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Physical activity and glucose tolerance in overweight and obese pregnant women

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ABSTRACT

Purpose: To investigate the association between self-reported physical activity levels and glucose tolerance among overweight and obese pregnant women.

Methods: 55 overweight or obese pregnant women (mean age ± SD; 31.6 ± 3.8 years), who had been included in the ongoing Exercise Training in Pregnancy (ETIP) study, were recruited for this sub study. 49% of the study's participants were nulliparous while 96% were obese (BMI≥30). Self-reported physical activity in early gestation (range 12-14 weeks) and late gestation (range 34-37 weeks) was assessed using standardized questionnaires. Oral glucose tolerance test was also assessed at these periods to determine 2-hour plasma glucose in both early and late pregnancy. Spearman's correlation coefficient was use to assess the association. A general linear regression (forward model) was carried out to assess the strength of the association. Fisher's exact test was used to determine difference in the prevalence of GDM across physical activity levels.

Results: We found moderate to no correlation between self-reported physical activity levels and 2-hour plasma glucose in late pregnancy. However, correlation was moderate to low, with 2-hour plasma glucose in early pregnancy (ρ =0.468; $0.01 < p < 0.05$) while age was found to be highly correlated with 2-hour plasma glucose in late pregnancy (ρ =0.292; $0.001 < p < 0.05$). Despite adjusting for confounders (BMI in early pregnancy, parity, weight gain in late pregnancy and PA-level at inclusion and follow-up), linear regression revealed that 2-hour glucose level in early pregnancy (p=0.004) and age (p=0.04) was found to be predictive of glucose level in late pregnancy. Physical activity level in both early and late pregnancy, BMI at inclusion, parity and weight gain were not found to be predictive of 2 hour plasma glucose in late pregnancy ($p \geq 0.05$). There were no statistical differences in prevalence of GDM across the physical activity groups (p=0.55).

Conclusions: This observational cohort study provides evidence that there is no association between self-reported physical activity levels and 2-hour plasma glucose in late pregnancy (nor with other risk factors such as body mass index (BMI) in early pregnancy, weight gain in pregnancy, parity status) among the studied population. However, a highly significant association between 2 hour plasma glucose in early pregnancy and 2 hour plasma glucose in late pregnancy suggest that prenatal and early antenatal physical activity interventions are very important in the prevention of GDM. These interventions could be too late if commenced in late pregnancy.

Keywords: Physical activity, Glucose tolerance, Gestational Diabetes Mellitus (GDM)

Overweight, Obesity

DEDICATION

This work is dedicated to all who are in persistent search for knowledge that will be of benefit to humanity and all other things in the universe!

Acknowledgement

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Abbreviations

ADL   Activities of Daily Living

BMI   Body Mass Index

ETIP   Exercise Training In Pregnancy study

GDM   Gestational diabetes Mellitus

IADPSG   International Association of Diabetes and Pregnancy Study Groups

MET   Metabolic Equivalent

NCDs   Non-Communicable Diseases

OGTT   Oral Glucose Tolerance Test

PA   Physical Activity

T2DM   Type 2 Diabetes Mellitus

WHO   World Health Organization

x

1.0 INTRODUCTION

Non-Communicable Diseases (NCDs) such as diabetes are among the greatest public health challenges of the 21st century [1, 2] and obesity is documented to be a significant risk factor for the development of many of the NCDs and other chronic health problems [3]. They are known to be, by far, leading cause of morbidity and mortality in both developed and developing countries and the documented increasing trend across the globe is of great concern [4] [5] [6]. Other NCDs apart from diabetes include cardiovascular diseases, cancer, chronic respiratory diseases [1].

 Diabetes is a well-recognized cause of premature death and disability, increasing the risk of cardiovascular disease, kidney failure, blindness and lower-limb amputation [7, 8] [9]. In recent decades, the prevalence of diabetes has been increasing globally, and has been particularly accelerated in low- and middle-income countries [8]. This rise is largely driven by modifiable risk factors; particularly physical inactivity, overweight and obesity [8]. Obesity in turn, also increases the likelihood of hypertension, coronary heart disease, stroke, certain cancers, obstructive sleep apnoea, osteoarthritis impaired glucose tolerance (pre-diabetes) and diabetes itself [10] [11] [12], [13].   Decreased insulin sensitivity, which is also "resistance to insulin mediated glucose uptake" [14], is related to impaired glucose intolerance. Impaired glucose intolerance   first recognized in pregnancy is referred to as Gestational Diabetes Mellitus (GDM) [7] [15].

GDM is among the most common complications of pregnancy, and it is also recognized as a risk factor for many adverse pregnancy outcomes for both mother and the foetus.   GDM affects both the life of the mother and the unborn foetus during antenatal, perinatal and postnatal periods [16]. Examples are fetal- macrosomia, shoulder dystocia, nerve plexus injury, prematurity and increased proportion of instrumental deliveries and caesarean sections in obese pregnancies [17] [18] [19]. Obesity in pregnancy may also lead to an increased prevalence of both pre-eclampsia and Large for Gestational Age (LGA) neonates among women delivering at term [20] .

 An increasing trend in the prevalence of GDM is thus seen around the globe following an increase in the prevalence of maternal obesity in women of reproductive age [21] [22].

Maternal obesity is associated with a two- to three-fold increased risk of perinatal death when compared with normal weight. This aggregate of multiple interrelated abnormalities, whose underlying pathophysiology is thought to be related to decreased insulin sensitivity and decreased glucose tolerance has also been linked with physical inactivity [23] [24, 25] .

Insufficient physical activity contributes to 3.2 million deaths worldwide while regular moderately intense physical activity on the other hand, is a key determinant of energy expenditure and is therefore fundamental to energy balance, weight control and prevention of obesity [2]. Together with healthy meal plan and weight loss, physical activity is regarded as tenet of medicine and a vital key element when it comes to the prevention and management of lifestyle related diseases in general [26].

Increasing physical activity and promoting an active lifestyle has been demonstrated to lower the risk of progression from GDM and Type 2 Diabetes Mellitus [27], after the gestational period. It has been documented that moderate /vigorous physical activity in early pregnancy (and if maintained throughout pregnancy), is associated with improved insulin sensitivity, insulin response, and decreased plasma triglyceride in overweight and obese pregnant women [28] and higher levels of physical activity before pregnancy or in early pregnancy have been documented to be associated with a significant lower risk of developing GDM [29]. In addition, various other studies have also documented the effect of exercise training on insulin resistance among normal weight [30] , obese pregnant women [31] and also in individuals diagnosed with GDM [32] [33] . Recreational physical activity performed before and/or during pregnancy has been shown to be associated with a reduced risk of GDM   [34]. Despite these numerous benefits of physical activity, evidence shows that only about 15% of pregnant women in Norway followed the current exercise prescription for exercise during pregnancy (≥3 times a week, >20 min at moderate intensity) [35]. On the other hand, however, positive association between sedentary lifestyles and disease risk has also been well documented [36].

Bearing in mind that normal pregnancy is often associated with decreased daily physical activity due to the gynecological and physiological changes that hinder participation in physical activity for example nausea and fatigue [35, 37, 38], women with a high pre-pregnancy BMI are less likely to be physically active [38]. This puts this high risk group of pregnant overweight individuals, who probably have reduced insulin metabolism [39], at higher risk levels for diseases associated with physical inactivity. A strong need to develop

effective strategies for increasing PA levels, especially in women at high risk for GDM who are often obese and inactive is therefore indicated [39] .

Guidelines regarding optimal intensity, frequency, duration as well as type of physical activity or exercise, aimed at GDM prevention is yet to be clinically specified [40]. There is evidence that overweight and obese pregnant women can achieve and maintain recommended levels of physical activity throughout pregnancy and it has been suggested that interventions that promote physical activity should target changes in habitual activities at work and at home, and in particular walking [41]. Although PA interventions have been reported to be effective at improving glycemic control in women who had already developed GDM, prenatal PA interventions aimed at preventing GDM was not effective in improving glucose/insulin metabolism or reducing GDM incidence in healthy pregnant women [28].

There is a dearth in literature and conflicting evidence as regards effectiveness of physical activity interventions in the prevention of glucose intolerance or GDM, and there is yet no conclusive indication to guide clinical practice [42]. A need for good quality research, especially in high risk groups, has therefore been advocated [43] .

As far as we know, research investigating associations between self-reported overall physical activity levels in form of Activities of Daily Living (ADL) and glucose tolerance as a continuous measure is limited. Improving physical activity levels through Activity of Daily Living (ADL) is known to be practical, economical, time saving and comes with potential long-term positive outcomes. Hence the aim of this study. If increase in PA through ADL is clinically encouraged and monitored, it may go a long way in preventing a number of adverse pregnancy complications that may affect both mother and the foetus before, during and after the gestational period.

Figure 1: Understanding the link between Physical inactivity, Obesity, GDM and Type 2 Diabetes (Adapted from Mottola M.F, 2007) [44]

1.1   Main Aims of the Study

The main aim of this study is to find possible associations between self-reported physical activity levels in pregnancy and glucose tolerance, among overweight and obese pregnant women. Secondarily, this study also aim to ascertain any possible differences in the prevalence of GDM across the different levels of self-reported physical activity.

1.2   Hypotheses

We hypothesize that there will be a no association between physical activity levels in early and late pregnancy and glucose tolerance in late pregnancy among overweight and obese pregnant women.

We also hypothesize that there will differences in the prevalence of GDM across the self-reported physical activity levels.

