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# Lifestyle Changes for Women with Gestational Diabetes

Brooklyn Feustel Elkan
*Bethel University*

Kristen McCammon
*Bethel University*

# LIFESTYLE CHANGES FOR WOMEN WITH GESTATIONAL DIABETES

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BROOKYN F. ELKAN

KRISTEN N. MCCAMMON

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Brooklyn F. Elkan

Kristen N. McCammon

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Approvals:

Project Advisor Name: **Bernita Missal**

Project Advisor Signature: _____

Second Reader Name: **Katrina Wu**

Second Reader Signature: _____

Director of Nurse-Midwifery Program Name: Jane Wrede, PhD, APRN, CNM

Director of Nurse-Midwifery Program Signature: _____

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## Abstract

**Background/Purpose:** The purpose of this paper was to evaluate the current literature to see if there was a common thread in treatment/prevention of the progression of gestational diabetes in pregnant women.

**Theoretical Framework:** Dorthea Orem's theory, The Self-Care Deficit Theory, was the theoretical framework used in this critical review of the literature. This theory asserts that patients should be self-reliant and responsible for their healthcare. This is achieved by providers giving them options and advice based on evidence to change their lifestyle and take control. This directly relates to managing GDM, because providers can only counsel the patients on changes, but the patient has to implement the change.

**Methods:** Twenty scholarly research articles were reviewed using current John's Hopkins Research Evidence Appraisal Tool and then categorized based on an approach to finding a way to reduce the incidence of the progression of GDM A1 to GDM A2.

**Results/Findings:** The most studied methods for treatment of GDM A1 was diet and exercise. A specific diet was not found, but overall a reduction in sweets and carbohydrates with an increase in vegetables, whole grains was encouraged. There was not a specific method of exercise identified, however the common recommendation was moderate exercise for 30 minutes spread out for a total of 150 minutes a week.

**Implications for Research and Practice:** There are numerous areas that need to continue to be researched in order to control the progression and prevent GDM. Larger sample sizes are needed with multiple ethnicities to make the results more generalizable. Another area to be researched is to target gestational weight gain goals that are appropriate for women with GDM. More studies

will also improve the efficacy of the integration of these changes to increase compliance and better glycemic control.

**Keywords:** Gestational diabetes, GDM, GDM A1, GDM A2, uncontrolled gestational diabetes, uncontrolled GDM A2, diabetes in pregnancy, lifestyle modifications, nutrition in gestational diabetes, diet, exercise, alternative therapies, integration of technology with gestational diabetes, midwifery care for gestational diabetes

## Table of Contents

## Chapter I: Introduction

Gestational diabetes mellitus (GDM) is a common complication in pregnancy that has increased in prevalence nationwide and encountered daily in obstetrical care. GDM is defined as impaired glucose intolerance due to pancreatic ß-cell dysfunction, which means these patients have an underlying chronic insulin resistance that pregnancy makes more prevalent (Plows, Stanley, Baker, Reynolds, & Vickers, 2018). GDM is diagnosed during pregnancy with routine laboratory screening, usually between 24-28 weeks' gestation unless there are high risk factors and it is tested with the initial pregnancy labs (Harrison et al., 2016). Adequate control of GDM is acquired when patients are able to achieve euglycemia (blood sugars in a normal range). When controlled without medications by diet and lifestyle changes, it is referred to as diet-controlled diabetes or GDM A1. If GDM is not able to be managed with these changes, medications are introduced, and it is referred to as GDM A2 (ACOG, 2018). The rates of type 2 diabetes in the United States have tripled in the last three decades and it is estimated that currently approximately 28 million people in the United States have diabetes (Shellhaas et al., 2019). As of 2009, the incidence of GDM was approximately 7% in the United States (ACOG, 2018).

The presence of GDM does not just have an effect during the pregnancy but can have long-term health effects as well. With poorly controlled GDM there can be a significant increase in negative outcomes for the mother and the child. The long-term effects for the mother include a 35-50% increased risk of reoccurrence of GDM and a seven-fold increase of developing type 2 diabetes mellitus later in life (Harrison et al., 2016). Women who have had GDM have a 50-70% chance of developing type 2 diabetes mellitus later in life, which makes it imperative to help control the progression of the disease and decrease the occurrence for the future health of these women (Shellhaas et al., 2019). GDM increases the chances of macrosomia (fetal weight at birth

over 4,000 grams) and birth complications (Plows et al., 2018). Children that are born from mothers with GDM not only have an increased risk for developing type 2 diabetes in their lifetime, but this also an increased risk for cardiovascular disease and leukemia (Harrison et al., 2016). Midwives and women's health care providers alike need to be informed of the best practice guidelines and education available to help control and possibly prevent the development of GDM to protect the health of mothers and their children.

As a society, if one can increase education, compliance, and management of GDM then the risk of both short-term and long-term health complications for the mother and child can be reduced. One way of doing this can include increasing education and bringing up the potential of a GDM diagnosis during first trimester antepartum visits. Early discussion and intervention could help drastically decrease the development of the disease, as well as increase compliance and management when diagnosed. This PICO question aims to demonstrate that there could be a reduction of gestational diabetes with lifestyle interventions in pregnancy and decrease the progression of GDM A1 to GDM A2. Moreover, the question remains, can it be demonstrated that women from various ethnicities and/or family history backgrounds, who implement physical activity and lifestyle changes into their lives early in pregnancy decrease their rates of gestational diabetes and prevent the diagnosis of GDM or need for medicinal intervention? This paper will address this PICO question and provide a critical review of the literature to identify if lifestyle modifications in pregnant women that are diagnosed with GDM can help in the control of GDM and decrease the progression to GDM A2

**Statement of Purpose**

The purpose of this paper is to critically examine scholarly writings and research to distinguish if those diagnosed with GDM can have a reduction in the progression from GDM A1

to GDM A2, as well as a reduction in delivery complications. The areas of focus will be on diet modifications, social contributors, weight gain, and exercise, both before and during the pregnancy. Further research and examination of these modifications will help to identify the most substantial changes needed to implement into the education given to women in preconception counseling, new obstetric care, and at the time of diagnosis in order to improve the control of their diabetes, as well as long term health for the mother and their child.

**Evidence Demonstrating Need**

Worldwide prevalence of the population's health is declining due to obesity and poor health (Diabetes, 2020). Obesity and poor health are risk factors for the development of type 2 diabetes and GDM. It is estimated that by 2030 type 2 diabetes will affect almost half a billion people worldwide (Koivusalo et al., 2016). Women who have GDM have a 10% chance of developing type 2 diabetes soon after delivery and a 70% chance of developing type 2 diabetes within 10 years after delivery (Koivusalo et al., 2016). It would be expected that with the ongoing preference or necessity of a fast-paced lifestyle in most cultures, the increased need for convenience in food choices and lack of time for self-care, the rates of GDM will continue to inflate as those factors have been correlated with GDM and the continued rise of type 2 diabetes. Therefore, understanding ways to help increase social awareness of the impact of those lifestyle choices could prevent GDM and is crucial to the health of women and newborns worldwide as it could help to establish new practice guidelines for health care. Health care providers have the responsibility to provide adequate and functional interventions in order to create a healthier and safer environment for women and their pregnancy. Providers also have the moral responsibility of providing the best care and education for their patients. Women who develop GDM not only have risks of having macrosomia, but GDM also leads to an increased risk for a cesarean

delivery and/or shoulder dystocia (Lefkovits et al., 2019). This diagnosis can also have an increased risk of preeclampsia, GDM in future pregnancies, and developing type 2 diabetes later in life compared to women who do not develop GDM (ACOG, 2018). Babies of mothers with GDM have risks of macrosomia, neonatal hypoglycemia, shoulder dystocia, birth trauma, bone fracture, nerve palsy, hyperbilirubinemia, and stillbirth (Lefkovits et al., 2019).

Costs of treating and managing GDM continue to climb as the occurrence of the condition rises. In 2007, it was estimated that 180,000 babies born to mothers with GDM increased medical costs by 636 million dollars (Dall et al., 2014). When women are diagnosed with GDM they utilize more health care access during prenatal care, delivery, and postpartum which leads to an increased expenditure of healthcare funds. An increased rate in cesarean deliveries', adverse pregnancy complications, and effects on the newborns leads to longer hospitalization; therefore, increasing healthcare expenditure. During prenatal care, patients with GDM are also more susceptible to health conditions such as urinary tract infections, increased rates of preeclampsia, and complications of elevated blood sugars (Dall et al., 2014). Additionally, they have more visits to monitor the health of the baby leading to an increase in cost of their care (Dall et al., 2014). The national cost of healthcare related to GDM in 2012 was 1.3 billion dollars, averaging 5800 U.S. dollars per case of GDM (Dall et al., 2014). Therefore, as the rates of GDM increase, the national financial burden increases as well. Conclusively, increasing research and education into prevention of GDM could in the long term lower the healthcare costs for women with GDM.

There have been numerous randomized controlled trials examining exercise and other lifestyle interventions and how they affect the control of type 2 diabetes in adults, but studies are scarce on these interventions in GDM (ACOG, 2018). Limited research and conclusions to the

best interventions for lifestyle management in GDM necessitates a critical review of the available literature to identify areas of need for continued study to understand the most appropriate actions to decrease the rates of GDM. Additionally, ongoing critical review of literature and research in this area could help to develop safe and effective interventions that can be offered to women throughout the prenatal period to improve pregnancy outcomes and overall health.

**Significance to Nurse-Midwifery**

The philosophy of care of the American College of Nurse-Midwives (ACNM) stated that midwives are to affirm the power and strength of women as well as the importance of their health and wellbeing of their families (ACNM, 2012). This statement reiterated that nurse-midwives are essential in promoting health habits and educating women on reducing the risks of adverse effects for them and their babies. Midwifery practice should give the most accurate information on prevention and management of GDM. One of the hallmarks for midwifery is to promote continuity of care, as well as health promotion, disease prevention, and health education (ACNM, 2012). Research into GDM and lifestyle interventions and prevention of GDM, can also decrease the progression of GDM to GDM A2 that relates directly to this hallmark of midwifery.

Continuing to be informed on the latest standards of practice is crucial to midwifery care. By doing a critical review of the evidence and research into GDM treatment midwives will be able to better implement changes to make a difference. Reviewing the literature and research on diet modifications, social contributors, weight gain, and exercise and the way that they influence GDM and the progression will help contribute to more precise education backed by evidence. A

better understanding of management and prevention of GDM by lifestyle modifications will also decrease health care funds being spent on GDM and type 2 diabetes.

Lifestyle changes that can be implemented into the lives of these women and their families can be simple and sustainable. It seems that with a few interventions in one's daily life, midwives will not only change the lives of their patients but family members as well, increasing the overall health of society. Midwifery care is known to be associated with a holistic approach to wellness and overall health, it's important to consider lifestyle interventions to prevent the progression of GDM, and to requiring medication or with the likelihood of GDM A1 progressing to GDM A2 patients may no longer be able to receive midwifery care and be transferred to a physician; another compelling argument for continuing research in this area and reduce the level of medical intervention needed.

**Theoretical Framework**

The Self-Care Deficit Theory by Orem directly relates to the discussion of managing glucose with lifestyle modifications as it encourages educating women on GDM and the effects of diet and exercise. In following this approach, the clinician is expected to provide their patients with knowledge about potential health problems to prevent-future conditions and improve their overall self-care. This theory asserts that patients should be self-reliant and responsible for their health care and by giving them the evidence or options to change their lifestyle; the clinician is offering more responsibility to the patient to take control. This approach thereby helps reduce the risk of a prevalent medical condition such as GDM at an early onset. In Orem's theory, there are six major assumptions; people should be responsible for their care, people are distinct individuals, nursing is a form of action, successfully meeting universal and developmental needs are important in prevention and health, a person's knowledge of potential

health problems are needed to promote self-care, and self/dependent care are learned behaviors (Nursing Theory, 2016). Orem's model suggested that nursing is required when the individual is not able to provide continuous effective self-care and then identified five methods of helping. These are: acting for and doing for others, guiding others, supporting another, providing an environment to promote personal development, and teaching another (Nursing Theory, 2016). Thus, the clinician's role can be to advocate for patients when their learned self-care behaviors are no longer effective or may relate to a medical condition such as gestational diabetes. By increasing education and preventative factors, patients can recognize the signs earlier in the stages of diagnosis that indicates they have a potential health problem or how to reduce risk of further symptoms and impact.

Incorporating Orem's theory into nursing is broken down into three parts; the assessment, diagnosis, and then implementation and finally evaluation (Orem, 2001). Basic conditioning factors are internal or external elements that can directly affect the individual's ability to engage in self-care that is required (Gatlin & Insel 2015). Orem inferred that people who already demonstrate their own self-care have the acquired ability to meet the requirements for self-care in changing and complex situations (Orem, 2001). Breaking down Orem's theory into this PICO question, in pregnant women who are diagnosed with GDM, what is the difference in progression from GDM A1 to GDM A2 and delivery complications between those who manage glucose with lifestyle modifications prior to and at the time of diagnosis and those who do not manage glucose with lifestyle modifications? One could apply that the therapeutic self-care demand would be the awareness of potential problems and adherence to a new activity regimen. If the patient had not incorporated activity into their lives prior to pregnancy, they could be thought to have an inadequate self-care agency. The provider would then apply the theory and

teach the patient how to incorporate activity changes and the potential benefits that it could have on their pregnancy and decreasing the risk for gestational diabetes.

Gestational diabetes is common but can be controlled and prevented. This diagnosis can be managed with self-care and added medications. Increasing knowledge of the components that can decrease the risks and control the diagnosis is an important concept to teach women. In response to a gestational diabetes diagnosis, women need to be held accountable for their well-being along with the health of their baby when diagnosed with this condition. Therefore, incorporating the Self-Care Deficit theory into education and prevention of gestational diabetes allows their care providers to empower them with the information that they need to take charge of their health and minimize risk to their personal health and their infant. Women taking responsibility for their gestational diabetes and clinician's using the self-care deficit theory can help them potentially avoid the risk or development of gestational diabetes. Additionally, increased knowledge to patients can spread through peer influences and the effect can have a significant impact on society. Women who might not seek medical services or receive the education could potentially hear from a friend, family member, or peer about the health information and recognize their own medical condition, seeking help and treatment when they otherwise would not have been reached. This accurate health information regarding self-care and prevention can spread from person-to-person, increasing the overall wellness as a society to perpetuate a future of improved self-care.

## Summary

Gestational diabetes is increasing in society and can lead to negative impacts for the mother and child not only during pregnancy, but later in life. In order to improve the overall health of women in society it is imperative that risks for developing the condition are decreased.

A decrease in the risk factors could help prevent this condition, therefore decreasing negative outcomes for mothers and their babies. This evidence from the research does not just impact midwives, but OB/GYNs and primary care providers who are have a role in implementing these changes. Lifestyle changes were also identified to have a tremendous impact on the progression of GDM and the health of patients. The methods that were utilized to search for research and appraise scholarly studies and writings for lifestyle changes in GDM will be explained in chapter two. The third chapter will discuss the findings in the articles with their strengths and limitations in the research along with recommended implementations into midwifery care and obstetric practices. The final chapter will provide a synthesis of the studies reviewed and identify gaps found in the literature along with recommendations for future research.

# Chapter II: Methods

The purpose of this chapter is to outline the methods used to accumulate scholarly literature in order to determine the effectiveness of alternative therapies in directly treating and preventing the worsening of gestational diabetes. Several databases and the recommendation of a professional peer were utilized. Overall, 1,392 articles were reviewed as represented on the database; through exclusion within titles and content, 20 articles met the inclusion criteria and were utilized in this literature review.

## Search Strategies

The literature review started with a list of resources provided by a peer-certified nurse-midwife (CNM) who was also conducting a literature review related to gestational diabetes. Her sources were from CINAHL and PubMed search engines. The 44 articles were reviewed and those that were too old to be relevant (anything older than five years) were eliminated. In addition, any meta-analysis, Cochrane or literature reviews, that were not accessible because of cost and resources available were also eliminated. This left seven articles. The reference lists from these seven articles were reviewed for additional relevant sources which resulted in eight more studies that met inclusion criteria for a total of fifteen articles.

Next, a search utilizing the Bethel University Online Library was performed using the following key terms: gestational diabetes, management, and lifestyle intervention. These key terms were added together as inclusion criteria and individual searches on these topics resulted in too large of a sample size. Then, articles were limited to those that were peer reviewed, available in English, and written within the last two years. This resulted in 1,932 articles. From this grouping of articles, they were further eliminated based on the titles, irrelevant content, studies

with very small sample sizes, Cochrane or other literature review and any meta-analysis. This left 20 articles as noted in the matrix.

**Criteria for Inclusion and Exclusion of Research Studies**

The research for this study started in 2019. The articles included from the original resources were limited to a five-year range from the origination of the research, despite continuing the project into 2020. The 20 articles that remained were from the years 2014 – 2018. There is one article outside the requirement from 2011, but it was relevant to the overall study and was determined appropriate to include in the literature review. Titles were initially reviewed to eliminate non-pertinent articles. Examples of titles that were automatically ruled out had the use of medicine for GDM control, the impact or emotional toll on a person with gestational diabetes, and childhood diabetes. The focus was on lifestyle modifications that focused on exercise, diet, peer support, phone applications or other digital advances for the treatment and prevention of GDM. Abstracts were then reviewed, and further eliminations were made due to the small sample size, unrelated content, inconclusive findings and other factors such as poor study quality and/or design.

**Summary of Selected Studies**

The 20 articles included in this study were then broken down and studied resulting in a retrospective observational study, a cross sectional study, a sociological design study, an observational study, a mixed method design study, an experimental study, and fourteen randomized controlled studies. Research locations were worldwide including the United States (four), Finland (three), Australia (three), China (two), Israel (one), France (one), Spain (one), Switzerland (one), England (one), India (one), Iran (one) and one large study that covered 10 areas in Europe. Since GDM is increasing worldwide, it was determined and was represented in

the articles, and several approaches from around the world that different approaches should be considered when trying to find a solution (Wang et al., 2017).

