

The Power of Yoga: Investigating the Feasibility and Preliminary Efficacy of a Prenatal  
Yoga Intervention to Prevent Excessive Gestational Weight Gain

by

Jennifer L. Green

A Dissertation Presented in Partial Fulfillment  
of the Requirements for the Degree  
Doctor of Philosophy

Approved July 2019 by the  
Graduate Supervisory Committee:

Jennifer L. Huberty, Chair  
Linda K. Larkey  
Jenn A. Leiferman  
Matthew P. Buman  
Chien C. Oh

ARIZONA STATE UNIVERSITY

August 2019

## ABSTRACT

Excessive gestational weight gain (EGWG) affects 50% of US pregnant women and may be an important contributor to obesity in both the mother and child. Novel strategies to prevent EGWG are needed to reduce the risk of adverse health outcomes for the mother and child. This dissertation presents three manuscripts that 1) propose a novel model to explain how prenatal yoga may prevent EGWG through behavioral, psychological/emotional, and physical factors, 2) test the feasibility and preliminary efficacy of a prenatal yoga intervention to prevent EGWG compared to a pregnancy education comparison group, and 3) qualitatively investigate pregnant women's experiences participating in a prenatal yoga intervention to prevent EGWG. In manuscript two, 49 women were recruited and randomized to a 12-week prenatal yoga intervention (n=23) or a time-matched pregnancy education comparison group (n=26). A satisfaction survey was administered at post-intervention to assess feasibility outcomes (e.g., acceptability, demand). Mindfulness, emotion regulation, self-awareness, sleep quality, depression, anxiety, and perceived stress were assessed at baseline and post-intervention (12-weeks) and GWG was assessed weekly. Linear mixed models were used to analyze pre-post changes in primary (i.e., GWG during pregnancy) and secondary (i.e., mindfulness, emotion regulation, self-awareness, sleep quality, depression, anxiety, and stress) outcomes. In manuscript three, interviews were conducted with pregnant women who participated in the prenatal yoga intervention (n=13). Interview responses were summarized using an inductive approach to thematic analysis. Findings in manuscript two suggest that prenatal yoga was a feasible method to prevent EGWG with high enjoyment and satisfaction reported among participants. The average number of prenatal

yoga sessions attended was 8.84 (SD = 3.85). There was no significant group differences on the rate of GWG or total GWG throughout the intervention and a significant group x time interaction effect for stress ( $p=.03$ ). In manuscript three, twelve themes were identified among the data and were organized into the following categories (three themes each): 1) experiences of prenatal yoga, 2) prenatal yoga and weight, 3) barriers to prenatal yoga, and 4) facilitators of prenatal yoga. This initial evidence suggests that prenatal yoga has potential as a strategy to prevent EGWG in pregnant women.

## DEDICATION

*To my husband, Gavin, for his unwavering support in all of my academic and professional pursuits. Thank you for believing in me and for being the one to help me always see the bright side of things and always reminding me to breathe. Your love, patience, and encouragement inspired me to complete this research.*

## ACKNOWLEDGMENTS

I would like to acknowledge my dissertation committee for their mentorship and guidance throughout my doctoral program. To my Chair, Dr. Huberty, for spending countless hours reading and editing all my work over the years. I am grateful for your mentorship and guidance throughout my doctoral program. I could not have accomplished all that I have without your support and leadership. Thank you for providing me with so many opportunities to grow. To Dr. Larkey, for your ever present demeanor and always being a listening ear. I appreciate your thoughtful feedback on my work over the years and look up to you as a positive role model. Your personal strength and passion for what you do is inspiring. To Dr. Leiferman, for your enthusiasm and dedication to this work and guiding me remotely from Colorado. I am thankful for your expertise and for providing the opportunity to share this work in your department. To Dr. Buman, for always making time for me and for your tenderhearted patience. I am grateful for your mentorship on statistical procedures and for challenging me to think more deeply and critically. To Dr. Oh, for your unwavering support and medical oversight in this work. I appreciate all the clinical connections you helped to facilitate and your assistance recruiting the women into this study. The mentorship provided from this phenomenal team has helped me to become a stronger and more passionate researcher.

I would also like to thank the Kripalu Institute for Extraordinary Living and the Office of Knowledge Enterprise Development, Graduate and Professional Student Association, and Graduate College at Arizona State University for providing the funding that supported this project. This work would not have been possible without these

contributions and I am sincerely grateful to have been selected as a recipient of these awards.

Finally, I would like to acknowledge my fellow lab mates and peers in the doctoral program for providing the emotional support, vegan donuts, and motivation needed to finish this project. I appreciate all the words of encouragement, laughter, and hugs. I would also like to acknowledge my family and friends both near and far for their patience, support, and love they provided me throughout my program. I am grateful for their understanding of missed social outings and sacrificing quality time to complete this work. To my Dad for always being proud of me, teaching me to never half-ass anything, and for always being there when I need you. I truly love each one of you! I would also like to thank my unborn baby for being that extra spark of motivation needed to finish this project. I cannot wait to meet you in just a few short weeks. It has been an amazing journey and being pregnant throughout this project has made it an even more enjoyable experience that I feel connected to. All of you help keep me balanced, have made a major impact in my life, and I would not be who I am today without each of you. Love, peace, and Namaste.

## TABLE OF CONTENTS

	Page
LIST OF TABLES .....	xi
LIST OF FIGURES .....	xii
CHAPTER	
1 INTRODUCTION .....	1
2 MANUSCRIPT #1: A NOVEL MODEL TO PROPOSE MECHANISMS OF PRENATAL YOGA TO PREVENT EXCESSIVE GESTATIONAL WEIGHT GAIN IN PREGNANT WOMEN .....	6
Background .....	6
Prenatal Yoga and Behavioral Factors .....	10
Diet Behavior .....	10
Diet Behavior and Prenatal Yoga .....	12
Mindfulness.....	12
Mindfulness and Prenatal Yoga.....	14
Prenatal Yoga and Psychological/Emotional Factors .....	15
Self-awareness .....	15
Self-awareness and Weight-related Outcomes.....	17
Emotion Regulation .....	18
Emotion Regulation and Prenatal Yoga .....	20
Stress .....	21
Stress and Prenatal Yoga .....	22
Mood .....	23

CHAPTER	Page
Mood and Prenatal Yoga .....	25
Prenatal Yoga and Physical Factors .....	26
Pregnancy Discomforts.....	26
Pregnancy Discomforts and Prenatal Yoga.....	28
Physical Activity.....	29
Physical Activity and Yoga .....	30
Sleep Quality.....	31
Sleep Quality and Prenatal Yoga.....	33
Discussion .....	34
Conclusion .....	36
 3	
MANUSCRIPT #2: INVESTIGATING THE FEASIBILITY AND PRELIMINARY EFFICACY OF A PRENATAL YOGA INTERVENTION TO PREVENT EXCESSIVE GESTATIONAL WEIGHT GAIN: A RANDOMIZED CONTROLLED TRIAL.....	37
Introduction.....	37
Methods.....	40
Power Calculations for Planned Sample Size .....	41
Recruitment.....	41
Procedures .....	43
Interventions.....	44
Prenatal Yoga Intervention Group (YG) .....	44