1.3   Relevance of the study

If self-reported physical activity level in pregnancy is positively associated with glucose tolerance, then measures to improve physical activity either through incorporating it into ADL or through pre-planned exercise training will be of paramount importance. The results of this study will contribute to existing knowledge, which could form a basis for the development of specific strategies that will encourage women in reproductive age to at maintain and if possible exceed the minimum recommendations of physical activity before conception, as well as during and after the gestational period. Such health promotion measures may be considered as part of routine pregnancy care for this target group.

2.0   THEORETICAL BAKGROUND

Non-Communicable Diseases (NCDs) such as diabetes mellitus are among the greatest public health challenges of the 21st century [1]. They are known to be, by far, leading cause of morbidity and mortality in both developed and developing countries and the documented increasing trend across the globe is of great concern [4] [5] [6]. Other NCDs apart from diabetes include cardiovascular diseases, cancer, chronic respiratory diseases. Consequent health complications for individuals diagnosed with diabetes are significant and lifelong, and for this reason, proactive efforts towards prevention of this condition is crucial and worthwhile [45].

Obesity is documented to be a significant risk factor for the development of many of the NCDs and chronic health conditions. Obesity also increases the likelihood of hypertension, coronary heart disease, stroke, certain cancers, obstructive sleep apnoea, osteoarthritis impaired glucose tolerance (pre-diabetes) and diabetes itself [10] [11] [12], [13]. Other conditions that often co-exist in the obese individuals include glucose intolerance, hyperinsulinemia, dyslipidemia and hypertension [45, 46].

Overweight, an antecedent to obesity, is an important factor in health promotion and disease prevention. According to World Health Organization, overweight and obesity is regarded as BMI$\geq$25 kg/ /m^2 and $\geq$30 kg/m /m^2 respectively [3] [11]. The prevalence of overweight and obesity has been increasing in all countries. Globally, 39% of adults aged 18 years and older (38% of men and 40% of women) were either overweight or obese. It is documented that the worldwide prevalence of obesity has nearly doubled between 1980 and 2014 [47]. Maternal obesity has been recognised as the major risk factor with a 2.6 fold risk for GDM (four-fold in morbid obesity) among obese women [39] [48].

Diabetes Mellitum is a well-recognized cause of premature death and disability, increasing the risk of cardiovascular disease, kidney failure, blindness and lower-limb amputation. People with impaired glucose tolerance and impaired fasting glycaemia are also at risk of future development of Type 2 Diabetes Mellitus. In recent decades, the prevalence of T2DM has been increasing globally, and has been particularly accelerated in low- and middle-income countries. This rise is largely driven by modifiable risk factors; particularly physical activity, overweight and obesity [49].
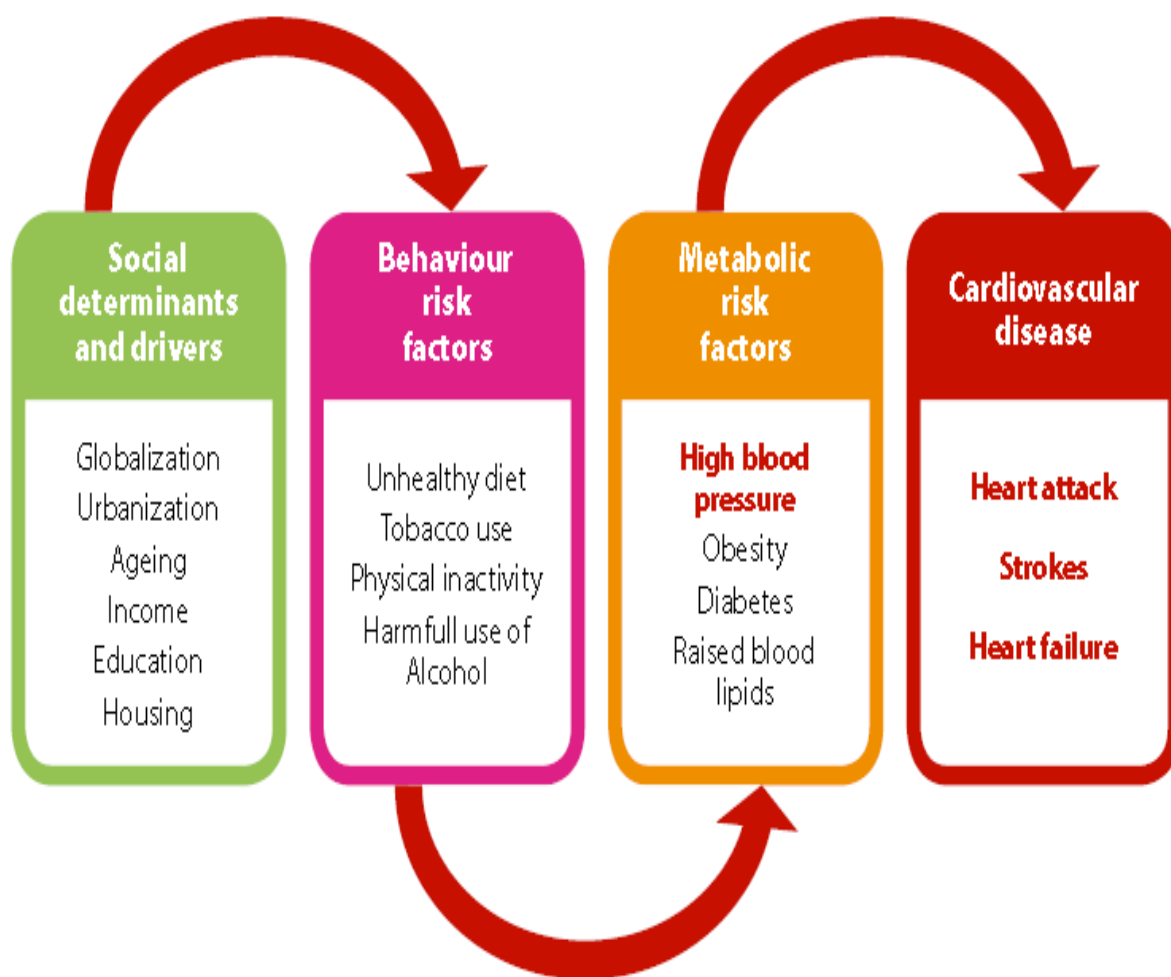
Figure 2: Main contributory factors to NCDs (WHO, 2014)

Impaired glucose intolerance, first recognized in pregnancy, is referred to as Gestational Diabetes Mellitus (GDM and it carries an additional significant impact because of the potential adverse health outcomes on both the mother and the foetus [7].

2.1 Gestational Diabetes Mellitus (GDM) and Maternal Obesity

According to the World Health Organization, GDM is defined carbohydrate intolerance resulting in hyperglycaemia of variable severity with onset or first recognition during pregnancy [7]. The prevalence of GDM is approximately 7% in the United States, but varies

between 1%-14% of all pregnancies depending on the population studied and the diagnostic test employed [21]. In Norway, the incidence of GDM has increased from 0.78% in 2003 to 2.98 % in 2013 [50] . An increasing trend in the prevalence of GDM is seen around the globe following an increase in the prevalence of obesity in women of reproductive age (Association 2004) (Cordero et al. 2014). In United States alone, over one-third of reproductive age women are obese, and another 29% are overweight (BMI 25.0-29.9 kg/m²) [51] .

In the Norwegian Mother and Child Cohort Study (MoBa) consisting of more than 108 000 pregnancies from 1999 to 2009, pre-pregnancy weight analysis showed that over 30% of the women were either overweight or obese. (22.3% were overweight while 9.1% were obese) [52]   The increasing trend in the prevalence of overweight and obesity over the past few decades is more marked among the younger population [53].

Women with GDM have increased risk for later development of both type 2 diabetes and cardiovascular risks (Shah, Retnakaran, and Booth 2008). It has been documented that the risk of being dispensed drug used to treat T2DM within the first years after pregnancy was estimated to be 41 times higher in women with GDM when compared to women without GDM (Engeland, Bjørge, Daltveit 2011).

2.2   Glucose homeostasis

Normal glucose homeostasis is maintained by a delicate balance between insulin secretion by the pancreatic β-cells and insulin sensitivity of the peripheral tissues i.e muscle, liver and adipose tissues [54]. Insulin resistance is defined as a failure of target organs to respond normally to the actions of insulin. Decreased insulin sensitivity, which is also "resistance to insulin mediated glucose uptake" [14], is related to glucose intolerance. Both relates to a cluster of other abnormalities such as glucose intolerance, dyslipidemia, and endothelial dysfunction [23].

Although glucose tolerance is normal in most normal weight women, it is thought that pregnant women who develop Gestational Diabetes Mellitus may have a compromised capacity to adapt to the significantly greater metabolic changes that occurs in late pregnancy [39]. Efficiency of glucose metabolism may therefore be reduced in order to favour nutrient

transfer to the rapidly growing fetus [55]. As muscle glycogen synthesis is the principal pathway of glucose disposal in both normal and diabetic subjects, defects in muscle glycogen synthesis may have a dominant role in the insulin resistance that occurs in persons with diabetes type II [56].

Recreational physical activity performed during the year before the index pregnancy has been associated with statistically significant reductions in GDM risk [34] . However, women who engaged in physical activity before and during gestational periods experienced the greatest reduction in risk [34]. Despite controlling for BMI, dietary factors and other covariates, a significant inverse association between vigorous physical activity (such as brisk walking) and the risk of developing GDM has been observed [55].

Women, who increased their physical activity levels to 150 minutes per week of moderate intensity, had a 47% lower risk of Type 2 Diabetes mellitus, when compared to women who maintained their total physical activity levels [27] and exercise training has consistently been documented to reduce the risk of type 2 diabetes risk [57] [58]   Long-term exercise programs have been documented to have similar effects on glucose control as long-term drug use or insulin therapy in patients with type 2 diabetes [59]. Increasing physical activity and promoting an active lifestyle may lower the risk of progression from GDM and Type 2 Diabetes Mellitus [27]. Adoption and continuation of an active lifestyle (especially vigorous activities) among women of reproductive age is an important step towards the prevention of GDM.