**Evaluation Criteria**

The Johns Hopkins Research Evidence Appraisal Tool was utilized to then breakdown the remaining articles (Dang & Dearholt, 2018). The articles were categorized into appraisal categories of qualitative, quantitative, and mixed methods. Quantitative studies have numerical data, qualitative studies have narrative data, and mixed methods have a combination of both types of data. Then, studies were evaluated on their level of evidence based on what type of studies were performed, level I – IV. This resulted in 17 level I studies, two level II studies, and one level III study. Level I studies are randomized controlled trials (RCTs), experimental studies, and systematic reviews of RCTs with or without meta-analysis. Level II studies are quasi-experimental studies, systematic review of a combination of RCTs, quasi-experimental studies, and quasi-experimental studies with or without meta-analysis. Level III studies are non-experimental studies, systematic review of combination of RCTs, quasi-experimental and non-experimental studies, and non-experimental with or without meta-analysis. Lastly, they were graded on their strength and quality: A/High, B/Good, or C/Low. There was one study with a A/High rating, and the remaining 19 were B/Good quality. Most studies had good design, but small sample sizes were challenging to evaluate as they could not easily be translated to a larger audience. A high-quality study has generalizable results and requires an adequate sample size to evoke statistical relevance, consistent data, and contains a literature review to substantiate the reasoning for the study. It is rare that a single study can achieve this rating and limited the literature review available.

## Summary

In the research process, twenty articles were selected for inclusion for the literature review. Sources were from professional colleagues as well as search engines such as PubMed, CINAHL, and the Bethel University Online Library. Specific inclusion and exclusion criteria were set for both researchers to pare down the large amount of research available. The remaining twenty articles ranged from 2014 – 2018, with one article from 2011. Both researchers used the same Johns Hopkins Research Evidence Appraisal Tool for evaluating the research in order to compile the set of articles that remained. Overall, the majority of the articles (85%) were level I articles with a B/Good rating (95%). These articles were determined as comprehensive representations of the current literature and provided a worldwide view of alternative therapies being tested to reduce the incidence and progression of GDM along with promoting the health of both the mother and the infant through alternative therapies.

## Chapter III: Literature Review and Analysis

In this chapter, the scholarly articles and their studies are broken down by their findings and results. The articles were grouped into alike categories and contrasted with one another to identify commonalities which decrease the incidence of GDM occurring and GDM progressing to GDM A2. The most successful factor remained to be diet and exercise, but the form and how much support given varied greatly without one result standing out more than the others.

### Synthesis of Matrix

The matrix included fifteen randomized controlled studies, one cross sectional study, one mixed methods design, one observational study, one retrospective observational study, and one sociological design study. The level of evidence and quality of each research study were appraised using the Johns Hopkins Research Evidence Appraisal Tool (Dang & Dearholt, 2018). The matrix includes the purpose of the study, descriptions of the samples and settings used, design including the methods and instruments used, results of the study, conclusion, strengths and limitations, as well as the Johns Hopkins evidence appraisal rating, strength, and quality. The matrix is displayed in alphabetical order.

### Synthesis of Major Findings

Of the 20 scholarly articles reviewed, there are several approaches to finding lifestyle modifications in pregnant women who are diagnosed with GDM and decreasing the progression from GDM A1 to GDM A2. All of the studies incorporated some sort of diet and/or exercise routine as part of the routine pre-natal care; but did not study the effectiveness of that treatment. Three studies looked specifically at diet and exercise (Han et al., 2016; Koivusalo et al., 2015; Wang et al., 2015) and two introduced the intervention in the first trimester of pregnancy (Koivusalo et al., 2015; Wang et al., 2015), before the diagnosis of GDM was concluded. Four

studies in this critical review looked at how physical exercise alone specifically affected the progression of GDM (Anjana et al., 2016; Cordero et al., 2015; Halse et al., 2014, Wang et al., 2017). Five studies tried to better understand the social factors affecting why women were developing GDM and/or how it affected their emotional status during their pregnancy (Colicchia et al., 2016; Engberg et al., 2018; Horsch et al., 2016; Jarvie, 2017; Singh et al., 2018). Two studies looked at the use of integrated technology and how it could encourage women to follow the routine interventions suggested (Miremberg et al., 2018; Rasekaba et al., 2018). Another two studies addressed gestational weight gain (GWG) specifically to see if weight gain could be quantified to correlation with the progression of GDM (Aiken et al., 2018; Simmons et al., 2018).The remaining four studies looked at alternative therapies, including self-reporting of home testing (Cosson et al., 2017), integration of vitamins and probiotics (Jamilian et al., 2018), individual counseling (Luoto et al., 2011), and 1:1 group care for those with GDM (Mazzoni et al., 2015). The following section will review those studies and their conclusions.

**Treatment of Diabetes Type II and Gestational Diabetes**

Diet and exercise have been known for a long time as an important factor in treating diabetes mellitus type II in non-pregnant women (Wexler, 2020), so it is not surprising that diet and exercise were included in the majority of studies as routine treatment. The main goal of better nutrition and exercise is weight loss and better glycemic control within the body, thus reducing the fluctuation of insulin needs throughout the day. As one will see with the results in pregnancy, most patients with diabetes type II have a difficult time losing large amounts of weight and instead try to maintain their weight (Wexler, 2020). However, a complex 4,413-person study found that dietary adjustments alone can control fasting glucose to a normal level in women with gestational diabetes and reduce their chances of developing diabetes mellitus type II

later in life (Tobias et al., 2012). As with several of the studies reviewed for GDM, diabetes type II patients are recommended to include 150 hours of moderate exercise per week (Koivusalo et al., 2015; Engberg et al., 2018; Wexler, 2020).

***Diet and exercise.*** Two of the studies reviewed were quantitative studies with a Level I strength and a quality of B/good rating. They targeted high risk patients for developing GDM and started their intervention at 6 (Wang et al., 2015) and 13.3 weeks gestation (Koivusalo et al., 2015). Both studies excluded women with pre-existing diabetes. Koviusalo et al. (2015) tested using an early oral glucose tolerance testing (OGTT) and Wang, Ma, and Yang (2015) used fasting plasma glucose (FPG) in the patients noted as high risk to rule out undiagnosed diabetes mellitus type 2. This practice is recommended by the American College of Obstetrics and Gynecology (ACOG, 2018). These studies were conducted in Finland (Koivusalo et al., 2015) and China (Wang et al., 2015). Risk factors used for inclusion in these studies were a history of polycystic ovarian syndrome (PCOS), GDM in a previous pregnancy, a BMI (body max index) greater than 25-30 k/㎡, advanced maternal age (over 35 years old at time of delivery), macrosomia in a previous pregnancy, and family history of diabetes mellitus (Wang et al., 2015).

The results of these two studies varied. Koivusalo et al. showed a 39% reduction in the progression of GDM in patients with at least a history of GDM in the past or a BMI ≥ 30 k/㎡ (2015). In this study, women were given group counseling with a dietician and individualized visits with the study nurse at 13.3 weeks gestation, 23.1 weeks gestation, and 35.1 weeks gestation. They were encouraged to maintain moderate exercise for 150 minutes a week and given free access to a pool and exercise groups (Koivusalo et al., 2015). Although the outcome of this study is very promising, it had a small sample size of 269 Finnish women. In addition, Finland has socialized medicine, which offers free healthcare including access to health

facilities/programs. Reproducing these results in the United States may prove to be difficult as the cost of healthcare services individually ranges and can be costly for both participants in a study along with the research design; requiring significant funding to complete.

Wang, Ma, and Yang (2015) did not find that their study proved any statistical significance. This article was also a quantitative study evaluated at Level I strength and a quality of B/good rating. The participants were given courses on nutrition, physical activity, and weight gain by a physician in groups of five women or less. They also saw nutritional counselors who suggested diet and proper weight gain at 12-13 weeks gestation. Then participants resumed routine prenatal care. At 24-28 weeks, the women were given an OGTT (oral glucose tolerance test) per the International Association of Diabetes and Pregnancy Study Groups (IADPSG) recommendation. Both the control group and the intervention group had equal representation of their prior medical history and risk factors. Ultimately 17.16% (23/134) of the intervention group was diagnosed with GDM, whereas the control group had an incidence of 23.91% (33/138). In this $P = 0.168$, which did not meet the standards of statistical significance of $P < 0.05$ (Wang et al., 2015). Less weight gain was also noted, but not at statistical significance. Although this study had a small sample size it was a level I article with good quality. The researchers only provided extra intervention at one point during their pregnancy and provided no further re-education.

Halse, Wallman, Newnham, and Guelfi (2014) took a different approach and looked at women who were already diagnosed with borderline GDM in Australia and how a booklet with information and a way to record diet and exercise affect adherence to the recommendations determined for them. Once diagnosed, the participants were given booklets to assist in tracking their progress with their diet and exercise habits. These were reviewed at each prenatal visit and goals for weight gain/loss and amount of exercise were adjusted on a monthly basis. Over the

course of the program, women went from using the booklet at a rate of 92.9% (52/56) once diagnosed to 78.6% (44/56) at the end of the pregnancy (Halse et al., 2014). After using the booklet for one month, 86.4% of the women achieved their exercise goals. Only 25% of those were met by walking and 80% of them were also achieving their overall goals but only 20-30% by including more vegetables and avoiding foods high in sugar, fat, or salt. Additionally, the research demonstrated that a significant factor in diet changes that improved their health was related to participants choosing better grains and dairy products (Halse et al., 2014). The women who reported success in having a moderately active lifestyle already demonstrated similar choices and were not making any changes which consequently, continued to present positive health outcomes. Despite this uptick in adherence to the program by the third trimester, women experienced less success with the program. Halse et al, (2014) did not provide data on whether the booklet had any effect on women who progressed beyond the diagnosis of borderline GDM to requiring interventions with medicine for GDM II.

***Physical exercise.*** All four of the studies chosen for review that focused solely on physical activity were quantitative studies with level I strength and a quality rating of B/good. They covered a wide variety of countries such as Australia (Halse et al., 2014), China (Wang et al., 2017), India (Anjana et al., 2016), and Spain (Cordero et al., 2015). All the studies also included education about proper diet as part of their routine prenatal care, except Wang et al., which was also the only article that specifically targeted overweight/obese individuals ($24 \leq 28$ k/㎡). Overall, the conclusions showed that the lower the activity level, the higher the incidence of GDM (Wang et al., 2017; Anjana et al., 2016; Cordero et al., 2015) and poorer glycemic control once already diagnosed with GDM (Halse et al., 2014).

The types of exercise varied from study to study. The most successful exercise was introduced at 10-12 weeks' gestation and was a mix of aerobic, stretching, and pelvic floor work twice weekly and water aerobics and stretching once a week (Cordero et al., 2015). All exercise routines were monitored by a fitness specialist and an obstetrician which proved to have a success rate of reducing GDM risk factors by 90% as evidenced by only 1% (1/100) of the intervention group developing GDM and 8.8% (13/146) of the control group developing GDM (Cordero et al., 2015). Wang et al. also introduced their cycling exercise program before 13 weeks' gestation and supervised the activity, but only offered it to high risk pregnant women. They had a success rate of a 45.8% reduction of diagnosis of GDM (2017). Anjana, et al. simply encouraged women to increase their activity by walking more and gave them all pedometers to monitor their activity (2016). They showed that there was an increase in activity once the women were exercising and had awareness that their activity level was being monitored. Of those diagnosed with GDM, 86.2% were sedentary (Anjana et al., 2016). Overall, these studies showed that higher activity levels can reduce the incidence of diagnosis of GDM and that the type of activity can be different, but the highest success is with monitored, free exercise.

The last study by Halse, Wallman, Newnham, and Guelfi looked at introducing home-based exercise once the patient was diagnosed with GDM (2014). They received a home visit to assess their activity level and what they could increase. Household work as well as job requirements were considered when evaluating current exercise level as well as participation in sports and regular exercise. Participants in the intervention group were encouraged to do at least five home based cycling exercises every week till they were 34 weeks' gestation. All groups had ongoing counseling with a diabetes educator and nutritionist (Halse et al., 2014). There was a noticeable decrease in the postprandial blood glucose numbers for the intervention group, but

only slightly better fasting blood glucose number, and no overall change in A1C levels or insulin response (Halse et al., 2014). This study was only done on 40 women in Australia and was not a large enough sample to justify the results to a larger population. Although the postprandial result is important in showing tight glycemic control, the fasting result is also valuable and was not achieved in this study (ACOG, 2018).

***Gestational weight gain.*** Higher weight gain during pregnancy has been linked to an increased risk of developing GDM (Hedderson et al., 2010). The overall weight gain recommended during pregnancy (gestational weight gain) is based on the BMI of the women in pre-pregnancy, which is adversely affected in that the higher the weight the lower the recommendation and if the person is underweight the recommended weight gain is higher (Centers for Disease Control and Prevention, 2019). The two studies that specifically looked at gestational weight gain and its relation to GDM were both quantitative studies with level I strength and quality rating of B/good. These studies took pace over ten European centers (Simmons et al., 2018) and in the United States (Aiken et al., 2018).

Simmons et al. (2018) looked at how exactly gestational weight gain affected the rate of GDM diagnosis. It was a large randomized controlled study with post hoc analysis. This study addressed women who either did not gain enough weight or gain more than recommended. Then, the study introduced either the DALI intervention of lifestyle changes and introduction of Vitamin D, or just healthy eating and physical activity. This intervention was used to determine which intervention would bring more women to their target weight. It was found that women who had the greatest weight gain early in pregnancy were smokers and had never given birth before (Simmons et al., 2018). Those with the highest amount of weight gain between 24-28 weeks' gestation had the lowest fasting glucose. If their weight gain was even further delayed to

35-37 weeks' gestation then they had not only low fasting glucose numbers, but low one-hour and two-hour postprandial glucose levels. Therefore, the later in gestation the weight gain the less incidence of diagnosing GDM; however, the numbers were not significant enough to quantify that the lower the overall gestational weight gain, the lower the incidence of GDM (Simmons et al., 2018). There was a direct correlation noted that the lower the gestational weight gain, the lower the incidence of large for gestational age (LGA) babies being born from those mothers.

Aiken, Hone, Murphy, and Meek (2018) specifically studied how the weight gain in either early gestation, classified as 0-28 weeks, or late gestational weight gain (28-36 weeks') related to both maternal and fetal outcomes. This was a retrospective observational study. Overall higher gestational weight gain was also associated with a higher risk of a cesarean section and higher fetal weight at time of delivery. Early gestational weight gain was associated with the incidence of developing GDM, just as in the Simmons, et al. study. However, the 205 person Simmons et al. study (2018) determined that lifestyle intervention after the second trimester was not enough to elicit a positive response in change and the 546 person study by Aiken, Hone, Murphy, and Meek (2018) showed that controlled late gestational weight gain should be a priority to improve outcomes for both the mother and infant. Together these studies show that the earlier the gestational weight gain, the higher the risk for GDM, and the earlier lifestyle interventions can be introduced the better the outcome, but they should be encouraged even late in gestation.

***Social factors.*** The United States has a population of many different religions, ethnicities, and beliefs, there are many different social factors that can affect women with GDM. Social factors have been shown to have an impact on how people deal with stress and emotions, which

consequently affects their physical and emotional health along with their ability to implement effective coping skills. This review included five studies of good quality that investigated the impact of psychological stress and the stress response on the following areas: glucose concentrations, individualized counseling on diet, physical activity, weight management, diet modifications with social support and sweet success program, as well as to determine how women with GDM perceive their treatment.

In a quantitative level I study by Collicchia et al. (2016), the researchers had the purpose of evaluating the association of social factors to the control of glucose in GDM patients. Participants for the study were recruited from high risk clinics and maternal fetal medicine clinics from the University of Pittsburg Medical Center. Surveys were administered to 111 women to collect data after diagnosis and then again at 4-12 weeks after treatment was started. Of the 111 women only 97 completed the follow up questionnaire. These surveys were done by telephone, email, mail, or in person. The data from these surveys determined that 76.5% of women achieved glycemic control. In these women, 44.6 % were treated with dietary modifications, 40.9% received glyburide, and 14.6 % were using insulin for control. In weekly glucose logs that were given to the clinics, there was an average of 17.3% missing values on those logs. In those with good glycemic control, the number of missing values were lower at 12.7% and higher, 32.7%, in those with poor control ($p<.001$). Women with better glycemic control had a lower baseline BMI, lower fasting values on glucose tolerance testing, more likely to be married ($p= .004$) and have a higher household income ($p=.041$). These women were also less likely to have public insurance ($p=.012$), have a history of depression or anxiety $p= .015$), and exercise three or more times a week ($p= .002$). Collicchia et al. (2016) concluded that chaotic lifestyles, marital status, use of government assistance, and exercise were all associated

with poor glycemic control. After reviewing the modified shortened social support scale score, there was no correlation with a P value of 0.817. When women have a chaotic lifestyle, it was shown that they have difficulty adhering to GDM care and lifestyle changes to control their capillary blood glucose. This pattern was determined to lead to poor control and potential adverse outcomes for mother and the child. Social factors were also significantly correlated to have an influence glycemic control and could be modifiable in order to improve glucose control. Married women and women with a higher household income were shown to have better glycemic control (Collicchia et al., 2016). Women with a history of depression or anxiety as well as those on public insurance were more likely to have poorer glycemic control (Collicchia et al., 2016). There was no association between social support and glycemic control in this study (Collicchia et al., 2016).

Engberg et al. (2018) used a randomized control trial with 266 participants to examine the effects of a lifestyle intervention on self-rated health in participants at high risk for GDM from pregnancy to twelve months postpartum. Data was collected over six years in a maternity hospital in Finland. Participants in the intervention group (n=144) got individualized counseling on diet, physical activity, and weight management from trained staff during each trimester of pregnancy as well as six weeks, six months, and twelve months postpartum. Participants were counseled with recommendations from Nordic Nutrition that optimizes consumptions of fruits, vegetables, berries, and whole grains while lowering the intake of sugar-rich foods. They were also given a physical activity goal of 150 minutes of moderate intensity activity each week. Self-rated health surveys were self-administered for data collection. From the first trimester until the end of the study at 12 months postpartum, self-rated health varied over time ($p<0.001$). Self-rated health achieved higher scores in the intervention group (good 37%, quite good 49%) versus

the control group (good 27%, quite good 41%), but this data did not reach statistical significance. In this study there was no evidence that the intervention improved the self-rated health scores.

