5-2021

Effectiveness of Diet/Exercise in Prevention of Gestational Diabetes Mellitus and Associated Cesarean Section Delivery

Jonathyn Andrew Marx
University of North Dakota

Effectiveness of Diet/Exercise in Prevention of Gestational Diabetes Mellitus and Associated Cesarean Section Delivery

by

Jonathyn Andrew Marx PA-S

Bachelor of Arts, University of Wisconsin Stevens Point, 2004

Contributing Author: Julie Solberg PA-C

A Scholarly Project

Submitted to the Graduate Faculty of the University of North Dakota

in partial fulfillment of requirements for the degree of

Master of Physician Assistant Studies

Grand Forks, North Dakota

May 2021

Table of Contents

Acknowledgements

I would like to extend a heartfelt thank you to my family, including my wife Daidri and three children Gabria, Abrina, and Xavi. Completion of my scholarly project was achievable due to your tremendous patience, understanding, love, and support. I would also like to extend a thank you to my advisor, Professor Julie Solberg, PA-C and Professor Daryl Sieg, PA-C, for their unwavering support and guidance throughout the development of my scholarly project. I would also like to extend an appreciation to my fellow UND student colleagues for their encouragement throughout our academic journey.

Abstract

Gestational diabetes mellitus (GDM) is becoming a more common diagnosis during pregnancy. GDM is defined as glucose intolerance diagnosed during pregnancy. Women diagnosed with GDM during pregnancy are at an increased risk for emergent or planned cesarean section delivery and the development of overt diabetes mellitus post pregnancy. Complications related to GDM include eclampsia, macrosomia, shoulder dystocia, stillbirth, and cesarean section delivery. Initial treatment consists of diet and exercise and if glucose can not be controlled then pharmacotherapy is introduced. A literature review was performed utilizing scientific databases, mesh terms, and keywords to gather statistically relevant research to analyze the effects of diet and exercise on the prevention of GDM and cesarean section delivery. Studies that met criteria for inclusion analyzed the effects of diet and exercise individually, as well as, combined effects on GDM prevention and cesarean section delivery. The current data available indicates that exercise is safe during pregnancy and when combined with diet prove beneficial in prevention of GDM and cesarean section delivery.

Keywords: gestational diabetes mellitus, diet, exercise, cesarean section, prevention, female, macrosomia, pregnancy.

Introduction

Gestational diabetes mellitus (GDM) is becoming a more prevalent disease commonly diagnosed in the second or third trimester of pregnancy. Women are generally screened for GDM around 24 -28 weeks gestation with a one-hour glucose tolerance test. If the original glucose test is positive, then a three-hour glucose tolerance test is performed for confirmation. A few risk factors for developing GDM are family history, history of GDM, cardiovascular disease (CVD), hypertension (HTN), hypercholesterolemia, polycystic ovarian syndrome (PCOS), obesity, and a sedentary lifestyle. The American Diabetes Association (2014) stated, "Approximately 7% of all pregnancies (ranging from 1 to 14%, depending on the population studied and the diagnostic tests employed) are complicated by GDM, resulting in more than 200,000 cases annually" (para. 29). Due to the prevalence of type 2 diabetes, these numbers are felt to be increasing in our society. Complications related to GDM include, but are not limited to, preeclampsia, eclampsia, preterm delivery, stillbirth, shoulder dystocia, macrosomia, and planned or emergent cesarean section delivery. Control of GDM starts with diet and exercise, and if uncontrolled, initiation of pharmacotherapy.

Statement of the Problem

Women who put themselves at risk during pregnancy of developing gestational diabetes are categorized with a 37% chance of having a birth by cesarean section delivery. This statistic does not factor in an individual's increased potential if the pregnant woman does not control the GDM diagnosis. In turn, GDM can lead to increased fetal growth causing the cephalo-pelvic ratio to be disproportionate. This increased fetal growth rate is referred to as macrosomia. Furthermore, the fat deposition in these babies is more often than not found to be disproportionate with an increase in the chest to head and shoulder to head ratios. This

macrosomia often leads to either a planned cesarean section delivery at roughly 38-39 weeks gestation or a cesarean section delivery intrapartum due to a failed trial of labor.

Research Question

What are the effects of diet and exercise on the prevention of gestational diabetes mellitus and associated cesarean section delivery?

Literature Review

A review of the literature shows that diet and exercise will reduce the risk of GDM and the likelihood of having a cesarean section delivery. Incorporating dietary factors and following a low impact exercise routine is the key to limiting the risks of being diagnosed with GDM, which will, in turn, characteristically reduce the occurrence of cesarean section delivery.

Methodology

Studies included in the review of research demonstrated limited data in the past 10 years, so the time frame was expanded to include studies from the past 15 years. Databases used for research included: Cochrane Review Database, Embase, PubMed, DynaMed, ClinicalKey, and AccessMedicine. MeSH terms used to gather statistically relevant research included: *gestational diabetes mellitus, diet, exercise, cesarean section, prevention, female, macrosomia, pregnancy.* The population of patients focused on pregnant women diagnosed with GDM. Research studies reviewed included meta-analysis, systematic reviews, cohort studies, and randomized clinical trials. The analysis of studies focused on pregnant women diagnosed with GDM and the effects of diet/exercise on GDM prevention and reduction of a cesarean section delivery.

Pathophysiology of Gestational Diabetes Mellitus

Gestational diabetes mellitus is ultimately defined as glucose intolerance diagnosed

during pregnancy. The following articles help breakdown the causes of glucose intolerance and complications that can result from being diagnosed with gestational diabetes mellitus.