2.3   Physical Activity and Sedentary Behaviour

Physical activity is defined as any bodily movement produced by skeletal muscles that require energy expenditure [60] [61] [62]. In order to promote and maintain good health, either 30 minutes of moderate intensity 5 days per week, or 75 minutes of vigorous-intensity physical activity per week or an equivalent combination of moderate- and vigorous-intensity physical activity is recommended [62]. This translates to accumulating at least 600 MET (Metabolic Equivalent) -minutes per week. MET is the ratio of a person's working metabolic rate relative

to the resting metabolic rate. (One MET is defined as the energy cost of sitting quietly, and is equivalent to a caloric consumption of 1 kcal per kg per hour) [61].

It is established that regular and adequate levels of recommended physical activity levels in adults reduce the risk of developing hypertension, coronary heart disease, stroke, diabetes, breast and colon cancer, depression, the risk of falls and improve bone and functional health [2]. However, Moholdt et al indicated that current physical activity guidelines are insufficient to decrease long-term weight gain [63].

Despite these numerous benefits of physical activity, evidence shows that only about 15% of pregnant women in Norway followed the current exercise prescription for exercise during pregnancy (≥3 times a week, >20 min at moderate intensity)   [35]. The term "physical activity" differs from "exercise training". Exercise, is a subcategory of physical activity that is planned, structured, repetitive, and purposeful with the aim of improving or maintaining maximal oxygen uptake (VO2 peak) of an individual or other components of physical fitness [64] [63]. Physical activity therefore comprises of exercise as well as other daily activities which involve bodily movement and are done as part of playing, working, active transportation, house chores and recreational activities [62] [2].

Physical inactivity also called sedentary behaviour, are now identified as the fourth leading risk factor for global mortality accounting for about 6% of death globally. People who are insufficiently active have a 20% to 30% increased risk of death compared to people who are sufficiently active [2]. Moreover, physical inactivity is estimated to be the main cause for approximately 21–25% of breast and colon cancers, 27% of diabetes and approximately 30% of ischaemic heart disease burden. Despite the general knowledge that physical activity has significant health benefits and contributes to prevent these diseases, about 25% of the world's adult population are not active enough [2]. The drop in physical activity is may partly be due to inactivity during leisure time and sedentary behaviour on the job and at home. Likewise, an increase in the use of "passive" modes of transportation also contributes to insufficient physical activity [2]. For the first time, the Norwegian Health Directorate recommended that sedentary behavior should be reduced across all age groups [62]. Evidence suggest that daily decreased physical activity (in skeletal muscles) also leads to a rapid decline in insulin sensitivity [65], and daily physical activity levels that are below moderate thresholds significantly leads to type II diabetes mellitus in at risk-population [66, 67].

Sedentary behaviour was suggested to be a key driver of hyperglycaemia [68]. In a meta-analysis of 18 existing studies including almost 800,000 participants, authors concluded that sedentary behavior such as sitting time is independently positively associated with, and carries 112% increased risk of developing diabetes [36]. Independent of physical activity time and adiposity status, studies show strong association between 2 hour plasma glucose and television viewing, even in adults without diabetes [69]. Interrupting sitting time with short bouts of light- or moderate-intensity walking lowers postprandial glucose and insulin levels in overweight/obese adults [70] [71]. This may improve glucose metabolism and potentially be an important public health and clinical intervention strategy for reducing cardiovascular risk [70, 72].

Physical Activity Pyramid

Figure 3: Physical Activity Pyramid [73]

http://www.nutriweb.org.my/MDG/Physical-Activity-Pyramid-English.jpg

2.4   Physical Activity and Glucose Tolerance in Maternal Obesity

Similar to all healthy adults, it is also recommended that pregnant women exercise with moderate intensity on most, if not all days of the week [38] . All pregnancy-related physical activity guidelines from around the world generally discouraged sports with high risk of falls, trauma or collisions [74]. It has been documented that moderate /vigorous physical activity in early pregnancy (and if maintained throughout pregnancy), is associated with improved insulin sensitivity, insulin response, and decreased plasma triglyceride in overweight and obese pregnant women [28] [40]. Higher levels of physical activity before pregnancy or in early pregnancy have also been documented to be associated with a significant lower risk of developing GDM [29]. However weight gain in early pregnancy has been demonstrated to be more beneficial for reducing risk of GDM [75].

Guidelines regarding optimal intensity, frequency, duration as well as type of physical activity or exercise, aimed at GDM prevention is yet to be clinically specified [40]. There is evidence that overweight and obese pregnant women can achieve and maintain recommended levels of physical activity throughout pregnancy and it has been suggested that interventions that promote physical activity should target changes in habitual activities at work and at home, and in particular walking [41]. Although PA interventions have been reported to be effective at improving glycemic control in women who had already developed GDM, prenatal PA interventions aimed at preventing GDM was not effective in improving glucose/insulin metabolism or reducing GDM incidence in healthy pregnant women [28].

There is a dearth in literature and conflicting evidence as regards effectiveness of physical activity interventions in the prevention of glucose intolerance or GDM, and there is yet no conclusive indication to guide clinical practice [42]. A need for good quality research, especially in high risk groups, has therefore been advocated [43] . As far as we know, research investigating associations between self-reported overall physical activity levels in form of Activities of Daily Living (ADL) and glucose tolerance as a continuous measure is limited. Improving physical activity levels through Activity of Daily Living (ADL) is known to be practical, economical, time saving and comes with potential long-term positive

outcomes. Hence the aim of this study. If increase in PA through ADL is clinically encouraged and monitored, it may go a long way in preventing a number of adverse pregnancy complications that may affect both mother and the foetus before, during and after the gestational period.

3.0 METHODS

3.1 Study design

This study is a secondary analysis of a larger ongoing randomized controlled trial named Exercise Training in Pregnancy (ETIP) study [76]. The main aim of ETIP is to assess whether exercise training during pregnancy in overweight or obese women can reduce gestational weight gain. In the present study, all women were treated as cohort independent of randomization.

3.2 Subjects

Pregnant women who have a pre-pregnancy body mass index (BMI) at or above 28 kg /m² were invited to participate in this study. Women are eligible if they are 18 years or older, with a singleton live foetus confirmed at the routine ultrasound scan. Exclusion criteria were high risk for preterm labour or diseases that could interfere with participation, as well as participation in habitual exercise training that is more than twice weekly. Subjects were randomly allocated (following a computerized randomization procedure) into two parallel arms; intervention and control groups. The concealed randomization was in blocks. Only women who gave their oral and written informed consent were randomized to groups. The research team involved in this study had no influence and was not involved in the randomization process. For this present sub study, women were included if we had complete data on glucose tolerance measured by oral glucose tolerance testing (as described below), pre and post intervention.

3.3 Recruitment Strategies

Written information about the ETIP study (Appendix I) as well as invitation to participate was given to potentially eligible participants during their routine visit to general practitioners and midwives, and at outpatient clinics at the hospital. In addition, participants in another study (regarding early ultrasound in week 12 and pre-eclampsia) received information about this study.
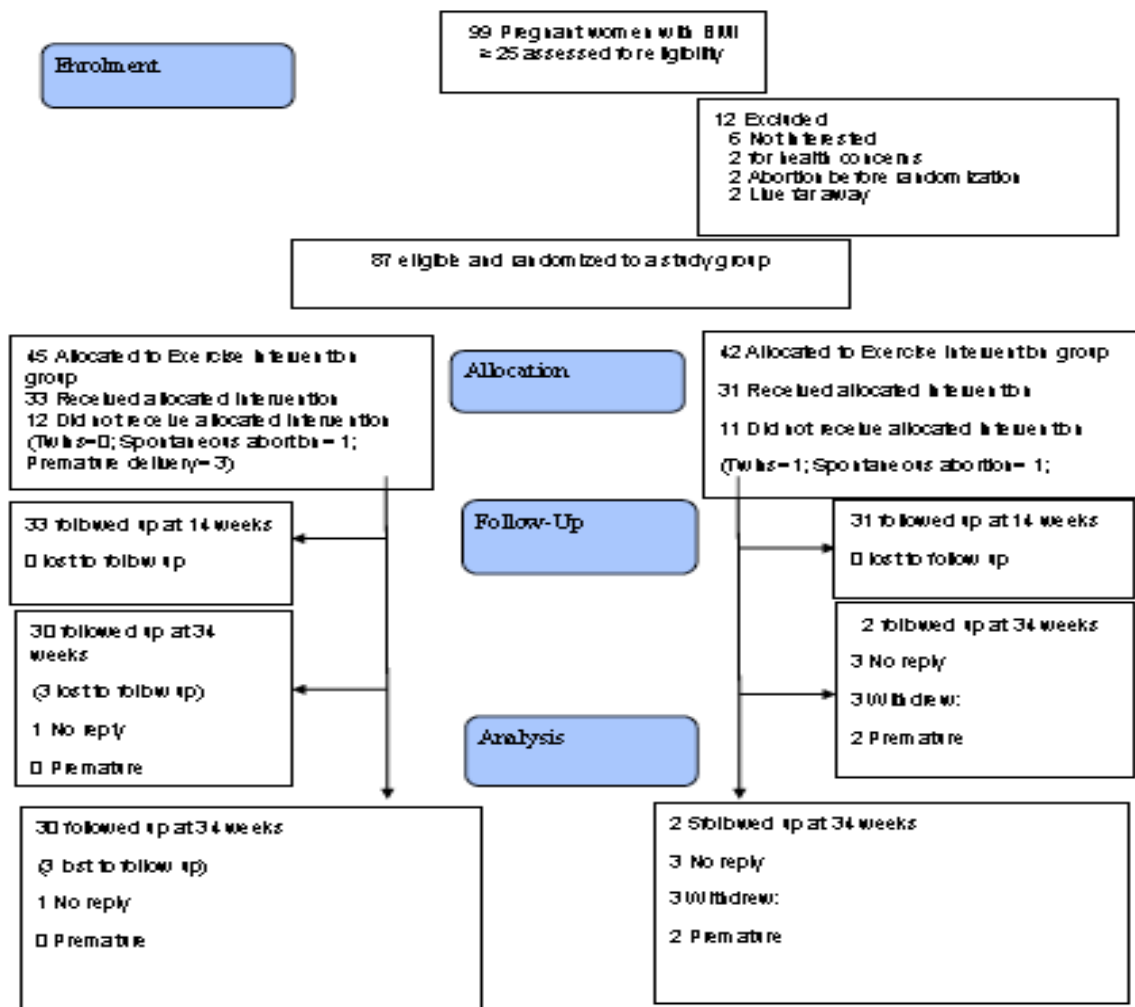
Figure 4: Flow chart of study participants

