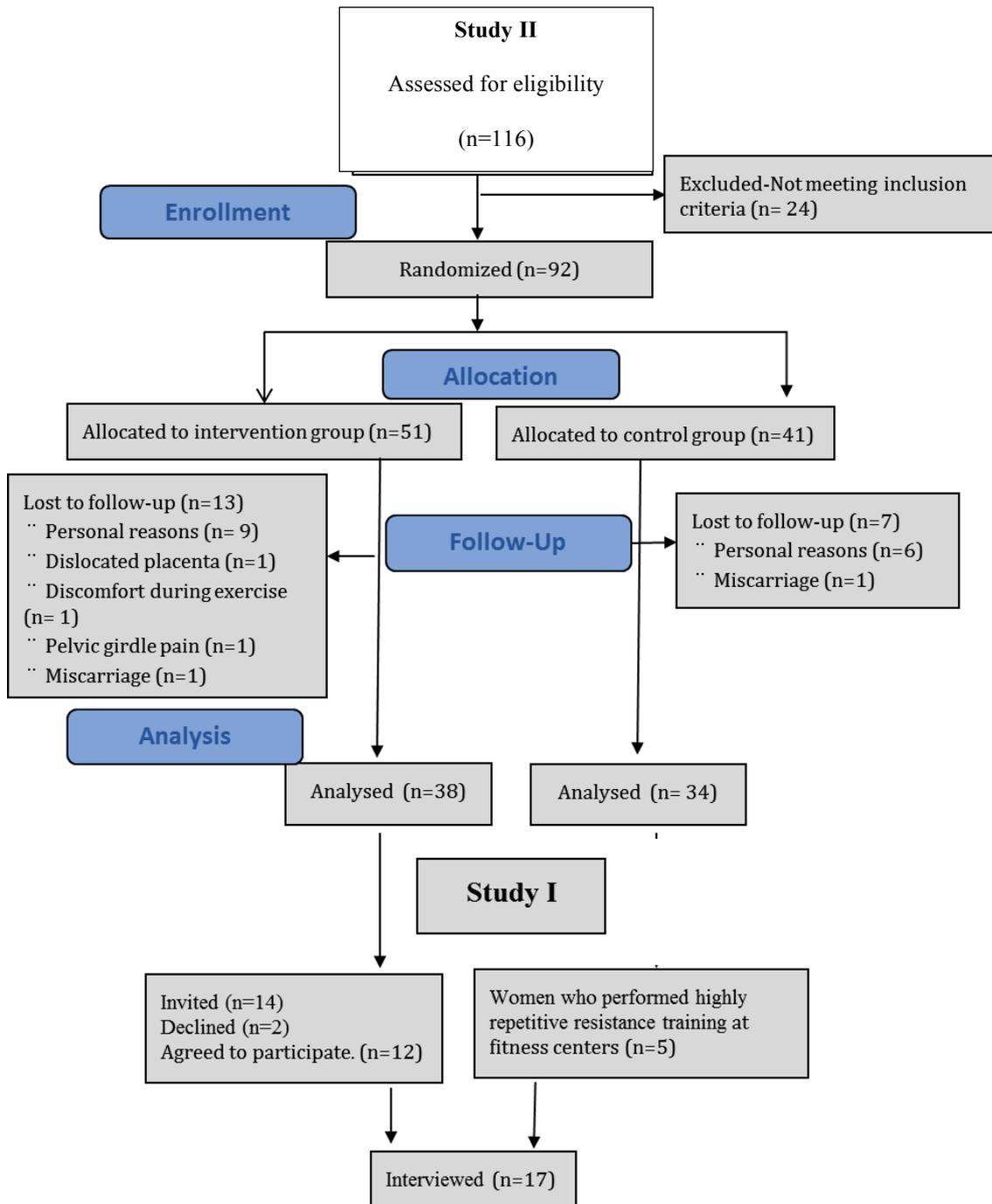


Figure 1. Flow chart summarizing Studies I-II.

Effects and experiences of exercise during pregnancy

Table 6 shows demographic data and the exercise level of the participants in Study I.

*Table 6. Demographic data and exercise level in 17 pregnant women who engaged in regular resistance training during pregnancy*

<b>Socio-demographic factors</b>	<b>N</b>
<b>Age (yr)</b>	
25-29	4
30-34	7
35+	6
<b>Parity</b>	
Primipara	9
Parous	8
<b>Education</b>	
Higher education	2
Collage graduate with diploma	15
<b>Gestational week at interview</b>	
15-19	2
20-24	3
25-29	10
30-35	2
<b>Primary exercise prior to pregnancy</b>	
Resistance training	5
Running	5
Walks	5
Bicycling	2
<b>Exercise during pregnancy versus pre-pregnancy</b>	
Increased	5
Maintained	5
Reduced	7
<b>Further exercise during pregnancy, in addition to regular resistance training</b>	
Walks	4
Bicycling	2
Swimming	1
Yoga	2
Running	2

In Study II, mean maternal age was 30.8 years in the intervention group and 30.6 years in the controls, they were highly educated (15.4 and 16.3 years at school respectively), with a normal mean pre-pregnancy BMI (22.6 and 23.0 respectively). Most of the participants were married/cohabiting and primiparae. The participants were physically active with walks and/or moderate/vigorous activity.

Study III included 20 healthy pregnant women at pregnancy week 21 with self-perceived good health. Mean maternal age was 32.9 years, pre-pregnancy BMI was 20.0, all of the participants were employed and 70 % were primiparae. The participants were physically active with walks and/or moderate/vigorous activity.

Study IV included eleven pregnant women with obesity. They had participated in the lifestyle intervention “Mighty Mums” (73), were Swedish-speaking and still pregnant (week 36–39). The lifestyle intervention included *i*) systematized, individualized counselling and motivational sessions with a midwife, who emphasized diet, physical activity and weight monitoring; *ii*) the option of individual or group discussions with a dietician; *iii*) aquanatal classes with a midwife and physiotherapist; *iv*) guidance concerning suitable and locally available physical exercise activities; and, *v*) pedometers and walking poles for Nordic walking. Midwives were offered general education about obesity during pregnancy and specific education about healthy physical activity and diet. The age of the participants ranged from 25–38 years, they were both primiparae and parous, their ethnicity were Swedish or from an African country, the education level ranged from nine years of Primary school education to college graduate with diploma, their occupation were employed/unemployed/student, BMI ranged from 30–36 or more and weight gain during pregnancy was between 3–10 kg or more.