Investigating how the impact of stress exposure, psychological stress responses, and physiological stress response on the glucose concentrations during pregnancy was the cross-sectional study approach that Horsch et al. (2016) completed. They approached women in the waiting room during their routine appointment at a Swiss University hospital. In this study, 203 women chose to participate in this study and completed routine GDM screening at 24-30 weeks per the guidelines of the International Association of Diabetes, ADA, and the Endocrine Society. They were asked if they have been exposed to negative pregnancy related major events and negative pregnancy unrelated events. Of these women, 39 (19.2%) were diagnosed with GDM. Those that were diagnosed were significantly older ($p=.002$), had a higher pre pregnancy BMI ($p=.006$), and had a higher current BMI ($p=.008$) when compared with those not diagnosed with GDM. Positive associations that worsened fasting glucose were found between the number of pregnancy related major life events and fasting glucose ($p=0.26$), but there was no association with pregnancy unrelated major life events ($p>.22$). Fasting glucose levels were higher in women who had more anxiety and depressive symptoms or a higher level of general distress ($p<.030$) and shorter duration of sleep ($p=.009$). This study proved that physiological stress responses were not associated with glucose concentrations ($p>.05$). Horsch et al. (2016) showed that there are indicators of stress exposure and psychological stress responses that are associated with fasting glucose concentrations and that stress exposure and current stress levels are an important risk factor for GDM development.

Moreover, it's important to acknowledge the impact of how women feel about their GDM treatment and the diagnosis of GDM as this has been indicated as an important social factor in

the treatment and prevention of GDM. Jarvie (2017) aimed to address this variable in a level I sociological design study with a sample of 27 women. These women were chosen from two hospitals in the South West of England. Women were surveyed using narrative interviews during pregnancy and post birth. Jarvie (2017) found that patients with GDM tend to have more accumulative stressors as well as daily stressors, which lead to lower self-esteem. This highlights that women dealing with this diagnosis tend to have higher stress levels that they are attempting to manage along with the perceived judgment or societal prejudices, often causing additional stress and an impact on their mental health. This judgment could seemingly cause women to feel like the general public as well as the healthcare team has stigmatized them due to their weight and diagnosis as the study correlated that mentioning weight gain increased the amount of stigma these women reported. Another primary concern that was brought forth during this study were the financial concerns, as finances were a barrier to buying the proper food to control weight gain and manage euglycemia.

Knowing the effect of managed GDM on perinatal outcomes and the experiences these women have is important in guiding treatment and care. Singh et al. (2018) used a mixed-method design to evaluate the outcomes of women who were enrolled in the Sweet Success program in California. This study was split into two phases, the first consisting of 564 women and the second of 29 women from phase one who agreed to participate further. Instruments that were used to collect data were semi-structured interviews. Singh et al. (2018) found that Hispanic women were the most likely to have a cesarean delivery (45.3%) and utilize the emergency department (15%), whereas Southeast and East Asian women were the least likely (4.9%). Not only did ethnicity play a role in cesarean rates, but maternal age and obesity were also shown to be contributing factors. In the interviews, many women reported that with the

diagnosis of GDM they felt like a failure and did not routinely check their capillary blood glucose levels due to being busy and overwhelmed. Women reported that they felt that the healthcare team should be doing a better job of not only providing them with support but connecting them with other patients in similar situations.

***Integrating technology.*** Two studies in this review, Miremberg et al. and Rasekaba et al. evaluated the effectiveness of glycemic control and the impact that different methods have on compliance as well as the pregnancy outcomes. These studies each used a different method to encourage tighter glycemic control. When asking women to manage their blood sugars and report capillary blood glucose levels, providers are relying on the patients to report accurate numbers to the office from their glucometer. This is an important factor in addressing GDM as a woman's glucose during pregnancy is the only way to make an accurate conclusion if their diabetes is controlled by diet alone or if medications are needed to keep the readings in range.

In the level I, high quality randomized controlled trial by Miremberg et al. (2018), 120 English and Hebrew speaking and reading women that were newly diagnosed with gestational diabetes at less than thirty-four weeks gestational age were enrolled in a study where sixty of them received a smartphone application to help with tracking their readings. The control group (n= 60) had a 66% compliance rate of tracking capillary blood glucose while the smartphone app group (n=60) had a higher rate compliance at 84%. Insulin use also ended up being lower in the smartphone app group, 8 versus 18 patients in the control group. Daily feedback and communication between patients and their multidisciplinary diabetes in pregnancy team improved not only compliance in patients, but also glycemic control. This lowered the rate of insulin treatment in patients using the application (Miremberg et al., 2018). Within the smartphone app group women reported satisfaction with the application as well as being easy for

the participants to use. The study integrated home data collection with provider feedback creating a link between the two entities (Miremberg et al., 2018).

The Rasekaba et al. study (2018) was a level I, B/good quality exploratory randomized control trial that reviewed the use of telemedicine services in GDM patients. Ninety-five women were recruited for this trial and 61 were placed in the intervention group and 34 in the control group. The intervention group used electronic devices to record their blood glucose levels that were then sent to the provider. Patients in the intervention group reached glycemic control more quickly than those in the control group ($p = 0.015$). Even though euglycemia (normal blood sugar) was achieved sooner in the intervention group there were no differences in the number of face-to-face appointments, cesarean section rate, or fetal complications. This study highlighted the importance of patients being accountable for entering their food choices and blood sugars in a database because it demonstrated that it creates awareness of their overall health and GDM. Due to increased awareness, patients have shown a quicker realization of their blood sugars and how to take better control of them to improve their health. The use of telemedicine or other recording methods may also help the patient achieve glycemic control sooner than if there were no interventions used as there were no known disadvantages to using this method (Rasekaba et al., 2018). One of the major strengths of this study is the outcome that women were studied from the time of their diagnosis to the time of delivery. However, this study is difficult to assess the wider implications due the participant's limited access to computers, smartphone, or internet service and small sample size which also led to uneven randomizations of the control and intervention group.

***Alternative therapies for therapy.*** The final four studies that were compiled for this literature review evaluated other lifestyle changes that are not linked to the previous topics.

Three of these studies were level I studies, and one was a level III and they were all good quality. These include self-reporting of test results, adding vitamin D and probiotics to diets, counseling, and group versus one on one prenatal care and their effects on the management of GDM and pregnancy outcomes.

Self-monitoring blood glucose and reliably turning in logbooks to providers is a common way of tracking blood sugar numbers for management and treatment of GDM. Compliance with self-monitoring blood glucose and the reliability of patient logbooks and the associated determinants and outcomes were evaluated by Cosson et al. (2017) in a level I RTC. This trial took 94 newly diagnosed GDM patients and referred them to a diabetes management program. In this one-day program, women were taught about accurate testing, recording capillary blood glucose (CBGs), and using a postprandial alarm. Information was taken from the logbooks and downloaded from their glucometers. After analyzing patients for 13+3 days, 91 participants 78% performed > 80 % of required pre-prandial tests, and 65.9% performed > 80% of postprandial only, and 61.5% performed > 80% of all required tests. Timing of postprandial testing is important in getting accurate readings, only 46.5% of women performed the tests $\geq$80% of the time within a 100-140-minute postprandial range. Women who had inadequate timing of the postprandial testing had a higher baseline HbA1c and a higher HbA1c at delivery, despite more frequent insulin ($p<0.01$). This study highlights the importance of patients reporting actual CBGs that they are receiving with their meters and was emphasized as a goal in this study. The research concluded that 23.1% of women had < 90% of matching values in the logs and meters. It was also concluded that poor compliance with testing was associated with elevated risk for preeclampsia ($p= 0.049$). Self-monitoring blood glucose is an integral part of GDM care.

Consequently, patients that had a family history of diabetes were more likely to be non-compliant.

Group care is an emerging process for pregnancy and therefore seemed important to address in this literature review as a possible contributing factor in improving patient's health with GDM when most other studies focus on traditional one on one care. Mazzoni et al. (2015) completed an observational study of 165 patients (62 in group care and 103 in traditional care) to compare group care to traditional single patient care. Women who chose to participate in group care had less prenatal visits and less OB (obstetrical) triage problems. The management of their GDM was also affected, they required less antenatal diabetic medications (like insulin), and improved glucose tolerance in the postpartum period. It was reported in the study that women participating in group care had higher rates of increased activity and diet modifications. The peer-to-peer interactions were also shown to enhance their interactions and developed more frequent and in-depth education. Group care in this situation demonstrated a decreased transition to A2GDM and better glucose tolerance postpartum without affecting obstetric or neonatal outcomes.

This review evaluated one study exploring the effectiveness of vitamin D and probiotic supplementation on the metabolic status of women with GDM. Vitamin D deficiency has been previously correlated with an increased risk for GDM as significantly lower concentrations of vitamin D have been reported in patients with GDM (Jamilian et al., 2018). Evidence also suggested that there is a change in the microbiota composition during pregnancy. Probiotics produce antimicrobial substances in the gastrointestinal tract by altering the composition of the microbiota. The rationale being, probiotics may increase the gene expression of vitamin D receptors in the intestinal cells (Jamilian et al., 2018). In this level I RTC, Jamilian et al. (2018)

studied 87 first time mothers that were diagnosed with GDM. The women were matched by BMI and age and then randomly assigned into three different groups (probiotic and vitamin D, probiotic only, and placebo). There were no significant changes in the macro & micro-nutrients in any other groups. The vitamin D and probiotic combination group significantly reduced fasting plasma glucose (95.4 to 83.1) as well as serum insulin levels, and the homeostasis model of assessment-insulin resistance. The probiotic supplementation group also showed a reduction in fasting glucose (96.6 to 86.5), serum insulin levels, and the homeostasis model of assessment-insulin resistance. There were no reported changes in other metabolic parameters. This research concluded that both vitamin D and probiotic supplementation showed significant improvements in glycemic control in women with GDM (Jamillian et al., 2018).

Lifestyle modifications are known to be a complementary therapy for treatment of GDM, but there are no adequate trials on the primary prevention of GDM. Luoto et al. (2011) aimed to examine whether incorporating intensified individual counseling about lifestyle changes into routine prenatal visits could prevent the development of GDM as well as macrosomia. This sample screened 2271 women, of those 399 were inclined in the study (219 in the intervention group and 180 in the control). During this cluster RTC the intervention of counseling was done at 8-12 weeks until 37 weeks gestational age. Counseling included discussion about weight gain, physical activity, and diet. If a patient was diagnosed with GDM at 26-28 week screening they were referred to specialists for further education. It was found that there were no significant differences in the groups at the baseline or 26-28-week glucose tolerance measurements. Data also showed that in women who were diagnosed with GDM there were no significant differences in total gestational weight gain, preeclampsia, or use of diabetic medications. Babies that were born to mothers in the intervention group did have a lower average weight (3,532 g vs. 3,659 g,

p=0.035). Furthermore, the data reports that the birthweight per gestational age continued to be significant after taking into account the clinic, nurse, maternal age, education, sex, parity, pre-pregnancy BMI, gestational weight gain, and smoking (p=0.024) (Luoto et al., 2011). In comparison of gestational age in infants, the control group had a higher rate of 19.7% compared to the intervention group at 12.1% (p=0.042). The results are inconclusive on the effectiveness of controlling or reducing the number of patients with GDM. It was noted however, that there are beneficial effects of lifestyle counseling in women who adhered to education and had a lower incidence of GDM as well as macrosomia.

## Summary

Overall, there are many factors that lead into the success of a woman either making lifestyle changes early in pregnancy to prevent the progression of GDM entirely, or later in pregnancy so that they do not need medication to control their GDM. Lifestyle interventions requiring diet and exercise were most successful when they were monitored closely and offered for free (Anjana et al., 2016; Cordero et al., 2015; Wang et al., 2017; Koivusalo et al., 2015). When small classes are offered to high risk women for GDM early in their pregnancy and then routine prenatal care is resumed, they reported have low compliance for the lifestyle changes (Wang et al., 2015). When lifestyle modifications were introduced at the beginning of pregnancy and the majority of the pregnancy weight gain was later in pregnancy, they were reported to have a greater chance of reducing the incidence of GDM. Moreover when lifestyle modifications were introduced in the third trimester of pregnancy and the overall gestational weight gain was reduced, it still helped to control postprandial glucose levels and reduce the incidence of fetal weight being large for gestational age at birth (Aiken et al., 2018; Simmons et al., 2018; Halse et al., 2014). The reduction in postprandial glucose levels is important for reducing the incidence of

medication use for GDM control, but the effect on fasting glucose was not mentioned, and per ACOG medicine should be introduced when fasting glucose is not controlled adequately (ACOG, 2018). Those who were able to make diet changes were more inclined to make better choices of the types of whole grains they consumed over lowering their intake of sweets and increasing their intake of vegetables (Halse et al., 2014). Of those who made physical activity changes, increasing their daily steps/ walking more frequently did not increase their caloric usage unless it was monitored and tracked by the provider (Halse et al., 2014; Anjana et al., 2016). Overall, it was determined that the most effective programs involved both diet and exercise to achieve better glycemic control and had close monitoring of both the exercise and diet offering specialist along with 1:1 care.

There are other alternatives to treating gestational diabetes as well as social factors that affect how well a person can or will follow the recommended lifestyle changes in order to improve their health and the health of their child. Their existing personal social support itself did not affect how well women were able to keep good glycemic control, but social factors did affect their compliance and some of those could be modified (Colicchia et al., 2016). Women with GDM also reported having a low overall rating of their health, even when able to change their diet and exercise habits (Engberg et al., 2018). Women reported feeling judged by their peers and clinicians, which lowered their self-esteem and demonstrated an impact on their mental health (Jarvie, 2017). Women also reported financial concerns when trying to buy healthier food choices and wanting more connection with other women suffering from GDM. The stress of lower self-esteem and past trauma related to pregnancies was shown to increase the risk of developing GDM (Horsch et al., 2016). When having negative feelings about oneself and the GDM diagnosis, the literature concluded that this leads to poor compliance with checking blood

sugars, which consequently makes it harder to determine if the patient is controlled (Singh et al., 2018). Most patients also requested more group care, which was shown to result in less progression of GDM (Mazzoni et al., 2015). Those who have poor compliance also demonstrated worse A1C results; therefore, poor compliance with testing is directly related to poor control of GDM and higher use of medicine (Cosson et al., 2017). When women had increased access to technology or telemedicine such as  a smart phone app or a database were they could enter their testing results for food choices with feedback from their clinician, they had better glycemic control and less need of medicine to control their GDM (Miremberg et al., 2018; Rasekaba et al., 2018). Ongoing counseling was also shown to be inconclusive in GDM patients (Luoto et al., 2011). However, the inclusion of Vitamin D and a probiotic were shown to be successful additions to lifestyle interventions of diet and exercise in the reduction of the progression of GDM to GDM II (Jamilian et al., 2018)

## Chapter IV: Discussion, Implications and Conclusions

The purpose for this review was to explore the available literature for efficacious lifestyle interventions to manage Gestational Diabetes Mellitus (GDM) and possibly decrease the progression from GDM A1 to GDM A2, as well as reduce delivery complications. This review investigates 20 scholarly articles that were chosen using the John Hopkins Research Evidence Appraisal Tool and their impact on GDM. Throughout the literature review, many implications for midwifery practice and the opportunities for further research were uncovered. This chapter will discuss the implications of GDM research to midwifery and opportunities for continued research. The integration of Orem's Self-Care Deficit theory in contemplation of the lifestyle interventions in reducing progression of GDM A1 to GDM A2 will conclude the chapter.

### Literature Synthesis

Overall, the studies reviewed several methods to determine how to best support women to achieve glycemic control through diet and exercise lifestyle modifications. When looking at the contributing factors for women's diet and exercise patterns, it was determined that social support (Colicchia et al., 2016) and stress levels (Horsch et al., 2016) did not negatively affect glucose readings or have a significant correlation. However, women did report that financial burdens inhibited them from being able to comply with the recommended diets (Jarvie, 2017). Women also reported that they lowered their personal viewing of their health with the diagnosis of GDM, but when participating in exercise and diet modifications they did not improve their own views on their health (Engberg et al., 2018). Specific counseling for women with GDM was inconclusive (Luoto, et al., 2011). When women were asked what they wanted from providers they requested more support and connection with other GDM patients (Singh et al., 2018). In response to women's request for more support with a GDM diagnosis across the literature

review, it was substantiated by research that group therapy was shown to reduce the number of prenatal visits in GDM patients as well as increase the adherence to diet and exercise recommendations, largely reducing the progression of GDM A1 to GDM A2 (Mazzoni et al., 2015). This could be concluded that social factors such as peer support, a sense of connection and improved self-esteem from feeling aligned with others during a stressful situation were indicative of improving a patient's health.

Another study determined a method to reduce the progression of GDM A1 to GDM A2 by adding 50,000 IU of Vitamin D every 2 weeks and a probiotic that was introduced after the diagnosis of GDM. This approach was correlated to decrease the overall fasting glucose of patients, therefore reducing the incidence of needing insulin (Jamilian et al., 2018). Overall, changing social factors alone would not improve GDM outcomes but the initiation of Vitamin D and probiotics, coupled with group therapy could potentially significantly increase the progression of GDM A1 to GDM A2 and provide more holistic support to these women.

In comparison, research that attempted to determine the effectiveness of exercise alone as a treatment for GDM versus combining diet and exercise together, yielded mixed results. One study found that women with a GDM diagnosis are more sedentary, thus indicating the need for increased exercise (Anjana et al., 2016). Overall, the research studies concluded that adjusting diet and exercise is important throughout pregnancy but when the majority of pregnancy weight gain is in the third trimester, it has been found to increase the incidence of GDM diagnosis (Simmons et al., 2018). Research demonstrated that when exercise and diet are changed solely in the third trimester and weight gain is reduced, it has been found to have positive results on the research (Aiken et al., 2018). Several studies reviewed the implications of diet and exercise throughout pregnancy and the impact on the incidence and progression of GDM. Two studies

that only monitored exercise had positive results of the reduction of GDM by 90% Cordero et al., 2015) and 50% (Wang et al., 2017). Two additional studies gave ongoing instruction and recommendations for exercise throughout pregnancy and one had a reduction in GDM by 39% (Koivusalo et al., 2015) and the other had inconclusive results (Wang et al., 2015). Another study highlighted that when exercise without diet recommendations were given after the diagnosis of GDM, only the postprandial glucose numbers were improved but overall insulin tolerance was not, and the effect directly on GDM progression was not specific (Halse et al., 2014). However, during the cases where strict instruction on diet and exercise were provided, it was noted that women were likely to improve their choices of grains, fruits, and dairy but not improve their exercise, vegetable choices, or reduction in sugars (Han et al., 2016). Whether lifestyle modifications are introduced at the beginning of pregnancy or after diagnosis, there are clear benefits on pregnancy outcomes (Jarvie, 2017). The evidence is clear that diet and exercise will reduce the incidence of the diagnosis of GDM when initiated at the beginning of pregnancy and when initiated after the diagnosis, it will reduce the incidence of GDM A1 to GDM A2; but the best techniques for monitoring and adherence to diet and exercise recommendations is not clear and depends on the resources available.