Catalano and Gabbe (2021) define macrosomia as a fetal birth weight of more than 4000 g to 4500 g, or birth weight exceeding the 90th percentile for population and sex-specific growth curves. Macrosomia is a complication that can occur in up to 40% of pregnant women with type I or type II diabetes and 50% of pregnant women with gestational diabetes mellitus. Due to macrosomia occurrence, infant delivery birth weight greater than 4500 g has a higher probability of occurring in women with diabetes than women without diabetes. An increase in birth weight leads to an increase in birth trauma and or shoulder dystocia. Also, pregnant women diagnosed with gestational diabetes mellitus can lead to an increase in fetal fat mass, that can cause an unequal increase in the chest to head and shoulder to head ratios of the fetus. Excessive fetal growth in pregnancies complicated by diabetes may reflect several essential factors that include maternal pregnancy weight and weight gain, maternal hyperglycemia with frequent excursions in blood glucose levels, and increased fetal levels of amino-acids, triglycerides, and fatty acids (Catalano & Gabbe, 2021).

Another article through DynaMed (2018) defines gestational diabetes as glucose intolerance diagnosed for the first time during pregnancy without meeting diagnosis standards for type II diabetes. Associated factors that increase the risk of gestational diabetes diagnosis are a history of gestational diabetes, glucose intolerance, family history of type II diabetes, and multiple gestations (DynaMed, 2018). Complications arising from gestational diabetes diagnosis are stillbirth, shoulder dystocia, brachial plexus injury, preterm birth, preeclampsia, cesarean section delivery, and maternal or fetal morbidity (DynaMed, 2018).

After being diagnosed with gestational diabetes mellitus, management should begin with

a consultation on diet and exercise (DynaMed, 2018). If glycemic objectives can not be obtained with diet and exercise, consultation on pharmacologic therapy initiation is recommended (DynaMed, 2018). Standard initial pharmacotherapy should begin with either insulin or oral hypoglycemic medications (DynaMed, 2018).

A publication by authors McCance, Huether, Brashers, and Rote (2019) define gestational diabetes mellitus as any degree of glucose intolerance with onset or first recognition during pregnancy. Around 7% of all pregnancies are complicated by gestational diabetes mellitus (McCance et al., 2019). The cause of gestational diabetes mellitus during pregnancy is unknown, but leading factors are related to insulin resistance and impaired insulin secretion (McCance et al., 2019). The American Diabetes Association (ADA) recommends initial screening for pregnant women with decreased risk of gestational diabetes during 24-28 weeks gestation (McCance et al., 2019). Gestational diabetes mellitus can lead to diabetes after pregnancy and cause metabolic and cardiovascular complications in an individual's later years (McCance et al., 2019). Due to these possible long-term complications, the ADA recommends women diagnosed with gestational diabetes be screened for diabetes 6-12 weeks post-delivery and once every 1-3 years after that based on individual risk factors (McCance et al., 2019).

Papadakis, McPhee, and Rabow (2020) define gestational diabetes mellitus as an abnormal glucose tolerance during pregnancy, which is believed to be related to physiological changes in carbohydrate metabolism. After delivery, one out of every two patients diagnosed with gestational diabetes mellitus will develop and be diagnosed with overt diabetes (Papadakis et al., 2020). The primary concern after the diagnosis of gestational diabetes mellitus is increased fetal growth, which can increase the risk of morbidity to the mother and infant

(Papadakis et al., 2020). This increase in fetal growth leads to an increase in risk for cesarean section delivery and preeclampsia (Papadakis et al., 2020).

Nutritional counseling is a priority in treating women diagnosed with gestational diabetes (Papadakis et al., 2020). Medication initiation can be performed in pregnant women with consistent fasting hyperglycemia (Papadakis et al., 2020). Standard pharmacotherapy includes insulin or oral hypoglycemic agents (Papadakis et al., 2020). The standard protocol for medication initiation consists of starting with insulin for glycemic control (Papadakis et al., 2020). Metformin or Glyburide are oral hypoglycemic agents that have been shown to achieve similar success as insulin without increasing the mother's risk of infant mortality (Papadakis et al., 2020). However, these oral hypoglycemic agents have not been approved by the US Food and Drug Administration (FDA) because of insufficient data demonstrating their long-term effects on mother and infant safety (Papadakis et al., 2020). Macrosomia, shoulder dystocia, and preeclampsia have been proven to have decreased risk in women undergoing intensive therapy with dietary restrictions/modifications, insulin initiation, or both (Papadakis et al., 2020).

Cesarean Section Delivery with Gestational Diabetes Mellitus

Cesarean section delivery is typical in patients diagnosed with gestational diabetes mellitus due to macrosomia. The following articles focus on the occurrence of cesarean section delivery, perinatal complications, and their relationship to patients diagnosed with gestational diabetes. Boriboonhirunsarn & Waiyankikorn (2016) conducted a study at Siriraj Hospital in Thailand comparing the occurrence of emergency cesarean section deliveries between pregnant women with and without gestational diabetes. The study included two groups entailing the study group and the comparison group. The study group consisted of 237 singleton pregnant women with gestational diabetes (Boriboonhirunsarn & Waiyankikorn, 2016). The comparison group

consisted of 237 uncomplicated normal pregnant women (Boriboonhirunsarn & Waiyankikorn, 2016). Study exclusions included those scheduled for elective cesarean delivery and those women diagnosed with diabetes mellitus (Boriboonhirunsarn & Waiyankikorn, 2016).

The study group had an overall higher mean age, body mass index (BMI) and were more likely to be overweight or obese (Boriboonhirunsarn & Waiyankikorn, 2016). The study group demonstrated an increased emergency cesarean delivery rate than the comparison group, 31.6% vs. 19.4% with a $p = .002$ (Boriboonhirunsarn & Waiyankikorn, 2016). There were increased odds of cephalon-pelvic disproportion in the study group, 20.3% vs. 13.1%, $p = .036$, as an indication for cesarean delivery (Boriboonhirunsarn & Waiyankikorn, 2016). Birthweight was significantly higher by an average of 200 g in the study group (Boriboonhirunsarn & Waiyankikorn, 2016). Logistic regression analysis demonstrated an increased risk of emergency cesarean section in patients diagnosed with gestational diabetes, adjusted odds ratio 1.9, 95% CI [1.03, 3.50], $p = .039$, but only among nulliparous women, which was adjusted for age, BMI, and gestational weight gain (Boriboonhirunsarn & Waiyankikorn, 2016).