CHAPTER	Page
Pregnancy Education Comparison Group (CG).....	45
Measures .....	45
Mindfulness.....	48
Emotion Regulation .....	48
Self-Awareness .....	48
Sleep Quality.....	49
Depression.....	49
Anxiety.....	49
Perceived Stress .....	50
Statistical Analysis.....	50
Results .....	51
Participant Characteristics .....	54
Acceptability .....	56
Demand .....	59
Preliminary Efficacy .....	61
Discussion .....	70
Acceptability .....	70
Demand .....	71
Preliminary Efficacy .....	72
Limitations .....	75
Future Research Suggestions .....	76

	Page
CHAPTER	
Conclusions .....	77
4    MANUSCRIPT #3: AN EXPLORATORY QUALITATIVE ANALYSIS OF PREGNANT WOMEN’S EXPERIENCES IN A WEIGHT MANAGEMENT PRENATAL YOGA INTERVENTION .....	79
Introduction .....	79
Methods .....	81
Research Design .....	81
Participants .....	81
Procedures .....	82
Prenatal Yoga Intervention .....	82
Measures .....	83
Analytic Procedures .....	85
Results .....	85
Participant Characteristics .....	86
Emerging Themes .....	88
Experiences of Prenatal Yoga .....	88
Positive Experiences/Enjoyment .....	88
Pain Relief .....	88
Connecting to Body .....	89
Prenatal Yoga and Weight .....	89
Increased Mindfulness/Awareness .....	89

	Page
CHAPTER	
Increased Physical Activity .....	90
Weight Management.....	90
Barriers to Prenatal Yoga.....	91
Physical Body .....	91
Commute/Traffic.....	91
Schedule .....	91
Facilitators of Prenatal Yoga .....	92
Health Pregnancy .....	92
Support from Other Pregnant Women.....	92
The Feeling from Prenatal Yoga .....	93
Discussion .....	93
Limitations .....	98
Implications for Future Research .....	99
Conclusion .....	100
5 DISCUSSION.....	101
Future Directions .....	105
Conclusions.....	107
REFERENCES .....	108

## LIST OF TABLES

Table	Page
1. IOM Recommendations for Gestational Weight Gain .....	1
2. Eligibility Criteria .....	42
3. Summary of Data Collection .....	47
4. Demographic Characteristics of Study Participants (N=49) .....	55
5. Satisfaction Survey Responses (N=16) .....	57-58
6. Mixed Model Analysis of Differences in Weight by Group Across Time .....	65
7. Mixed Model Analysis of Differences in Stress by Group Across Time .....	68
8. Baseline and Post-Intervention Mean Scores of Secondary Outcomes .....	69
9. Semi-Structured Interview Guide .....	84
10. Demographic Characteristics of Study Participants (N=13) .....	87

## LIST OF FIGURES

Figure	Page
1. Proposed Model of the Effects of Prenatal Yoga on Excessive Gestational weight Gain .....	10
2. Enrollment Flow Diagram .....	53
3. Percentage of Participants Attending Weekly Sessions by Group .....	60
4. Total GWG During the Intervention in Completer Only and ITT Analysis .....	62
5. Rate of GWG Change in Completer Only and ITT Analysis .....	63
6. Pre-post Differences in Stress by Group Across Time .....	67

## CHAPTER 1

### INTRODUCTION

Excessive gestational weight gain (EGWG) [i.e., weight gain exceeding the Institute of Medicine (IOM) recommendations] occurs in 50% of U.S. pregnant women.<sup>1</sup> More than 6 million women in the U.S. become pregnant each year and the average GWG has been increasing exponentially over the last three decades.<sup>2</sup> From 1990-2014 there was a 35% increase in the number of pregnant women with GWG  $\geq$ 40lbs (16% to 21.8%).<sup>3</sup> Based on pre-pregnancy body mass index (BMI), the IOM recommends four healthy GWG ranges (see Table 1).<sup>4</sup>

**Table 1. IOM Recommendations for Gestational Weight Gain**

Pre-pregnancy BMI (kg/m <sup>2</sup> )	Total Weight Gain Range (lbs.)
Underweight (<18.5)	28-40
Normal (18.5-24.9)	25-35
Overweight (25-29.9)	15-25
Obese ( $\geq$ 30)	11-20

*Table adapted from the IOM<sup>1</sup>*

Women who have EGWG have a higher risk of post-partum weight retention and long-term weight gain and EGWG is a contributor to obesity in both women and their children.<sup>5-7</sup> As such, several Healthy People 2020 objectives are aimed toward improving the well-being of mothers and their children.<sup>8</sup> Healthy People 2020 states, “Their [mothers] well-being determines the health of the next generation and can help predict future public health challenges for families, communities, and the health care system”.<sup>8</sup> Specifically, Healthy People 2020 aims to increase the proportion of women who achieve a recommended weight gain during pregnancy.<sup>8</sup> This nationwide goal underscores the

urgent need to investigate effective strategies to prevent EGWG and subsequent adverse health risks for the mother and infant.

EGWG may lead to adverse health risks for the mother and infant including delivery complications,<sup>9</sup> type 2 diabetes,<sup>4,10</sup> gestational diabetes,<sup>11,12</sup> prenatal hypertensive disorders,<sup>13</sup> and large for gestational age infants.<sup>14</sup> Sadly, these risks may be compounded by the lack of physical activity and high rates of sedentary behavior reported by pregnant women.<sup>15,16</sup> Additionally, both the mother and child are at risk for the future development of obesity.<sup>6,17-20</sup> Data from a large population-based cohort study (N=23,524) suggests that pregnant women who had EGWG during pregnancy are two times more likely to be overweight or obese up to 17 years after delivery.<sup>21</sup> Additionally, infants born to mothers who had EGWG during pregnancy have a four-fold risk of developing obesity in childhood.<sup>21</sup>

Diet and physical activity are leading strategies to reduce and/or manage weight and have been tested as strategies to prevent EGWG in pregnant women.<sup>22,23</sup> For example, a healthy diet and regular physical activity [e.g., walking at  $\geq 3$  metabolic equivalents (METs) for 150 min/week] is beneficial for managing EGWG.<sup>24,25</sup> However, many weight management interventions in pregnant women have inconsistent findings, low adherence rates, poor methodological quality, and small sample sizes.<sup>26</sup> A 2015 Cochrane review reported an averaged reduced risk of EGWG by 20% for diet or exercise (or combined) randomized controlled trials (RCTs).<sup>27</sup> Conversely, a systematic review and meta-analysis of interventions for weight management during pregnancy reported no statistically significant effect on GWG among a range of dietary, physical activity, and education interventions.<sup>23</sup> Another systematic review of interventions to prevent EGWG identified

10 studies that primarily focused on physical activity and/or diet.<sup>22</sup> Only three of the 10 studies showed that women in the intervention were more likely to gain within the IOM guidelines compared to controls. The authors and others concluded that the lack of success may be attributable to a lack of psychological health factors (e.g., stress, depression) within the interventions.<sup>28</sup> They (and others) recommend that future studies consider a psychological health component (e.g., manage mood or depressive symptoms) to increase adherence and effectiveness.<sup>29-32</sup>