## Data collection

### Study I

All of the women participating in Study II during a defined period of time (November 2008–February 2009) received verbal and written information by the researcher about the interview study (Study I). To be able to evaluate the experiences of highly repetitive resistance training in general and not only the exercises used in Study II which were adjusted to pregnancy, another five women who performed highly repetitive resistance exercise at fitness centers were included. They were recruited by written information at the prenatal clinics, and contacted the researcher. The semi-structured, face-to-face inter-

## Effects and experiences of exercise during pregnancy

views took place in health care facilities and were digitally recorded. An interview-guide with open-ended questions was developed. An independent researcher (a physiotherapist) conducted the interviews. The interviews were transcribed verbatim by the first author.

### **Study II:**

Participants for this study were recruited from February through November 2006 and from September 2008 through April 2009, from two prenatal clinics. The participants were verbally informed about the study by midwives or they received written information available at their antenatal clinic. Data was collected at a primary health care center by a blinded investigator (physiotherapist). After the intervention was complete, data was obtained from prenatal medical records and from the Sahlgrenska University Hospital's perinatal medical records.

### **Study III:**

Participants for this study were recruited from four prenatal clinics from September 2014 through May 2015. The participants were verbally informed about the study by midwives or they received written information available at the antenatal clinic. Data were collected at a primary health care center.

### **Study IV:**

Participants received verbal and written information from the researcher about the interview study during July and December 2012. The women themselves chose the interview location, either in health care facilities or at home. The interviews were conducted and digitally recorded by a researcher (physiotherapist) with no connection to the "Mighty Mums" intervention. The interviews were transcribed verbatim by the first author.

## **Studied variables**

### **Baseline demographics (Studies I-IV)**

Demographic data with regard to maternal age, parity, pre-pregnancy BMI, GWG, marital status, occupation and nationality were collected.

The participants were asked to describe their degree of physical activity, according to the short form of the International Physical Activity Questionnaire (IPAQ) (Studies II-III) (74).

Education was categorized as "years at school" (Studies I-II) or as "Nine years of primary school"/ "High school or some higher education"/ "College graduate" (Study IV).

### **Treatment/intervention-related variables (Study II)**

Short Form-36 Health Survey (Swedish Acute Version 1.0) (75) comprises 36 items, 35 of which are arranged in eight physical and mental health sub-scales, and one is a self-report of health change. Scores can range from 0 to 100. Higher scores positively correlate with higher levels of functioning. The eight sub-scales are: 1) physical functioning, 2) role physical, 3) bodily pain, 4) general health, 5) vitality, 6) social functioning, 7) role emotional and 8) mental health. The instrument has proved to be valid and reproducible (75).

Pain was measured using a graphic (drawings) depiction of body locations, on which the participant localized the area of pain. Scores were assigned to indicate the presence or absence of pain in each of 45 body areas (76). Five areas located in the lower back and pelvis were selected for analysis. It has been asserted that the pain drawing instrument is valid, reproducible and stable over time (77) and has low inter-rater variation (78).

Hand-grip isometric strength was defined as the peak voluntary hand-grip force applied using the Grippit® electronic hand-grip strength detector (Grippit®AB, Gothenburg, Sweden), administered in accordance with standard laboratory protocol (79). Grip strength correlates with upper extremity strength (80).

GWG and BP (mmHg) were obtained from prenatal medical records. Weight gain was measured in kg, wearing clothes but not shoes.

Functional status was measured with the Disability Rating Index (DRI) and recorded on a visual analogue scale, i.e., a self-estimation scale from 0–100, where 0 indicated no restriction in activity and 100 indicated inability to perform the activity (81). The DRI includes 12 items that measure functions, including dressing, outdoor walks, climbing stairs, sitting for a longer period, standing bent over a sink, carrying a bag, making a bed, running, light physical activity, heavy physical activity, lifting heavy objects and participating in exercises/sports. DRI proved to have high reliability and acceptable validity (81).

A structured diary of daily physical activity was kept by the women, according to the short form of IPAQ (74). Each activity was divided into “vigorous intensity”, “moderate intensity”, “walking” and “sedentary”. The participants estimated the number of minutes per day that they had performed the different activities. IPAQ has been shown to have acceptable validity (82).

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Perinatal data, including birth weight, birth length, gestational age at delivery and cesarean section rate, were obtained from perinatal medical records.

### **Treatment/intervention-related variables (Study III)**

BP (mmHg) and HR (bpm) were measured by digital monitor (OMRON, M6 Comfort).

The RPE scale was used to monitor exercise intensity (see table 2 in Background) and has shown high validity and reliability (83, 84).

An oral thermometer (Apoteket AB) was used to measure the oral temperature in ° C.

## **Data analysis (Studies I-IV)**

### **Qualitative analysis (Studies I, IV)**

#### **Study I**

Qualitative content analysis (85, 86) was used in Study I.

The interviews were repeatedly read, bearing the aim of the study in mind. An open coding was then conducted while reading the text, by writing notes and headings on the informants' experiences of physical exercise. All codes were cross-checked through the entire text and some were revised. The codes were also compared, to detect similarities and differences with other codes. The next step was to condense and abstract the data, by grouping similar codes into sub-categories. The sub-categories were then sorted and abstracted into categories. The data categorization was modified during the course of the analysis, to ensure the best fit of the data. The first author conducted the first steps of the analysis. The last author read the interview transcripts and checked codes and categories created by the first author; these were discussed until consensus was reached. Finally, all authors discussed the sub-categories and categories until consensus was reached (85, 86). Table 7 shows an overview of analyses of data.