The authors concluded that the incidence of emergency cesarean section delivery was significantly increased among nulliparous gestational diabetes mellitus pregnant women compared to normal pregnant women (Boriboonhirunsarn & Waiyankikorn, 2016).

Crowther et al. (2005) conducted a randomized clinical trial to determine if there is a decreased risk of perinatal complications related to the treatment of women with gestational diabetes mellitus. The trial included randomly assigned women between 24-34 weeks gestation who were diagnosed with gestational diabetes mellitus (Crowther et al., 2005). The intervention group consisted of 490 women who received dietary advice, blood glucose monitoring, and insulin therapy as part of their care (Crowther et al., 2005). The standard care group consisted of

510 women who received no intervention as part of their care. Primary outcomes of perinatal complications were death, shoulder dystocia, bone fracture, nerve palsy, admission to a neonatal unit, jaundice requiring phototherapy, induction of labor, and cesarean birth, maternal anxiety, depression, and health status (Crowther et al., 2005).

Results of the randomized trial demonstrated a substantially lower rate of serious perinatal complications among the intervention group when compared to the standard care group, 1% vs. 4% with the relative risk-adjusted for maternal age, race, ethnic group, and parity 0.33, 95% CI [0.14, 0.75], $p = .01$ (Crowther et al., 2005). However, more infants of women from the intervention group were admitted to neonatal units, 71% vs. 61%, adjusted RR 1.13, CI [1.03, 1.23], $p = .01$ (Crowther et al., 2005). They also had a higher rate of induction of labor than the routine group at 39% vs. 29%, adjusted RR 1.36, CI [1.15, 1.62], $p = < .001$ (Crowther et al., 2005). The rate of cesarean section delivery were similar at 31% vs. 32%, adjusted RR 0.97, CI [0.81, 1.16], $p = 0.73$ (Crowther et al., 2005).

Limitations of the randomized trial consisted of a small sample size. The trial's bias was physician knowledge of the diagnosis corresponding to the reduction in perinatal complications through early induction of labor. From an ethical standpoint, participants were not made aware of their diagnosis during the trial.

The authors concluded that the treatment of gestational diabetes mellitus through diet, blood glucose monitoring, and insulin therapy helps reduce perinatal morbidity and improve the maternal quality of life (Crowther et al., 2005).

Gorgal et al. (2011) conducted a retrospective cohort study to assess whether the diagnosis of gestational diabetes mellitus and a non-elective cesarean section delivery are related. Methods of inclusion into the study consisted of women in labor or spontaneous rupture

of membranes, and with a single, headfirst presentation (Gorgal et al., 2011). The study consisted of 220 women with gestational diabetes mellitus and 660 women with glucose tolerance (Gorgal et al., 2011). The association between gestational diabetes mellitus and a non-elective cesarean was estimated using modified Poisson regression analysis (Gorgal et al., 2011). There were adjustments of relative risks for age, prepregnancy BMI, gestational weight gain, previous cesarean, gestational age at delivery, and birth weight (Gorgal et al., 2011).

The cohort study results demonstrated that the non-elective cesarean section rate for women diagnosed with gestational diabetes mellitus was 19.5% compared with just 13.5% for glucose tolerant women (Gorgal et al., 2011). Data demonstrated an increased risk of cesarean section RR 1.45, 95% CI [1.04, 2.02], for women with gestational diabetes (Gorgal et al., 2011). After adjusting for relative risks, the correlation remained statistically significant for the relationship between gestational diabetes mellitus and non-elective cesarean section at RR 1.52, CI [1.06, 2.16] (Gorgal et al., 2011). However, there was no disparity among indications for a cesarean section delivery between the two groups.

The authors concluded an increased risk for non-elective cesarean section delivery in patients diagnosed with gestational diabetes mellitus (Gorgal et al., 2011). The study's limitations and bias were related to previous knowledge of gestational diabetes mellitus and the favoring of cesarean section delivery (Gorgal et al., 2011).

Zeki et al. (2018) conducted a population-based cohort study among women with and without diabetes to identify main contributors to cesarean section delivery. The study also aimed to compare cesarean section rates within the assigned study groups. The study included all women who gave birth during the years 2002 and 2012 in New South Wales, Australia (Zeki et al., 2018). Women with pregestational diabetes type I and II, gestational diabetes mellitus, and

no diabetes were grouped using Robson classification (Zeki et al., 2018). The total cesarean section rate differed amongst the three classifications of women. Pregestational diabetes cesarean rate was 53.6%, gestational diabetes mellitus cesarean rate was 36.8%, and no diabetes cesarean rate was 20.5%. The main factor contributing to cesarean section delivery was a previous cesarean section delivery (Zeki et al., 2018).

The authors concluded that reducing risks and needs for the initial cesarean section are the first steps to reducing the cesarean section rate in women with diabetes (Zeki et al., 2018). This study also brought forth the importance of understanding the clinical issues of preterm birth and cesarean section associated with women diagnosed with gestational diabetes mellitus (Zeki et al., 2018).

Diet Effects on Gestational Diabetes Mellitus and Cesarean Section Delivery

Initial treatment of gestational diabetes mellitus begins with diet. The following articles focus on dietary interventions that decrease the risk of developing gestational diabetes mellitus and associated complications. Brown et al. (2017) conducted a Cochrane Systematic Review evaluating the combined effects of lifestyle interventions with or without pharmacotherapy in treating women with gestational diabetes mellitus. The study included trials and studies from Pregnancy and Childbirth Group's Trials Register (May 14, 2016), ClinicalTrials.gov, WHO International Clinical Trials Registry Platform (May 14, 2016). Inclusion criteria consisted of randomized trials comparing lifestyle intervention, other interventions, or the usual care of pregnant women with gestational diabetes mellitus (Brown et al., 2017). Exclusions included quasi-randomized trials, cross-over trials, and women with preexisting type I and or II diabetes (Brown et al., 2017).