3.3.1 Study Setting

This research was carried out both at the Exercise Training Laboratory, NTNU and the Clinical Research Facility, St. Olav's Hospital, Trondheim Norway, in collaboration with the Women's clinic at St. Olav's Hospital.

3.4 Outcome Measurements

All women met at the hospital for assessment at 14 weeks (range 12-18weeks) and 37 weeks (range 34-38weeks) of pregnancy. Baseline measurements were taken before randomization. Data was collected through physical assessments, laboratory tests as well as through self-administered questionnaires.

The primary outcome measure was glucose tolerance measured following a 2 hour 75mg per-oral glucose tolerance test (75g OGTT). Fasting plasma glucose concentrations were taken after a 10 hour overnight fast. Gestational diabetes mellitus was diagnosed according to the standard international guideline (IADPSG guidelines) with fasting plasma glucose (FPG) $\geq$ 5.1 mmol/l and /or 2 hour plasma glucose $\geq$8.8 mmol/l [16]. Glucose tolerance was assessed as a continuous variable and was quantified based on the results of the 2-hour plasma glucose.

Level of physical activity and socio-demographic data such as age, Body Mass Index, and gestational age was recorded on a questionnaire that was designed for our study. The self-reported questionnaires also provided information about participants' daily physical activity levels including exercise training they may participate in. Questions were related to frequency, duration and intensity of both occupational and leisure time physical activity (Appendix V). These questions are similar to the questions that were used in the HUNT study, and they have been previously validated [64]. The questions on duration and intensity have been validated against direct measurement of maximal oxygen uptake [77]. Significant and positive associations between self-reported exercise activities and objective motion sensor measurement have also been observed [78].

The study participants were also asked to report duration, frequency and intensity of their daily activity levels, as well as type of occupation and mode of transportation to their place of work at inclusion in early pregnancy and at follow-up in late pregnancy.

Their physical activity levels were classified into: Inactive, Low and Moderate/High levels according to predefined mutually exclusive combinations based on the response on the self-reported questionnaires (Appendix III and Appendix IV).

3.5 Sample Size Calculation

The sample size for the ETIP study is calculated based on the primary outcome which weight is gained during pregnancy [76]. In this sub study, we have not made a sample size calculation as we are using all available data from the ongoing trial.

3.6 Description of the Intervention

Women in both intervention and control groups received routine antenatal care. This includes visits to their general practitioners and midwives. This is usually done in gestational weeks 8-12, 24, 28, 32, 36, 38, 40, and 41. In addition to routine visits, women were invited to an ultrasound scan is gestational week 18 as usual. According to the Norwegian Health Directorate [60] and in line with the international guidelines [38] [79], the study participants were advised to maintain optimal physical activity levels during pregnancy. No special advice about physical activity was given to women beyond the one that is routinely given to all pregnant women. Standard dietary advice was also given to all women as usual.

3.6.1 Exercise training group

The exercise training group followed a specially designed exercise program including aerobic training and specific strengthening exercises for stabilization of the lower back and pelvis, and strength exercises for the pelvic floor muscles. They attended 60 minutes group exercise sessions, four times weekly, between 14 and 34 gestational weeks. The women were also encouraged to continue exercises training after gestational week 34 if they wished to do so. The endurance training consisted of walking on treadmills for 25 minutes after warming up for 10 minutes. The exercise intensity was moderate, reaching ~80% of their maximal capacity (corresponding to Borg scale12-15) [80].

In addition to the above, the women carried out a 50 minute home exercise program at least once per week (35 minutes endurance training and 15 minutes strength exercises). The women also carried out daily exercises to the pelvic floor muscle and they are encouraged to be physically active in their activities of daily living overall. Adherence was strongly emphasized and registered in the women's personal training diary as well as through progress reports written by exercise group leaders. Specific adjustments were made to the aerobic exercises if necessary (for example by using a stationary bike instead of treadmill walking) and by modifying the strength exercises to the actual strength level of the participants).

3.6.2   Control group

Women in the control group received the routine regular consultations with midwife, general practitioner or obstetrician. They were not discouraged from exercising on their own if they wished to do so.

3.7   Analysis of Data

Data was analyzed using SPSS version 20.0 for Windows. Descriptive statistics of mean and standard deviation was used to describe socio-demographic data. Spearman's correlation co-efficient was used to the determine the correlation between 2-hour glucose level in late pregnancy and risk factors associated with Gestational Diabetes Mellitus such as age, parity, BMI in early pregnancy, and weight gain in late pregnancy. In order to further quantify the strength of linear relationship between 2-hour glucose level in late pregnancy and these risk factors, a general linear regression model (forward model) was performed. The 2-hour glucose level in late pregnancy was set as the dependent variable to be studied. The regression analysis was conducted to be able to predict 2-hour glucose level in late pregnancy based on levels of self-reported physical activity. Fisher's exact test was used to compare prevalence of Gestational Diabetes Mellitus by assessing the difference in proportions across different categories of self- reported physical activity levels in late pregnancy.

Results are being given as mean values with 95% confidence intervals. P-value < 0.05 is considered significant.

3.8   Ethical Considerations

Detailed information (both oral and written) about the background and relevance of the study, as well as methods, and the intended use of the registered data were given to the eligible participants (Appendix II). Both oral and written informed consent were collected from the participants and only women who give their informed, written consent were recruited to participate in this study.

In order to ensure anonymity of the participants, their health information and the list of names were coded, and only authorized personnel involved with this study had access to the original list of names. Information was given to the participants that they could withdraw from the study at any time without any accompanying consequences and that their anonymity would be preserved. There were no potential adverse effects or disadvantages related to this study. However, participants were required to give venous blood samples and were willing to participate in physical exercise training of moderate intensity.

Ethical issues were carefully considered according to guidelines from the Regional Committees for Medical and Health Research Ethics (REK). This study has been approved by REK (Appendix II) and it was conducted in accordance with the Declaration of Helsin

4.0   RESULTS

In total, 99 pregnant women with BMI $\geq$ 25 kg/m^2 were assessed for eligibility in the study, of which 12 (12.1%) were excluded due to not meeting the study's' inclusion criteria (Figure 1). At inclusion 87 women carried out an OGTT, however 32 women were lost to follow-up, giving 55 women (63.2%) with complete data. Reasons for loss to follow up were: spontaneous abortion, premature delivery and lack of motivation/interest to continue with the study. Data with invalid or incomplete blood test results were also not analyzed (Figure 1).

Descriptive data of study population in early pregnancy (12-14 weeks) and late pregnancy (34-37 weeks) are given in Table 1. Women were categorized according to self-reported physical activity level in late pregnancy.

Table 1: Descriptive data of study population in early pregnancy (12-14 weeks) and late pregnancy (34-37 weeks) according to self-reported physical activity level in late pregnancy.

	Total (n = 55)	Inactive (n= 27)	Low (n= 14)	Moderate/high (n= 14)
Pregnancy week 12-14				
Age (years)	31.6 ± 3.8	-	-	-
Weight (kg)	97.9 ± 12.7	-	-	-
BMI (kg/m^2)	34.8 ±4.1	-	-	-
Parity		-	-	-
0	27 (49.1 %)			
1	21 (38.2 %)			
2	6 (10.9 %)			
3	1 (1.8 %)			
Glucose 0 (mmol/L)	4.8 ± 0.7	-	-	-
Glucose 120 (mmol/L)	6.0 ± 1.4	-	-	-
GDM	14 (25.5 %)	-	-	-
Pregnancy week 34-37				
Weight (kg)*	105.6 ± 12.9	104.3 ± 11.3	109.2 ± 17.1	104.3 ± 11.1
Weight Gain (kg)*	7.3 ± 4.9	6.3 ± 5.3	7.1 ± 5.2	9.5 ± 2.7
BMI (kg/m^2)*	37.4 ± 4.3	37.4 ± 4.1	37.6 ± 5.6	37.1 ± 3.3
Glucose 0 (mmol/L)	4.6 ±0.5	4.7 ± 0.6	4.6 ± 0.6	4.5 ± 0.4
Glucose 120 (mmol/L)	6.5 ± 1.2	6.6 ±1.4	6.6 ±1.1	6.1 ± 0.9

Data are means ± standard deviation or n (%). *Data missing for one subject.