Table 7. Overview of analyses, examples (Study I)

Quotes	Codes	Sub-categories	Categories
<p>I: How does it feel when you exercise?</p> <p>I:5: It feels great. I often exercise after work. I am often tired, but exercising gives me energy and I feel really good afterwards. I feel calm and at the same time energized.</p>	<p>Feels great</p> <p>Gives energy</p> <p>Feel really good afterwards</p>	<p>Immediate positive feedback.</p> <p>Reduced pregnancy-related problems</p>	<p><b>Positive impact on body and mind</b></p>
<p>I: How come you exercise when pregnant?</p> <p>I:8: Because I do a large amount of training when I'm not pregnant. So I don't see why I should stop because I'm expecting. I think that the body needs movement and you need exercise in order to feel good, irrespectively of whether or not you are pregnant.</p>	<p>Normally exercise a great deal</p> <p>The body needs movement</p> <p>You need exercise in order to feel good</p>	<p>Part of one's lifestyle</p> <p>Knowledge of health benefits</p>	<p><b>Expected benefits and facilitators</b></p>
<p>I: How does it feel when you exercise?</p> <p>I:3: A kind of restriction. I can't press myself as much as before. But that is only natural. The body sets the limit.</p>	<p>A kind of restriction</p> <p>The body sets the limit</p>	<p>Physical limitations</p>	<p><b>New exercise barriers</b></p>

## Effects and experiences of exercise during pregnancy

I:12: The intensity is not the same, but you still do something. I don't put on weight as much as I otherwise do.	The intensity is not the same	Lowering the intensity	<b>Overcoming exercise barriers</b>
I: The intensity is not the same as before pregnancy?	Not put on weight as usual		
I:12: No, I don't think it is.			

### Study IV

“Phenomenon” is a central concept within phenomenology, emanating from the Greek word “phainomenon”, and can be understood to signify a thing, a matter or a part of the world. Phenomenology is both a philosophical tradition and a methodological approach. In the former, Husserl (1859–1938), Heidegger (1889–1976) and Merleau-Ponty (1908–1961) are important philosophers. As humans, we live as subjects through our bodies and immediate environment. All understanding, memory and cognitive and emotional relations to the world are intentionally directed towards and “embodied” in the surrounding world. The phenomenological idea includes the aim of approaching the world as it is experienced, in all its variety, and of describing and elucidating the lived world that expands the understanding of human beings and human experience (87).

The analysis was conducted, in accordance with Dahlberg et al. (87), by two of the authors together. First, the interviews were reread several times to obtain a global sense of the data. In order to analyze the data and thus gain a deeper understanding, the text was divided into smaller parts, i.e. meaning units (88). In two of the interviews, meaning units were identified with a high degree of consistency between both researchers, while they were identified by the physiotherapist in the remaining interviews. The next phase was to group meaning units that were related to each other into clusters of meanings. When all meaning units had been clustered, interrelationship patterns of the phenomena were identified and constituents were defined. All of the clusters were reread to identify possible missing meaning units. Finally, the essence of the phenomenon was formulated (87).

## Statistical methods

Data were analyzed using the SPSS (Statistical Package for the Social Sciences, IBM Corp, NY, USA) version 22.0 for Microsoft Windows.

Descriptive statistics were used to describe participant baseline demographics (*Studies I-IV*).

### Study II

Group mean differences in physical strength, BMI, BP, activity level, birth weight, birth length and gestational age were analyzed by the Student's t-test or chi-square test. Subgroup SF-36 and DRI scores were analyzed using the Mann-Whitney U test. Birth weights, adjusted for gestational week, were converted to Z-scores. A p-value <0.05 (two-sided) was defined as significant. Only participants who fully completed the trial according to the protocol were considered compliant and included in the analysis.

Sample size calculation was based on a difference in health-related quality of life (HRQoL), measured by SF-36. To detect a clinically significant difference between groups with 80% power and at the 5% significance level, and a difference between groups of ten units, 40 participants were needed in each group.

### Study III

Since there are only a few studies on this topic, no power analysis was performed. Instead, the study was planned as a pilot study.

Paired sample t-tests were used to perform pairwise comparisons between types of exercise for each time-point and to examine changes from baseline in BP, HR and body temperature. The Wilcoxon signed-rank test was used to perform pairwise comparisons of RPE related to the different types of exercise. Spearman's correlation between HR and RPE were calculated. Correlations were defined as: poor ( $r_s > 0.20$ ), fair ( $r_s = 0.21-0.40$ ), moderate ( $r_s = 0.41-0.60$ ), good ( $r_s = 0.61-0.80$ ) or very good ( $r_s = 0.81-1.00$ ) (89). A p-value <0.05 (two-sided) was defined as significant.

## Ethical considerations

The World Medical Association has developed ethical principles for medical research involving human subjects. Some of the more important principles for this thesis are presented here.

One of the first principles (No. 3) states that the health of the patient should be the first consideration. Additionally, one of the primary aims of medical research is to improve preventive and therapeutic interventions (Principle No. 6). Furthermore, groups that are underrepresented in medical research should be provided appropriate access to participation (No. 13). Predictable risks and burdens must be assessed with foreseeable benefits to the subjects and to other groups affected by the conditions under investigation (No. 17).

The researcher should consider the benefits and risks. The health of the participants was the first consideration. The designs and inclusion criteria of the quantitative studies followed existing recommendations although it was discovered, when analyzing the IPAQ diary (Study II), that some of the women had rated their exercise intensity as vigorous instead of following the instruction to remain at light to moderate intensity. However, the exercise sessions were conducted in a group setting and supervised. If pain, discomfort or any questions had arisen during the session, the participants thus had the opportunity to report and discuss this with the physiotherapist leading the group. The participants also had the possibility to discuss the study exercises with the midwife at the prenatal care center.

Furthermore, since women are generally underrepresented in medical research, the research reported in this thesis has provided appropriate access to participation.

All of the quantitative data were coded; the code keys and the data were separated and stored securely. The digitally recorded interviews were coded, separated and stored securely. All participants in this thesis were informed of the studies' aims, methods, anticipated benefits and that they implied no potential risks. The individuals participated voluntarily and they were informed that they could withdraw at any time without any consequences. They all gave their informed consent.

In the case of the qualitative studies, an interview can stir up memories and emotions that the interviewees did not even know they had (87). There were however, no tears, upset or anger during the interviews; although the researchers were prepared to stop and wait if this had been the case. On the

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other hand, an interview may also provide relief and insight through the opportunity to talk to someone who is interested and listening (87).