The systematic review found 15 trials that included 4501 women and 3768 infants (Brown et al., 2017). The lifestyle interventions group consisted of patient education, diet, exercise, and blood glucose monitoring. The control group participants underwent standard care or diet only. In regards to the mother, there was no substantial change when comparing lifestyle intervention and control groups for cesarean section delivery, RR 0.90, 95% CI [0.78, 1.05]; 10 trials, 3545 women, and induction of labor, RR 1.20, CI [0.99, 1.46]; four trials, 2699 women (Brown et al., 2017). In regards to the infant, lifestyle interventions were associated with a reduction of large for gestational age, RR 0.60, CI [0.50, 0.71]; 6 trials, 2994 infants, which led to lower birth weight and incidence of macrosomia (Brown et al., 2017). Also, there was decreased neonatal fat mass with the lifestyle intervention group, mean difference -37.30 g, CI [-63.97, -10.63]; 1 trial, 958 infants (Brown et al., 2017).

The Cochrane Systematic Review's conclusions demonstrated lifestyle interventions as the standard treatment strategy for women diagnosed with gestational diabetes mellitus (Brown et al., 2017). Lifestyle interventions were defined as a healthy diet, exercise, and blood glucose monitoring (Brown et al., 2017). Women undergoing lifestyle interventions were found to have a decreased infant delivery risk with large for gestational age and neonatal fat mass (Brown et al., 2017).

The review's limitations demonstrated limited knowledge of long-term maternal and childhood outcomes of lifestyle intervention due to insufficient reporting (Brown et al., 2017). Also, 10% of the participants received some form of pharmacological therapy, therefore, making the lifestyle intervention as the monotherapy for treatment inconclusive (Brown et al., 2017). However, lifestyle interventions are useful as a primary therapeutic strategy in treatment and reduction in complications associated with gestational diabetes mellitus (Brown et al., 2017).

Future studies that would impact treatment of gestational diabetes mellitus should be conducted on specific lifestyle interventions, such as diet and or exercise as the sole intervention without pharmacological treatment and the evaluation of long term effects on mother and infant (Brown et al., 2017).

Han, Middleton, Shepherd, Ryswyk, and Crowther (2017) conducted a Cochrane Systematic Review to assess the effects of different dietary advice types for women with gestational diabetes mellitus on improving health outcomes for women and infants. The systematic review included randomized controlled trials demonstrating the effects of 10 different diets for women diagnosed with gestational diabetes mellitus (Han et al., 2017). The study included 19 trials randomizing 1398 women with gestational diabetes mellitus (Han et al., 2017).

Primary outcomes were the results of 10 different diets. Low moderate glycemic index vs. moderate-high GI diet included one trial that demonstrated no clear evidence of differences in cesarean section, RR 0.66, 95% CI [0.29, 1.47]; one trial, 63 women (Han et al., 2017). Energy restricted vs. no energy-restricted diet demonstrated no clear evidence of a difference in cesarean section, RR 1.12, CI [0.80, 1.56]; 2 trials, 420 women (Han et al., 2017). Dietary Approaches to Stop Hypertension (DASH) diet demonstrated fewer cesarean sections, RR 0.53, CI [0.37, 0.76]; 2 trials, 86 women (Han et al., 2017). Low carbohydrate vs. high carbohydrate diet demonstrated no clear evidence of differences in cesarean section, RR 1.29, CI [0.84, 1.99]; 2 trials, 179 women (Han et al., 2017). High unsaturated fat vs. low unsaturated fat diet demonstrated no clear evidence of differences in cesarean section, RR 1.08, CI [.07, 15.50]; one trial, 27 women (Han et al., 2017). Low GI vs. high fiber moderate GI diet demonstrated no clear evidence of differences in cesarean section, RR 1.91, CI [0.91, 4.03]; 92 women (Han et al., 2017). Diet recommendation plus diet-related behavioral advice vs. diet recommendation

demonstrated no clear evidence of differences in cesarean section, RR 0.78, CI [0.38, 1.62]; 99 women (Han et al., 2017). Soy protein vs. no soy protein diet demonstrated no clear evidence of differences in cesarean section, RR 1.00, CI [0.57, 1.77]; 68 women (Han et al., 2017). High fiber vs. standard fiber diet had no primary outcomes reported (Han et al., 2017). Ethnic-specific vs. standard health diet demonstrated no clear evidence of differences in cesarean section, RR 1.20, CI [0.54, 2.67]; 20 women (Han et al., 2017).

Conclusion of the Cochrane Systematic Review demonstrates no clear evidence of primary outcomes in dietary advice for women with gestational diabetes, except for the DASH diet, which represented a decreased incidence of cesarean section delivery (Han et al., 2017). The review's limitations include the small number of trials in each diet comparison, small population samples, and variable methodological quality (Han et al., 2017). Future trials should include evaluating short and long-term outcomes in participants (Han et al., 2017).

Shepherd et al. (2017) conducted a Cochrane Systematic Review to address the effects of combined diet and exercise interventions for pregnant women to prevent gestational diabetes mellitus and associated detrimental health sequela for the mother and infant. Criteria for study inclusion consisted of randomized controlled trials and cluster randomized controlled trials rivaling study groups undergoing diet and exercise interventions with standard care groups undergoing no intervention (Shepherd et al., 2017). Exclusions consisted of quasi-randomized controlled studies, cross-over trials, and randomized controlled trials utilizing two or more different diet/exercise interventions as a comparison (Shepherd et al., 2017).

Results included 23 randomized controlled trials involving 8918 women and 8709 infants compared to an intervention group undergoing diet and exercise with standard care that included no interventions (Shepherd et al., 2017). The risk of bias is unclear due to a lack of

methodological detail reported (Shepherd et al., 2017). The study's limitations were participant diversity, as most studies were conducted among high-income countries (Shepherd et al., 2017). Other limitations included the inability to evaluate the effect of maternal age, parity, and specific features of the diet and exercise interventions (Shepherd et al., 2017). Data demonstrated a possible reduction in risk of gestational diabetes in the diet and exercise group compared to the standard group, RR 0.85, 95% CI [0.71, 1.01]; 19 trials, 6633 women (Shepherd et al., 2017). There was also a possible reduction in the risk of cesarean section, RR 0.95, CI [0.88, 1.02]; 14 trials, 6089 women (Shepherd et al., 2017).