A qualitative study also suggests a psychological health component may be lacking in physical activity interventions for pregnant women. Currie et al., 2016 conducted focus groups in 15 pregnant women to determine their experiences of physical activity (e.g., walking).<sup>33</sup> Women reported that psychological health issues (e.g., poor mood, stress) and boredom were major barriers to participation in physical activity and that social support and self-efficacy would help facilitate their engagement in physical activity.<sup>33</sup> Considering the prevalence of depression has been estimated to affect up to 50% of pregnant women and between 25-78% experience anxiety or stress the psychological health state of pregnant women should be an important consideration in GWG interventions.<sup>34-38</sup>

Prenatal yoga (i.e., yoga during pregnancy) may be a feasible (i.e., acceptable, preliminary effective) strategy to prevent EGWG in pregnant women. Prenatal yoga is a type of mind-body practice<sup>39</sup> that in addition to moderate intensity physical activity [i.e., 3-6 METs],<sup>40,41</sup> includes breath control and meditation. Prenatal yoga is a unique activity that not only aims to improve the physical health of the practitioner, but also their psychological (e.g., depressive symptoms, stress, anxiety) and emotional health.<sup>42,43</sup> Several benefits related to psychological health, well-being, pain, and labor/birth outcomes



have been documented in the literature as positive outcomes of prenatal yoga practice.<sup>43,44</sup> Pregnant women have also reported that prenatal yoga is a very pleasurable and enjoyable activity.<sup>45,46</sup> However, no studies have investigated the efficacy of prenatal yoga on EGWG. In non-pregnant populations, literature suggests that yoga is efficacious for improving weight outcomes.<sup>47,48</sup> A review evaluating the health benefits of yoga and physical activity (e.g., walking, running, cycling) concluded that yoga may be as effective or better than physical activity on every outcome measured (e.g., pain, depression, anxiety, sleep, fatigue) except short-term physical fitness (e.g., VO2max) in both healthy and diseased populations.<sup>49</sup> Another recent systematic review and meta-analysis on the effects of yoga on weight related outcomes concluded that yoga is a safe and effective intervention to reduce BMI in overweight/obese individuals.<sup>47</sup> Yoga may also mitigate the aforementioned barriers to participation in physical activity as it improves mood and reduces stress and the sequencing of yoga poses in each class varies to prevent boredom. Additionally, pregnant women participating in a pregnancy group that incorporated prenatal yoga reported that prenatal yoga helped prepare them for birth, increased their connection to their baby, and improved their psychological health, well-being, and social support.<sup>50</sup>

The purpose of this dissertation is to investigate the feasibility and preliminary efficacy of a 12-week prenatal yoga intervention to prevent EGWG. This dissertation reports findings from a single study formatted into a three-manuscript style. Manuscript one aims to serve as a review of the literature to propose a model that explains how prenatal yoga may provide a novel way to prevent EGWG in pregnant women through behavioral, psychological/emotional, and physiological mechanisms. Manuscript two

aims to investigate the feasibility (i.e., acceptability, demand) and preliminary effects of a prenatal yoga intervention to prevent EGWG. Utilizing a qualitative approach, manuscript three aims to 1) examine and describe pregnant women's experiences in a prenatal yoga intervention to prevent EGWG, 2) explore pregnant women's perceptions of prenatal yoga as a tool to help with weight management during pregnancy, and 3) identify facilitators and barriers to participation in a weight management prenatal yoga intervention during pregnancy.

## CHAPTER 2

MANUSCRIPT #1: A novel model to propose mechanisms of prenatal yoga to prevent excessive gestational weight gain in pregnant women

### **Background**

On average, one out of every two pregnant women in the United States gain too much weight during pregnancy [i.e., excessive gestational weight gain (EGWG)] which may lead to detrimental health outcomes for both the mother and fetus.<sup>1</sup> EGWG has been associated with gestational diabetes, prematurity, increased risk of cesarean section, large-for-gestational-age infants, increased postpartum weight retention (PPWR), and long-term obesity.<sup>51,52</sup> It is recommended that pregnant women participate in moderate-intensity physical activity for 20-30 minutes per day on all or most days of the week to help prevent EGWG.<sup>53</sup> However, up to 60% of pregnant women do not meet these guidelines and spend the majority of their waking day engaged in sedentary (i.e., sitting) activities.<sup>54,55</sup> Therefore, preventing EGWG has become a major nationwide priority. In fact, an objective of Healthy People 2020 is to increase the proportion of mothers who achieve a recommended weight gain during pregnancy.<sup>8</sup>

In light of these nationwide initiatives, many studies have been conducted to learn more about factors associated with EGWG and explore ways to prevent EGWG.<sup>22,27,56-58</sup> Diet, physical activity/exercise, and lifestyle interventions in particular have been highly coveted as gestational weight management strategies due to their success in weight loss interventions in non-pregnant populations.<sup>59-62</sup> Several reviews and/or meta-analyses have reported greater reductions in GWG (or a lower odds of EGWG) in physical activity/diet interventions compared to controls.<sup>22,63,64</sup> A recent Cochrane review

examining randomized controlled trials (RCTs) for preventing EGWG and associated pregnancy complications reported an averaged reduced risk of EGWG by 20% [average risk ratio (RR) 0.80, 95% confidence interval (CI) 0.73 to 0.87] for diet or exercise (or combined) interventions.<sup>27</sup>

In addition to these two prevalent approaches (diet and exercise) and evidence related to prevention of EGWG, a number of studies have identified the importance of psychological factors and their potential association to health behaviors during pregnancy.<sup>65,66</sup> Improving psychological health (e.g., depression, stress) in itself is associated with weight loss and may also improve targeted weight loss outcomes.<sup>67–70</sup> Adding a psychological component within diet and/or exercise interventions may enhance the efficacy of the intervention. Types of physical activity or exercise that address psychological health, such as yoga (i.e., includes strategies to improve psychological health) may be promising approaches to prevent EGWG.

Prenatal yoga is a form of exercise that includes physical postures, breath control, and meditation that is specifically adapted for pregnant women (e.g., no inversions, deep twists, or lying on the belly).<sup>71</sup> Evidence suggests that prenatal yoga may improve mental health (e.g., improved mood, decreased depression and stress)<sup>43,72</sup> and is associated with better labor outcomes (e.g., shorter labor duration, decreased pain perception).<sup>73,74</sup> However, to our knowledge, there are no studies testing prenatal yoga to prevent EGWG despite the evidence for yoga to reduce weight and BMI in non-pregnant populations.<sup>47,75–80</sup>

Prenatal yoga may improve behavioral factors that have been linked to weight management including improving diet behaviors and mindfulness. Prenatal yoga has been

shown to improve dietary behavior with regard to increased servings of fruits and vegetables, fewer servings of sugar sweetened beverages and snack foods, and less fast food consumption.<sup>81</sup> As mentioned previously, better diets have been shown to reduce the risk of EGWG.<sup>27</sup> Several studies have also reported that prenatal yoga improves mindfulness (non-judgmental present moment awareness).<sup>82-85</sup> Behavioral interventions implementing mindfulness strategies to control weight have reported significant weight loss among intervention participants<sup>86,87</sup> or improvements in eating behaviors (e.g., binge eating, emotional eating).<sup>87,88</sup>