Approval was obtained from the Regional Ethical Review Board at the University of Gothenburg. Studies I-II: D no. 353-05, approved 2005-11-14; Study III: D no. 483-09, approved 2010-01-14; Study IV: D no. 310-12, approved 2012-05-21.

## RESULTS

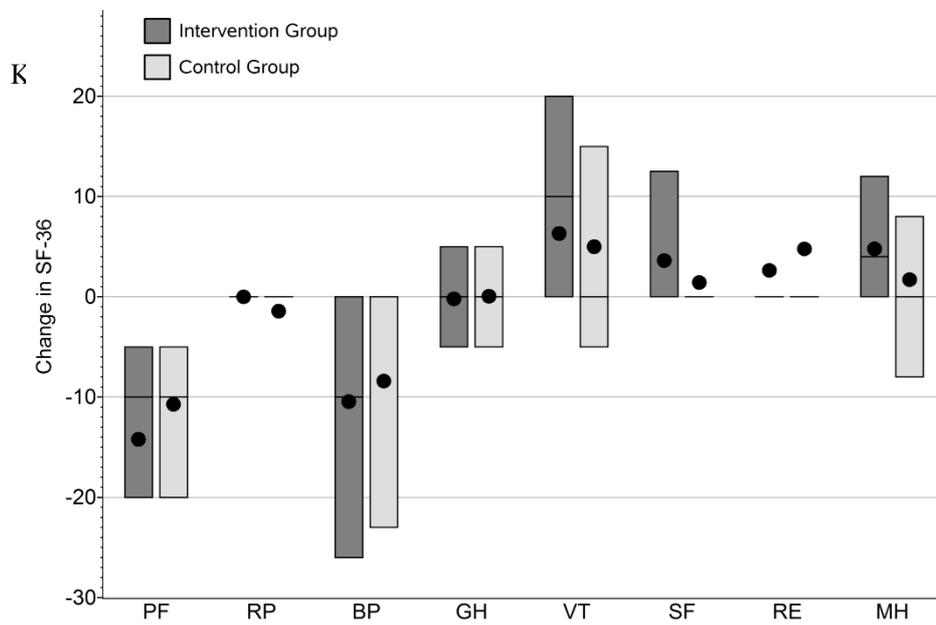
### **Positive impact on body and mind (Study I)**

The women described experiences of exercise during pregnancy were classified in four categories reflecting their perceptions of exercise in general, and resistance training in particular, during pregnancy. The four categories that emerged were: “Positive impact on body and mind”, “expected benefits and facilitators” “new exercise barriers,” and “overcoming exercise barriers.” As an overall theme (90), pregnant women made more effort to exercise if “facilitators” outweighed “barriers”. Beneficial short-term effects led to continued exercise, often with lowered intensity, adjustment to exercise activity and alteration of exercise goals. Exercise was perceived to have a positive impact on body and mind and was thus described as generating both immediate and short-term health benefits, recognized from previous experiences before pregnancy or influenced by pregnancy. The women experienced that exercise led to a sense of control in pregnancy; problems related to pregnancy such as weight gain, poor posture, nausea, fatigue, headache, insomnia and back pain were perceived to be solved or addressed. Doing resistance exercise generated an experience that the body was capable of many types of exercise, and was also perceived as valuable for acquiring good posture. The women thought that resistance training was a suitable type of exercise during pregnancy.

Regardless of physical, psychological and social barriers, all of the women exercised during pregnancy. The exercise could be adapted to pregnancy by applying different strategies, including lowering exercise intensity, modifying the type of exercise, altering exercise goals and being extra attentive. These strategies were generated based on recommendations and by gradually learning from experience and adapting.

### **Effects of resistance exercise during pregnancy (Study II)**

HRQoL did not differ between the intervention group and controls (Figure 2), when it came to either the number of women with PLBP or with PGP.



Box edges are 25th percentile and 75th percentile, horizontal line is median and large dot is mean.

Figure 2. Group differences in Quality of Life (SF-36) between gestational week 13 and 25, respectively, Intervention group (n=38) and Control group (n=34). PF: Physical Functioning, RP: Role Physical, BP: Bodily Pain, GH: General Health, VT: Vitality, SF: Social Functioning, RE: Role Emotional, MH: Mental Health.

There were no significant differences between the groups in physical functioning, measured by the DRI. Group mean scores for peak voluntary strength, weight gain, BP and activity level did not differ significantly (Table 8).

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Table 8. Pain, peak voluntary strength, weight, systolic blood pressure (BP), diastolic blood pressure (BP), activity level. Mean values  $\pm$  SD or n/(%). Gw= gestational week.

Outcome			Intervention group (n=38)	Control group (n=34)	p-value
Pain (n, %)		Gw13	12 (31%)	12 (36%)	
		Gw25	22 (58%)	21 (52%)	
Peak voluntary Strength (Newton)	Left hand	Gw13	311 ( $\pm$ 47)	309 ( $\pm$ 58)	0.92
		Gw25	317 ( $\pm$ 52)	311 ( $\pm$ 55)	0.65
	Right hand	Gw13	338 ( $\pm$ 46)	342 ( $\pm$ 58)	0.73
		Gw25	344 ( $\pm$ 54)	248 ( $\pm$ 67)	0.69
Weight (kg)		Gw13	66.5 ( $\pm$ 9.3)	65.0 ( $\pm$ 10.3)	0.61
		Gw25	72.7 ( $\pm$ 9.2)	70.5 ( $\pm$ 11.0)	0.80
BP (mmHg)	Systolic	Gw13	109 ( $\pm$ 18.8)	111 ( $\pm$ 10.5)	0.39
		Gw25	112 ( $\pm$ 8.8)	112 ( $\pm$ 9.7)	0.56
	Diastolic	Gw13	66.2 ( $\pm$ 8.3)	63.7 ( $\pm$ 7.7)	0.35
		Gw25	65.7 ( $\pm$ 8.2)	63.4 ( $\pm$ 7.8)	0.56
Activity level, minutes/week	Walking	Gw13	52 ( $\pm$ 47)	47 ( $\pm$ 58)	0.68
		Gw25	118 ( $\pm$ 109)	79 ( $\pm$ 76)	0.08
	Moderate	Gw13	11.7 ( $\pm$ 14.8)	18.3 ( $\pm$ 20.7)	0.12
		Gw25	15.8 ( $\pm$ 12.9)	16.8 ( $\pm$ 15.4)	0.76
	Vigorous	Gw13	1.1 ( $\pm$ 3.2)	1.2 ( $\pm$ 4.3)	0.89
		Gw25	11.2 ( $\pm$ 26.9)	4.6 ( $\pm$ 7.1)	0.15
	Sedentary	Gw13	316 ( $\pm$ 196)	366 ( $\pm$ 170)	0.25
		Gw25	372 ( $\pm$ 171)	384 ( $\pm$ 171)	0.77