The Cochrane Systematic Review conclusion demonstrates a reduction in risk of gestational diabetes and a cesarean section with combined diet and exercise interventions during pregnancy compared with standard care (Shepherd et al., 2017). Future studies could differentiate and describe specific diet and interventions in more detail to impact the ability to inform practice guidelines (Shepherd et al., 2017).

Watter et al. (2019) conducted a multicentered randomized trial to assess whether a Mediterranean style diet helps decrease adverse pregnancy outcomes in women with high-risk metabolic factors. The trial consisted of 1252 women from five maternity units in London and Birmingham between September 12, 2014, and February 29, 2016 (Watter et al., 2019). Women in standard care, consisting of the control group, underwent no dietary intervention. Women from the inner-city with metabolic risk factors underwent a Mediterranean style. Watter et al. (2019) defined the Mediterranean style diet as follows:

> The key components of this diet included high intake of nuts, extra virgin olive oil, fruit, vegetables, nonrefined grains, and legumes; moderate to high consumption of fish; low to moderate intake of poultry and dairy products such as yoghurt and

> cheese; low consumption of red meat and processed meat; and avoidance of sugary drinks, fast food, and food rich in animal fat. (p. 5)

There were 593 women in the intervention group, and 612 in the control group of standard care (Watter et al., 2019). Women in the intervention group underwent individualized dietary advice at 18, 20, and 28 weeks gestation (Watter et al., 2019). Primary maternal outcomes were gestational diabetes or preeclampsia (Watter et al., 2019). Primary infant outcomes were stillbirth, small for gestational age, or admission to a neonatal unit (Watter et al., 2019).

Results from the trial demonstrated a reduction in odds of gestational diabetes mellitus in the intervention group when compared to the control group by 35%, aOR 0.65, 95% CI [0.47, 0.91], $p = .01$, but not in other individual maternal or infant outcomes (Watter et al., 2019). When comparing findings from the Effect of Simple, Targeted Diet in Pregnant Women With Metabolic Risk Factors on Pregnancy Outcomes (ESTEEM) trial with comparable trials, results demonstrated statistical noteworthy decreased risk in gestational diabetes mellitus, odds ratio 0.67, 95% CI [0.53, 0.84]; 2 trials, 2397 women (Watter et al., 2019). Data limitations included the participant's reliance on reporting outcomes/findings instead of unbiased biological features that could not be falsely reported (Watter et al., 2019). The authors concluded that a Mediterranean style diet in pregnancy has the prognostic markers to decrease the risk of gestational diabetes mellitus (Watter et al., 2019). However, findings did not demonstrate a decrease in the mother or infant complications (Watter et al., 2019).

Exercise Effects on Gestational Diabetes and Cesarean Section Delivery

In addition to diet, exercise is recommended as a standard initial treatment in patients diagnosed with gestational diabetes mellitus. The following articles focus on the benefits of

exercise and help define types, frequency, and duration of exercises that decrease the incidence of gestational diabetes mellitus diagnosis and associated complications to mother and infant.

Ming et al. (2018) conducted a systematic review and meta-analysis to assess the effect of exercise during pregnancy on the incidence of gestational diabetes mellitus in normal-weight women. Inclusion criteria consisted of randomized controlled trials investigating normal-weight women with gestational diabetes and the effects of exercise as prevention (Ming et al., 2018). Exclusion criteria consisted of elements that included dietary factors, maternal characteristics, obstetric outcomes, and diagnostic criteria of gestational diabetes mellitus (Ming et al., 2018). The primary outcome constituted the occurrence of gestational diabetes (Ming et al., 2018). Secondary outcomes were defined as gestational weight gain, gestational age at birth, birth weight, and odds of cesarean section (Ming et al., 2018).

The results of the meta-analysis included eight studies. The primary outcome of gestational diabetes mellitus decreased in participants undergoing exercise during pregnancy, RR 0.58, 95% CI [0.37, 0.90], $p = .01$ (Ming et al., 2018). Secondary outcomes demonstrated that exercise during pregnancy can reduce gestational weight, MD -1.61, CI [-1.99, -1.22], $p = < .01$, but had no significant effects on outcomes related to cesarean section, RR 0.88, CI [0.72, 1.08], $p = 0.21$ (Ming et al., 2018). The authors concluded that gestational diabetes mellitus is associated with a decreased incidence in normal-weight women undergoing exercise during pregnancy without increasing the occurrence of cesarean section (Ming et al., 2018).

Russo, Nobles, Ertel, Chasan-Taber, and Whitcomb (2015) conducted a systematic review and meta-analysis assessing existing randomized controlled studies on the effect of physical activity and gestational diabetes. Inclusion criteria consisted of 10 trials with 3401 participants (Russo et al., 2015). Trial studies consisted of participants randomly assigned to a

group undergoing exercise only based intervention, excluding diet and a control group undergoing ordinary standard care (Russo et al., 2015). Exclusion criteria consisted of trials that included results from combined physical activity and dietary intervention (Russo et al., 2015). All trials included exercise interventions with an aerobic component that consisted of walking, land or water aerobics, or both, and cycling (Russo et al., 2015). Four studies included an anaerobic component of strength training and balance exercises (Russo et al., 2015). Participants underwent an average of 105 to 240 minutes of exercise per week (Russo et al., 2015). The trial diagnosed gestational diabetes mellitus through screening participants utilizing criteria ranging from 75 g oral glucose tolerance test, two-step 50 g oral glucose challenge test, and 100 g oral glucose tolerance test (Russo et al., 2015).

The systematic review and meta-analysis demonstrated a significant decrease in the risk of developing gestational diabetes mellitus in the assigned intervention group of 28%, RR 0.72, 95% CI [0.58, 0.91], $p = .005$ (Russo et al., 2015). Based on the results, no bias was found or observed in the findings (Russo et al., 2015). Limitations of the study were the observance of exercise regimen and participants not reporting data or lost to trial follow up (Russo et al., 2015). The authors concluded findings supporting a correlation in the reduction of gestational diabetes mellitus and the utilization of exercise during pregnancy (Russo et al., 2015). Future research is needed to closely link a reduction in gestational diabetes mellitus to specific exercise types, duration of exercise, and intensity of exercise (Russo et al., 2015).