Prenatal yoga may also improve psychological/emotional factors that may influence weight outcomes including increasing self-awareness and emotion regulation, reducing stress, and improving mood. Increasing body awareness (a component of self-awareness) has been associated with increased yoga practice<sup>89,90</sup> and it has been suggested that increasing self-awareness may decrease food consumption<sup>91,92</sup> or allow opportunities for behavioral adjustments that may increase the likelihood of behavioral change (e.g., override impulses).<sup>93</sup> Prenatal yoga may even foster emotion regulation skills (e.g., attention allocation or increased acceptance)<sup>94</sup> which may play a role in eating behaviors particularly those influenced by emotions (e.g., binge eating, stress eating).<sup>95-99</sup> Several studies have reported the stress-reducing effects of prenatal yoga<sup>100-102</sup> and stress may trigger the release of cortisol which is related to weight gain.<sup>103</sup> Several studies have also reported positive impacts on depression and anxiety in prenatal yoga interventions<sup>104-108</sup> and evidence suggests a positive relationship between depressive symptoms and EGWG.<sup>109,110</sup>

Prenatal yoga may also influence physiological factors such as reducing pregnancy discomforts, increasing physical activity both, or improving sleep quality which may affect EGWG. Women practicing prenatal yoga report fewer pregnancy discomforts (e.g., back or pelvic pain).<sup>111,112</sup> Pain has been commonly cited in those with greater weight<sup>113–115</sup> and may inhibit physical activity and normal daily functioning and ultimately lead to a more sedentary lifestyle.<sup>116–120</sup> Because prenatal yoga is a type of physical activity, it naturally increases energy expenditure and some studies suggest that some types of yoga may be a moderate-intensity activity.<sup>121,122</sup> Energy balance (calorie consumption and expenditure) is directly related to weight loss or weight maintenance<sup>123</sup> and increasing physical activity levels may help pregnant women prevent EGWG. Furthermore, practicing yoga during pregnancy has been linked to reductions in sleep disturbances and fewer nighttime awakenings compared to controls.<sup>124,125</sup> Though not explored during pregnancy, several studies in non-pregnant populations support a strong link between poor sleep and weight gain or the development of obesity.<sup>126–129</sup>

Given the evidence related to the potential for prenatal yoga to improve behavioral, psychological/emotional, and physiological factors and their relationship to weight, it is important to explore these plausible mechanisms in-depth as a way to prevent EGWG. Therefore, the purpose of this paper is to propose a model (See Figure 1) that explains how prenatal yoga may be a novel approach to prevent EGWG in pregnant women through behavioral, psychological/emotional, and physiological mechanisms.

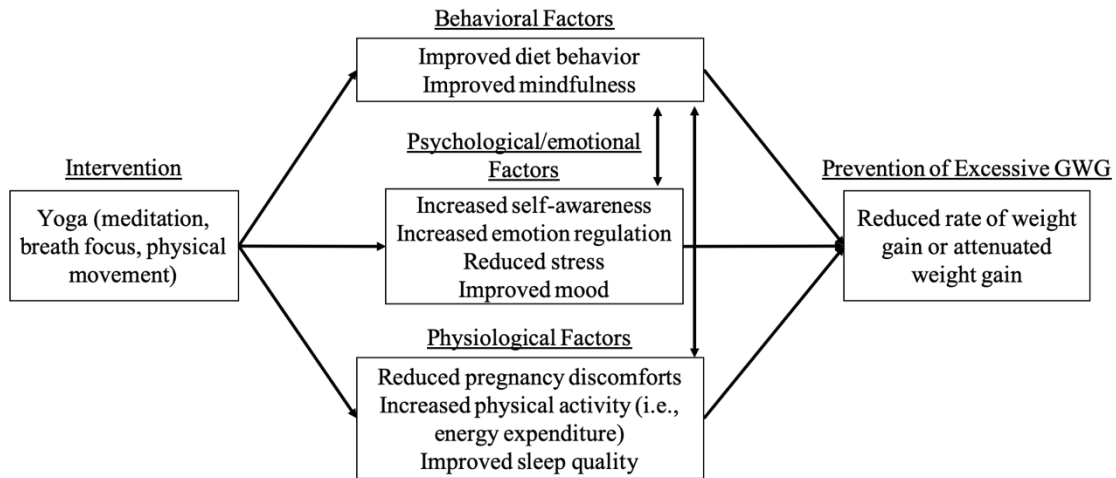


Figure 1. Proposed Model of the Effects of Prenatal Yoga on Excessive Gestational Weight Gain.

### **Prenatal Yoga and Behavioral Factors**

There is literature to suggest that prenatal yoga may lead to changes in behavioral factors such as diet behavior and mindfulness. Our proposed model in Figure 1 describes a potential pathway through which yoga may prevent EGWG through changes in these specific behavioral factors. Changes in diet behavior and mindfulness may also influence psychological/emotional (i.e., increased self-awareness, emotion regulation, reduced stress, and improved mood) and physiological factors (i.e., reduced pregnancy discomforts, increased physical activity, and improved sleep quality) which can directly influence weight gain during pregnancy. The following sections describe the complex relationship of prenatal yoga and behavioral factors and how this relationship may prevent EGWG during pregnancy.

#### *Diet behavior*

Poor diet has been reported in up to 80% of pregnant women<sup>130</sup> and diet-related diseases (e.g., heart disease, cancer, diabetes) are the leading causes of death in the United States.<sup>131</sup> Diet quality and behaviors (e.g., eating habits) during pregnancy are

particularly important for optimal maternal and fetal health. Better diet quality during pregnancy has been associated with child neurodevelopment and cognitive development,<sup>132</sup> reduced risk for small-for-gestation infants,<sup>133</sup> reduced likelihood of preterm birth,<sup>134</sup> reduced risk of EGWG,<sup>27</sup> and a lower odds of pre-eclampsia and gestational diabetes mellitus.<sup>135</sup> Pregnant women who are younger, less educated, have more children, and have a higher pre-pregnancy BMI are more likely to have poorer quality diets.<sup>136,137</sup> Despite maternal characteristics, all pregnant women should be encouraged to modify their dietary behaviors to improve diet quality and promote optimal maternal and fetal health outcomes.

The aforementioned Cochrane review suggested that diet or exercise, or both, reduced the risk of EGWG by 20% on average among 24 studies that were reviewed.<sup>27</sup> This was particularly true for diet interventions that involved low glycemic load diets. Many studies in the report were multifaceted and varied based on the approach of the intervention (e.g., type, delivery, content). One cohort study reported that total energy intake along with dairy and fried food consumption was directly associated with EGWG.<sup>138</sup> One cross-sectional study reported a reduced risk of EGWG for pregnant women who consume whole grains, vegetables, legumes, fish, milk and dairy products, have more frequent meals throughout the day, and drink greater amounts of liquids.<sup>139</sup> Conversely, other studies have reported no effect on EGWG after implementing a dietary intervention or no association of diet quality and EGWG.<sup>140–143</sup>

It is important to note the relationship between stress and diet particularly the inverse relationship observed between high stress and poor diet (more discussion about stress found below in the stress section).<sup>144</sup> Pregnant women reporting higher stress have



been shown to consume energy-dense and nutrient-poor comfort foods<sup>145,146</sup> which promotes central fat distribution.<sup>147</sup> In non-pregnant women, those with higher stress have higher BMI's and waist-to-hip ratios compared to women with lower stress levels.<sup>147</sup> Psychological factors such as stress may play an important role in behavioral outcomes (e.g., poor diet) which may influence weight gain during and after pregnancy and should be evaluated in future studies.