Birth weights were significantly higher in the intervention ( $\bar{x}_i = 3561 \pm 452$  g) than the control ( $\bar{x}_c = 3251 \pm 437$  g) group ( $p=.02$ ). However, when adjusted for gestational age, this difference did not remain ( $p=.059$ ). The mean birth length was 50.7 ( $\pm 2.1$ ) cm in the intervention group and 49.4 ( $\pm 2.6$ ) cm in controls ( $p=.10$ ). Gestational age at birth was 280.1 ( $\pm 12.5$ ) days in the intervention group and 276.7 ( $\pm 7.7$ ) in controls ( $p=.16$ ). There were no differences in cesarean section rates; five women in each group had a cesarean section (14% and 15% in the intervention group and the control group, respectively).

## **Hemodynamic effects of aerobic and resistance exercise during pregnancy (Study III)**

Table 9 shows the hemodynamic responses at baseline, during and after exercise. There were no significant differences between aerobic exercise and resistance exercise.

Maternal systolic BP increased significantly during both types of exercise ( $p<.001$ ) (Figure 3).

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**Table 9.** Maternal systolic and diastolic blood pressure (BP) and heart rate, beats per minute (bpm) at 15 and 30 minutes of aerobic or resistance exercise. Mean values  $\pm$  SD and 95% confidence interval (CI). n=20

Outcome		Aerobic exercise	Resistance exercise	p-value	CI
Systolic BP (mmHg)	Baseline	104( $\pm$ 13)	105 ( $\pm$ 8)	0.93	-3.6–3.3
	15 min	118 ( $\pm$ 13)	118 ( $\pm$ 11)	0.89	-4.8–5.5
	30 minutes	119( $\pm$ 16)	119 ( $\pm$ 12)	0.85	-6.5–5.4
	Post-exercise	105 ( $\pm$ 10)	106 ( $\pm$ 10)	0.55	-4.2–2.3
Diastolic BP (mmHg)	Baseline	67 ( $\pm$ 6)	66 ( $\pm$ 4)	0.61	-2.1–3.5
	15 min	72 ( $\pm$ 8)	70 ( $\pm$ 9)	0.26	-2.2–7.6
	30 minutes	71 ( $\pm$ 7)	71 ( $\pm$ 9)	0.74	-3.4–4.8
	Post-exercise	70 ( $\pm$ 8)	68 ( $\pm$ 7)	0.33	-1.9–2.3
Heart rate (bpm)	Baseline	68 ( $\pm$ 9)	70 ( $\pm$ 9)	0.12	-4.6–0.6
	15 min	94 ( $\pm$ 16)	94 ( $\pm$ 13)	0.86	-6.2–5.2
	30 min	99 ( $\pm$ 15)	96 ( $\pm$ 17)	0.46	-4.3–9.2
	Post-exercise	77 ( $\pm$ 10)	78 ( $\pm$ 11)	0.63	-5.5–3.4

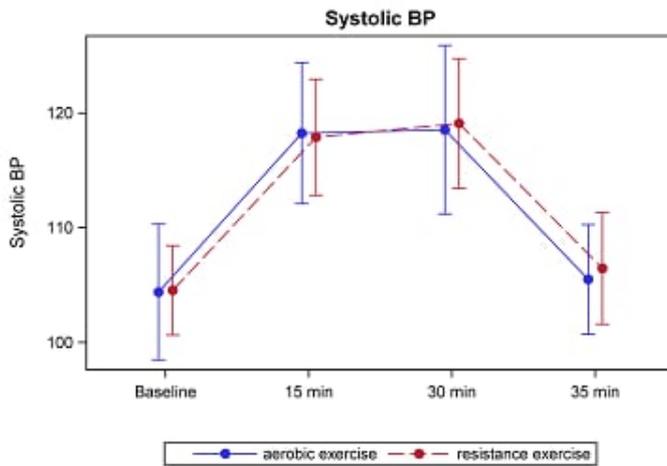


Figure 3. Maternal systolic blood pressure (BP) responses during aerobic exercise and resistance exercise in pregnancy, in comparison to baseline,  $p < .001$ . Mean and Standard Deviation.

Also diastolic BP increased during exercise, more so during aerobic exercise ( $p = .01$ ) than resistance exercise ( $p = .12$  and  $p = .03$ ). Systolic and diastolic BP dropped steadily after exercise, returning to pre-exercise levels within five minutes. HR increased irrespective of exercise type ( $p < .001$ ), but did not return to pre-exercise levels within five minutes ( $p = .001$ ) (Figure 4).

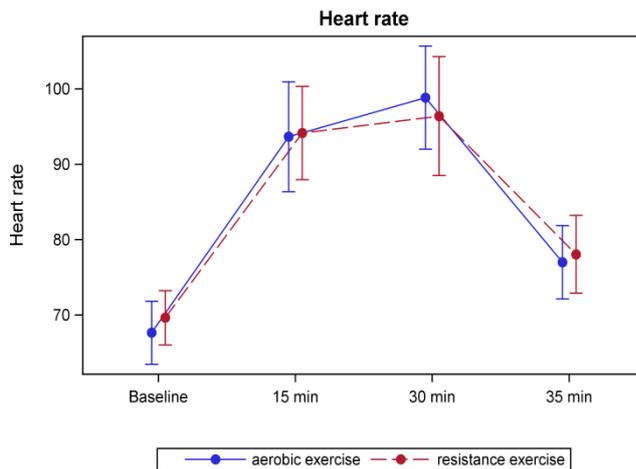


Figure 4. Maternal heart rate responses in pregnant women during aerobic exercise and resistance exercise, compared to baseline,  $p < .001$ . Mean and standard deviation.