In reviewing the integration of technology in midwifery or medical practice for the treatment of GDM, it is evident that technology can assist both the provider and the patient. In the research study that was reviewed, several challenges were documented in the current literature: the lack of variance in reporting the correct numbers, lack of testing, and testing outside of the suggested time. Women were asked to keep a log of their glucose monitors to verify their reporting however the reliability of this data is questionable since the literature indicated that women were testing outside the suggested times (Cosson et al., 2017).

Furthermore, women who had higher variances and less frequent testing had higher needs for insulin and a higher risk of developing pre-eclampsia. When using a smart phone application woman reported satisfaction with the application and adhered better to the dietary and exercise recommendations, as well as monitor their blood sugars at the appropriate times and more often (Aiken et al., 2018). The application used directly reported the results to the provider for feedback. Patients did reach euglycemia at a faster rate when utilizing telemedicine instead of waiting till their next office visit (Rasekaba et al., 2018). Thus, the importance of instant feedback, using technology, was reported to improve the outcomes of GDM patients.

## Current Trends and Gaps in the Literature

The studies that were used in this literature review specifically addressed methods to initiate change and improve outcomes for women with GDM and their babies. Although this method is effective for performing a scientific study, it does not capture the holistic picture of an individual and consider that a multitude of factors may indicate the best outcomes for the patient and her baby. The highly successful studies that were reviewed had wide access to resources and education. Several studies provided access to a gym or other local free programs, some even with fitness coaches on hand. This close supervision and universal access to health care services is generally not feasible in the United States as the resources are typically limited based on insurance, location of services or require significant personal cost.

***Current successful tactics.*** A limitation that was determined in this literature review was the absence of a systematic study that studied areas around the world with the lowest incidence of GDM and compared the tactics they utilize for more effective treatment. This could be highly beneficial to identifying practices that can be generalized without having to invent a new form of education; thus, reducing time and resources spent on finding a new solution when one already

exists. If a working solution is found, then further study can be done to expand those programs to areas with different resources. GDM is not a new challenge woman face during pregnancy and creatively reviewing current practice to implement more effective strategies may open new doors for opportunity.

***Access to care.*** The types of healthcare in existence globally were also not mentioned in the studies, nor were the access to care. Despite GDM being an identified world problem, there are several different types of healthcare in the world which create different inequalities of care for populations and individuals (Dawkins et al., 2020). The literature review also did not mention the relativity of appointments kept and outcomes for mothers with GDM. Appointment availability, frequency and access to care is data that could be brought to local or larger government agencies to support the need for healthcare supplementation for patients with this disease. Increasing global access to care and recognizing the barriers could also reduce social inequalities and better the outcomes for all women, not just those diagnosed or at both mothers with high risk for GDM and their babies.

**Implication for Midwifery Practice**

One of the hallmarks of midwifery is to utilize current scientific evidence in clinical practice (ACNM, 2012). This literature review demonstrated areas for improvement for women and their babies when at risk or already diagnosed with GDM. Exercise and diet, including the addition of a probiotic and Vitamin D, should not only be recommended by midwives for control of GDM, but it should be recommended in the first trimester for high risk patients to achieve maximum benefit. It should not only be recommended and reviewed, but the patient should be given a method to track their diet and exercise, either through technology or through a log that the provider can review during their prenatal visit and continue to offer positive reinforcement

and alterations to choices. Logs can be made digital for ease of use for both the patient and the clinician so that timely feedback can be given which was shown to be a contributing factor in tracking health changes effectively. Specific diet and exercise should be tailored to the patient in order to achieve better overall glycemic control and reduce gestational weight gain in the last trimester of pregnancy. Group visits can also improve glycemic control and reduce the progression of GDM AI to GDM A2 along with offering women support that was indicated to be needed for not just their physical health but emotional and mental well-being.

**Recommendations for Future Research**

After reviewing the current research, there are numerous areas that would enumerate the literature and need continued study to develop recommendations for managing prenatal care and gestational diabetes. Further research and awareness could decrease the stigma of GDM and minimize the occurrence and/or reoccurrence of the disease. Koivusalo et al. (2015) suggests that, in order to reveal the true effects of lifestyle changes, bigger sample sizes are needed with multiple ethnicities in order to be more generalizable as current research does not capture the differences across multiple ethnicities and cultures as this disease is not specific to one population but a global pandemic.

In the instance of gestational weight gain, further methods are needed to explore weight control in GDM. Limiting further weight gain can be a benefit to GDM and stable weight after the diagnosis results in better maternal and neonatal outcomes (Aiken et al., 2018). More research is also needed to identify targets of weight gain that are appropriate for GDM in women who are already at higher risk of pregnancy complications, compared to those who have a normal glucose tolerance in pregnancy. Research conducted by Simmons et al. (2018) suggests that there

is a need for more randomized controlled trials in the first trimester to gain a better understanding of the mechanisms behind a metabolic trajectory in these women.

In order to improve compliance and control of GDM with lifestyle changes, the literature review determined that providers need to improve the motivation in women with GDM to develop better compliance with self-monitoring. Adjusting patient education and being more supportive in the diagnosis and management was demonstrated to increase patient empowerment, self-esteem and thus overall health as social factors play an important role in the control of GDM and the stigma of the diagnosis. Additionally, adequately interpreting the readings of blood sugars is important for developing accurate readings which can impact treatment and patient progress. The literature review also indicated that the assessment of glucose control can be improved by having a process as well as guidance for clinical management by using the memory from the glucose meters (Cosson et al., 2017). Research conducted by Jarvie (2017) suggests that offering women collaborative care can help with management of GDM. Collaborative care and group prenatal care have improved models of care that result in enhanced screening for diabetes and a decrease in resources that are utilized in prenatal and antenatal care (Mazzoni et al., 2015). However, more research is still needed on collaborative and group prenatal care to understand all the benefits.

One of the major recommendations throughout all of the research is that larger sample groups are needed, as well as further studies, in order to prove the efficacy of the integration of these changes to increase the glycemic control in women with gestational diabetes. Due to the complexity of GDM and multiple targets for interventions to improve glycemic control, repeat studies are needed in all aspects with larger sample sizes. These larger studies could elucidate whether these findings are applicable across the world. Results throughout the research show that

preventing GDM in women who have multiple risk factors may be challenging, but it is important to find effective ways to reduce the incidence and manage control in high risk women. Continued research in lifestyle changes will help to ensure more information and results of interventions.

**Integration of the Self-Deficit Theory**

The findings in this review have shown the benefits of lifestyle changes and interventions in improving the outcomes of GDM and reducing the progress from GDM A1 to GDM A2. For women to be able to incorporate these lifestyle changes and improve their outcomes, they need to approach their treatment from a holistic perspective and to take an active role in their care/health. Orem's Self-Care Deficit Theory will help direct the responsibility of the patient and the responsibility for their own health with the help of nursing staff and education about lifestyle changes. The Self-Care Deficit Theory was developed by Dorthea E. Orem, as she had the desire to understand the developments that she observed in order to improve nursing practice (Smith & Parker, 2010). Reviewing this model shows there are different ways of looking at a specific circumstance and implementing changes. This overarching theory offers a blueprint for nurse and patient roles, composed of three different underlying theories; theory of self-care, theory of self-care deficit, and theory of nursing systems. (Smith & Parker, 2010). The simplicity of this theory makes it generalizable to an ample array of patients, including pregnant women. It is indicated that health care providers, especially nurse midwives, give patients the information they need for them to take an active role in their health.

The involvement of pregnant women in their own care has clinically significant positive outcomes of their care and the growth of the patient. Patient engagement is consistent with Dorthea Orem's Self-Care Deficit Theory; patients should be responsible for their health and

take an active role. Orem's theory suggests that patients should have knowledge of potential health problems in order to promote self-care behaviors (Orem, 2001). By knowing what lifestyle interventions are best, can help manage GDM, providers can give women this information and guide them in the direction they need to go but leave the plan of action up to them. Encouraging the patient to make these lifestyle changes will help them be more adherent to the plan to improve their health.

This review of lifestyle changes in women with GDM is focused on allowing patients to take control of their health by making them aware of small and achievable changes that they can make to help with the prevention and treatment of GDM. Nurse midwives can give patients all the resources available to them, but in order to successfully implement the changes, patients need to be actively involved in their own care and take initiative. Due to Orem's theory being based on self-care, this model can help facilitate the successful implementation of lifestyle changes in these women and provides an ideal conceptual framework for this review.

## Conclusion

This critical review has identified effective lifestyle interventions to manage GDM and decrease in the progression from GDM A1 to GDM A2, as well as a reduction in delivery complications. In using the Johns Hopkins Research Evidence Appraisal tool, 20 scholarly articles were analyzed to identify various lifestyle interventions and their significance. The review found that diet and exercise, physical activity, social factors, integrating technology, gestational weight gain, and alternative therapies show promising results in the management of GDM and a decrease in progression from GDM A1 to GDM A2, resulting in a reduction in delivery complications.

Nurse midwives providing prenatal and antenatal care are in an optimal position to educate women on various lifestyle changes and promote maternal well -being to be beneficial to women and pregnant women. The presence of GDM does not just have an effect during the pregnancy, but can have long-term health effects as well, leading to negative outcomes for the mother and child. As of 2009, the incidence of GDM was approximately 7% in the United States and it continues to rise (ACOG, 2018). Pregnancy may be the first time a patient seeks medical care and the impact providers have in patients can influence the care for the rest of their lives. Therefore, nurse-midwives should remain current on research in the field and trends in healthcare, as well as effective interventions. This will help regarding GDM and limiting progression to help promote the health of mothers and their babies. In order to implement these lifestyle interventions to improve health, nurse-midwives should use Orem's Self-Care Deficit Theory to facilitate the achievement of the patient's goals and manage GDM with their own will and lifestyle changes.

Patients can be hesitant to implement changes and come to terms with the diagnosis of GDM, but these alternative lifestyle changes and preconception education found in this review, can be beneficial. The findings of this review would be useful to nurse midwives, OBGYNs, Physicians, Nurse Practitioners, and other medical providers in order to recommend appropriate lifestyle interventions for management of progression of GDM. The most important contribution of the articles researched, and the conclusion of this literature review is in understanding the effectiveness of the lifestyle changes and factors in the prevention of the progression of GDM and adverse delivery complications.

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Appendix 1 – Literature Review Matrix

| **Source:** Aiken, C. E., Hone, L., Murphy, H. R., & Meek, C. L. (2018). Improving outcomes in gestational diabetes: Does gestational weight gain matter? *Diabetic Medicine, 36*(2), 167-176. doi:10.1111/dme.13767 | | | |
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| **Purpose/ Sample** | **Design (Method/ Instruments)** | **Results/ Conclusion** | **Strengths/ Limitations** |
| **Purpose:** To assess whether total gestational weight gain during pregnancy, 0-36 weeks (wks), early gestational weight gain (EGWG) (0-28 wks), or late gestational weight gain (LGWG) (28-36 wks) are associated with maternal-fetal outcomes. Weight control may improve metabolic health and reduce pregnancy complications.<br><br>**Sample/Setting:** 546 pregnancies, 417 had pre-pregnancy weight documented. Total gestational weight gain (TGWG) in 376, EGWG in 129, LGWG in 144, 36 wks weight Women with a diagnosis of GDM who delivered a singleton infant ≥ 24 wks at the Cambridge Universities NHS foundation trust between 10/2014 and 3/2017. The first eligible pregnancy was included when women had | **Design:** Retrospective observational study<br>**Instruments:** Participants identified using EHR. Accuracy of diagnosis and treatment was confirmed by hand searching each record. Measurements of maternal weight and height measured at antenatal booking in the community, pre pregnancy BMI was based on this (8-12 wks). If no booking weight self-reported weight used (approx 2% of cases). Weighed every 2 wks at the clinic on regularly calibrated scales. Offered GDM screening with random plasma glucose at antenatal booking. If results were >7.0 mmol/l or had prev dx of GDM they were offered | **Results:** TGWG was negatively associated with pre-pregnancy BMI (beta coefficient -0.79: CI -0.89 to -0.68. *p*,0.001) and positively associated with infant birth weight z-score (adjusted for sex and gestation, beta coefficient 0.02; CI 0.01 to 0.04, $p<0.001$. TGWG was associated with fetal growth both positively (LGA $p<0.001$) and negatively (SGA $p<0.05$) Increased TGWG increased likelihood of c/s ($p<0.01$) and reduced likelihood of SVD ($p< 0.001$) EGWG is important for development of GDM but not associated with the studied pregnancy outcomes. LGWG was associated with increased odds of | **Strengths:** Protocols for initiation of GDM treatment, dose titration and delivery planning were done by a single clinical team which minimized unintentional variation within the cohort. Sample size of 546 was sufficient to draw useful conclusions. Approved as a service evaluation, IRB granted approval for further analysis of data.<br>**Limitations:** Self-reported data. Only done in patients who had a hx of GDM |

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| multiple eligible pregnancies.<br><br>**Level of evidence: Johns Hopkins Evidence**<br>**Appraisal:** Quantitative<br>**Strength:** Level II<br>**Quality:** B/ Good | 75g OGTT within a week. Participants without pre-existing GDM were screened at 24-28 wks with 50g OGTT. Dx was based on IADPSG criteria.<br>After dx of GDM seen every 2-4 wks and encouraged to monitor CBGs QID. Given dietary advice, advised to follow a low glycemic index diet, and avoid excessive weight gain. Hyperglycemia despite modifications received metformin or insulin per NICE guidelines.<br>Data was analyzed as continuous variables to avoid categorization of quantitative data. Weight gain was assessed per IOM guidelines and as a % of gain from baseline pre-pregnancy weight Associations were assessed using multivariate logistic regression and results presented as odds ratios. They were considered statistically significant at an alpha level of 0.05. | LGA ($p<0.05$) and instrumental delivery ($p<0.01$) Women who avoided substantial weight gain after GDM dx had 0.7 mmol/l lower postnatal 2-h glucose and needed ½ the insulin/day at 36 wks compared to those with higher LGWG.<br>Women with > LGWG had higher postnatal glucose ($p<0.05$ for fasting and 2h OGTT) The difference in fasting concentrations was (0.1 mmol/l). Difference was more marked in 2 h OGTT, 5.4 mmol/l (97 mg/dl)<br>**Conclusion:** Controlling GWG should be a priority after diagnosis of GDM to optimize pregnancy outcomes. This will also improve the maternal postnatal glucose. Waiting until after dx of GDM is not too late to offer lifestyle interventions to improve pregnancy and maternal outcomes. | |

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| **Author Recommendations:** Need to explore methods of weight control in GDM. It is not too late at dx of GDM to benefit from limiting further GWG. A stable weight after GDM dx had the best maternal & neonatal outcomes. Further work is needed to identify targets that are appropriate for GDM who are already at higher risk of pregnancy complications compared to normal glucose tolerance during pregnancy. |
| **Summary for current clinical practice question:** Weight control in women with GDM is important but controlling weight prior to pregnancy is a better way to prevent GDM. When controlling weight during pregnancy after the dx of GDM patients can have better control of the CBGs and management of their diagnosis. |

| **Source:** Anjana, R. M., Sudha, V., Lakshmipriya, N., Anitha, C., Unnikrishnan, R., Bhavadharini, B., . . . Mohan, V. (2016). Physical activity patterns and gestational diabetes outcomes – The wings project. *Diabetes Research and Clinical Practice, 116*, 253-262. doi:10.1016/j.diabres.2016.04.041 | | | |
|---|---|---|---|
| **Purpose/Sample** | **Design (Method/Instruments)** | **Results/ Conclusion** | **Strengths/ Limitations** |
| **Purpose:** To compare physical activity patterns in women with and without GDM and assess the effects of an exercise intervention on change in physical activity patterns, blood glucose levels, and pregnancy outcomes in GDM **Sample/ Setting:** 1086 pregnant women with GA less than 28 wks attending 6 maternity clinics located in Chennai, South India between 11/13 to 12/14. Exclusions: women with pre-existing diabetes, multiple pregnancies, or assisted pregnancies. | **Design:** RCT **Instruments:** Women with GDM were enrolled into the model of care (MOC) during their antenatal visits to maternity clinics. Women received in depth education about GDM and its implications for them and their babies. Instructions on dietary principles, monitoring, and pharmacotherapy management of GDM were given. All women with GDM were offered individualized 1on1 counseling about the benefits of physical activity in pregnancy and encouraged to meet guidelines at every visit. A pedometer was given to encourage an increase in step count. The intervention was provided by trained nutritionists and health care professionals for a mean of 12 wks. | **Results:** 247 were dx with GDM. 836 did not have GDM. Physical activity data was available for 84.4%. Patterns for physical activity analysis in 795 (189 had GDM and 606 no GDM). No sig. differences in age, GA, BMI, fasting and 1-h and 2h glucose values and HbA1c. Dx with GDM were significantly older, had higher BMI, likely to have a family hx of diabetes and previous hx of GDM compared to those without. 20 with GDM (10.6%) were on insulin. GDM were more sedentary compared to those without (86.2% vs. 61.2%)10.7% met recommended guidelines for physical activity (8.7% non GDM and 16.9% GDM $p$=0.001. After the MOC there was a sig. improvement in activity and decrease in sedentary behavior in GDM. Before MOC moderate activity 15.2%, sedentary 84.8%. After MOC moderate activity 26.5% sedentary 73.5% ($p$<0.001) Fasting and postprandial CBGs | **Strengths:** First study to have looked at maternal and fetal outcomes of women with GDM after exercise intervention. Adequate sample size, good response and follow up rates. Low cost intervention that was easily adapted into routine care. Approved by the Institutional Ethics Committee of the Madra Diabetes Research Foundation. Informed consent was obtained from all participants. **Limitations:** The absence of a comparator group. Done in selected antenatal centers and not generalized. |