#### *Diet behavior and prenatal yoga*

There has been minimal research evaluating the impact of prenatal yoga on diet behaviors but findings in non-pregnant populations are promising. A mixed methods study used survey data collected from a large population-based cohort study (N=1820) as well as qualitative interviews (N=46) to investigate how yoga practice might influence diet and physical activity behaviors. Findings suggested that regular yoga practice was associated with positive dietary behaviors such as greater servings of fruits and vegetables, fewer servings of sugar sweetened beverages and snack foods, and less frequent fast food consumption.<sup>81</sup> The findings were even more impressive for each additional hour of reported weekly yoga practice. Major themes that were identified in relation to yoga practice and eating behaviors included: motivated to make healthier choices, more mindful eating, management of stress and emotional eating, more healthy food cravings, and the yoga community. The findings may provide important implications for future studies investigating the impact of prenatal yoga on diet behaviors.

#### *Mindfulness*

Mindfulness can be described as the moment-to-moment, non-judgmental awareness, cultivated by paying attention on purpose to the present moment as non-reactively, non-judgmentally, and openheartedly as possible.<sup>85</sup> Mindfulness-based interventions have been used to alleviate emotional suffering (e.g., stress, anxiety, depression),<sup>148–150</sup> improve patient symptomology related to chronic illness (e.g., diabetes, cancer),<sup>151,152</sup> improve pain,<sup>153</sup> manage weight,<sup>154,155</sup> and improve sleep.<sup>156–158</sup> Several models have been developed to describe the possible mechanisms of mindfulness from a range of perspectives (e.g., psychosocial, neurological, biological). For example, mindfulness has been associated with, but not limited to, changes in brain structure, increasing activation in areas of the brain involved in attention, and reduced amygdala (i.e., emotion processing) volumes.<sup>159</sup> Other studies suggest possible mechanisms of change including metacognitive awareness, decentering, and decreased rumination.<sup>160</sup> Despite the various postulated mechanisms through which mindfulness works, there is a general consensus that mindfulness does indeed have benefits for a variety of health-related issues demonstrated from the literature cited previously.

Recently mindfulness has been used as a behavioral intervention (or component of) to manage weight in non-pregnant populations. One systematic review analyzing mindfulness-based interventions (N=19) for weight loss concluded that significant weight loss was documented among participants in 13 of the 19 studies reviewed.<sup>86</sup> However, there were several methodological weaknesses noted among studies which include various assessments of mindfulness, various doses, lack of appropriate control groups, small sample sizes and lack of control of study variables. Similarly, findings in a literature review investigating mindfulness-based interventions for obesity-related eating

behaviors reviewed 21 studies with targeted eating behavior outcomes including binge eating, emotional eating, external eating, and dietary intake.<sup>87</sup> The majority of studies (N=18/21) reported improvements in the targeted eating behaviors. Additionally, 10 studies included body weight outcomes and nine studies reported weight loss or weight maintenance. The mindfulness training was helpful to participants by providing them with skills to mitigate maladaptive eating behaviors and develop a positive relationship with food.

Mindfulness has been used in interventions with pregnant women but there has been limited studies conducted in the context of weight or weight-related outcomes. One study that tested an 8-week mindfulness-based intervention directed toward reducing stress and overeating in pregnancy found that increases in mindfulness were correlated with decreases in stress, depression, and emotional and external eating.<sup>88</sup> However, this study did not have a control group. In a quasi-experimental study, using the same sample and intervention reported in the previous study, researchers compared pregnant women in the mindfulness group to 105 sociodemographically and weight equivalent pregnant women receiving treatment as usual.<sup>161</sup> Women who participated in the mindfulness intervention had significant reductions in stress and depressive symptoms, reported greater levels of physical activity, and were less likely to have impaired glucose intolerance but there was no difference in the number of women with EGWG. Authors suggest a longer more intensive intervention might be more appropriate for weight management in this population.

*Mindfulness and prenatal yoga*

Mindfulness is an important component of prenatal yoga. Prenatal yoga provides the opportunity to practice mindfulness as many of the poses are to be performed with focused attention, a non-judgmental attitude, and focus on the present (e.g., what is happening with regard to sensations in the body and breath).<sup>162</sup> Studies conducted using prenatal yoga on outcomes other than weight suggest that prenatal yoga may increase levels of mindfulness.<sup>82</sup> Mindfulness has also been suggested as a potential mechanism of change from yoga on a range of outcomes such as stress<sup>163,164</sup> and depression<sup>82,165</sup> but has yet to be investigated in regard to prenatal yoga's potential impact on EGWG. However, the evidence that mindfulness may influence weight (e.g., weight loss and/or maintenance) and that prenatal yoga may increase mindfulness may be important considerations in future studies investigating prenatal yoga as a strategy to prevent EGWG.

### **Prenatal Yoga and Psychological/Emotional Factors**

A large number of studies have investigated the impact of prenatal yoga on psychological or emotional health (e.g., self-awareness, emotion regulation, reduced stress, improved mood).<sup>166-169</sup> What has been less explored is the impact of psychological or emotional health on weight outcomes. However, recent evidence suggests that there is a strong link between an individual's psychological/emotional health and weight outcomes.<sup>170-172</sup> Our proposed model in Figure 1 describes how prenatal yoga influences psychological/emotional factors that may directly affect EGWG and/or how psychological/emotional factors may influence behavioral factors (i.e., diet behavior and mindfulness) that may directly influence EGWG.

*Self-awareness*

Self-awareness can be described as focusing one's attention inward toward the self or having the capacity of becoming the object of one's own attention.<sup>173</sup> Self-awareness differs from consciousness as it involves the reflection on the experience of perceiving and processing stimuli whereas with consciousness one can perceive and process stimuli without explicitly knowing it.<sup>173</sup> One adaptive function of self-awareness is self-regulation which includes altering one's behavior such as resisting temptation, changing one's mood, selecting a response from various options, or filtering irrelevant information.<sup>174</sup> Self-awareness is positively correlated with mindfulness<sup>175</sup> and practices such as yoga may cultivate a heightened sense of self-awareness.<sup>176</sup>

To our knowledge, no studies have been conducted on self-awareness and prenatal yoga in pregnant women. Yoga is intended to elicit a heightened sense of self-awareness through its application of mindfulness, meditation, postures, and focus on the breath.<sup>44,177</sup> However, measuring self-awareness is difficult and yoga studies that have measured self-awareness are minimal; many only measure aspects of self-awareness (e.g., body awareness, interoceptive awareness) or self-regulation. Self-report instruments have been developed to measure self-awareness or related constructs<sup>173</sup> and recent evidence has emerged identifying important neurobiological mechanisms of self-awareness.<sup>176</sup> Findings in one cross-sectional study investigating the interactions between body awareness (e.g., awareness of bodily sensations) suggest that increased yoga practice was related to increased body awareness.<sup>89</sup> Similarly, findings in another cross-sectional study investigating mechanisms of yoga practice and psychological well-being found that body awareness was positively correlated with increasing yoga practice and mediated the relationship between yoga practice and well-being.<sup>90</sup> Gard et al., 2014

developed a model explaining the potential self-regulatory mechanisms of yoga for psychological health.<sup>93</sup> The authors describe how increased self-awareness may allow individuals to assess their current state of being and make any necessary behavioral adjustments and that individual's gain perspective of their world-view and habits and therefore increases the likelihood of behavioral change (e.g., reduced response to stress, override impulses). Though this paper was specifically focused on psychological health, it has important implications for self-awareness and self-regulation in a weight management context.