After aerobic exercise, the orally measured temperature was registered as lower, compared to before exercise ( $p = .008$ ), but was unaffected after

resistance exercise ( $p=0.76$ ). As seen in Figure 5, RPE was significantly higher during both 15 and 30 minutes of resistance exercise ( $p=.02$  and  $p=.001$ , respectively), with a median score of 14 after 30 minutes. The corresponding score was 12 during aerobic exercise.

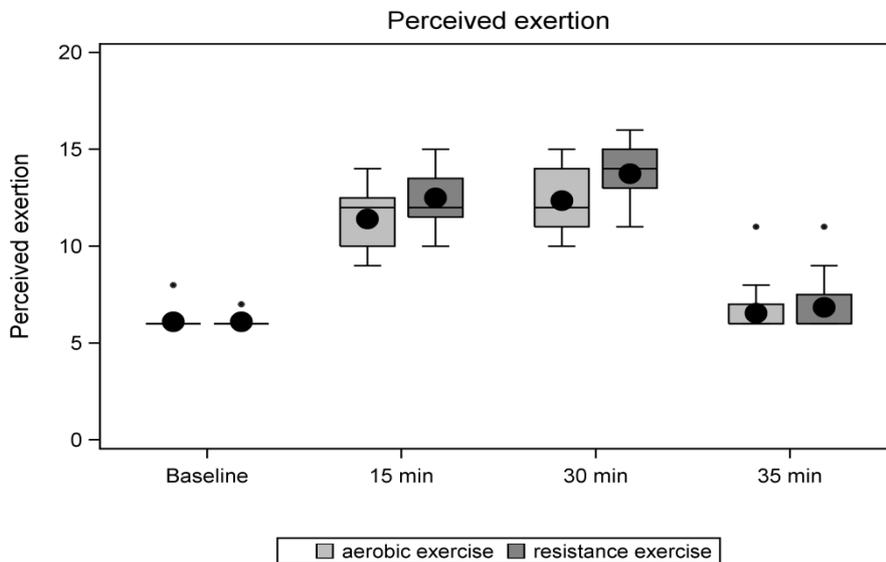


Figure 5. Rating of perceived exertion (RPE scale 6–20) in pregnant women during aerobic exercise and resistance exercise. There were significant differences between the types of exercise at 15 minutes and 30 minutes of exercise,  $p=.02$  and  $p=.001$  respectively. Box edges represent the 25<sup>th</sup> percentile and the 75<sup>th</sup> percentile, respectively; the horizontal line is the median and the large dot is the mean.

There was a moderate but non-significant correlation between HR and RPE during 15 minutes of aerobic exercise, ( $r_s=.43$ ). The other correlations were weak ( $r_s<0.2$ ) and non-significant.

## A need for a non-judgmental support to implement healthy habits (Study IV)

The essence of the women’s experiences of participating in a lifestyle intervention during pregnancy was their expressed need for support to implement new habits, provided by midwives, partners, relatives and friends—as well as by obese pregnant women in the same situation. Additionally, taking part in the intervention as such was perceived as supportive. The midwives’ support was experienced as non-judgmental with a balanced outlook on weight. Those who lacked knowledge of how to eat

healthily felt they had been given appropriate recommendations from the midwife. The women described the opportunity to set their own goals for lifestyle changes as crucial.

Meeting other pregnant obese women was viewed as a generally positive experience among the women who participated in a group activity. The discussions with a dietician made it possible to reflect on other participants' stories and they experienced a sense of affinity with the others. The participants were motivated to try to control GWG, although not all of them were initially convinced that this would be possible.

The essential structure of participation can be described with the following constituents: "pregnancy encourages change"; "non-judgmental support"; "from bad habits to conscious choices" and "barriers to change".

## DISCUSSION

### Methodological considerations

This thesis addresses resistance exercise during pregnancy with different methodologies, including a qualitative approach, a RCT and a cross-over design. Study IV explored women's experiences of a lifestyle intervention, using another qualitative approach. Naturally, this broad approach also created a challenge with regard to understanding different methods and approaches.

In the case of qualitative studies, handling subjectivity is a critical concern of the researcher. This was addressed through a) shared analysis and discussion with co-researchers and b) use of a journal in which preconceptions at the start of the study were outlined. Researchers must also find ways to scrutinize themselves and keep their preconceptions in check, in order to encounter the data in an open manner (87). This enhances the chances to be surprised by the results, to see "the otherness" of the phenomenon, which is unknown in advance (87).

The choice to apply both qualitative content analysis and a phenomenological approach presented an opportunity to become acquainted with different qualitative approaches by collaborating with co-authors competent in the specific approach. Qualitative content analysis takes content to emerge in the process of researcher condensing and analyzing a text (86). The "phenomenon" in Study IV was both participating in a lifestyle intervention and being obese. As humans we live as subjects through our bodies (87), as mentioned above. However, a previous study had reported that both caregivers and obese pregnant women can have a problematic approach to an obese pregnant woman's body (91). Nyman et al. (91) reported that obese pregnant women experienced a separation between the self and their bodies. The body was experienced as an "it" and a "carrier" for the baby (91).

One way to strengthen the content validity (86) was to employ interviewers that were independent with regard to the intervention, enhancing impartiality (Studies I, IV). In order to verify consistency of the data during the analysis process (*stability*) (86), the transcripts were re-read several times during the analysis. The trustworthiness of Studies I and IV was strengthened by the analysis of data, as two of the authors conducted the analysis together.

The question of generalizability is of great concern in both qualitative and quantitative research (87). Results based on qualitative methods can be generalized, although the idea of generalization must be problematized and it is important to find out to what extent conclusions can be drawn, with regard to each study, context and aims and questions (87).

An issue in Studies I and IV was that no drop-outs were interviewed. To fully understand a phenomenon also drop-outs should also have been included. In Study IV, when interpreting the data it was a strength of the study to have experiences from different occupations and research areas. None of the data interpreters were working in obesity care or connected to the lifestyle intervention. The interviewer's profession was not revealed, except to one woman who specifically requested it.