Association between 2-hour glucose level in late pregnancy, known risk factors and physical activity level were assessed with Spearman's correlation coefficient. Correlation was moderate to low, with only 2-hour plasma glucose in early pregnancy and age being highly correlated with late pregnancy 2-hour glucose level (Table 2).

Table 2: Correlation between outcome variable and risk factors.

	2-hour plasma glucose in late pregnancy	N
2-hour plasma glucose in early pregnancy	0.468**	55
Age	0.292*	55
Parity	0.215	55
BMI early pregnancy	0.099	55
Weight gain in study period	-0.260	54
Physical activity level at baseline	0.154	55
Physical activity level at follow-up	-0.087	55
Allocation to intervention group	0.182	55

Self-reported physical activity levels are categorized into three groups (Sedentary, Low, Moderate/high). BMI denotes Body mass index.

Spearmans's correlataion coefficient; **$0.001 < p \leq 0.01$, *$0.01 < p < 0.05$

In order to quantify the linear relationship between 2-hour glucose level in late pregnancy and risk factors a general linear regression model (forward model) was performed. The 2-hour glucose level in late pregnancy was set as the dependent variable to be studied. The 2-hour glucose level in early pregnancy and age was found to be predictive of glucose level in late pregnancy. Physical activity level in early and late pregnancy, BMI at inclusion, parity and weight gain was not found to be predictive (Table 3). In total 10/55 (18.2%) was diagnosed with GDM. According to the self-reported physical activity level 6/27 (22.2%) in the sedentary group, 3/14 (21.4%) the low physical activity group, and 1/14 (7.1%) in the moderate/high physical activity group were diagnosed with GDM. There were no statistical differences in prevalence of GDM between physical activity groups (p=0.55).

Table 3: Factors predictive for 2-hour plasma glucose in late pregnancy measured with unadjusted and adjusted linear regression.

	Unadjusted	p-value	Adjusted*	p-value
Age	0.121 (0.038, 0.205)	0.005	0.086 (0.004, 0.167)	0.040
Glucose 120 – early pregnancy	0.408 (0.188, 0.628)	<0.001	0.338 (0.113, 0.562)	0.004
BMI early pregnancy	0.013 (-0.069, 0.096)	0.748		
Parity	0.458 (0.023, 0.893)	0.039		
Weight gain	-0.078 (-0.145, -0.010)	0.025		
Physical activity level at baseline	0.149 (-0.373, 0.671)	0.569		
Physical activity level at follow-up	-0.171 (-0.495, 0.153)	0.295		

Self-reported physical activity levels are categorized into three groups (Inactive, Low, Moderate/High).

*Adjusted for BMI in early pregnancy, parity, weight gain in late pregnancy and PA-level at inclusion and follow-up.

4.1 Discussion

This observational prospective cohort study of 55 overweight/obese pregnant women is aimed at investigating the association between self-reported physical activity and glucose tolerance in late pregnancy. We found that self-reported physical activity levels (categorized into Inactive, Low, Moderate /High) (Appendix III) is not correlated with neither fasting plasma glucose nor 2 hour glucose in late pregnancy.

Our results agree with that of Oostdam et al which reported that their exercise program did not reduce maternal fasting blood glucose levels among overweight and obese pregnant women. They however explained that their results could have been due to low compliance by the participants [81]. They also reported that only a small proportion (16.3%) of women attended at least half of the training sessions because many women had stopped exercising due to physical and pregnancy related limitations, and therefore suggested that starting the exercise program in the second trimester could have possibly been too late to achieve effects of exercise on glucose levels [81]. As explained by authors, decrease in physical activity could be due to physiological changes seen in women as they progress from early pregnancy through to late pregnancy. In agreement with this, it is documented that overweight and obese women who had greater decreases in moderate/vigorous physical activity (from early to late pregnancy) had the most reduced maternal glucose and insulin metabolism, compared to women with smaller decreases in moderate/ vigorous physical activity [28].

Remarkably, our results show that 2 hour postprandial glucose in late pregnancy is highly associated with and also predictive of the 2 hour glucose in early pregnancy (Spearman's correlation coefficient (rho) $\rho=0.468$) ; (p≤0.001)). This may suggest that prenatal and early antenatal physical activity interventions are may be an important decisive factor in the prevention of GDM. Hence interventions may be too late and ineffective if commenced in late pregnancy.

On the contrary, Halse et al [32] demonstrated that a lower mean daily postprandial glucose concentrations in their bicycling intervention group when compared with the non-exercising control group. They however found no difference in postprandial glucose amongst both exercise and control groups during the 6 week post-intervention assessment. This could

suggest a significant effect of the physical activity performed, in this case bicycling. Furthermore, it supports that the influence of physical activity is not long lasting, but should be carried out regularly in order to maintain optimal blood glucose control [82] [83]. Similarly following a 10 week supervised exercise of 12 obese pregnant women, Ong et al [31]observed that at 2h post intervention OGGT, blood glucose tended to remain elevated from baseline in the control group as compared with the intervention group. They proposed that further investigation in a larger sample size is warranted [31].

In another cohort study of 759 pregnant women that aimed at assessing the association between objectively recorded physical in early gestation and GDM (identified at 28 weeks gestation), it was observed that daily life physical activity in early gestation was associated with lower risk of GDM [84]. Although Hopkins et al suggested that exercise intervention initiated in the second half of pregnancy influences fetal growth, they nevertheless stated that the observed reduction in maternal insulin sensitivity is not affected by exercise intervention during late pregnancy [85]. Offering women with (normal BMI) a 12 week standardized exercise program during the second half of pregnancy did not also prove to prevent GDM nor improve insulin resistance in this group [30]. Farni et al. 2014 also noted that the inverse association observed between measures of physical activity and the prevalence of pre-diabetes (impaired glucose tolerance), can only be reported if confounding influence such as BMI and age is not taken into consideration [68].

Furthermore, our results also show that maternal age is correlated with the 2 hour postprandial glucose in late pregnancy. This is partly in line with Tarquini et al. 2014 [86], who demonstrated that Positive Oral Glucose Tolerance Test (OGTT) is associated with high values of pre-gestational BMI and age. Our results did not however show any associations between 2 hour glucose tolerance test in late pregnancy and other risk factors such as body mass index (BMI) in early pregnancy, weight gain in pregnancy, nor associated with parity status of the studied women. This differs partly from the findings of an 11 year follow-up study of over 9000 normal weight women in reproductive age which showed that leisure time physical activity has a moderate effect on BMI [87]. The study states however that, not even a high level of leisure time physical activity was sufficient to prevent weight gain and BMI increase in all subgroups of the study population over the course of the study period [87] [53, 88].

Contrary to the results of our study, another study found no relation between moderate to vigorous physical activity (MVPA) and sedentary behaviour with gestational weight gain or birth weight [89]. The small percentage of women meeting the recommended levels of PA indicates the need to inform and support pregnant women to maintain regular PA, as there seems to be no adverse effect either and maintaining PA also increases overall health [89].

4.2   Strengths of the study

The main strengths of this observational cohort study is that data is collected from a high risk homogeneous group of overweight and obese pregnant women, who may have otherwise not participated in studies designed to target general population.   Additionally, an objective glucose test was assessed at two different time points i.e. in early and late pregnancy. This provided the opportunity of comparing the possible influence of the gestational age on different factors.

Another strength of this study is that plasma glucose test was measured objectively in the clinic in order to further improve this study's internal validity. Glucose tolerance was assessed as a continuous variable, as opposed to the use of diagnostic threshold to identify those with GDM. This reason is that the continuum of GDM risk is linear and continuous, extending to the lower limit of the range and becoming disproportionately greater at the higher end of the range [22].

4.3   Limitation of study

Results obtained from this study are based on data from a high risk group consisting of overweight and obese pregnant women.   Hence, the study findings may have been exaggerated as it may constitute a subgroup of outliers if compared with a group representative of the general population. As stated earlier, women who had high risk of preterm labour (or other diseases) that could interfere with participation, as well as participation in habitual exercise training that is more than twice weekly were excluded from our study. This could mean that a sub-group of these women with similar characteristics has been excluded, which might have influenced the results of our study. To minimize the above

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stated influence, we propose that a secondary analysis of combined data from both normal weight as well as overweight and obese pregnant population should be carried out.

We acknowledge that different factors could have influenced our results. As reported previously, use of self-reported questionnaires may well over-estimate those who participate in moderate to vigorous physical activity (MVPA). Self-reported questionnaires showed poor ability to discriminate women on the basis of their participation in MVPA [90]. It was suggested that objective methods should be used where possible in studies measuring physical activity in pregnancy, but further noted that questionnaires remain valuable to define types of activity [90]. The use of objective physical activity monitor is not without accompanying errors either. Previous experience shows that participants may simply forget to wear the sensors. Most sensors are required to be removed during water activities [78]. It is therefore essential to know the type of physical activity monitor being used especially when comparing physical activity level among different studies [91].

In this study, the IADPPSG criteria have been used to diagnose glucose intolerance. It has however been documented that the use of the IADPSG diagnostic criteria moderately increase GDM prevalence compared with the use WHO diagnostic criteria [92] and therefore, the prevalence of GDM in our study may have been overestimated [93]. Nevertheless, we thought that in this case, obtaining false positive results is relatively better than obtaining false negative results, especially when eventual adverse outcomes on both mother and offspring are taken into consideration. The use of IADPPSG criteria also appears to identify additional women at risk of adverse pregnancy outcomes [94].

4.4   Physical activity versus sedentary activity

Levels of occupational and leisure time activities which also includes daily sitting time and sedentary time at work might have had important influence as well [95]. Our study did not however take this into consideration. However, this is beyond the scope of our study. It is therefore recommended that further research on sedentary occupational activity and its association with glucose tolerance should be conducted.