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| **Level of evidence:** **Johns Hopkins Evidence Appraisal:** Quantitative **Strength Level:** I **Quality:** B/Good | Intervention was reinforced at every antenatal visit. A "after model of care" visit (30-35 wks GA) questionnaires were repeated. Physical activity was measured using the Madara Diabetes Research Foundation-Physical activity questionnaire that measured work, transport, recreational, and general activity, this was measured once before MOC and once after MOC to assess changes in physical activity changes. | decreased after the MOC, $p<0.001$. No change in HbA1c before or after MOC. C/S rate was 60.9% (42.3% emergency), 32.5% had normal delivery, and 6.6% had instrumental delivery. 94% delivered at term. 13.2% macrosomia, 3.3% NICU admission, 1.3% neonatal hypoglycemia and others. Recreational walking showed a 70% decreased risk for adverse neonatal outcomes (p=0.04). **Conclusion:** Physical activity levels are inadequate amongst this group studied. Sedentary behavior was more common with GDM. A low cost, culturally appropriate model of care can bring about significant improvements in physical activity in GDM. These changes are associated with improved glycemic control and reduction of adverse neonatal outcomes. GDM with increased sedentary time have a 4-fold increase of adverse neonatal outcomes. | Pedometer data was only available to a subset of women who were motivated by it. Interventions consisted of dietary and exercise it was difficult to tease out effects of diet versus exercise. |
| **Author Recommendations:** Larger studies are needed to elucidate whether the findings from this study are applicable in GDM across the world. Research also needs to be done to understand the mechanisms of the benefits of physical activity and the long-term benefits. | | | |
| **Summary for current clinical practice question:** Physical activity has an impact on GDM, but still needs to be researched for the long-term benefits. Adding physical activity after the diagnosis of GDM can help with better control of GDM. | | | |

| **Source:** Colicchia, L. C., Parviainen, K., & Chang, J. C. (2016). Social contributors to glycemic control in gestational diabetes mellitus. *Obstetrics & Gynecology, 128*(6), 1333-1339. doi:10.1097/aog.0000000000001740 | | | |
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| **Purpose/Sample** | **Design (Method/Instruments)** | **Results Results/ Conclusion** | **Strengths/ Limitations** |
| **Purpose:** To evaluate the association of social factors with glycemic control in GDM. **Sample/Setting:** 145 approached**,** 111 completed baseline surveys, 97 completed follow up surveys. Participants were recruited from the MFM office and high-risk resident clinic at Magee-Women's Hospital University of Pittsburgh Medical center. March to October 2015. Needed a dx of GDM based on 2 or more elevated values on a 3 hr 100-g GTT or one or more elevated values on a 2-hr 75-g GTT. Exclusions- pre-gestational diabetes or dx | **Design:** RCT **Instruments:** Surveys administered in 2 parts. After GDM dx & after 4-12 wks of treatment (by telephone, email, mail, or in person at a follow up visit). Managed according to usual care. QID blood sugar readings with weekly reporting, dietary modifications, & initiation of meds if dietary modifications didn't achieve control. Social support evaluated using the Shortened Social Support Scale & the Diabetes Social Support Questionnaire. Higher scores on both scales = more social support. Chaotic lifestyle assessed using the Confusion, Hubbub and Order Scale to measure organization, instability, & ability to anticipate the future & plan ahead. Higher scores indicate poor organization and high instability. Questionnaires on where food purchased, transportation to food stores, use of WIC benefits or SNAP, & difficulty affording | **Results:** 86/111 (76.5%) achieved satisfactory glycemic control. 49 (44.6%) were treated with dietary modifications, 45(40.9%) received glyburide, and 16 (14.6%) received insulin treatment. An average of 17.3% missing values on weekly logs (12.7% for good control & 32.7% for poor control, P<.001). Satisfactory glycemic control had lower baseline BMI, lower fasting values on GTT, & more likely to be married, have a higher household income. Less likely to have public insurance, report a hx of depression or anxiety, & more likely to exercise 3 or more times a week. Chaotic lifestyle (confusion, hubbub & order scale score 12.5 $\pm$ 2.9 for those with good control, 16.3 $\pm$ 3.9 for poor control; odds ratio 0.71 (95 % CI 0.59-0.85) & receipt of food stamps (11/86 [12.9%] for good control and 10/25 [40%] for poor control; OR | **Strengths:** Didn't receive financial compensation. Approval from University of Pittsburgh IR board. Socioeconomically diverse population & prospectively collected data with clearly defined outcomes. **Limitations:** Single institutional study. Small sample size was likely too small to identify all association between social factors and primary/secondary outcomes. |

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| before 20 wks GA.<br><br>**Level of evidence:**<br>**Johns Hopkins Evidence Appraisal:**<br>Quantitative<br>**Strength:** Level 1<br>**Quality:** B/ Good<br>Consistent results<br>Used RTC design.<br>There were no definitive conclusions.<br>Diverse Population.<br>Significant associations were found.<br><br>Could use a larger sample size. | food. Food purchases & access to healthy food were adapted from the National Household Food Acquisition and Purchase Survey.<br>Asked questions related to cooking & meal prep focusing on time and stress and number of meals eaten outside the home. Physical & emotional responses to food were assessed using a 3-point scale on food cravings & feeling anxious about food or eating. Employer support and shifts were assessed as well.<br>Surveys were reviewed by 4 MFM providers, 2 diabetic educators.<br>Data from EHR for baseline health information, pregnancy complications, delivery outcomes, &CBGs. | 0.22, 95% CI 0.08-0.62) associated with decreased likelihood of achieving glycemic control. Being married (67/86 [77.9%] for good control and 12/25 [48.0%] for poor control; OR 3.82, 95% CI 1.49-9.74) & regular exercise (49/86 [57.0%] for good control and 5/25 [20.0%] for poor control; OR 5.03, 95% CI 1.72-14.72) increased achieving glycemic control. Time to stores, home cooking, & social support, not associated with glycemic control.<br>**Conclusion:** Chaotic lifestyle, marital status, food stamps, & exercise were associated with glycemic control. Chaotic lifestyle is associated with difficulty adhering to GDM care leading to poor control. Social factors are associated with glycemic control in GDM and may be modifiable to improve glucose control. There was no association between social support and glycemic control. | |
| **Author Recommendations:** Associations suggest there are multiple targets for interventions to improve glycemic control in GDM. Repeat study with a larger sample size. | | | |
| **Summary for current clinical practice question:** Women who are diagnosed with GDM and have a chaotic lifestyle or social factors that impact their access to healthy food and activity and have a negative impact on their control of GDM. If we are able to help with access to food and services, we may be able to help improve glycemic control. | | | |

| **Source:** Cordero, Y., Mottola, M. F., Vargas, J., Blanco, M., & Barakat, R. (2015). Exercise is associated with a reduction in gestational diabetes mellitus. *Medicine & Science in Sports & Exercise, 47*(7), 1328-1333. doi:10.1249/mss.0000000000000547 | | | |
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| **Purpose/Sample** | **Design (Method/Instruments)** | **Results/ Conclusion** | **Strengths/Limitations** |
| **Purpose:** Examine efficacy of exercise during pregnancy to prevent GDM.<br>**Sample/Setting:** 257 participants Pregnant living in Madrid Spain. Recruited at 10-12 weeks (wk) GA. All had medical clearance for exercise & had no medical contraindication.<br><br>**Johns Hopkins Evidence Appraisal:** Quantitative<br>**Strength:** Level 1<br>**Quality:** B/Good Consistent results with a sufficient sample size and they used RTC design. There were no definitive conclusions. | **Design: RCT**<br>Intervention group (IG) followed exercise program Control group (CG) remained inactive Introduction of exercise and appearance of GDM, set with a confidence level of 95%. Exercise program from 10-14 wks GA until the end of pregnancy. IG exercised for 50-60 min per session 3 x a week. 2 sessions on land &1 aquatic based program. Land exercise- 10 min warm up, 20 min aerobic, 12 min resistance, 10 min pelvic floor, and 8 min stretching.<br>Water- 10 min warm up, 30 min aerobic, 20 min stretching. Borgs scale was used for intensity & an 12-14 level was maintained (not allowed to surpass 60% of calculated HR reserve). All sessions were also supervised by a fitness specialist & an OB. | **Results:** Differences for the 50-g maternal glucose screen at 24-28wk GA were not found. The oral glucose tolerance test at 180 minutes had lower values in the IG (98.00 +- 29.48mg dL) vs CG (116.25 +- 29.90mg dL.IG had a 90% reduced risk of GDM. IG also had less maternal weight gain according to pre-pregnancy BMI (22.8% vs 34.8% in the CG)<br>**Conclusion:** Exercise reduced the incidence of GDM & is associated with decreased gestational weight gain & preserved glucose tolerance. Weight gain & obesity promote type 2 diabetes. Increasing evidence there is better glucose | **Strengths:** RCT study design. Dynamic, controlled, supervised program. Offers a variety of options while using the dynamics of a group. A high level of adherence<br>**Limitations:** "Fails to statistically confirm that a causal relationship between a variable exists, but the literature seems to indicate so" (Cordero et al., 2015 pg. 1332).<br>Not using more contact via email, telephone, or increased visits where information is collected through interviews and questionnaires.<br>No nutritional analysis in this study. |

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| | Diagnosis of GDM was the primary outcome. Tested by using the criteria of the National Diabetes Data Group. 50g maternal glucose screen at GA from 24-28 wks & plasma glucose after one hour. A positive screen test when the values were equal or greater than 140 mgIdL, If this was positive then they had a 3 hour GTT (fasting 100 g oral glucose with plasma levels at 1, 2, &3 hrs. **Other pregnancy outcomes**-Excessive maternal weight gain defined according to pre-pregnancy body mass index. | control in pregnant women who exercise compared to those who are sedentary. | |

**Author Recommendations:**
Further studies need to be done to statistically confirm that the relationship of the existence of predisposition to diabetes in obese women rather than the independence of the pre-pregnancy BMI category.

**Summary for current clinical practice question:**
Glucose control can be improved when exercise is incorporated into the lifestyle of women with GDM. Not only does this decrease gestational weight gain but preserves glucose tolerance.

| **Source:** Cosson, E., Baz, B., Gary, F., Pharisien, I., Nguyen, M., Sandre-Banon, D., & . . . Valensi, P. (2017). Poor reliability and poor adherence to self-monitoring of blood glucose are common in women with gestational diabetes mellitus and may be associated with poor pregnancy outcomes. *Diabetes Care, 40*, 1181-1186. doi: 10.2337/dc17-0369 | | | |
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| **Purpose/Sample** | **Design (Method/Instruments)** | **Results/ Conclusion** | **Strengths/ Limitations** |
| **Purpose:** Evaluate compliance with self-monitoring of blood glucose & the reliability of diabetes logbooks in GDM as well as the associated determinants and outcomes.<br><br>**Sample/Setting:** 94 French speaking with newly dx GDM referred to diabetes management program & understood self-monitoring of blood glucose.<br>3 were excluded for not bringing back meter or being hospitalized.<br><br>**Johns Hopkins Evidence Appraisal: Quantitative Strength: Level 1 Quality: B/Good** | **Design: RCT**<br>**Instruments:**<br>Referred to a 1-day diabetes program & self-monitoring blood glucose teaching. Instructed on accurate testing, recording CBGs & using a postprandial alarm. Given target CBGs & advised insulin could be necessary if targets not achieved. Data extracted from EHR. Logbooks duplicated & glucometer data downloaded. Considered compliant if performed at least 80% of pre- and postprandial glucose tests. Inadequate timing was classified as before 100min or later than 140 min after the preprandial test.<br>5 categories of data were<br>1) underreported data- values in glucometer but not in logbook<br>2)concordant data- log book matching glucometer<br>3)non concordant data- different in the diary than meter<br>4)overreported- data in the diary with no data in meter | **Results:** Analyzed over 13 ± 3 days in 91. 78.0% performed ≥80% of required preprandial tests. 65.9% performed ≥ 80% of postprandial Only 61.5% performed ≥80% of required test. Average time between pre and postprandial tests was 141 ± 20 min, 46.5% of women performing ≥80% of postprandial test 100-140min after meals. Inadequate timing associated with higher HbA1c at baseline. 23.1% of had <90% matched values in diary and meter. Poor adherence associated with more preeclampsia (12.2 vs. 1.9%, $P$ = 0.049), & inadequate postprandial test timing with a higher HbA1c at delivery (5.3 ± 0.4 vs. 5.0 ± 0.3% [34 ± 2 vs. 31 ± 2 mmol/mol], $P$ < | **Strengths:** Included parameters dealing with psychosocial deprivation including dedicated social insurances<br>**Limitations:**<br>Analyses were carried out in a short period of time.<br>Results may not be generalizable.<br>Did not evaluate some parameters that may impact compliance and reliability (health beliefs, behavioral intentions, psychological factors, and fear of inadequate glucose control) |

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| | 5)concordant empty- no meter or self-reported data | 0.01), despite more frequent insulin. Poor compliance associated with a family hx of DM, social deprivation. Poor concordance associated with a family hx of DM. Underreported values high. Nonconcordant values underestimated **Conclusion:** Self-monitoring of blood glucose is an integral part of GDM care. Non-compliant were more likely to have family hx of DM in first degree relatives. Poor compliance associated with social insurance dedicated to people w/ social deprivation. Poor compliance was more likely to experience preE, the neonatal outcomes were the same either way. | |
| **Author Recommendations:** We need to improve motivation in women with GDM for self-monitoring. We should trust self-monitoring diaries with caution. We can adjust patient education with a supportive approach which in turn develops empowerment. Using the memory of blood glucose meters should improve the assessment of blood glucose control and guide clinical management in turn improving prognosis. | | | |
| **Summary for current clinical practice question:** Education of patients and importance of strict self-monitoring is key. Elevated CBGs are not a failure and reporting them can help the health of their baby and is needed for adequate treatment. | | | |

| **Source:** Engberg, E., Stach-Lempinen, B., Rono, K., Kautiainen, H., Eriksson, J., & Koivusalo, S. (2018). A randomized lifestyle intervention preventing gestational diabetes: effects on self-rated health from pregnancy to postpartum. *Journal of Psychosomatic Obstetrics & Gynecology, 39*(1), 1-6. http://dx.doi.org/10.1080/0167482X.2017.1286642 | | | |
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| **Purpose/Sample** | **Design (Method/Instruments)** | **Results/ Conclusion** | **Strengths/Limitations** |
| **Purpose:**<br>Examine effects of a randomized lifestyle intervention on self-rated health from pregnancy to postpartum (12-month PP) in participants at high risk for GDM<br><br>**Sample/Setting:**<br>266 (144 in intervention and 122 in control) women over 18 years old with a history of GDM, and/or BMI ≥ 30 kg/m² and currently pregnant < 20-weeks' gestation without diabetes, physical disability, current substance abuse, severe psychiatric disorder, or significant cooperation difficulties.<br>Conducted over 6 years in the maternity hospital of Helsinki and Lappeenranta in Finland. | **Design: RCT**<br>**Method:**<br>Individualized counseling on diet, physical activity, and weight management from trained nursing staff during each trimester of pregnancy and at 6 weeks, 6 months, and 12 months PP. Using the Nordic Nutrition Recommendations (optimizing participants' consumption of vegetables, fruits, and berries, whole-grain products, and on lowering intake of sugar-rich foods.)<br>Physical activity goal was 150 minutes of moderate-intensity activity per week. With an overall active lifestyle. Intervention group had access to supervised exercise groups.<br>All groups checked-in at six different times for various measurements.<br><br>**Instrument:**<br>Self-rated health survey with one | **Results:**<br>There was evidence that the intervention improved the self-rated health scores, but the data points did not reach statistical significance.<br><br>**Conclusion:**<br>Self-rated health was poorest in third trimester for both groups.<br>There was evidence that the intervention improved the self-rated health scores and pregnancy decreased the health rated health scores in pregnancy. | **Strengths:**<br>Randomized controlled study.<br>Study looked at pregnancy and postpartum.<br>Considered the personal perspective of their health and not just raw data.<br><br>**Limitations:**<br>Loss of 30% of the sample during the 12-month PP follow-up. Resulting in uneven groupings in the control and intervention group.<br>12-months may have been too short to fully evaluate the effectiveness of the study.<br>Both groups were being measured, which means it could have tipped off the control group as to what the goals of the study were and caused an effect of them having better diet choices and exercise habits.<br>Self-perception was not measured against medical perception of health. – No actual psychological evaluation.<br>Nurse patient relationship could have affected control group. |