#### *Self-awareness and weight-related outcomes*

Self-awareness may play a critical role in weight management. Several studies have reported that self-monitoring the diet increases self-awareness and may decrease food consumption.<sup>91,92</sup> In a model that was developed from investigating a group of women who maintained weight loss for at least one year, six patterns of behavior emerged from the data.<sup>178</sup> Women began from 1) an initial pattern of low confidence and self-awareness, 2) recognition of the problem and readiness to change, 3) taking control, 4) learning new skills, 5) social support and validation, and 6) increased confidence and self-awareness. This data underscores the importance of developing self-awareness to promote weight loss and maintenance. Interestingly, theory explaining binge eating suggests that it is motivated by a desire to escape from self-awareness.<sup>179</sup> Binge eaters suffer from high standards and expectations and develop an aversive pattern of high self-awareness that is characterized by unflattering views of self which is accompanied by emotional distress. In an effort to escape this unpleasant state, binge eaters narrow their attention to the immediate stimulus environment, disengaging normal inhibitions against

eating, and promotes irrational beliefs and thoughts. Similarly, pregnant women have reported to have poor body image or satisfaction which has been found to be associated with a greater risk for EGWG<sup>180–182</sup> and depressive symptoms.<sup>29,30</sup> One study reported 57% of women with EGWG desired a thinner body size and pregnant women who preferred a thinner body size were more like to have EGWG when compared to pregnant women satisfied with their body image.<sup>183</sup> Perhaps increasing self-awareness during pregnancy may help women make better behavioral choices and perceive a more positive body image and therefore reduce their risk of EGWG.

### *Emotion regulation*

Emotion regulation refers to shaping which emotions one has, when one has them, and how one experiences or expresses them.<sup>184</sup> Individuals can change the intensity (e.g., hiding feelings of distress) or duration (e.g., sharing positive news with others) of an emotion or even the quality of an emotional response (e.g., seeing humor in an embarrassing situation).<sup>185</sup> There are many ways that an individual can regulate their emotions from punching a boxing bag, screaming into a pillow, calling a friend, or going on a run. Successful emotion regulation has been associated with a greater well-being and better physical health.<sup>186–188</sup> Specifically, emotion regulation has been an important factor for reducing symptoms of depression or anxiety,<sup>189,190</sup> stress,<sup>191</sup> and anger<sup>192</sup> and more recently has been viewed as an important contributor to weight management.

While much of the literature surrounding weight gain and obesity has primarily been focused on poor diet and lack of physical activity, more evidence suggesting the impact of emotions on weight gain or obesity is unfolding. Eating behavior in particular may be highly influenced by emotions. Some theories suggest eating as a coping strategy

in response to emotional distress.<sup>95</sup> Many emotion regulation theories, that aim to explain disordered eating, suggest that specific or unspecific negative emotions act as a trigger and in order to feel relief (i.e., reduce intensity of emotion) the individual will overeat, or binge eat.<sup>95,96</sup> Obese individuals have reported emotional eating which describes the consumption of high-caloric, highly palatable foods to deal with negative emotions including frustration, fatigue, boredom, anxiety, and depressive symptoms.<sup>97,98</sup> One cross-sectional study in 25-64 year old adults (N=3,714) reported a positive association between emotional eating and depressive symptoms.<sup>99</sup> Findings also suggest that emotional eating and depressive symptoms affect unhealthy food choices (e.g., sweet foods). Another study investigating adaptive (e.g., reappraisal) and maladaptive (e.g., suppression) emotion regulation strategies suggested those who used maladaptive emotion regulation strategies consumed more comfort foods compared to those using adaptive strategies.<sup>193</sup> These findings highlight that how individuals respond to their emotions may influence their behavioral decisions regarding food intake. There is a need for further testing of emotion regulation strategies in a weight management context especially in pregnant women.

Data linking emotion regulation and eating behaviors during pregnancy is limited. Restrained eating and emotional eating have been positively associated with greater weight gain during pregnancy.<sup>194-197</sup> One quasi-experimental, longitudinal study assessed pregnant women's (N=65) emotion regulation strategies on infant feeding behaviors 7-months after delivery.<sup>198</sup> Findings suggest that overweight pregnant women had more difficulties in emotion regulation, were more psychologically distressed and had poorer feeding interactions with their babies. It is known both anecdotally and empirically that



many pregnant women may experience heightened emotional instability possibly due to inadequate management of pregnancy-related difficulties including nausea, increased production of hormones, fear of labor/birth, bodily changes, and employment/social limitations.<sup>31,199</sup> As pregnant women may be in a more vulnerable emotional state, and evidence in both pregnant and non-pregnant populations suggest that emotions may play a major role in weight gain, there is a need for studies to explore weight management strategies that incorporate emotion regulation skills to enhance efficacy.

#### *Emotion regulation and prenatal yoga*

Yoga has been suggested as a tool for developing emotion regulation skills as it is strongly linked with improved psychological health.<sup>93,94</sup> Practicing yoga is intended to decrease mental fluctuations and considered a path to greater balance to achieve homeostasis.<sup>200</sup> Meditation, a component of yoga, has also been independently linked to better emotional regulation.<sup>201</sup> One review investigated the relationship between yoga and emotion regulation and found 24 articles that fit their search criteria.<sup>94</sup> Their findings suggest that yoga may foster emotion regulation skills such as attention allocation or increased acceptance, which might function as an antagonist of more negative emotional coping strategies (e.g., suppression, rumination). Findings also suggest that from a neurocognitive perspective, yoga may facilitate regulation of autonomic activity (e.g., decreased sympathetic activation and increased parasympathetic activation). Taken together, individuals who practice yoga may be less responsive to negative stimuli and may use more positive emotion regulation strategies. However, to our knowledge, there are no studies that have investigated the relationship of emotion regulation and prenatal yoga. Because yoga in the general population has relatively similar teachings as prenatal

yoga (modifies common poses and may be less intense), researchers are encouraged to test the emotion regulation properties of prenatal yoga and their relation to weight outcomes in pregnant women.