The samples in Studies I–III consists of healthy women who were used to exercising during pregnancy, from regular walks to exercise at moderate to vigorous intensity. Furthermore, the participants were volunteers with a normal pre-pregnancy BMI and motivated to participate. Thus, the results can be generalized to healthy pregnant women accustomed to light to vigorous exercise who do resistance exercise during the second trimester of pregnancy. In Study IV, the results can be generalized to obese women who completed a lifestyle intervention and who were motivated or neutral, but not negative, to participation.

A major issue in Study II was the sample, since both groups exhibited a high level of physical activity at baseline. An alternative approach would have been to study sedentary women, or women with some kind of complication, such as PLBP, GDM or depression/reduced HRQoL. This type of intervention would have increased the probability of finding differences between groups.

It is also important to discuss the choice to use HRQoL as an effect variable (Study II). Da Costa et al. (92) found that sleep problems, depressed mood and greater pregnancy-related anxiety were independently associated with poorer HRQoL, including poorer physical function and increased pain. This means that one has to be aware of the presence of different independent determinants that affect HRQoL during pregnancy.

Another major issue (Study III) was the oral temperature measurement, since the validity can be influenced by breathing rate and consequent cooling of the oral membranes (93). Rectal temperature has greater accuracy but is less

likely to be acceptable (93). Despite the variety of methods, measuring body temperature accurately is challenging, especially during exercise (93).

Blinded tests enhance the quality of a study, since a researcher can always affect the participants. The findings in Study II might thus have been even more reliable if a physiotherapist not involved in the study had supervised the intervention group. Study III was not blinded and was regarded as a pilot study.

Since pregnancy is dynamic in itself, it presents a methodological challenge. It is hard to determine a baseline when conducting prospective studies. This underscores the benefit of RCTs.

## **General discussion of the results**

There is limited research on resistance exercise during pregnancy (6, 8). Results from Study III indicate that maternal hemodynamic responses to submaximal aerobic and resistance exercise are very similar, and within healthy limits. Bgeginski et al. (13) recently showed that BP responses to resistance exercise are significantly lower among pregnant women, compared with a matched non-pregnant group. Additionally, HR responses were higher in the pregnant group after one set of resistance exercise and lower after three sets of resistance exercise (13). Diastolic BP and HR during exercise in Study III participants resembled those in the study by Bgeginski et al. (13), although systolic BP was 6–7 mmHg lower in our study. Both of the studies were conducted in the second trimester of pregnancy.

The results of Study III show differences in perceived exertion between types of exercise; resistance exercise was perceived as more intense. The reasons for this difference can be speculated upon. RPE monitors the total feeling of exertion, combining heart and breathing rates and muscle fatigue. The resistance exercises might have been experienced as more intense in terms of muscle fatigue and thus scored higher. In previous studies monitoring pregnant women's exercise intensity, the RPE score is regarded as the parameter least likely to be affected by physical changes during pregnancy (94). Wolf et al. (35) suggest the RPE scale for estimating exercise intensity during pregnancy, since increased resting HR, reduction in maximal HR and lower HR reserves make HR a less precise basis on which to base estimates (35).

Study II found that birth weight in the intervention group was higher than that in infants born to control women, but the difference was not significant

after adjustment for gestational age. There is inconsistency in the literature concerning exercise and birth weight. Exercise has been shown to reduce the risk of low birth weight (95), leading to a hypothesis that it enhances growth in the fetoplacental unit (96, 97) and reduces the risk of preterm birth (96). However, a recent review (46) found that exercise was associated with a minor reduction in neonatal birth weight ( $p=0.04$ ), compared to sedentary women's babies.

Furthermore, Study II showed that women from both the intervention group and control groups reported PLBP and PGP equally as often. In a RCT, Stafne et al. (98) concluded that prenatal exercise does not modify the risk of PLBP and PGP, although the women they studied who exercised regularly seemed to handle the disorder better.

It is important to note that physical and emotional status changes accompany pregnancy, including a decrease in pain and functional status, irrespective of physical exercise. Results in Study II did not find any differences in HRQoL between the intervention or the control groups. Previous studies were inconclusive. Barakat et al. (99) reported improved self-perception among previously sedentary women. However, other studies failed to show a significant increase in HRQoL among exercisers (100, 101).

## **The role of health care providers and significant others**

Pregnancy is a time of life with extra focus on risks. Safety is usually prioritized, even related to relatively minor and unusual risks (102). Pregnancy may generate a sense of insecurity and uncertainty, both objective and existential, in both health care providers and the individual herself (102). Peers can offer advice but also question the pregnant women's lifestyle decisions. Old recommendations and myths flourish, which means that pregnant women are exposed to conflicting recommendations (103) regarding both exercise (103-105) and GWG control (65, 106). The findings in Study I show that significant others may have an important impact on the woman's exercise performance, yet both as an exercise facilitator and a barrier. Accordingly, as reported in previous studies (3, 32, 107) support from friends and family members, as well as and support from health care professionals are important exercise facilitators. Pregnancy can be considered a unique time for behavior modification and, thus, offers a propitious moment for health care professionals to give social support to enhance and implement healthy habits. Health care providers thus play an important role in providing pregnant women with appropriate recommendations.

Obese pregnant women are at risk of feeling discriminated against in encounters with midwives and physicians during pregnancy (91). Women with obesity sometimes have a perception that health care professionals are rude, tending to focus on physical status and risks, rather than considering the woman as a whole person (91). The results of Study IV underscore the importance of midwives being supportive and non-judgmental, which concur with previous findings among pregnant woman with obesity (70, 108).

## Exercise recommendations

Resistance exercise is a common type of exercise during pregnancy, and approximately 5–10% of pregnant women in general engaged in it (57). According to the literature and the results present in this thesis (Studies I-III), there are no indications that moderate resistance exercise in healthy pregnancy entails maternal or fetal risks. Study I showed that women doing resistance exercise considered this type of exercise suitable, while other types of exercises were avoided, e.g. running and spinning. The fact that resistance exercise began to be recommended to the general population as late as 1990 (52) might explain why it is not recommended in all of the national guidelines for pregnancy (6). Also, in the Western world, exercise has generally been considered inappropriate during pregnancy (3), as mentioned above. During the last decades, physical exercise recommendations during pregnancy have become more proactive. In the review of national guidelines for physical activity during pregnancy (6) some activities are listed as best avoided, such as vigorous intensity exercise and exercise in the supine position. This is of interest for the discussion in this thesis.