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| **Johns Hopkins Evidence Appraisal:** Quantitative **Strength:** Level I **Quality:** B/Good | question, self-administered. | | |
| **Author Recommendations:** None | | | |
| **Implications:** Self-rated health directly correlates with actual health. The poorer the person rates themselves the higher their incidences of morbidity and mortality. | | | |

| **Source:** Halse, R. E. (2014). Home-based exercise training improves capillary glucose profile in women with gestational diabetes. *Medicine & Science in Sports & Exercise, 46*(9), 1702-1709. doi:10.1249/mss.0000000000302 | | | |
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| **Purpose/ Sample** | **Design (Method/Instruments)** | **Results/ Conclusion** | **Strengths/ Limitations** |
| **Purpose:** Study the effectiveness of a home-based cycling program upon diagnosis of GDM on daily fasting and postprandial blood glucose levels, hbA1c, & the response of glucose and insulin to a 75-g oral glucose load.<br>**Sample/ Setting:**<br>40 women recruited from diabetes service at King Edward Memorial Hospital in Perth, Australia within one week if GDM dx.<br>Inclusions: Single pregnancy between 26-30 wk GA with a normal anatomy scan. BMI ≤45, non-smokers, not engaged in a structured exercise program, | **Design:** RCT<br>Visited at home for a baseline assessment to confirm standard medical & OB demographic data & to do a Pregnancy Physical Activity Questionnaire (PPAQ) to evaluate the weekly average of energy expenditure (MET·h·wk−1) to assess household/caregiving, occupational and sports/exercise, & sedentary, light, moderate, & vigorous activity. Randomization placed each participant in the exercise intervention in combination with conventional management (EX, *n* = 20) or continue conventional management alone (CON, *n*=20)<br>The EX group participated in 5 home-based exercise sessions/week until 34wks.CON continued with their usual physical activity. Groups were assessed for glycemic control & counseling visits with a diabetes | **Results:** Baseline-no differences in maternal age, gestation, gravidity, parity, or pre intervention gestational weight gain (P > 0.05). No difference in degree of glucose intolerance at diagnosis w/ pre intervention fasting, 60- and 120-min venous plasma glucose after OGTT between groups (P > 0.05. Pre-Intervention HbA1c was similar between CON (5.3% ± 0.5%) & EX (5.2% ± 0.4%) (P > 0.05). 5 had GDM in a previous pregnancy (CON, n = 3, EX, n = 2). Compliance with cycling program for each participant was 96%. Mean capillary concentrations of glucose from pre to post exercise decreased from 6.3± to 0.8 mM pre exercise to 4.9±0.7 mM postexercise (P<0.001). The decline in CBG was ≥1.0 in 62% of all analyzed sessions with 26% of sessions in a drop less than 1.0mM. 12% resulted in an increase in CBG postexercise (in 68% of these cases | **Strengths:** Written informed consent Reviewed by University of Western Australia ethics committee. Excellent compliance to program. Home environment & support from exercise physiologist could have increased comfort & familiarity to eliminate barriers to exercise.<br>**Limitations:**<br>Diet not strictly controlled. The group volunteered for an exercise intervention, which could indicate greater awareness & commitment to managing condition. Small sample size. Short intervention period. |

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| medically cleared for exercise. Exclusions: less than 18 years old, unable to understand the implications of participation, on any medications at time of recruitment, had low lying placenta, preexisting diabetes, or cardiac disease. **Level of evidence: Johns Hopkins Evidence Appraisal:** Quantitative **Strength:** Level 1 **Quality:** B/ Good | educator & dietician. Participants checked CGBs QID, fasting & 2 hrs postprandial) daily recorded by the participant. Diet evaluated by a food diary that recorded all food & drink intake in the first & last 7 days of the intervention. Nutritional intake was determined using a commercially available program to analyze the average daily energy intake, absolute & relative intake of carbohydrate (CHO), fat & protein, & absolute intake of sugars and dietary fiber. EX group completed 3 home-based sessions on stationary cycle supervised by an exercise physiologist & 2 unsupervised on alternative days. Sessions were 5 min of low intensity warm up (55-65% of max HR) followed by continuous moderate intensity (65-75% max HR) & high intensity bouts (75-85% max HR) every 2 minutes alternated for 25-30 minutes up to the goal of 45 min by week 4 concluded with a 5-10 min cool down. BP & CBGs were measured pre & post workout at the supervised sessions as well as the time of the last meal.If blood | participants ate within 30 min of session). 2 CON and 2 EX had to start insulin therapy according to routine care. Mean CBG concentration was within the target ranges in the other 38. Tendency for lower daily fasting glucose concentrations in EX compared with those in CON ($P = 0.083$). Overall mean postprandial (PP) glucose concentration was significantly lower in EX compared with that in CON ($P = 0.046$). PP glucose concentration was lower specifically after breakfast ($P = 0.036$), with a tendency for lower values at dinner ($P = 0.054$), whereas glucose concentrations after lunch were similar between EX and CON groups ($P = 0.312$).Glucose response to the post intervention OGTT no significant difference between CON and EX ($P > 0.05$) or within groups when compared with the pre intervention values ($P > 0.05$). Insulin response to the OGTT was similar between groups ($P > 0.05$) with no statistical difference calculated whole-body insulin sensitivity between CON ($4.2 \pm 2.3$) & EX ($5.0 \pm 3.0$) ($P > 0.05$). HbA1c was higher at the post | |

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| | glucose was <3.0 mM before exercise participants ate 15-30g of high glycemic index food prior to exercise. HR was measured at regular intervals during exercise to monitor intensity. | intervention assessment in both CON (5.4% ± 0.3%, *P* =0.029) and EX (5.3% ± 0.4%, *P* = 0.012) compared with pre intervention values, with no difference between groups (*P* > 0.05).Total weekly activity based on the PPAQ similar in CON and EX at baseline & post intervention (P > 0.05). Post Intervention, EX group reported an increase from pre intervention weekly sports/exercise participation, with higher MET-hours per week compared with those in CON (CON, 8 ± 9 MET·h·wk−1; EX, 25 ± 9 MET·h·wk−1; P < 0.001). All other components of physical activity were similar between groups pre- & post-intervention (P > 0.05).Nutritional intake similar during the first & last 7 d of the intervention, no difference in mean daily total intake of energy & absolute intake of CHO, sugars, fat, protein, & dietary fiber (P > 0.05) Intake of protein was lower in the EX group during the first (P = 0.033) & last week of the intervention (P = 0.009).Intake of CHO was higher in EX during | |

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| | | the last week of the intervention (P = 0.035) **Conclusion:** Started at diagnosis of GDM improved daily postprandial glucose control but did not alter HbA1c, glucose tolerance, or the insulin response to the post intervention OGTT.Home based exercise programs may help to maintain normal postprandial CBGs in diet controlled GDM. | |
| **Author Recommendations:** Using a home-based program may help patients with diet-controlled GDM manage daily PP CBGs. Adding supervision and home based may increase compliance and help overcome barriers to exercise and establish lifestyle changes. Implementing a specific exercise program while providing support may be an integral part of routing OB counseling in management of GDM. | | | |
| **Summary for current clinical practice question:** Home based programs are good for monitoring CBGs in GDM patients, but there needs to be some direction to increase the compliance of patients. Interviewing and asking about barriers in their life & implementing ways to overcome this can help increase their compliance and management of GDM | | | |

| **Source:** Han, S., Middleton, P. F., Tran, T. S., & & Crowther, C. A. (2016). Assessing use of a printed lifestyle intervention tool by women with borderline gestational diabetes and their achievement of diet and exercise goals: A descriptive study. *BMC Pregnancy and Childbirth, 16*(42), 44. doi:10.1186/s12884-016-0825-z | | | |
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| **Purpose/Sample** | **Design (Method/Instruments)** | **Results/ Conclusion** | **Strengths/ Limitations** |
| **Purpose:** Assess the use of a booklet to record & assist dietary & lifestyle changes in GDM; to describe diet & exercise goals set during the initial discussions; & to assess goal achievement<br>**Sample/Setting:** 358 women given booklets, 56 returned booklets & used them at least once. Between 24& 35 wks GA with a singleton pregnancy classified as having borderline GDM<br>**Johns Hopkins Evidence Appraisal:** Quantitative<br>**Strength:** Level 1<br>**Quality:** B/Good | **Design:** RCT<br>**Instruments:** Placed in intervention (IG) or routine group (RG). IG- received booklets during initial lifestyle discussions with a dietician & invited to return them after delivery. Advised to bring to antenatal appts and delivery. Book was designed to record existing diet & exercise patterns & to see goals. Reviewed dietary monthly & exercise habits. Goals reset monthly. Counseled on recommendations & best available evidence. Information entered into a database. Dietary data was categorized into 7 categories. Grains, Veggies, fruit, dairy, meat & protein rich foods, foods high in fat, sugar &/or salt, & overall dietary goal. Exercise data was analyzed by systematic comparisons based on grounded theory methods. | **Results:** 56 completed initial lifestyle discussion at a mean gestation of 31.6 (1.7) wks. 52 (92.9%) used the booklet for setting dietary goals for the next month, 53 (94.6%) used booklets at least once for reviewing existing pattern of exercise, & 44 (78.6%) used the booklet for setting exercise goals for the next month. After 1 month 86.4% achieved exercise goals of maintaining current level of activity, only 25% of goals to increase walking were met. Most frequent dietary goal was to reduce foods high in sugar, fat, &/or salt. Set a total of 197 dietary goals & 65 exercise goals. In the 1st month over 80% of dietary goals that targeted grains, dairy, & overall diet were achieved. 20-30% of the goals about veggies & foods high in fat, sugar, &/or salt were met. **Conclusion:** | **Strengths:** Ethics approved. Written consent from participants.<br>**Limitations** Women were invited, but not required to return booklets. Majority of women who returned booklets were from 2 geographical areas. Self-reported data. |

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| | | Women who used pregnancy logbooks reported good achievement rates for goals related to grains, fruits, dairy, and overall diet, but were less likely to be successful in goals to increase vegetables and limit foods high in fat, sugar and/or salt.<br>Maintaining an active lifestyle during pregnancy was feasible. Increase in physical activity were less often achieved.<br>Using a pregnancy logbook may be helpful in assisting as well as encouraging behavioral changes. | |
| **Author Recommendations:** Further investigations of long-term effects in different populations are warranted. Information from this study may help to design behavioral intervention tools in the future to provide tailored care for women. | | | |
| **Summary for current clinical practice question:** When women are dx with GDM it is important to educate them on the management of this health condition and ways to improve long- and short-term outcomes for their health and their baby. Encouraging an active and healthy lifestyle can help in this management. Giving women the tools to achieve this is important for success. | | | |

| **Source:** Horsch, A., Kang, J., Vial, J., Ehlert, U., Borghini, A., Marques-Vidal, P. . . . Puder, J. (2016). Stress exposure and psychological stress responses are related to glucose concentrations during pregnancy. *British Journal of Health Psychology*, 21, 712-729. doi:10.1111/bjhp.12197 | | | |
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| **Purpose/Sample** | **Design (Method/Instruments)** | **Results/ Conclusion** | **Strengths/ Limitations** |
| **Purpose:** To investigate the impact of stress exposure, psychological stress responses, & physiological stress responses on glucose concentrations during pregnancy. **Sample/Setting**203 pregnant women at the maternity department of a Swiss University hospital between 11/2012 & 7/2013. Asked to participate while waiting for their routine appt in the waiting room. Excluded if they were not able to complete the self-report questionnaires due to difficulties with French or if they had medical problems or used medications that could influence their cortisol and/or glucose levels**.** | **Design:** Cross sectional study<br>**Instruments:**<br>Routine screening for GDM at 24-30 wks GA with a 75-g OGTT. Diagnosis using the guidelines of the International Association of Diabetes and Pregnancy Study group, ADA, & the Endocrine Society. Given a list of 3 negative pregnancy related major events & ten negative pregnancy unrelated events & were asked if they were exposed to any of these in the prior 12 months. Pregnancy-related & pregnancy-unrelated major life events, perceived stress (measured by PSS scale), general psychosocial distress, anxiety, depression, & amount of sleep (measured by Pittsburgh Sleep Quality Index) were assessed by validated self-reported questionnaires. Depression and anxiety were measured by the DASS-21 scale. | **Results:**<br>39 (19.2 %) were dx with GDM. With GDM were significantly older ($t$=313, $p$=.002, $g$=.56), had a higher pre-pregnancy BMI ($t$=2.75. $p$=.006, $g$=.51), & higher current BMI ($t$=2.66, $p$= .008, $g$=.52) than without GDM. Positive associations were found between the number of pregnancy related major life events ($r$=.16, $p$=0.26) & fasting glucose. No association with pregnancy-unrelated major life events ($p$>.22). More anxiety & depressive symptoms, a higher general level of distress (.15≤ $r$ ≤ .18, $p$ <.030), & shorter duration of sleep ($r$ = -.18, $p$=.009) were related to fasting glucose. When age & BMI were controlled for the general level of distress & shorter duration of sleep not significant. Physiological stress responses were not | **Strengths:**<br>Informative sheet and consent given to participants. Women were allowed to ask questions about the study.<br>Ethical approval from Cantonal Ethics Committee of Vaud, Switzerland.<br><br>**Limitations:**<br>Lack of consideration of dietary factors as potential confounders and lack of measuring social support and coping. |

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| **Level of evidence: Johns Hopkins Evidence Appraisal:** Quantitative **Strength:** Level III **Quality:** B/Good | Physiological stress was measured by cortisol samples. Cortisol was measured using fasting & bedtime saliva samples, and copeptin using fasting plasma. Measured prior to receiving the 75-g OGTT. Results of GTT were not given until after obtaining the evening cortisol sample. Samples were analyzed using CLIA. Inter-and intra-assay coefficients of variation were below 5%.<br>Participants were asked how many minutes/weeks they engaged in moderate physical activity in the last 7 days using the International Physical Activity Questionnaire (IPAQ). Education, history of GDM, family hx of diabetes, medical diseases, and current medication were assessed. Self-reported data (age, pre-pregnancy and current weight, and current height) were collected. | associated with glucose concentrations (all $p>.05$). Age correlated + with all 3 glucose indices ($.21\leq r\leq .25$, $p<.01$) suggests higher glucose if older. Family hx of DM was positively linked to 1-or 2-hour post load glucose concentrations ($r=.15$, $p=.036$, or $r=.19$, $p=.008$). Dx with GDM reported more pregnancy-related life events. Education level, migrant status, duration of physical activity had no correlate with any of the 3 glucose variables (all $p> .11$)<br>**Conclusion:** Some indicators of stress exposure and psychological stress response were associated with fasting glucose concentrations. Concludes that stress exposure & psychological stress are important risk factors for GDM development. | |

**Author Recommendations:**
Given the lack of studies on cortisol and copeptin levels in pregnancy further research is needed to clarify if copeptin is a useful predictor of metabolic disturbances in pregnancy. Results need to be replicated before firmer conclusions can be drawn.

**Summary for current clinical practice question:** Women who are exposed to increased stress could have higher fasting CBGs. Incorporating self-care and ways to decrease stress could help control elevated fasting CBGs.

| **Source:** Jamilian, M., Amirani, E., & & Asemi, Z. (2018). The effects of vitamin D and probiotic co-supplementation on glucose homeostasis, inflammation, oxidative stress and pregnancy outcomes in gestational diabetes: A randomized, double-blind, placebo-controlled trial. *Clinical Nutrition*. doi:10.1016/j.clnu.2018.10.028 | | | |
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| **Purpose/Sample** | **Design (Method/Instruments)** | **Results/ Conclusion** | **Strengths/Limitation** |
| **Purpose:** To assess the effects of the combination of vitamin D and probiotic supplements on the metabolic status of women with GDM<br>**Sample/Setting:** 87 Primigravida women age 18-40 and with a GA between 24-28 wks that were diagnosed with GDM by a 2 hr 75g GTT based on guidelines by the American Diabetes Association guidelines. Performed at a gynecology clinic in Iran. Exclusions- taking vitamin D, probiotic, or symbiotic supplements 3 months prior to the intervention. Being on insulin therapy, pre- | **Design:** RCT<br>Matched by BMI and age & then randomly assigned into 3 groups.1 group received a probiotic, 1 received a probiotic & 50000 IU vitamin D3 every 2 weeks, or the placebo group. The duration of intervention was 6 weeks but were followed until delivery. Participants advised to maintain routine dietary habits & activity. They also completed 3-day food records & 3 physical activity measures as metabolic equivalents at weeks 0, 3, & 6 during treatment<br>All followed standard pregnancy protocol in Iran which included taking 1000 IU Vitamin D3 & 400 ug vitamin B9 daily from the beginning of pregnancy & 60mg per day of ferrous sulfate per day starting at the second trimester. Compliance monitored by assessing serum levels of vitamin D. Intake of the participants was monitored by asking the participants to return medication containers. To increase compliance, | **Results:** Mean BMI & weight were not statistically different between treatment or placebo groups at the end of the study. No significant changes in macro & micronutrients among the groups. Vitamin D & probiotic co supplementation significantly reduced fasting plasma glucose (from 95.4 to 83.1) serum insulin levels (12.8 to 10.8), homeostasis model of assessment-insulin resistance (3.0 to 2.2). An increase of the quantitative insulin sensitivity check index was also noted (0.32 to 0.34) Probiotic supplementation also resulted in a significant reduction of fasting plasma glucose (96.6 to 86.5), serum insulin levels (13.1 to 11.7), homeostasis model | **Strengths:** That study used a large group of participants and also had similar average ages, heights, and BMIs in each group to prevent any bias.<br>**Limitations:** The study had funding limitations and they were not able to characterize the microbiota and therefore unable to establish in the microbiota changed its composition. There was also no examination of the effects of vitamin D and probiotic supplementation on gene expression related to metabolic profiles. |

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| eclampsia, smoking, hyper and hypothyroidism<br><br>**Johns Hopkins Evidence Appraisal:** Quantitative<br>**Strength:** Level 1<br>**Quality:** B/ Good<br>The researchers used a significant sample size and the results are generalizable. They also used RTC for the design study. The article is not high quality because there are not definitive conclusions or consistent recommendations. | they received daily calls reminding them to take supplements.<br>**Instruments**<br>Measurement of weight & height at baseline & 6 weeks following intervention.<br>Primary outcomes- markers of insulin metabolism.<br>Secondary outcomes- lipid profiles, biomarkers of inflammation, & oxidative stress.<br>Ten milliliters of fasting blood samples were collected at the beginning of the trial. 25-hydroxyvitamin D concentrations were measured using ELISA kits. Enzymatic kits were used to quantify fasting plasma glucose, serum triglycerides, LDL, HDL, & total cholesterol. Used the Statistical Package for Social Science version 18 for analysis. | of assessment-insulin resistance (3.1 to 2.5). An increase of the quantitative insulin sensitivity check index was also noted (0.33- 0.34)<br>Both treatment groups did not show any change in other metabolic parameters.<br>**Conclusion:**<br>Vitamin D & probiotic supplementation was showed significant improvements in glycemic control but did not affect other metabolic profiles & pregnancy outcomes. | |
| **Author Recommendations:**<br>Further studies are needed to continue to explore possible mechanisms for decrease in insulin levels and hyperbilirubinemia in infants. | | | |
| **Summary for current clinical practice question:**<br>Adding in supplements such as vitamin D and probiotics may help with glycemic control in GDM. | | | |

| **Source:** Jarvie, R. (2017). Lived experiences of women with co-existing BMI ≥ and Gestational Diebetes Mellitus. *Midwifery, 49*, 79-86. doi: 10.1016/j.midw.2016.12.009 | | | |
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| **Purpose/Sample** | **Design (Method/Instruments)** | **Results/ Conclusion** | **Strengths/Limitations** |
| **Purpose:**<br>Discover how women with GDM feel about their treatment.<br><br>**Sample/Setting:**<br>27 women with a BMI ≥ 39 AND GDM.<br>Diabetes antenatal clinic at two NHS hospital trusts in the South West of England<br><br>**Johns Hopkins Evidence Appraisal:**<br>Qualitative<br>**Strength:** Level I<br>**Quality:** B/Good | **Method:**<br>sociological design.<br><br>**Instrument:**<br>Narrative interviews during pregnancy, post-birth and fieldnotes | **Results:** GDM patients tend to have more daily and cumulative stressors, and lower self-esteem. Women felt judged for their GDM and this made their mental health decrease. Financial concerns were a barrier to buying the proper food to control weight. Several patients requested for blood sugar log reviews that they be done over the phone for reasons of time and cost.<br>**Conclusion:**<br>Women had several other outside factors that hindered their ability to manage their pregnancy, weight, and diabetes. Women felt that there was a stigma placed on them by the healthcare teams and the general public due to their weight. The more it was mentioned the greater the stigma felt. | **Strengths:**<br>Good use of article review and in-depth review of interview results.<br><br>**Limitations:**<br>Interviewees could report inaccuracies. Majority of participants were of low socio-economic status; not fully representative of general population.<br><br>Low number of participants. |
| **Author Recommendations:**<br>Offer women collaborative care which would track who and how many times their weight and lifestyle changes were being addressed. | | | |
| **Implications:**<br>Study noted that in order to assist women in not having to come into the clinic as frequently they were given access to a smartphone and an app to track sugars, diet, and exercise and they were able to comply better with the program(s). | | | |