### *Stress*

Studies have reported up to 84% of pregnant women experience stress.<sup>35</sup> Prenatal stress can be defined as psychological influences or threatened homeostasis during pregnancy challenging the ability to cope.<sup>202–204</sup> Stressors (i.e. stress producing factors) can vary from daily life hassles (e.g., job strain, personal relationships, finances) to major life events (e.g., divorce, unemployment, death).<sup>205–207</sup> Pregnancy may even provoke feelings of stress due to a variety of stressors including lack of sleep or support, fear of labor or birth outcome, finances, complications of pregnancy or high-risk pregnancy, fatigue, work related problems, increased discomfort (bodily pain), or reduced mobility.<sup>208</sup> Mothers experiencing high levels of stress during pregnancy may be more likely to have high blood pressure, cardiovascular disease, some cancer, insulin resistance, decreased lean body mass, inflammation, and hypercortisolemia.<sup>103,205</sup> Other risks include an increased risk of cesarean section, preterm birth and low birth weight,<sup>204,209–211</sup> poor/insecure attachment to the child, decreased likelihood of breastfeeding, and an increased likelihood of prenatal anxiety and depression.<sup>209</sup> Moreover, stress can contribute to changes in diet and physical activity (e.g., sedentary lifestyle, increase calorie consumption) that may lead to weight gain.<sup>202</sup>

The impact of prenatal stress on EGWG has been less explored, but findings suggest that prenatal stress may lead to increased weight gain during pregnancy. Prenatal stress and other emotionally distressed states (e.g., depression, anxiety) trigger the release

of stress hormones (e.g., cortisol)<sup>103</sup> that may contribute to EGWG or an even greater PPWR. This occurs due to an increased production of cortisol (hypercortisolemia); a hormone that may stimulate hunger, appetite and feeding, and may increase overeating, during times of stress.<sup>208,212,213</sup> Hypercortisolemia may cause imbalances between normal hormone functioning that also contributes to visceral fat production<sup>103,204</sup> and a decrease in lean body mass.<sup>202</sup> One study found that pregnant women who are at high risk for EGWG typically exacerbated negative behaviors (i.e., poor diet, physical inactivity) due to weight gain promoting beliefs (e.g., ok to indulge in cravings and eat for two, women can't be active because of fatigue and are physically uncomfortable).<sup>67</sup> Additionally, a recent study by Thomas et al., (2014), reported low-income pregnant women consumed more food when they felt stressed, and that eating was a coping mechanism for their stress.<sup>103</sup> Moreover, being overweight pre-pregnancy is a predictor of eating more when experiencing stress and subsequently increasing risk of EGWG.<sup>103</sup> Because an overwhelming number of pregnant women report feeling stressed and the link between stress and weight, there is a need for stress management interventions in pregnant women to improve maternal and child health outcomes.

### *Stress and prenatal yoga*

Several studies have investigated the impact of prenatal yoga on stress during pregnancy.<sup>100-102</sup> A systematic review investigating the effects of prenatal yoga analyzed only randomized controlled trials (RCT) and found 10 studies that met their search criteria.<sup>102</sup> Though the number of trials found were limited, the authors suggest that prenatal yoga may improve mental conditions particularly stress, anxiety, and depression. However, most studies were conducted on international samples and the methodologies

between studies varied greatly. One RCT by Satyapriya et al., (2009) recruited 122 healthy pregnant women and randomized them into either a yoga/deep relaxation group or a control group (standard prenatal exercises).<sup>214</sup> Participants in the yoga group were instructed to do physical yoga poses, breathing exercises, meditation and relaxation techniques, and participated in 15-minute yogic counseling sessions. Findings suggest that participants in the yoga group decreased perceived stress scores by 31.57% as compared to the control group. Similarly, another RCT that tested prenatal yoga compared to a social support group in depressed pregnant women (N=92) reported that prenatal yoga significantly decreased depression, anxiety, stress and cortisol levels.<sup>215</sup> In a more recent RCT investigating the effect of prenatal yoga on stress and immune function, researcher's assigned women to a 20-week prenatal yoga intervention or a routine prenatal care control group.<sup>100</sup> Participants attended two 70-minute yoga sessions each week and provided saliva samples before and after yoga every four weeks. The findings suggest that participants in the yoga group significantly reduced their salivary cortisol concentrations immediately after yoga ( $p<.001$ ) and had infants who weighed more ( $p<.001$ ) compared to the control group. The data reported across these studies highlight the potential for prenatal yoga to reduce stress and cortisol (a hormone significant in both weight and stress outcomes) in pregnant women. More studies are needed to evaluate the stress reducing impact of yoga on EGWG.

### *Mood*

Nearly 50% of pregnant women experience depressive symptoms and less than half of depressed women are identified and therefore fail to receive proper treatment.<sup>34,216</sup> Many symptoms of depression overlap with common pregnancy symptoms which poses a

challenge when trying to distinguish between the two (e.g., fatigue, changes in sleep or appetite).<sup>217-219</sup> Poor mood (e.g., depression, anxiety, stress) during pregnancy may lead to major consequences for both the fetus and mother including preterm birth, low birth weight, delayed neuromotor development, increased irritability in infancy, behavioral problems in childhood, decreased intention to breastfeed, and a greater likelihood of postpartum depression.<sup>220,221</sup> Depression often co-occurs with stress and anxiety and individuals who experience depressive symptoms are more likely to report higher levels of stress and anxiety.<sup>35,222,223</sup> In addition, depression may lead to poor health behaviors (poor diet, lack of physical activity) during pregnancy<sup>221,224</sup> which may play a major role in weight gain during pregnancy.

It has been reported that depressive symptoms and EGWG have a positive relationship which may lead poor behavioral choices that negatively impact a mother's energy, eating habits, weight, physical activity levels, and sleep.<sup>109,110</sup> Depressive symptoms have also been identified as a risk factor for EGWG.<sup>65</sup> Studies have suggested that obese women are more likely to have major depressive disorder (MDD) compared to normal weight women.<sup>225,226</sup> Findings from a prospective cohort study in pregnant women (N=238) reported that an increase of 10- and-15 units in BMI is associated with a 1.5- and 1.9-fold increase in risk of MDD, respectively.<sup>226</sup> Another study assessed maternal stress, depression and anxiety in pregnant women (N=1,605) from  $\leq 20$  week's gestation through delivery and found women with high depression scores at both  $\leq 20$  weeks ( $p=0.05$ ) and between 24 and 29 weeks ( $p=0.03$ ) gestation had a significantly greater percentage of EGWG compared to women with lower depression scores.<sup>227</sup> Even pregnant women reporting few depressive symptoms on average exhibited EGWG.

Parcells et al., (2010) found that pregnant women self-reporting depressive symptoms and perceived life stress mirrored measured cortisol levels (i.e., elevated cortisol levels indicate higher depressive symptoms and/or stress)<sup>228</sup> increasing their vulnerability for EGWG; elevated cortisol levels may contribute to weight gain. The link between poor mood and EGWG presents an opportunity for researchers and clinicians alike to investigate effective strategies to prevent EGWG in pregnant women.