Although some misclassification of physical activity was inevitable, however, the questions in this present study are similar to the questions used in other studies, which has been shown to correlate well with measured oxygen uptake [64]. Classifying study participants into Inactive, Low and Moderate/High into predefined groups (Appendix VI) might not have been accurate. There is therefore a chance that participants with borderline values could have been misclassified.

Further limitations of this study include a relatively high dropout rate that is either due to spontaneous abortion, early delivery, or simply lack of motivation to continue with the physical exercise training. However, efforts were made to encourage continued participation among women who are clinically able to participate in the study. It would be informative to research further on incomplete data, as this might be indicative of a subgroup of subjects who probably have a higher risk for GDM and other co-morbidities. Due to a relatively small sample size of this study, the results are limited to the participating subjects, hence it is not generalizable. Hence external validity of this study is uncertain. Further research that will include a larger number of subjects is therefore needed.

Our study only shows the associations between the risk factors and outcome variables. Due to the fact that data on both risk factors and outcome variables are collected at the same time, information about the cause/effect relationship between these variables is unclear and therefore impossible to infer causality. This is however outside the scope of this study. Further studies is therefore warranted to asses possible cause and effect relationships by investigating   a study population before they develop the risk factors and following them to see who develop the clinical conditions or not.

In addition, there are confounding factors associated with both physical activity and glucose tolerance for example presence of comorbidities such as cardiovascular diseases, and other socioeconomic factors as well as family history of diabetes and dietary behaviour were not taken into consideration. In order to avoid erroneous conclusions, it would have been useful to control for as many cofounding factors as possible.

4.5   Conclusion

This observational prospective cohort study of 55 overweight/obese pregnant women is aimed at investigating the association between self-reported physical activity and glucose tolerance in late pregnancy. We found that self-reported physical activity levels (categorized into Inactive, Low, Moderate /High) is not correlated with neither fasting plasma glucose nor 2 hour postprandial glucose in late pregnancy.

Remarkably, our results show that 2 hour postprandial glucose in late pregnancy is highly associated with an d thus predictive of the 2 hour postprandial glucose in early pregnancy Spearman's correlation co-efficient=)(p≤0.001). This may suggest that prenatal and early antenatal physical activity interventions are very important in the prevention of GDM. These interventions could be too late if commenced in late pregnancy.

Furthermore, our results also show that maternal age is correlated with the 2 hour postprandial glucose in late pregnancy. Our results did not however show any associations between 2 hour postprandial glucose in late pregnancy and other risk factors such as body mass index (BMI) in early pregnancy, weight gain in pregnancy, nor associated with parity status of the studied women

4.6   Suggestions for future research

Based on the results of this study that 2 hour glucose in late pregnancy is highly predictive of 2 hour glucose in early pregnancy, suggesting that adequate physical fitness and optimal glucose homeostasis in the preconception stages is a decisive factor in the prevention of GDM. As opposed to preventing GDM in the high risk group, we therefore recommend that an increase in awareness about the importance adequate physical fitness in the pre conceptive period should be propagated. Actively implementing and facilitating these strategies at the societal levels among all women of reproductive age is essential.

Further research is therefore necessary to investigate the efficacy of such health promoting strategies among the target population. Details of type, intensity, frequency and duration of

physical activity that will be suitable for a particular individual to be in order to achieve optimal physical fitness levels should also be researched. Follow-up studies should be carried among the target group during the post-partum period and up to two years after the delivery of the baby. It is also recommended that further research on sedentary occupational activity and its association with glucose tolerance should be conducted.

Finally, it is recommended that secondary analysis is carried out on data obtained from women with normal weight and data obtained from overweight women, to further understand the influence of increase BMI on GDM.

Increasing physical activity is a societal, not just an individual problem. Health promotion and disease prevention is an invaluable tool when it comes to tackling the insurgence of obesity.

Therefore it demands a population-based, multi-sectoral, multi-disciplinary, and culturally relevant approach. To encourage the population to be more physically active, policies should be made, in cooperation with relevant sectors, and aimed at promoting physical through activities of daily living. Cultivating a healthy lifestyle by incorporating physical activities that stimulates both cardiovascular and musculoskeletal systems, may go a long way in promoting health and prevention of chronic diseases related to sedentary lifestyle behaviours such as GDM.

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92.   Helseth, R., et al., *Gestational diabetes mellitus among Nordic Caucasian women: Prevalence and risk factors according to WHO and simplified IADPSG criteria.* Scand J Clin Lab Invest, 2014. **74**(7): p. 620-8.

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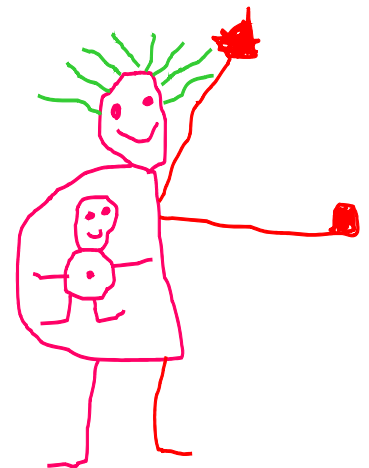
Forespørsel om å delta i en vitenskapelig undersøkelse

TRENING I SVANGERSKAPET

En randomisert klinisk studie av trening av gravide med en kroppsmasseindeks ≥ 25
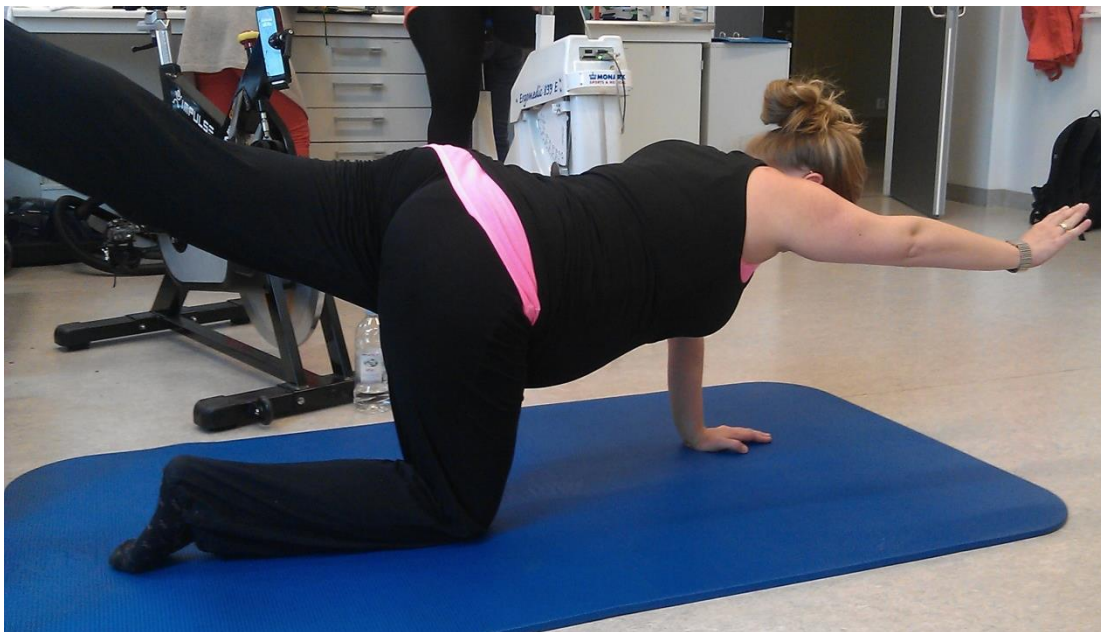
Studien er et samarbeidsprosjekt mellom NTNU

og Kvinneklinikken ved St. Olavs Hospital

NTNU
Det skapende universitet

HELSE ••• MIDT-NORGE

Bakgrunn og målsetting

I perioden 2010-2015 gjennomføres et forskningsprosjekt ved St. Olavs Hospital, med målsettingen å øke kunnskapen om helsen hos gravide med kroppsmasseindeks ≥ 28. Undersøkelsen tar sikte på å finne ut mer om effekter av trening under svangerskapet, i forebygging og behandling av svangerskapsrelatert sykdom (svangerskapsdiabetes, høyt blodtrykk, rygg- og/eller bekkenrelaterte smerter, urin- og/eller avføringslekkasje). Vi vil også undersøke om treningen påvirker fødselen. **Hvem kan delta, og hva innebærer deltakelse** Gravide kvinner (≥18 år) med kroppsmasseindeks* ≥ 25 inviteres til å delta. For at vi skal få vite mer om helsetilstanden generelt, og om helsen i svangerskapet spesielt, ber vi om å få ta blodprøver av alle deltakerne i prosjektet, og at alle svarer på spørreskjema og gjennomfører enkelte tester. Testingen foregår ved St. Olavs Hospital hovedsakelig i svangerskapsuke 14 (12-14) og 37, samt tre måneder etter fødselen. Testingen vil foregå over to dager, og den ene dagen må du være på sykehuset i ca tre timer fordi det skal gjøres en sukkerbelastningstest, der blodprøvene skal tas med to timers mellomrom. Du møter fastende denne dagen og vil bli tilbudt mat etterpå. Vi vil også se på blodårene dine med ultralyd, registrere vekt og gjøre målinger av kroppssammensetning, teste utholdenhet (kondisjon), og gjøre noen tester av bekkenbunns-funksjon og bekkensmerter. Dessuten ber vi om at vi får benytte informasjon om vekt og blodtrykk fra svangerskapsjournalen, og opplysninger om fødselsforløpet og barnets vekt, lengde samt rutine barnelegeundersøkelse fra fødselsjournalen. Vi ber også om å få ta blodprøve fra navlestrengen like etter fødsel, og på barselavdelingen vil barnets kroppssammensetning beregnes. Når det gjelder trening under svangerskapet, vet man ennå ikke sikkert om svangerskapsproblemer kan behandles og forebygges, og eventuelt hvilke tiltak som har best effekt. Deltakerne i denne undersøkelsen blir derfor tilfeldig fordelt i to grupper. En datamaskin avgjør ved loddtrekning (randomisering) hvilken behandling du skal ha. Du får et tilfeldig nummer i databasen, og bare prosjektkoordinator kjenner koblingen mellom nummeret i databasen og din identitet. Deltakerne i den ene gruppen får den informasjonen som nå gis rutinemessig til gravide. Den andre gruppen er en treningsgruppe, hvor deltakerne skal delta i en times trening to-tre ganger i uka ved St. Olavs hospital. I tillegg skal et hjemmetreningsprogram på 45 minutter gjennomføres minst en gang i uka. Treningen gjennomføres fra oppstart i studien og til tester i uke 37, eventuelt helt til fødsel hvis du orker. Treningen tilpasses din fysiske form. **Kroppsmasseindeks beregnes ved:**