Regarding exercise intensity, only a few national guidelines recommend vigorous exercise, and only for no more than 15 minutes or among women who have engaged in it already or prior to pregnancy (6). In Study II, the women perceived the exercise level as moderate to vigorous although the participants were instructed to exercise at a light to moderate intensity. During resistance exercise, peaks of higher intensity appear at the end of the sets, which can explain why some of the women estimated their total exercise level as vigorous. The effects of vigorous exercise during pregnancy have not been extensively studied (109), although no adverse effects have been seen, either on the health status of the offspring or the course of pregnancy (96, 110, 111). It might be suggested that women who exercise at a moderate level need not worry if they have peaks of higher intensity during exercise, although the importance of maintaining control of the trunk and the body in general while exercising must be kept in mind. Hormonal changes during

pregnancy increase joint laxity, which in turn increases the risk of injuries (6) and pain (38). Study I showed that the women wanted to be extra attentive during exercise, also reported by Hegaard et al. (31). This must be taken into account by pregnant women who want to exercise, especially at higher intensities.

A majority of national guidelines (6) warn against the supine position (lying on one's back) after 16 weeks' gestation, due to the risk of decreased cardiac output and orthostatic hypotension caused by the enlarged uterus, which may obstruct venous blood flow from the vena cava (6). In Study II, several of the exercises were conducted in the supine position, although no participants experienced symptoms such as dizziness while exercising in this position. Had this occurred, it would have been possible to rest for a while lying on their side or exercise in a standing position. Exercising in the supine position in this context—a group setting and supervised—was not considered risky.

One woman in the intervention group (Study II) dropped out due to “discomfort during exercise” in her case while doing squats, a lower-body resistance movement. Hormonal changes generate greater flexibility and extensibility in the cervix and affect pelvic floor muscles relaxation (33). The importance of good control of the trunk (transverso-spinal and pelvic floor muscles) during exercise must be emphasized, especially when the hip is flexed and a heavier load is placed on the pelvic floor muscles and cervix (for example squats or cycling in a forward-leaning position). Maintaining control of the trunk can be easier while exercising in the standing or lying position.

During the last decades, physical exercise recommendations during pregnancy have become more proactive. Today, recommendations in the Western world concerning exercise during pregnancy are essentially based on evidence or expert consensus (6). However, as mentioned above, these recommendations differ between countries and may still reflect current social and cultural norms.

Physical therapy provides services to maintain movement potential. Since pregnancy can be regarded as a “condition” where functional ability decreases, physiotherapists can facilitate physical activity and exercise by providing information about appropriate exercise, initiate exercise groups targeting pregnant women or supply adjusted exercises. Furthermore, also women who are used to a high level of pre-pregnancy exercise can be of great need for accurate exercise advice. Physiotherapists should be aware that most pregnant women in the Western world do not reach recommended amounts of physical activity.

## CONCLUSION

The findings in this thesis indicate that regular, self-rated moderate-intensity resistance exercise seems to be appropriate during the second trimester of pregnancy among healthy women who are used to regular exercise, from walking to moderate-to-strenuous exercise. When beginning to exercise, pregnant women should follow the exercise recommendations and start at an exercise level corresponding to light-to-moderate intensity. BP and HR are essentially the same and within healthy values, regardless of whether the exercise is sub-maximal aerobic or resistance exercise, although resistance exercise is perceived as more intense. Aerobic and resistance exercise corresponding to 13–14 on the Borg RPE-scale seems to be safe with regard to maternal hemodynamic responses (BP and HR) in healthy second-trimester pregnancy. Among women who perform resistance exercise during pregnancy, this type of exercise is considered as suitable. In general, if exercise facilitators outweighed the barriers, pregnant women strive to exercise.

In order to implement new habits, participants of a lifestyle intervention express a need for support, given with a non-judgmental attitude and a balanced outlook on weight; they needed a supportive midwife but they also required encouraging attention as mothers-to-be. They experience that lifestyle changes is less burdensome than they had previously imagined, and that small changes can yield unexpectedly successful results.

## CLINICAL IMPLICATIONS

Since group-training is an exercise facilitator, physiotherapists can provide information about appropriate training groups, or even more preferably recommend or initiate exercise-groups targeting pregnant women. Physiotherapists (and midwives) have a major role by giving updated information on exercise-guidelines in pregnancy and encourage and support the pregnant woman to follow the recommendations.

For obese pregnant women, a non-judgmental attitude among health care providers is important. Affinity with other obese pregnant women in an exercise group or dietary group setting is supportive. In a physiotherapeutic context, it is important to take the positive health impact of exercise and physical activity into account. However, lifestyle interventions focusing on healthy eating patterns are of major importance in order to control GWG.

The results presented in this thesis can be considered when updating guidelines for exercise in pregnancy, with regard to intensity, body position and type of exercise (Studies II–III).

## **Future research**

When it comes to future research, research on resistance exercise is still scarce; more of RCTs are needed, e.g. studying the efficacy of resistance exercise in sedentary pregnant women or in women with PLBP or poor HRQoL. Future trials should have similar designs and the same out-come measures, evaluated in the same time frame in order to enable comparison of their respective results. Furthermore, multi-center trials increase the number of participants.

Research on hemodynamic effects of light to moderate aerobic and resistance exercise in pregnancies with complications, such as obesity or hypertension, is warranted. Additionally, there are as yet no studies investigating immediate and longer-term effects of resistance and aerobic exercise during the third trimester. Furthermore, trials investigating vigorous-intensity second trimester exercise in healthy pregnancies are warranted, since no of safe exercise intensity has been established.

If possible, creation of a worldwide guideline on exercise during pregnancy, including rationales for exercise recommendations and restrictions, is desirable. This is important while existing guidelines sometimes do not specify the reasons for cautions and recommendations.

More knowledge about reasons for dropping out or declining participation in lifestyle interventions targeting obese pregnant women is crucial. Furthermore, investigations into effects of minor dietary lifestyle changes aiming at controlling GWG are also warranted.

Knowledge about the effect of exercise on body temperature during pregnancy is still limited.

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