**Source:** Koivusalo, S. B., Rönö, K., Klemetti, M. M., Roine, R. P., Lindström, J., Erkkola, M., . . . Stach-Lempinen, B. (2015). Gestational diabetes mellitus can be prevented by lifestyle intervention: The Finnish gestational diabetes prevention study (RADIEL). *Diabetes Care, 39*(1), 24-30. doi:10.2337/dc15-0511

| **Purpose/Sample** | **Design (Method/ Instruments)** | **Results/ Conclusion** | **Strengths/ Limitations** |
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| **Purpose:** To examine the effect of combined moderate physical activity & diet intervention in high-risk women on the incidence of gestational diabetes<br>**Sample/Setting:** Participants recruited from obese women's in association with the first trimester screening ultrasound, women with previous GDM were recruited by personal invitations based on hospital data. There was also notices in newspapers, social media, and antenatal clinics. 540 women were recruited, 247 did not meet study criteria. Most common reason was preliminary OGTT result. 24 women were | **Design:** RCT<br>**Intervention group (IG):** received lifestyle counseling from study nurses and dieticians that were specifically trained. Got structured, but individualized visits at around 13.3 wks gestation, 23.1 wks gestation, & 35.1 wks gestation with the study nurse. Attended 2-hour group counseling sessions with a dietician in addition to normal antenatal visits per the standard national practice.<br>If the participants BMI was $\geq$ 30 they were advised to not gain weight during the first 2 trimesters. Given dietary advice to optimize consumption of vegetables, fruits & berries, whole grain products rich in fiber, low-fat dairy products, vegetable fats high in | **Results:** Demographic & clinical characteristics did not differ between the 2 groups at baseline. 66 reported chronic disease and 22% Parental hx of diabetes with no group differences. Both groups visited antenatal clinic 4 times prior to the 2nd trimester OGTT. GDM was dx in 20 (13.9%) in the IG and 27 in the CG (21.6%). Crude relative risk for GDM was .64 in the IG. IG had crude reduction in fasting plasma glucose concentration of -0.18 mmol/L from baseline in the 3rd trimester compared with -0.07 mmol/L in the control group. In the IG the 2-h glucose value increased in baseline to 2nd trimester by 0.54 mmol/L & in the CG by 0.55 mmol/L. Weight gain difference from baseline to 2nd trimester: intervention | **Strengths:** Participants entered the study voluntarily Signed an informed consent. Allowed to leave the study at any point they wanted. Participants did not have to be labor intensive to participate. In compliance with the Declaration of Helsinki Approved by the ethics committees. Registered at clinicaltrials.gov . Intervention started early in pregnancy & had a longer intervention period. Study nurses were midwives with strong |

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| excluded due to miscarriage or loss to follow up.<br>269 women ≥ 18 years old with a history of GDM and/or a pre pregnancy BMI ≥ 30 were enrolled at <20 weeks of gestational age.<br>144 were assigned to the intervention group and 125 to the control group.<br>Exclusions: type 1 or 2 diabetes, the use of medication that influences glucose metabolism (continuous therapy with oral corticosteroids or metformin), multiple pregnancy, physical disability, current substance abuse, severe psychiatric disorder, and significant difficulty in cooperating, and women with GDM prior to 20 weeks GA.<br>Conducted between 2/2008 and 1/2014 in 4 maternity hospitals (Helsinki University Central Hospital, Katiloopisto Maternity Hospital, | unsaturated fatty acids, fish, low-fat meat products, & lower intake of sugar rich foods.<br>Physical activity: achieve a minimum of 150 minutes of moderate physical activity per week, as well as an overall active lifestyle. Also got free access to pools and exercise groups once a week.<br>**Control Group:**<br>Received general info on diet and exercise provided by antenatal clinics. Had 3 visits with study nurse for data collection.<br>Incidence of GDM was defined as one or more pathological glucose values in a 75-g, 2 -h oral glucose tolerance test with thresholds of; fasting ≥5.3 mmol/L, 1-h ≥10.0 mmol/L, and 2-h ≥ 8.6 mmol/L. All participants underwent OGTT at enrollment then at 24-28wks GA unless insulin or metformin treatment was initiated earlier.<br>Blinded-study physicians reviewed OB records and maternal and neonatal diagnosis.<br>At each visit in both groups they filled out | group 2.5 kg & CG 3.1 kg, mean difference of -0.2kg. Dietary index score improved in the IG (0.7) compared to the CG (0.3) mean difference of 0.4. Activity was increased in the IG by 15 min, where the physical activity in the CG remained the same. Goal of 150 min/week was met by 26% of the IG and 23% of the CG, no significant differences in the groups. No differences in the other maternal pregnancy or birth outcomes assessed between the groups.<br>**Conclusion:**<br>The first randomized controlled lifestyle intervention trial that succeeded in reducing overall incidence of GDM among high risk pregnant women. Combining moderate physical activity with diet intervention the overall incidence of GDM was reduced by 39%. IG increased activity & improved diet during pregnancy which indicated a real effort to change lifestyle in a healthier direction. CG did not improve in a significant manner. Results are encouraging and | expertise in counseling pregnant women.<br>**Limitations:**<br>Control group was more of a mini intervention group since they received general health advice at antenatal clinics. Performed in a white population. |

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| Jorvi Hospital, and South-Karelia Central Hospital in Lappeenranta).<br><br>**Level of evidence: Johns Hopkins Evidence Appraisal:** Quantitative<br>**Strength:** Level 1<br>**Quality:** B/ Good<br>Consistent results with a sufficient sample size and they used RTC design. They did have conclusions but need to be implemented in a larger group and with different ethnicities. | questionnaires as well as physicals with measurements and blood samplings. Food questionnaires were filled out prior to each visit with the nurse to measure adherence to the recommended diet. Physical activity was self-reported by time spent weekly being active measured by sweating. | similar to findings in Type 2 diabetes prevention studies. It was evident that study was directed at high risk women due to the number of elevated OGTT existing at the beginning of pregnancy. The largest effect of a lifestyle intervention is seen in high risk individuals. The tailored counseling helped to get participants to engage in activities per their personal preferences | |
| **Author Recommendations:**<br>Setting would need a bigger sample size to reveal the effect of lifestyle intervention. Also including other ethnicities to be less generalized. Since the interventions were simple and easily modifiable it would be easy to implement in other ethnic groups. | | | |
| **Summary for current clinical practice question:**<br>GDM can be prevented in a high-risk population by simple and easy applicable lifestyle change/intervention. This intervention should be initiated early and continued throughout the pregnancy for the best outcomes. Prevention of GDM can have short- and long-term health consequences for the mother and the child. | | | |

**Source:** Luoto, R., Kinnunen, T. I., Aittasalo, M., Kolu, P., Raitanen, J., Ojala, K., & . . . Tulokas, S. (2011). Primary prevention of gestational diabetes mellitus and large-for-gestational-age newborns by lifestyle counseling: A cluster-randomized controlled trial. *PLoS Medicine, 8*(5), p.e1001036. doi:10.1371/journal.pmed.1001036

| **Purpose/ Sample** | **Design (Method/Instruments)** | **Results/ Conclusion** | **Strengths/ Limitations** |
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| **Purpose:** Examine whether gestational diabetes or a newborn's high birth weight can be prevented by lifestyle counseling in pregnant women who are at a high risk for gestational diabetes. **Sample/Setting:** Screened 2271. 640 agreed to participate, 24 had a miscarriage, 174 had abnormal OGTT at baseline, 29 did not respond to the final survey, 14 had a miscarriage. 399 participants were included. 219 in the intervention group and 180 in the control group. Mean age was 30. Eligible if they had at least one of the following: pre pregnancy BMI $\geq$25, GDM, any signs of glucose | **Design:** Cluster RTC Intervention 8-12 wks until 37 wks. Recommendations for weight gain discussed. A graph was given to monitor weight gain. Physical activity counseling was implemented at 8-12 wks Diet counseling at 16-18 wks. If OGTT was dx of GDM at 26-28 wks participant was also referred to specialists. Physical activity counseling aimed to increase leisure time activity in those not meeting recommended activity for the level of health as well as maintain or adjust those who were already meeting recommendations. Min weekly leisure time physical activity dose 800 MET (multiples of resting metabolic equivalents) minutes. Evaluation of leisure time activity was evaluated on self-report. Dietary counseling aimed to help achieve a diet containing $\leq$10 % saturated fat, 5-10% polyunsaturated fat, 25-30 | **Results:** No significant differences between the intervention and control group at baseline or 26-28 wks in glucose tolerance measurements. The proportion of women with GDM, total gestational weight gain, preeclampsia, or used of diabetic medication did not differ significantly. Gestational age of newborns was 39.4$\pm$ 1.9 wks vs 39.6$\pm$1.3wks. The average weight of newborns was lower in the intervention group (3,532 g) vs control group (3659 g) adjusted $p$=0.035. When looking at between group differences in birth weight (absolute size-133g, 95% CI-231 to -35) and birthweight per gestational age (absolute effect size -3.08, 95%C CI-5.29 to -0.87) remained significant after taking cluster, clinic, nurse, | **Strengths:** Approved by review board and ethical committee of Pikanmaa Hospital District, and the physicians in charge of the clinics. Participants also provided written informed consent. **Limitations:** Absence of late pregnancy measurement of maternal glucose intolerance and not being able to measure and assess maternal endpoints close to delivery, so high birthweight was used as a |

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| intolerance, or newborn's macrosomia (≥4500 g) in any earlier pregnancy, type 1 or 2 DM in 1st or 2nd degree relatives, or age ≥40. Exclusions: at least 1 of 3 baseline (8-12 wk) OGTT measurement was abnormal, pre pregnant type 1 or 2 DM, inability to speak Finnish <18 yr old, multiple pregnancy, physical restriction preventing physical activity, substance abuse, or treatment or clinical hx of a psychiatric illness. Conducted in maternity clinics of primary health care centers of 14 municipalities in Pirkanmaa region in SW Finland. Study conducted between 10/1/07 and 12/31/08. **Level of evidence: Johns Hopkins Evidence Appraisal:** Quantitative **Strength:** Level 1 | % total fat, <10% saccharose of total energy intake, & 25-35 g/d fiber. Counseling cards standardized counseling. Used notebooks to set plans for physical activity & dietary changes & to record adherence to the plan. Control group received no counseling beyond usual care. Dx of GDM was based on 2-h OGTT with results of fasting ≥5.3 mmol/L, 1h ≥10.0mmol/L,& 2h ≥ 8.6 mmol/L. Birthweight based on hospital records & the research group. Level of insulin resistance & glucose tolerance based on homeostasis model assessment insulin resistance (HOMA-R) calculator & calculated as fasting insulin x fasting glucose concentration /22.5. Blood samples were taken at 8-12 & 26-28 wks Neonatal outcomes reported: sex, proportions of Macrosomic, LGA (above 90%) and SAG (below 10%), GA at delivery, birthweight standard deviation (SD), crown-heel length (measured with measuring board), crown-heel length SD score, ponderal index (birth weight in kg divided by the cube of the crown-heel length in meters), and newborn head circ. (measuring tape to the nearest millimeter). | maternal age, education, sex of the infant, parity, prepregnancy BMU, gestational weight gain, and smoking into account ($p$=0.024). Birthweight SD was not significantly different. The proportion of LGA infants was lower in intervention group (12.1%) than the control (19.7%, $p$=0.042) **Conclusion:** Using a cluster-controlled design lifestyle counseling was effective in controlling the proportion of LGA newborns, be the result concerning the effectiveness on controlling/reducing GDM was inconclusive. There were beneficial effects on the dietary aims of intake of dietary fiber, saccharose, and saturated and polyunsaturated fatty acids. Women who were adherent to lifestyle aims had lower proportion of LGA newborns and lower incidence of GDM. The proportion of the incidence of GDM was expected to be | marker of longstanding glucose intolerance in pregnancy. There could also be inaccuracy of measurement of the newborn taken in the hospital since they are nondifferentia l and errors can be made. Women and nurses of the control group could not be blinded for the purpose of the study and this could have changed their health behavior and/or counseling practices. |

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| **Quality:** B/ Good | Measurements collected through medical records. Leisure time physical activity was reported by a self-report at baseline, 26-28 wks, and 36-37 wks Follow ups questioned physical activity in the prior 3 wks. Intensity based on the breathlessness of the wmn. METs were quantified 3 for light, 5 for moderate & 7 for vigorous. Dietary habits were assessed using questionnaire at baseline, 26-28 wks & 36-37 wks. Data underwent statistical analysis and numbers and percentages were reported with standard deviations (SD) or 95% confidence intervals (CI). SPSS software and STATA were used for multilevel analysis to examine cluster, clinic, nurse, and individual influences on outcomes and correlation of results. | half lower than the control group according to power calculations, but results didn't support the reduction. The time of the initiation of dietary counseling (16-18 wks) to the measurement of GDM (26-28 wks) may have been to short of a time period to produce changed that have an effect on the development of GDM. | |

**Author Recommendations:**
Researching with a larger sample group may have changed the study results. Also, most of the women included had a quite low risk of developing GDM. If higher risk women were included the results may have been different. The counseling may have been more applicable if the interventions were delivered by research nurses or other staff.

**Summary for current clinical practice question:**
Interventions for prevention of GDM need to be given very early in gestation to see if they can have an impact on preventing GDM. Diet and lifestyle interventions do have an impact on reducing LGA newborns, which can lead to better health later in life.

| **Source:** Mazzoni, S., Hill, P., Webster, K., Heinrichs, G., & Hoffman, C. (2015). Group prenatal care for women with gestational diabetes. *Journal of Maternal-Fetal and Neonatal Medicine, 29*(17), 2852-2856. doi: 10.3109/14767058.2015.1107541 | | | |
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| **Purpose/ Sample** | **Design (Method/Instruments)** | **Results/ Conclusion** | **Strengths/ Limitations** |
| **Purpose:** Compare group prenatal care for GDM patients versus traditional 1:1 care.<br><br>**Sample/Setting:** 165 GDM Patients: 62 in group care and 103 in traditional in the Denver Health Hospital Authority System.<br><br>**Johns Hopkins Evidence Appraisal:** Quantitative **Strength:** Level III **Quality:** B/Good | **Method:** Observational Study<br><br>**Instrument:** Most traditional patients were previous patients as the group setting was made available to all patients if they wished. The group was led by OBs and MFM practitioners. | **Results:** Women in group care had less prenatal visits, and less OB triage problem visits. They also required less antenatal diabetic medication (namely insulin) and had improved glucose tolerance in the postpartum period. Those in group had higher rates of increased activity and diet modifications. Those in group received "more frequent and in-depth" education that was enhanced by peer-to-peer interaction. They had an average delivery at 39 weeks; and had the same occurrences of spontaneous preterm births. Weight gain was also similar between groups.<br>**Conclusion:** Group care for GDM patients shows decreased transition to A2 GDM and better glucose tolerance in the post-partum period; without affecting obstetric or neonatal outcomes. | **Strengths:** Mix of private and state assisted healthcare patients.<br><br>**Limitations:** Groups were studied at different times, not a true control group. Small sample size. |
| **Author Recommendations:** Group prenatal care for GDM patients is an improved model of care resulting in improved screening for diabetes outside of pregnancy and decrease resource utilization for antenatal care and long-term benefits. | | | |
| **Implications:** When considering alternate therapy for GDM patients it would be prudent to consider the group setting for education and support. | | | |

**Source:** Miremberg, H., Ben-Ari, T., Betzer, T., Raphaeli, H., Gassnier, R., Barda, G., . . . Weiner, E. (2018). The impact of daily smartphone-based feedback system among women with gestational diabetes on compliance, glycemic control, satisfaction, and pregnancy outcome: a randomized controlled trial. *American Journal of Obstetrics and Gynecology, 218*(4), 453.e1 - 453.e7, https://doi.org/10.1016/j.ajog.2018.01.044

| **Purpose/Sample** | **Design (Method/Instruments)** | **Results/ Conclusion** | **Strengths/Limitations** |
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| **Purpose:**<br>To determine the effectiveness of using a smartphone app to encourage tighter glycemic control in gestational diabetic patients<br>**Sample/Setting:**<br>120 English and speaking and reading; as well as Hebrew reading and writing pregnant women age 18-45, with single gestation and newly diagnosed gestational diabetes less than 34 weeks' gestation at a multidisciplinary diabetes-in-pregnancy university-affiliated clinic; were split into groups of 60. Each group received care and one group used the smartphone application.<br>**Johns Hopkins Evidence Appraisal:**<br>Quantitative<br>**Strength:** Level I<br>**Quality:** A/High | **Design**: randomized control trial.<br><br>**Instruments:**<br>Smartphone and application *Glucose Buddy*.<br>Questionnaire in Hebrew about the ease of use of the application versus difficulties, and their satisfaction with their prenatal care. | **Results:**<br>Control group had 66% compliance of glycemic control and the smartphone group had higher glycemic control at 84%. The smartphone group also had less insulin use at 8 patients, and the control group had 18 patients on insulin.<br>**Conclusion:**<br>Smartphone based daily feedback and communication platform between gestational diabetes mellites patients and the multidisciplinary diabetes-in-pregnancy clinic team improved patient compliance and glycemic control and lowered the rate of insulin treatment. | **Strengths:**<br>Women who used the smartphone app reported satisfaction with the application: Glucose Buddy.<br>Integration of easily accessed instrument.<br>Smartphones are common (80% in developed countries).<br>Good integration of home data collection and provider feedback to that data.<br>Creating a link between those two worlds.<br>**Limitations:**<br>Women had to be able to converse in English and read and write in Hebrew.<br>Non-application using patients were not surveyed on their satisfaction with their prenatal care.<br>Application has cost associated with it and could exclude lower income families. Cost per website is $5/month.<br>There were no statistical benefits to birth outcomes or fetal weight.<br>Small sample size. |

**Author Recommendations:**
That further studies need to be done in order to prove efficacy of integration of smartphone applications to increase glycemic control of women with gestational diabetes.