Sanabria-Martinez et al. (2015) conducted a meta-analysis of randomized controlled trials for assessing the effects of physical exercise interventions during pregnancy on the prevention of gestational diabetes mellitus and excessive maternal weight gain. Inclusion criteria consisted of participants who were deemed healthy pregnant women but also lived a sedentary lifestyle with

limited exercise in daily life (Sanabria-Martinez et al., 2015). Participants were selected into randomized controlled trials that included an exercise program for the intervention group and no exercise or intervention for the control group (Sanabria-Martinez et al., 2015). Exclusion criteria for participants included those women with a high risk of early delivery, contraindications to exercise as determined by a physician, women already involved in a trial, and those with plans on infant delivery at a different hospital (Sanabria-Martinez et al., 2015).

A total of 13 randomized controlled trials, including 2873 pregnant women, were analyzed. The intervention group consisted of 1434 women, and the control group had 1439 women (Sanabria-Martinez et al., 2015). Every participant in the trial endured a pregnancy without an adverse event. Exercise programs consisted of aerobic, resistance, toning, flexibility, weight training, strength exercises, and strength exercises with the pelvic floor muscles (Sanabria-Martinez et al., 2015). Exercise programs of participants differed amongst participants in the trial as some underwent exercise throughout the pregnancy, and other participants underwent exercise starting in the second trimester. The frequency of exercise sessions was divided into two, three, four, and five sessions per week lasting from 15 to 60 minutes (Sanabria-Martinez et al., 2015). The intensity of exercise was defined as very light, light to moderate, and moderate (Sanabria-Martinez et al., 2015). Adherence to the trials exercise protocols was overall high >85% (Sanabria-Martinez et al., 2015). Reasons for leaving the program were related to scheduling conflicts and transportation issues. Participants dropping out of the trials were related to early delivery, bleeding, hypertension, and moving to another hospital (Sanabria-Martinez et al., 2015). There were no adverse outcomes, except for two studies that reported preterm deliveries of two women in the interventional and three women in the control groups (Sanabria-Martinez et al., 2015).

The meta-analysis demonstrated that physical exercise programs during pregnancy decrease the risk of gestational diabetes mellitus, RR 0.69, $p = .009$, primarily when exercise was performed throughout the pregnancy, RR 0.64, $p = .038$ (Sanabria-Martinez et al., 2015). Provided limitations include data extraction, which was nonblinded and may be a source of bias (Sanabria-Martinez et al., 2015). None of the studies addressed the physical activity performed outside the exercise protocol implemented in the trials (Sanabria-Martinez et al., 2015). The participants were volunteers, which may have led to higher adherence to protocols than the general population (Sanabria-Martinez et al., 2015). The studies involved had different diagnostic criteria for gestational diabetes mellitus diagnosis (Sanabria-Martinez et al., 2015). There was limited information and details about diet and daily eating habits during the participant's pregnancy (Sanabria-Martinez et al., 2015). Lastly, some of the studies were carried out by the same authors (Sanabria-Martinez et al., 2015).

The authors concluded a decreased risk of gestational diabetes with associated physical exercise during pregnancy (Sanabria-Martinez et al., 2015). The authors conclude that physical activity during pregnancy is associated with a 31% reduction in gestational diabetes risk (Sanabria-Martinez et al., 2015). A decrease of 36% risk of gestational diabetes is associated with the induction of physical activity throughout the pregnancy (Sanabria-Martinez et al., 2015). Also, the reduction in gestational diabetes risk is higher when the exercise intervention includes combined exercises consisting of resistance and aerobic training (Sanabria-Martinez et al., 2015). This reduction is due to resistance training leading to increased blood glucose uptake without affecting muscle response to insulin, and aerobic activity leads to increased blood glucose uptake due to insulin action (Sanabria-Martinez et al., 2015). The meta-analysis findings support physical activity engagement as a primary therapeutic intervention to decrease

gestational diabetes risk in clinical practice (Sanabria-Martinez et al., 2015). As a benefit, there are reduced complications associated with mother and infant mortality, leading to a healthier pregnancy (Sanabria-Martinez et al., 2015). Further studies would help establish recommendations on specific types, duration, and intensity of exercise (Sanabria-Martinez et al., 2015).

Savvaki et al. (2018) conducted a study review of international guidelines and exercise recommendations in patients during normal pregnancy and pregnancy with gestational diabetes mellitus. The study results revealed that all international guidelines approve aerobic training of at least 60 to 150 minutes of exercise per week, with a limit of 30 minutes per day (Savvaki et al., 2018). Daily exercise was proven safe through all national guidelines (Savvaki et al., 2018). In addition to aerobic exercise, five national guidelines included Australia, Canada, Denmark, Norway, and the UK recommended resistance exercise (Savvaki et al., 2018). Among the international guidelines, differences existed in the intensity of exercise. The only international guideline with specific recommendations was Canada, which based its recommendations on women's age and level of physical condition (Savvaki et al., 2018). The authors concluded that daily exercise is beneficial as long as the proper planning and induction of exercise are implemented to not put mother or infant at risk of complicating the overall health of the pregnancy (Savvaki et al., 2018).

Wang et al. (2017) conducted a randomized clinical trial assessing the effect of regular exercise on preventing gestational diabetes mellitus in women of Chinese heritage who were overweight or obese and pregnant. The trial's inclusion criteria consisted of nonsmoking pregnant women over 18 years of age with a singleton pregnancy who were overweight or obese and had uncomplicated pregnancy under 12 weeks of gestation (Wang et al., 2017).