___Vekt (kg)_____

Høyde (m) x høyde (m)   Eksempel: 84kg/1,65 m x 1,65 m = 31

Du må kunne møte til testing på dagtid. Hvis du kommer i treningsgruppa, kan du få velge mellom trening på dag- eller kveldstid. Alle deltakerne vil få en pakke med barnemat til en verdi av ca 500 kroner som takk for at de deltar.

Etter at forskningsprosjektet er avsluttet, vil alle deltakere få skriftlig informasjon om resultatene. Hvis trening viser seg å ha god effekt som behandling og forebygging, vil deltakerne i kontrollgruppen få informasjon om treningsprogrammet etter at prosjektet er avsluttet. For å kunne undersøke langtidsvirkningen av trening under svangerskapet, ber vi om samtykke til at data oppbevares i 20 år, slik at vi kan kontakte deltakerne igjen for eventuelle oppfølgingsstudier på din og barnets helse i årene etter fødselen.

Frivillighet og samtykke

- Deltakelse i prosjektet er frivillig.

- Alle deltakere i prosjektet har rett til å trekke seg fra prosjektet når de måtte ønske, uten at dette får konsekvenser for videre oppfølging og behandling. All informasjon deltakerne gir i forbindelse med prosjektet, behandles konfidensielt, og data avidentifiseres. Alle som skal ha kontakt med de innsamlede data, er underlagt taushetsplikt i henhold til Forvaltningslovens § 13 og Helsepersonellovens § 21.

- Deltakerne er dekket av Pasientskadeerstatningsordningen.

Etisk og faglig vurdering

- Prosjektet er vurdert av Regional komite for medisinsk forskningsetikk, Region Midt-Norge, og komiteen har godkjent at prosjektet gjennomføres.

Ansvarlige prosjektledere er Kjell Åsmund Salvesen, overlege ved Kvinneklinikken, St. Olavs Hospital, Siv Mørkved, Forskningssjef ved St. Olavs hospital, og Trine Moholdt, post doktor ved Institutt for samfunnsmedisin, NTNU.

HVIS DU ØNSKER Å DELTA, ELLER HAR SPØRSMÅL OM PROSJEKTET, BES DU KONTAKTE:

Prosjektleder: Trine Moholdt, tlf: 97 09 85 94, e-post: trine.moholdt@ntnu.no Eller

Kirsti Krohn Garnæs, e-post: kirsti.k.garnas@ntnu.no

Hvis du ønsker å delta må du fylle ut dette samtykkeformularet. Samtykkeformularet leveres til prosjektkoordinator ved oppmøte for første test.

SAMTYKKEERKLÆRING FOR PROSJEKTET

«TRENING I SVANGERSKAPET»

Jeg har lest informasjonsskrivet og har hatt anledning til å stille spørsmål. Jeg er også informert om at journalopplysninger fra det aktuelle svangerskap og fødsel vil bli gjennomgått og registrert og samtykker i å delta i studien.

Sted og dato, ………............................

Underskrift

Appendix II: Approval from Ethical Committee

REK
DE REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

To Whom It May Concern

Reference:
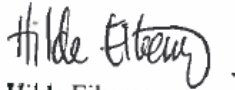2010/1522

Date:
31.01.2011

Exercise training in pregnancy.

Project leader: Trine Moholdt

The Regional Research Ethics Committee in Medicine, Central Norway, evaluated and accepted the prosject on June 18, 2010.

Sincerely

Sven Erik Gisvold /S/
Professor
Leader of the Committee

Hilde Eikemo
Advisor
Secretary of the Committee

Appendix III: Categorization of the participants according to their physical activity levels

Data on physical activity levels were collected at the beginning of the intervention period (in pregnancy week 12-18) and at late pregnancy (in week 34-38). Physical Activity was categorized into Inactive, Low, Moderate and High levels as predefined below;

1. **Inactive**

   Do not meet the minimum requirement of 30 minutes of moderately intense physical activity per day.

   Do not participate in any regular exercise training

   Do not carry out physical activity that bring about sweat

   Active transport to work is between 0 and 10 minutes

   Do have a sedentary occupation that requires sitting most of the time

2. **Low**

   Do not meet the minimum requirement of 30 minutes of moderately intense physical activity per day.

   Do participate in low intensity exercise training that is less than 30 minutes duration and less than 2 bouts per week

   Do not carry out physical activity or exercise training that bring about sweat

   Active transport to work is between 20 and 30 minutes

   Do have a active occupation that requires walking around

3. **Moderate /High**

   Do meet the minimum requirement of 30 minutes of moderately intense physical activity per day.

   Do participate in moderate intensity exercise training that is between ≥30 minute's duration and between ≥3 bouts per week

   Do carry out physical activity or exercise training that brings about sweat or may even feel exhausted

   Active transport to work is between ≥30 minutes

   Do have an active occupation that requires walking around and some heavy lifting

Appendix IV: Combinations of Physical Activity Categorizations

Inactive (0)

EXS_POST_INTERVENTION_S15 = 0 | EXS_POST_INTERVENTION_FREQUENCY_S16 < 1 |
EXS_POST_INTERVENTION_FREQUENCY_S16 = 1 &
EXS_POST_INTERVENTION_DURATION_S17 = 1 |
EXS_POST_INTERVENTION_FREQUENCY_S16 = 2 &
EXS_POST_INTERVENTION_DURATION_S17 = 1 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 1

Low (1)

EXS_POST_INTERVENTION_FREQUENCY_S16 >= 4 &
EXS_POST_INTERVENTION_DURATION_S17 =1 &
EXS_POST_INTERVENTION_INTENSITY_S18 < 3 |

EXS_POST_INTERVENTION_FREQUENCY_S16 = 1 &
EXS_POST_INTERVENTION_DURATION_S17 = 2 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 1 |

EXS_POST_INTERVENTION_FREQUENCY_S16 = 2 &
EXS_POST_INTERVENTION_DURATION_S17 = 2 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 1 |

EXS_POST_INTERVENTION_FREQUENCY_S16 = 2 &
EXS_POST_INTERVENTION_DURATION_S17 = 1 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 2 |

EXS_POST_INTERVENTION_FREQUENCY_S16 = 3 &
EXS_POST_INTERVENTION_DURATION_S17 = 1 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 1 |

EXS_POST_INTERVENTION_FREQUENCY_S16 = 3 &
EXS_POST_INTERVENTION_DURATION_S17 = 2 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 2 |

EXS_POST_INTERVENTION_FREQUENCY_S16 =1 &
EXS_POST_INTERVENTION_DURATION_S17 = 3
&EXS_POST_INTERVENTION_INTENSITY_S18 = 1 |

EXS_POST_INTERVENTION_FREQUENCY_S16 = 1 &
EXS_POST_INTERVENTION_DURATION_S17 = 2 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 2 |

EXS_POST_INTERVENTION_FREQUENCY_S16 = 1 &
EXS_POST_INTERVENTION_DURATION_S17 = 3 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 2 |

EXS_POST_INTERVENTION_FREQUENCY_S16 = 1 &
EXS_POST_INTERVENTION_DURATION_S17 = 4 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 2 |

EXS_POST_INTERVENTION_FREQUENCY_S16 = 1 &
EXS_POST_INTERVENTION_DURATION_S17 = 2 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 3 |

EXS_POST_INTERVENTION_FREQUENCY_S16 = 2 &
EXS_POST_INTERVENTION_DURATION_S17 = 2 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 2 |

EXS_POST_INTERVENTION_FREQUENCY_S16 = 3 &
EXS_POST_INTERVENTION_DURATION_S17 = 2 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 2 |

EXS_POST_INTERVENTION_FREQUENCY_S16 = 2 &
EXS_POST_INTERVENTION_DURATION_S17 = 1 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 3 |

EXS_POST_INTERVENTION_FREQUENCY_S16 = 3 &
EXS_POST_INTERVENTION_DURATION_S17 = 1 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 3 |

EXS_POST_INTERVENTION_FREQUENCY_S16 >= 4 &
EXS_POST_INTERVENTION_DURATION_S17 = 2 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 1 |

EXS_POST_INTERVENTION_FREQUENCY_S16 = 1 &
EXS_POST_INTERVENTION_DURATION_S17 = 2 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 1

*Moderate (2)

EXS_POST_INTERVENTION_FREQUENCY_S16 = 2 &
EXS_POST_INTERVENTION_DURATION_S17 = 4 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 1 |