**Implications:** This study shows that there is potential to use smartphones to decrease insulin use in pregnant women with gestational diabetes and should be considered.

**Source:** Rasekaba, T., Furler, J., Young, D., Liew, D., Gray, K., Blackberry, I., & W., L. (2018). Using technology to support care in gestational diabetes mellitus: Quantitative outcomes of an exploratory randomized control trial of adjunct telemedicine for gestational diabetes mellitus (TeleGDM). *Diabetes Research and Clinical Practice*, 142, 276-285. https://doi.org/10.1016/j.diabetes.2018.05.049

| **Purpose/Sample** | **Design (Method/Instruments)** | **Results** | **Strengths/Limitations** |
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| **Purpose:** Review the use of telemedicine in GDM patients.<br><br>**Sample/Setting:** 95 GDM women: 61 in intervention and 34 in control at a metropolitan Melbourne hospital.<br><br>**Johns Hopkins Evidence Appraisal:** Quantitative **Strength:** Level I **Quality:** B/Good | **Method:** Exploratory randomized control trial<br>**Instrument:** Application on internet access device, handwritten diary, and hospital/clinic records. | **Results:** Patients who utilized the telemedicine services reached glycemic control quicker; despite that there were no differences in face to face appointments, C/S, fetal macrosomia, and need for higher level of care for the newborn.<br><br>**Conclusion:** Telemedicine showed no increase of service utilization for GDM patients. Having to enter food and blood sugars creates an awareness of those results and quicker realization of how-to better control sugars. | **Strengths:** Women were studied from time of diagnosis to delivery. All participants were studied in the same place at the same time.<br><br>**Limitations:** Participants needed access to a computer, smartphone, or tablet with internet services to utilize services. Small sample size. Uneven randomization of control and intervention groups. Data did not cross over to patient records and still had to be reviewed by provider manually. |

**Author Recommendations:**
Use of telemedicine may help the patient achieve glycemic control sooner and does not pose a disadvantage otherwise.

**Implications:**
When considering alternative therapies for GDM patients telemedicine needs more research and better products available to fully be utilized by both the patient and the practitioner.

| **Source:** Simmons, D., Devlieger, R., Assche, A. V., Galjaard, S., Corcoy, R., Adelantado, J., . . . Poppel, M. V. (2018). Association between gestational weight gain, gestational diabetes risk, and obstetric outcomes: A randomized controlled trial post hoc analysis. *Nutrients*, 10(11), 1568. doi:10.3390/nu10111568 | | | |
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| **Purpose/Sample** | **Design (Method/Instruments)** | **Results / Conclusion** | **Strengths/ Limitations** |
| **Purpose:** To see if the hypothesis that the greater gestational weight gain limitation, the greater the difference in GDM rates, fasting glucose, and adverse outcomes between control and intervention subjects.<br>**Sample/Setting** 205 over 18 years of age, prior to 20 weeks GA with a pre-pregnancy BMI of greater than or equal to 29 kg/m2. The study took place in ten European centers (Cambridge, Amsterdam, Leuven, Barcelona, Galway, Pisa/Padova, Vienna, Poznan, Copenhagen, and Odense) between January 2012 and February 2014. | **Design:** RTC post hoc analysis<br>Initially compared women above and below the median gestational weight gain (GWG) independent of any intervention. Then used the DALI (Vitamin D & Lifestyle intervention for GDM prevention) lifestyle study & stratified it by site & treated each site as its own RTC to test if GDM rate was reduced in the 5 sites with the greatest GWG. Used the healthy eating & physical activity intervention.<br>DALI lifestyle study is a RCT trial registration, compares 3 different lifestyle approaches that could prevent GDM across 10 European centers. Randomized by site to usual care, healthy eating, physical activity, or healthy eating and physical activity. All completed a glucose tolerance test & any diagnosed with GDM were excluded from the study. Assessments made at baseline (before 20wks), between 24-28 wks, between 35-37 wks, & at gestation. Assigned to a lifestyle coach that provided 5 face to face and up to 4 telephone coaching | **Results:** GA ranged from 8 to 19+6 wks. The median GWG between the pre-pregnancy weight and 24-28 wks was 5.5 kg and at 35-37 wks was 9.5 kg. Greatest GWG commenced at a lower weight & BMI, were also more likely to be smokers & nulliparous. Greatest GWG at 24-28 wks had a lower fasting glucose. Greatest GWG at 35-37 wks had lower fasting, 1 hr, & 2 hr glucose concentrations at baseline. Homeostasis model assessment insulin resistance & insulin secretion were significantly higher among those with the greatest GWG at 24-28 wks & 35-37 wks. Highest GWG at 35-37 wks also had larger babies. Glucose levels, measures of insulin resistance & secretion, & GDM rates were not significantly different with the physical | **Strengths:** No other study has achieved the degree of GWG limitation as this study did. One of the larger RCT on lifestyle to prevent GDM. Encompasses a large number of different lifestyles and cultures. Approved by the relevant ethical committees and registered as an RCT.<br>**Limitations:** Number of patients successfully recruited was suboptimal in order to have definitive answers. Women that come into an RCT are more motivated than most women. The control group appeared to be more |

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| **Johns Hopkins Evidence Appraisal:** Quantitative **Strength:** Level 1 **Quality:** B/Good The researchers used a large sample size over different cultures therefore making results generalizable. They also used RTC for the design study. The article is not high quality because there are not definitive conclusions or consistent recommendations. There were also numerous limitations. | sessions based on principles of motivational interviewing. 4/5 face to face sessions were completed prior to the second measurement (24-28wks). All coaches received standardized training as and an interventional took kit. Healthy eating- promoted food-based, lower simple complex carb, lower fat, higher fiber, & higher protein diet with a focus on smaller portion size & limited calories. Physical activity- promoted aerobic & resistance physical activity. Questionnaires were used to gather information on demographics such as pre-pregnancy weight smoking, ETOH consumption, past/current medical history, obstetric history, & medication use. Data was collected from medical records for birth weight, obstetric and perinatal outcomes, and co-morbidities. | activity or healthy eating groups. They did have less GWG at 24-28 wks & 35-wks than the usual care group (2.6 kg). The group with combined intervention was associated with a significantly lower large for gestational ager rate. **Conclusion:** Gestational weight gain is associated with an increase in insulin resistance, adverse obstetric outcomes, and glycemia. This study showed that the sites with the greatest reduction in GWG had no reduction in GDM or its risks but did correlate with a reduction in babies that were large for gestational age. Lifestyle intervention in the second trimester is too late for the prevention of gestational diabetes. | motivated to improve their lifestyle and possibly reducing the rates between the intervention and control groups. Including hyperglycemia at baseline may have had a greater benefit from the intervention. |
| **Author Recommendations:** More randomized controlled trials are needed in the first trimester in order to understand the mechanisms behind a metabolic trajectory. | | | |
| **Summary for current clinical practice question:** Lifestyle interventions need to be done prior to pregnancy. Education & preconception counseling are key to help decrease the dx of GDM & health complications. | | | |

| **Source:** Singh, H., Soyoltulga, K., Fong, T., & Billimek, J. (2018). Delivery outcomes, emergency room visits, and psychological aspects of gestational diabetes results from a community hospital multiethnic cohort. *The Diabetes Educator, 44*(5), 465-474, https://doi.org/10.1177%2F0145721718795589 | | | |
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| **Purpose/Sample** | **Design (Method/ Instruments)** | **Results/ Conclusion** | **Strengths/Limitations** |
| **Purpose:**<br>To evaluate perinatal outcomes and experiences of women who had managed GDM.<br><br>**Sample/Setting:**<br>Phase 1:564 women with a diagnosis of GDM who participated in the Sweet Success program in California from multiple cultural backgrounds and had a delivery date between July 1, 2015 and June 30, 2016.<br><br>Phase 2: 29 of the women from phase 1 who agreed to participate further.<br><br>**Johns Hopkins Evidence Appraisal:**<br>Quantitative<br>**Strength:** Level I<br>**Quality:** B/Good | **Methods:**<br>Mixed-method design<br><br>**Instruments:**<br>Semi-structured Interviews<br>Multivariable logistic regression models. | **Results:**<br>Lowest rates of cesarean delivery and ED utilization during pregnancy was in Southeast and East Asian women (23.2%).<br>Hispanic women were most likely to have a cesarean delivery, then non-Hispanic whites, then Asian Indians.<br>Hispanics also had the highest percentage of at least 1 ED visit at 15%.<br>Maternal age and obesity were found to also have higher rates of cesarean deliveries.<br>Many women reported that the diagnosis of GDM felt like a failure, and consequently had no realization of the risk of post-natal diabetes. Several also reported not routinely checking their sugar due to being busy. They felt their healthcare team should do a better job of providing support groups and connecting them with other patients.<br>**Conclusion:**<br>Ethnic variation shows correlation with cesarean rates for GDM mothers. Culturally sensitive support groups as well as dietary recommendations are important for higher adherence rates. | **Strengths:**<br>Large sample size in effluent location.<br><br>**Limitations:**<br>Data was collected from interviews so information could have been altered or not included per personal preferences.<br>Unable to determine if culture, age, or body habitus had the highest influence of GDM diagnosis. |

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| **Author Recommendations:**<br>To consider culturally sensitive approaches when counseling women with GDM. |
| **Implications:**<br>Encourages to highlight culturally specific programs to improve utilizations of said programs. Also, consider with-in clinic group counseling or programs for patients who desire to speak with other women going through the same thing. |

**Source:** Wang, C., Wei, Y., Zhang, X., Zhang, Y., Xu, Q., Sun, Y., . . . Yang, H. (2017). A randomized clinical trial of exercise during pregnancy to prevent gestational diabetes mellitus and improve pregnancy outcome in overweight and obese pregnant women. *American Journal of Obstetrics and Gynecology*, 216(4), 340-351. doi:10.1016/j.ajog.2017.01.037

| **Purpose/Sample** | **Design (Method/Instruments)** | **Results/ Conclusion** | **Strengths/ Limitations** |
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| **Purpose:** To test efficacy of regular exercise in early pregnancy to prevent gestational diabetes in Chinese overweight/obese pregnant women<br>**Sample/Setting**<br>821 assessed, 521 excluded, 300 randomized. Analyzed 112 intervention & 114 control. Peking University First Hospital, Dec 2014 to July 2016.<br>Nonsmoking over the age of 18 with a uncomplicated singleton pregnancy at GA <12+6, who were overweight/obese (BMI 24≤28 kg/m2) the Group of Chinese Ministry and Health.<br>Exclusions: contraindications to physical activity, unwilling to provide informed consent, cervical insufficiency, on medication for preexisting HTN, DM, cardiac disease, renal disease, systemic | **Design:** RCT<br>Randomly allocated to an exercise group (EG) or control group (CG)<br>EG: assigned to exercise via a cycling program 3 times a week for at least 30 min with a perceived exertion between 12-14.<br>CG: continued with usual daily activities, were not discouraged from participating in exercise sessions on their own<br>Intervention started within 3 days of randomization and lasted until 37 wks GA<br>Both groups received standard prenatal care without special dietary recommendations.<br>All exercise studies were done at the Peking University First Hospital under supervision and conducted on alternate days.<br>International Physical Activity Questionnaire was used at study entry & at 25 and 36 wks to assess physical activity levels. | **Results:** 25.3-26% in each group were obese.<br>The number of exercise sessions attended was 73±10 over a period of 27±2 weeks. 90% of the participants in the EG compliant with the program. The lowest attendance rate was 73%. Mean duration of each session was 35±6 minutes with an RPE of 13±1 (somewhat hard).<br>Incidence of GM was 22% in EG and 40.6% in the CG (95% CI). Representing a 45.8% reduction in GDM.<br>EG had lower blood glucose levels at 0,1,&2 hrs at the post intervention GTT compared with CG. P=.001, P=.009, and P=.009. | **Strengths:** Written consent, ethics committee approval. Supervised exercise intervention ensured appropriate amount of intensity. Did not include nutritional component, so exercise was discerned itself. Equal number of obese patients in each group.<br><br>**Limitations:** Study may have been too small to demonstrate a positive result on perinatal outcomes. Done in one population. Not including dietary |

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| lupus erythematosus, thyroid disease, or psychosis. Currently being treated with metformin or corticosteroids.<br>**Level of evidence: Johns Hopkins Evidence Appraisal:** Quantitative<br>**Strength:** Level I<br>**Quality:** B/Good | | EG had higher total physical activity at 25 and 36 wks GA.<br>Levels of vigorous physical activity and walking were similar between the groups at 25 & 36 wks GA.<br>EG had significantly less GWG at 25 wks (4.08 $\pm$ 3.02 vs 5.92 $\pm$ 2.5 kg; P<.001) & at the end of pregnancy (8.38 $\pm$ 3.65 vs 10.47 $\pm$ 3.33 kg; P<.001). There was no significant difference in GWG between 25-36 wks (4.55$\pm$ 2.06 vs 4.59 $\pm$2.31 kg; P=.896).<br>Insulin resistance was lower in the EG than CG at 25 wks (2.92 $\pm$ 1.27 vs 3.38$\pm$2.00; P=.033).<br>No differences in gestational HTN, preeclampsia, and cesarean delivery.<br>No differences in GA at birth, preterm birth, or APGAR score at 1 or 5 min.<br>Infants born to women in the EG had a significantly lower birth weight than CG | measures restrained from further analysis. |

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| | | (3345.27±397.07 vs 3457.46 ± 446.00; P=.049). **Conclusion:** Cycling initiated early in pregnancy and performed for at least 30 minutes 3 times a week is associated with a significant reduction in the frequency of GDM in overweight/obese pregnant women. Relevant to that exercise at the beginning of pregnancy decreases GWG prior to mid second trimester. No evidence that exercise in this study increased the risk of preterm birth or reduced mean GA at birth. | |
| **Author Recommendations:** Results suggest that preventing the development of GDM in women with risk factors might be challenging but highlight the importance of seeing effective ways to reduce the incidence of GDM in high risk women. Pre-Pregnancy overweight and obesity are main health care challenges. | | | |
| **Summary for current clinical practice question:** Counseling women prior to pregnancy is important to decrease risk for GDM. Pre conceptional counseling should be done to help women maintain a healthy lifestyle and normal BMI. Women should be educated on the risks of GDM and what they can do to help decrease their chances of getting dx. They also should be educated on the impacts it has for the baby, pregnancy, and health complications later in life. | | | |

**Source:** Wang, S., Ma, J., & Yang, H. (2015). Lifestyle intervention for gestational diabetes mellitus prevention: A cluster-randomized controlled study. Chronic Diseases and Translational Medicine, 1(3), 169-174. doi:10.1016/j.cdtm.2015.09.001

| Purpose/Sample | Design (Method/Instruments) | Results/ Conclusion | Strengths/ Limitations |
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| **Purpose:** To determine if GDM can be prevented in the 1st trimester with early initiation of diet, exercise, and monitoring of weight gain.<br>**Sample/Setting:** 272 women with singleton pregnancies seen before 8 weeks' gestation with at least one risk factor for GDM, at Peking University First Hospital. 134 received intervention, 138 were in control group. (1664 women were screened.)<br>**Level of evidence: Johns Hopkins Evidence Appraisal:** Quantitative<br>**Strength:** Level I<br>**Quality:** B/Good | **Design: RCT**<br>**Method:** Those with one of these risk factors were excluded in the study: multiple pregnancy or pre-existing diabetes. Those with at least one risk factor were included. Risk factors are AMA, BMI ≥ 25 kg/㎡, history of GDM or PCOS, family history of DM or macrosomia from a previous pregnancy. 17% (299/1664) of pregnancies had high risk factors.<br>Lifestyle Interventions were introduced ay 6-8 gestation of diet, exercise, and monitoring of weight gain. Given in courses by a physician presented in groups of six. Nutritional counselors suggested diet and weight gain goals per person.<br>At 24-28 weeks the normal oral glucose tolerance test (OGTT) was administered per the International Association of Diabetes and Pregnancy Study Groups (IADPSG) criteria.<br>**Instruments:**<br>Questionnaire for risk factors.<br>Lab for biochemistry and nurse's assessment of body height, weight. | **Results:** Women in the intervention group gained slightly less weight and had lower fasting glucose rates; but the difference was not statistically significant. The intervention group had GDM at a rate of 17.16% (23/134) and the control group had GDM at a rate of 23.91% (33/138); but p=0.168, statistical significance was < 0.05.<br><br>**Conclusion:** Some GDM can be reduced with lifestyle intervention at the beginning of pregnancy, but more methods need to be studied. | **Strengths:**<br>New approach<br>No statistical difference in basic parameters between control and intervention group.<br><br>**Limitations:**<br>Small sample size<br>Risk factors were self-reported, and not verified.<br>Control group may have received some early counseling as well. |

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| **Author Recommendations:** More studies needing, especially ones with fasting plasma glucose (FPG) in early pregnancy. |
| **Summary for current clinical practice question:**<br>It may be pertinent to think outside of the box when approaching GDM and think about primary prevention over tertiary prevention. |