Participants of the trial were randomly selected for either the exercise intervention group or the nonexercised control group, which consisted of normal daily activities (Wang et al., 2017). The study included 300 women participants, with 150 participants in the intervention and control groups (Wang et al., 2017). The intervention group was subjected to exercise three times per week, which consisted of aerobic cycling with a duration of at least 30 minutes per session. The control group continued with their normal daily activities and routines (Wang et al., 2017). Both groups underwent standard prenatal care and had no specific diet instructions. The primary outcome was the occurrence of gestational diabetes mellitus. Secondary outcomes were defined as cesarean section, macrosomia, and large for gestational age infants (Wang et al., 2017).

The systematic review demonstrated that women in the intervention group had a significantly lower prevalence of gestational diabetes mellitus than the control group, 22% vs. 40.6%, $p = < .01$ (Wang et al., 2017). Secondary outcomes demonstrated a lower prevalence, but with a minimal statistical incidence of occurrence between the intervention and control group. Cesarean section prevalence was lower, 29.5% vs. 32.5%, 95% CI [0.494, 1.529], $p = 0.6$ (Wang et al., 2017). Macrosomia of birthweight > 4000 g demonstrated lower prevalence, 6.3% vs. 9.6%, CI [0.233, 1.673], $p = 0.3$ (Wang et al., 2017). Large for gestational age infants demonstrated lower prevalence, 14.3% vs. 22.8%, CI [0.284, 1.121], $p = 0.1$ (Wang et al., 2017).

Limitations of the study included a lack of data pertaining to the participants daily eating habits and nutrition (Wang et al., 2017). The study was also limited in sample size and to the Chinese population and did not compare other ethnic or racial backgrounds. Although the study proved that exercise has an effective measure to decrease the risk of gestational diabetes mellitus, further studies utilizing different ethnic and racial backgrounds comparing daily nutrition and eating habits combined with exercise are needed (Wang et al., 2017). The authors

concluded that cycling exercise, when performed at least three times per week, for a duration of at least 30 minutes, was associated with a decreased incidence of gestational diabetes mellitus in pregnant women of Chinese heritage who are overweight or obese (Wang et al., 2017). Also, there was no evidence that exercise during pregnancy increased the risk of adverse complications during pregnancy for the mother or infant (Wang et al., 2017).

Discussion

Based on the aforementioned literature review, diet and exercise play a unique role in the prevention of gestational diabetes and associated risk of cesarean section delivery. An initial study by Boriboonhirunsarn & Waiyankikorn (2016) suggested an increased risk of emergent cesarean section delivery among women with gestational diabetes compared to normal pregnant women. Gorgal et al. (2011) also compared the relationship of gestational diabetes diagnosis to non-elective cesarean section delivery. The authors concluded that women diagnosed with gestational diabetes were at higher risk for non-elective cesarean section delivery than glucose tolerant women. However, the increased rate of cesarean section delivery among patients diagnosed with gestational diabetes can be partly attributed to physician prior knowledge of a gestational diabetes diagnosis, corresponding to a reduction in perinatal complication risk through early induction of labor. Crowther et al. (2005) went on to evaluate the treatment of women diagnosed with gestational diabetes during pregnancy through dietary advice, glucose monitoring, and insulin therapy. Although there was a similar incidence of cesarean section delivery, there was a reduced incidence of perinatal complications. Again, as previously mentioned, the similar rate of cesarean section delivery can be partly attributed to physician bias related to prior knowledge of gestational diabetes diagnosis corresponding to a reduction in perinatal complications through early induction of labor.

Brown et al. (2017) evaluated the effects of lifestyle interventions, including patient education, diet, exercise, and blood glucose monitoring. Lifestyle interventions demonstrated a reduced risk of infant delivery with large for gestational age and neonatal fat mass. Reducing the risk of macrosomia, in turn, reduces the risk for cesarean section delivery. Although lifestyle interventions are recommended as a standard treatment for women diagnosed with gestational diabetes, one caveat to the study is that 10% of participants received some form of pharmacological therapy, therefore making lifestyle interventions as monotherapy inconclusive. Han et al. (2017) focused on dietary intervention for women diagnosed with gestational diabetes. Among ten different diets, only the DASH diet was found to reduce cesarean section delivery risk. In addition, Watter et al. (2019) evaluated the Mediterranean style diet during pregnancy and the reduction of gestational diabetes. The Mediterranean style diet is found to reduce the risk of gestational diabetes; however, there were no correlated findings in the reduction of a mother or infant complications. Shepard et al. (2017) went further and evaluated the combined effects of diet and exercise on the prevention of gestational diabetes in pregnant women. Combined diet and exercise are demonstrated to decrease the risk of gestational diabetes and associated cesarean section delivery. In addition to diet, exercise was evaluated as monotherapy in the reduction of gestational diabetes and reduced risk of cesarean section delivery. Ming et al. (2018) demonstrated a decreased incidence of gestational diabetes without increasing the occurrence of cesarean section delivery in women of normal weight diagnosed with gestational diabetes. Russo et al. (2015) and Sanabria-Martinez et al. (2015) went on to evaluate aerobic and anaerobic exercise to support the reduction of gestational diabetes. If exercise is conducted throughout the pregnancy, there is an associated greater reduction in the risk of gestational diabetes. Exercise was proven safe during pregnancy and should follow a guideline of at least

60-150 minutes per week, with a limit of 30 minutes per day (Savvaki et al., 2018). In addition, Wan et al. (2017) conducted a study on the effects of cycling as exercise on the reduction of gestational diabetes among pregnant women. Authors found that cycling if performed at least three times per week for 30 minutes, can reduce gestational diabetes risk without increasing adverse complications for the mother or infant during pregnancy.

Conclusion

In summary, gestational diabetes mellitus is becoming a more prevalent disease in our society. The literature review results demonstrate that combining diet and exercise will reduce the risk of gestational diabetes mellitus and associated cesarean section delivery. Patients who undergo a diet and exercise regimen demonstrate a reduction in gestational diabetes mellitus diagnosis and decreased risk of cesarean section delivery. In addition, newer research has shown that exercise throughout an entire pregnancy can reduce the risk of macrosomia and emergent or planned cesarean section more than exercise during the second and third trimesters alone. Although combined diet and exercise may not prevent the need for pharmacotherapy intervention, the literature review's significance provided data to demonstrate the importance of initiating a diet and exercise program in clinical practice.