EXS_POST_INTERVENTION_FREQUENCY_S16 = 3 &
EXS_POST_INTERVENTION_DURATION_S17 = 4 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 1 |

EXS_POST_INTERVENTION_FREQUENCY_S16 = 2 &
EXS_POST_INTERVENTION_DURATION_S17 = 4 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 2 |

EXS_POST_INTERVENTION_FREQUENCY_S16 = 3 &
EXS_POST_INTERVENTION_DURATION_S17 = 4 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 2 |

EXS_POST_INTERVENTION_FREQUENCY_S16 = 2 &
EXS_POST_INTERVENTION_DURATION_S17 = 3 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 2 |

EXS_POST_INTERVENTION_FREQUENCY_S16 = 3 &
EXS_POST_INTERVENTION_DURATION_S17 = 3 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 2 |

EXS_POST_INTERVENTION_FREQUENCY_S16 = 2 &
EXS_POST_INTERVENTION_DURATION_S17 = 4 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 2 |

EXS_POST_INTERVENTION_FREQUENCY_S16 = 3 &
EXS_POST_INTERVENTION_DURATION_S17 = 4 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 2 |

EXS_POST_INTERVENTION_FREQUENCY_S16 = 2 &
EXS_POST_INTERVENTION_DURATION_S17 = 2 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 3 |

EXS_POST_INTERVENTION_FREQUENCY_S16 = 3 &
EXS_POST_INTERVENTION_DURATION_S17 = 2 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 3 |

EXS_POST_INTERVENTION_FREQUENCY_S16 = 1 &
EXS_POST_INTERVENTION_DURATION_S17 = 3 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 3 |

EXS_POST_INTERVENTION_FREQUENCY_S16 = 1 &
EXS_POST_INTERVENTION_DURATION_S17 = 4 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 3 |

EXS_POST_INTERVENTION_FREQUENCY_S16 = 2 &
EXS_POST_INTERVENTION_DURATION_S17 = 3 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 1 |

EXS_POST_INTERVENTION_FREQUENCY_S16 = 3 &
EXS_POST_INTERVENTION_DURATION_S17 = 3 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 1 |

EXS_POST_INTERVENTION_FREQUENCY_S16 >= 4 &
EXS_POST_INTERVENTION_DURATION_S17 = 2 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 2 |

EXS_POST_INTERVENTION_FREQUENCY_S16 >= 4 &
EXS_POST_INTERVENTION_DURATION_S17 = 1 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 3

*High (3)

EXS_POST_INTERVENTION_FREQUENCY_S16 = 2 &
EXS_POST_INTERVENTION_DURATION_S17 >= 3 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 3 |

EXS_POST_INTERVENTION_FREQUENCY_S16 = 3 &
EXS_POST_INTERVENTION_DURATION_S17 >= 3 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 3 |

EXS_POST_INTERVENTION_FREQUENCY_S16 >= 4 &
EXS_POST_INTERVENTION_DURATION_S17 = 4 |

EXS_POST_INTERVENTION_FREQUENCY_S16 >= 4 &
EXS_POST_INTERVENTION_DURATION_S17 = 3 &
EXS_POST_INTERVENTION_INTENSITY_S18 >= 2 |

EXS_POST_INTERVENTION_FREQUENCY_S16 >= 4 &
EXS_POST_INTERVENTION_DURATION_S17 = 2 &
EXS_POST_INTERVENTION_INTENSITY_S18 = 3

*Moderate and High sub-groups were merged together as Moderate/High group.

Appendix V: Questionnaire for data collection

ID-nummer: ☐ ☐ ☐ ▐

FYSISK AKTIVITET OG TRENING

Statens råd for ernæring og fysisk aktivitet skiller mellom <u>fysisk aktivitet</u> og <u>trening</u>. Vennligst forhold deg til definisjonene nedenfor når du besvarer de neste spørsmålene.

<u>Fysisk aktivitet</u> defineres som "all kroppslig bevegelse produsert av skjelettmuskulatur som resulterer i en vesentlig økning i energiforbruket utover hvilenivå".

30) Sosial- og helsedirektoratet anbefaler voksne å være i fysisk aktivitet 30 minutter daglig for å oppnå helsegevinst. Oppfyller du dette daglig?

☐ Ja   ☐ Nei

<u>Trening</u> defineres som "fysisk aktivitet i fritiden som gjentas regelmessig over tid med målsetting å forbedre for eksempel form, prestasjon eller helse".

31) Trente du regelmessig siste året før du ble gravid?

☐ Ja   ☐ Nei *(gå videre til spørsmål 35)*

32) Hvis ja, hvor mange dager i uken trente du gjennomsnittlig det siste året før dette svangerskapet?

☐ 1 dag
☐ 2 dager
☐ 3 dager
☐ 4 dager
☐ 5 eller flere dager

33) Hvor lenge trente du vanligvis per økt?

☐ 0-30 min   ☐ 30-60 min   ☐ 60-90 min   ☐ >90 min

34) På hvilken intensitet trente du vanligvis?

☐ Uten å bli svett eller andpusten (oppleves litt anstrengende)
☐ Ble svett og litt andpusten (oppleves anstrengende)
☐ Ble veldig svett og pustet tungt (oppleves svært anstrengende)

35) Trener du regelmessig nå som du er gravid?

☐ Ja   ☐ Nei *(gå videre til spørsmål 39)*

36) Hvis ja, hvor mange dager i uken trener du gjennomsnittlig?

☐ 1 dag
☐ 2 dager
☐ 3 dager
☐ 4 dager
☐ 5 eller flere dager

40909

59

37) Hvor lenge trener du vanligvis per økt nå?

☐ 0-30 min   ☐ 30-60 min   ☐ 60-90 min   ☐ >90 min

38) På hvilken intensitet trener du vanligvis?

☐ Uten å bli svett eller andpusten (oppleves litt anstrengende)
☐ Blir svett og litt andpusten (oppleves anstrengende)
☐ Blir veldig svett og puster tungt (oppleves svært anstrengende)

39) Har du opprettholdt samme treningsnivå som før graviditeten?

☐ Jeg var mer aktiv før graviditeten
☐ Jeg er like aktiv som før graviditeten
☐ Jeg er mer aktiv nå enn før graviditeten

40) Hvilken form for trening bedriver du nå? *(sett ett eller flere kryss)*

☐ Spesiell gymnastikk/ aerobic for gravide   ☐ Aerobic/gymnastikk/ dans uten hopp og løp   ☐ Aerobic/gymnastikk/ dans med hopp og løp

☐ Folkedans/rock/swing   ☐ Sykling   ☐ Rask gange/turgange

☐ Løping/jogging/ orientering/skigåing   ☐ Ballspill/nettballspill   ☐ Svømming

☐ Helsestudio/styrketrening   ☐ Yoga/Pilates   ☐ Kampsport

☐ Annet:_____

41) Hvor ofte gjør du hjemmeøvelser for disse muskelgrupper?

	Aldri	1x/uke	2x/uke	3x/uke	>3x/uke
Magemuskler	☐	☐	☐	☐	☐
Ryggmuskler	☐	☐	☐	☐	☐
Bekkenbunnsmuskler (innvendig muskler rundt skjede, urinrør og endetarm)	☐	☐	☐	☐	☐

42) Hvor mange minutter bruker du hver dag på å sykle/gå/jogge til og fra arbeid?
(legg sammen tiden til og fra arbeidet)

☐ Ingen   ☐ 20-30 min   ☐ 30-60 min   ☐ >60 min

40909

ID-nummer: ☐ ☐ ☐ ■

FYSISK AKTIVITET OG TRENING

Statens råd for ernæring og fysisk aktivitet skiller mellom <u>fysisk aktivitet</u> og <u>trening</u>. Vennligst forhold deg til definisjonene nedenfor når du besvarer de neste spørsmålene.

***Fysisk aktivitet** defineres som "all kroppslig bevegelse produsert av skjelettmuskulatur som resulterer i en vesentlig økning i energiforbruket utover hvilenivå".*

14) Sosial- og helsedirektoratet anbefaler voksne å være i fysisk aktivitet 30 minutter daglig for å oppnå helsegevinst. Oppfyller du dette daglig?

☐ Ja   ☐ Nei

***Trening** defineres som "fysisk aktivitet i fritiden som gjentas regelmessig over tid med målsetting å forbedre for eksempel form, prestasjon eller helse".*

15) Trener du regelmessig nå?

☐ Ja   ☐ Nei *(gå videre til spørsmål 20)*

16) Hvis ja, hvor mange dager i uken trener du?

☐ 1 dag
☐ 2 dager
☐ 3 dager
☐ 4 dager
☐ 5 eller flere dager

17) Hvor lenge trener du vanligvis per økt?

☐ 0-30 min   ☐ 30-60 min   ☐ 60-90 min   ☐ >90 min

18) På hvilken intensitet trener du vanligvis?

☐ Uten å bli svett eller andpusten (oppleves litt anstrengende)
☐ Blir svett og litt andpusten (oppleves anstrengende)
☐ Blir veldig svett og puster tungt (oppleves svært anstrengende)

19) Hvilken form for trening bedriver du nå? *(sett ett eller flere kryss)*

☐ Spesiell gymnastikk/ aerobic for gravide   ☐ Aerobic/gymnastikk/ dans uten hopp og løp   ☐ Aerobic/gymnastikk/ dans med hopp og løp

☐ Folkedans/rock/swing   ☐ Sykling   ☐ Rask gange/turgange

☐ Løping/jogging/ orientering/skigåing   ☐ Ballspill/nettballspill   ☐ Svømming

☐ Helsestudio/styrketrening   ☐ Yoga/Pilates   ☐ Kampsport

☐ Annet:_____

7911

61