Applicability to Clinical Practice

With the information provided in the literature review, the medical provider will be able to review risks associated with increased odds of developing gestational diabetes mellitus and associated cesarean section delivery at the time of each pre-pregnancy planning and well visits for women of childbearing age. Provider and patient will be able to discuss the prevention and management of gestational diabetes through lifestyle modifications that include physical activity/exercise and diet, which will, in turn, reduce the likelihood of cesarean delivery.

References

American Diabetes Association. (2014). Diagnosis and classification of diabetes mellitus. *Diabetes Care*, 37, [Supplement_1], S81-S90. http://dx.doi.org/10.2337/dc14-S081

Boriboonhirunsarn, D., & Waiyanikorn, R. (2016). Emergency cesarean section rate between women with gestational diabetes and normal pregnant women. *Taiwanese Journal of Obstetrics and Gynecology, 55*(1), 64-67. http://dx.doi.org/10.1016/j.tjog.2015.08.024

Brown, J., Alwan, N., West, J., Brown, S., Mckinlay, C., Farrar, D., & Crowther, C. (2017). Lifestyle interventions for the treatment of women with gestational diabetes. *Cochrane Database of Systematic Reviews*. http://dx.doi.org/10.1002/14651858.cd011970.pub2

Catalano, P., & Gabbe, S. (2021). 45. Diabetes mellitus complicating pregnancy. In M. Landon, *Gabbe's Obstetrics: Normal and Problem Pregnancies* (pp. 871-904). Retrieved from https://www-clinicalkey-com.ezproxy.library.und.edu/#!/content/book/3-s2.0-B9780323608701000654

Crowther, C., Hiller, J., Moss, J., Mcphee, A., Jeffries, W., & Robinson, J. (2005). Effect of treatment of gestational diabetes mellitus on pregnancy outcomes. *New England Journal of Medicine, 352*(24), 2477-2486. http://dx.doi.org/10.1056/nejmoa042973

DynaMed. (2018, Nov. 30) *Gestational Diabetes Mellitus (GDM)*. Ipswich, MA: EBSCO Information Services. Retrieved July 1, 2020, from https://www.dynamed.com/topics/dmp~AN~*T116237*

Centers for Disease Control and Prevention. (2019). Gestational Diabetes. Retrieved April 10, 2020, from https://www.cdc.gov/diabetes/basics/gestational.html

Gorgal, R., Gonçalves, E., Barros, M., Namora, G., Magalhães, Â, Rodrigues, T., & Montenegro, N. (2011). Gestational diabetes mellitus: A risk factor for non-elective cesarean section. *Journal of Obstetrics and Gynaecology Research, 38*(1), 154-159. http://dx.doi.org/10.1111/j.1447-0756.2011.01659.x

Han, S., Middleton, P., Shepherd, E., Ryswyk, E., & Crowther, C. (2017). Different types of dietary advice for women with gestational diabetes mellitus. *Cochrane Database of Systematic Reviews*. http://dx.doi.org/10.1002/14651858.cd009275.pub3

McCance, K., Huether, S., Brashers, V., & Rote, N. (2019). *Pathophysiology: The biologic basis for disease in adults and children*. St. Louis, MO: Elsevier.

Ming, W., Ding, W., Zhang, C., Zhong, L., Long, Y., Li, Z., . . . Wang, Z. (2018). The effect of exercise during pregnancy on gestational diabetes mellitus in normal-weight women: A systematic review and meta-analysis. *BioMed Central Pregnancy and Childbirth, 18*(1). http://dx.doi.org/10.1186/s12884-018-2068-7

Papadakis, M., McPhee, S., & Rabow, M. (2020). *Current medical diagnosis & treatment 2020*. New York, NY: McGraw-Hill Education.

Russo, L., Nobles, C., Ertel, K., Chasan-Taber, L., & Whitcomb, B. (2015). Physical activity interventions in pregnancy and risk of gestational diabetes mellitus. *Obstetrics & Gynecology, 125*(3), 576-582. http://dx.doi.org/10.1097/aog.0000000000000691

Sanabria-Martínez, G., García-Hermoso, A., Poyatos-León, R., Álvarez-Bueno, C., Sánchez-López, M., & Martínez-Vizcaíno, V. (2015). Effectiveness of physical activity interventions on preventing gestational diabetes mellitus and excessive maternal weight gain: A meta-analysis. *British Journal of Obstetrics and Gynaecology: An International*

Journal of Obstetrics & Gynaecology, 122(9), 1167-1174. http://dx.doi.org/10.1111/1471-0528.13429

Savvaki, D., Taousani, E., Goulis, D., Tsirou, E., Voziki, E., Douda, H., . . . Tokmakidis, S. (2018). Guidelines for exercise during normal pregnancy and gestational diabetes: A review of international recommendations. *Hormones, 17*(4), 521-529. http://dx.doi.org/10.1007/s42000-018-0085-6

Shepherd, E., Gomersall, J., Tieu, J., Han, S., Crowther, C., & Middleton, P. (2017). Combined diet and exercise interventions for preventing gestational diabetes mellitus. *Cochrane Database of Systematic Reviews*. http://dx.doi.org/10.1002/14651858.cd010443.pub3

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. http://dx.doi.org/10.1016/j.ajog.2017.01.037

Wattar, B., Dodds, J., Placzek, A., Beresford, L., Spyreli, E., Moore, A., . . . Thangaratinam, S. (2019). Mediterranean-style diet in pregnant women with metabolic risk factors (ESTEEM): A pragmatic multicentre randomised trial. *Public Library of Science Medicine, 16*(7). http://dx.doi.org/10.1371/journal.pmed.1002857

Zeki, R., Oats, J., Wang, A., Li, Z., Homer, C., & Sullivan, E. (2018). Cesarean section and diabetes during pregnancy: An NSW population study using the Robson classification. *Journal of Obstetrics and Gynaecology Research, 44*(5), 890-898. http://dx.doi.org/10.1111/jog.13605