### *Mood and prenatal yoga*

Our model presents prenatal yoga as a strategy to prevent EGWG with one potential mechanistic pathway being through improvement in mood. Several systematic reviews and/or meta-analysis have been conducted reporting on prenatal yoga and mindfulness-based interventions to improve depression, anxiety, and/or stress with positive findings but none have investigated these outcomes in relation to EGWG.<sup>104–108</sup> One meta-analysis reviewing yoga studies (only RCTs) for maternal depression (N=6) reported that there is a statistically significant benefit of prenatal yoga interventions on mood during pregnancy with a pooled standardized mean difference (SMD) from baseline depressive score of  $-0.452$  (95%CI:  $-0.81616$  to  $-0.880$ ,  $P = 0.01515$ ).<sup>104</sup> However, most of the studies were preliminary and included small sample sizes and a lack of blinding. Another systematic review reporting on meditation randomized controlled trials (N=47) for psychological stress and well-being suggested that mindfulness meditation programs had moderate evidence of improved anxiety (effect size,  $0.38$  [95% CI,  $0.12-0.64$ ]) at 8 weeks and depression ( $0.30$  [ $0.00-0.59$ ]) at 8 weeks.<sup>105</sup> Prenatal yoga has been reported to reduce activation of the sympathetic nervous system, increase parasympathetic tone, and reduce levels of cortisol – systems which are

often impaired in pregnant women with poor mood.<sup>104</sup> Regulating these systems may reduce stress reactions and promote relaxation which is particularly useful in managing poor mood.<sup>104</sup> These findings support prenatal yoga as a strategy to improve mood in pregnant women. However, further testing of studies with methodological rigor is needed including those that explore weight-related outcomes.

### **Prenatal Yoga and Physiological Factors**

It is widely accepted that physical activity and/or exercise improves physiological functioning in both pregnant and non-pregnant women.<sup>229</sup> Though not as widely researched compared to other physical activities or exercise, prenatal yoga may have benefits relative to physiological functioning that may prevent EGWG. Our model in figure 1 describes the relationship between prenatal yoga and the prevention of EGWG through its potential to reduce common pregnancy discomforts, increased physical activity, and improved sleep quality. Alternatively, the improvements in pregnancy discomforts, increased physical activity, and improved sleep quality may contribute to improved behavioral factors (i.e., diet behavior and mindfulness) that subsequently impact weight gained during pregnancy. The sections below further unpack these relationships to demonstrate the ways through which prenatal yoga may prevent EGWG.

#### *Pregnancy discomforts*

For many, pregnancy is a time of excitement and hope in a woman's life that is accompanied by many changes (e.g., physical, psychological, social, financial). These changes may impact a woman's quality of life and may even limit normal daily activities.<sup>230</sup> Not all pregnant women report the same discomforts, and many differ regarding the duration and severity of symptoms. Discomforts may also be present at

different times throughout one's pregnancy (most notably during either the first or third trimester).<sup>231</sup> Commonly cited physical pregnancy discomforts include nausea, fatigue, back pain, edema or swelling, and headache.<sup>231</sup> In non-pregnant populations, pain and discomfort has been related to increased weight gain.<sup>232,233</sup> However, this relationship is more difficult to observe in pregnant women.

Research suggests that EGWG may be a risk factor for back pain during pregnancy.<sup>113</sup> Weight management strategies have been suggested as strategies to help back pain and even pelvic girdle pain during pregnancy.<sup>114,115</sup> Excessive weight increases mechanical stress to the joints on the body which may cause bodily pain or physical limitations.<sup>234-236</sup> Physical activity and exercise have been suggested as an effective means to help with pregnancy discomforts, especially pain related issues.<sup>229,237,238</sup> In non-pregnant populations bodily pain has been reported to inhibit participation in regular exercise and impacts performance of normal daily functioning<sup>116-119</sup> and in one study obese women cited pain as the major personal barrier to participating in physical activity.<sup>120</sup> Many pregnant women experience the inevitable discomforts of pregnancy which may lead to more sedentary lifestyles, limited engagement in physical activity and therefore increased weight gain during pregnancy. It may also be true that pregnancy discomforts are more severe if women are overweight or obese before pregnancy beginning. However, more studies are needed to better understand the influence of pregnancy discomforts on EGWG and identifying appropriate interventions to improve pregnancy discomforts.

Several studies have investigated the utility of yoga on improving various pain and bodily discomforts in both non-pregnant and pregnant populations.<sup>73,111,239</sup>



Interestingly, according to a survey administered to adults (N=34,525) about the use of yoga in the past year, 20% of respondents reported back pain as a reason for engaging in yoga<sup>240</sup> suggesting pain as a major reason for engagement in yoga practice. However, this study did not report on pregnancy status. Yoga may also improve back pain to a greater degree when compared to general exercise for back pain in non-pregnant samples.<sup>241</sup> One RCT in adults with back pain (N=60) assigned participants to a yoga group or general exercise group for four weeks. Both groups experienced reductions in pain but the visual analogue scale revealed participants in the yoga group reduced pain by 72.81% compared to the 42.50% reduction reported in the control group (p=.001). Yoga may reduce headache frequency and severity as demonstrated by two RCTs in non-pregnant women.<sup>242,243</sup> Findings in both studies suggest that women who engaged in the yoga group significantly decreased the frequency and severity of reported headaches when compared to controls. Yoga may be a particularly useful tool to manage pain in non-pregnant adults.

#### *Pregnancy discomforts and prenatal yoga*

Pregnancy discomforts were evaluated in a study (non-randomized) conducted in Taiwan, pregnant women between 26-28 weeks gestation were asked to participate in prenatal yoga for 12-14 weeks using a 30-minute videotape and booklet.<sup>111</sup> Researchers compared findings to a control group who walked for 30-minutes twice per day. Pregnancy discomforts were reported using the Discomforts of Pregnancy Questionnaire. Women in the prenatal yoga group reported significantly fewer pregnancy discomforts compared to the control group (38.28 vs. 43.26, p = .01) at 38-40 weeks gestation. Another study reported findings of a randomized controlled trial that tested the effects of prenatal yoga

on lumbopelvic pain in pregnant women (N=60).<sup>112</sup> Pregnant women were randomized into the prenatal yoga group or a postural orientation group and asked to participate once weekly for 10 weeks and their pain intensity was assessed using a visual analog scale. Findings from this study suggested a lower pain score observed in the yoga group compared to the controls (p<.0058). The data reported across these studies (in both non-pregnant and pregnant samples) demonstrate the potential for prenatal yoga to reduce common pregnancy discomforts. However, more research is needed to evaluate the impact of reduced pregnancy discomforts and EGWG.

### *Physical activity*

The American College of Obstetricians and Gynecologists recommend that pregnant women participate in an exercise program that includes 20-30 minutes of moderate-intensity physical activity per day on all or most days of the week.<sup>53</sup> Yet, studies report up to 60% of pregnant women do not achieve these guidelines<sup>54</sup> and spend over half of their waking day engaged in sedentary activities.<sup>55</sup> Participation in physical activity during pregnancy is associated with increased energy expenditure, reduced risk of gestational diabetes mellitus, hypertensive disorders, and EGWG and better birth outcomes.<sup>244,245</sup>

Increased physical activity results in a higher energy expenditure<sup>246</sup> or other words a greater “calorie burn”. Energy intake and expenditure (e.g., energy balance) is directly related to weight loss or weight maintenance in non-pregnant populations.<sup>123</sup> However, during pregnancy, energy requirements increase between 200-400 kcal/day depending on what trimester the woman is in.<sup>247,248</sup> Energy intake above this amount (not counterbalanced with energy expenditure) may contribute to EGWG. There is a need for

studies to identify strategies to encourage women to engage in physical activity throughout pregnancy to prevent EGWG and promote optimal pregnancy and birth outcomes.

### *Physical activity and yoga*

To our knowledge, prenatal yoga studies do not report on total physical activity levels outside of the intervention. Engaging in a prenatal yoga program in itself increases a woman's time spent in physical activity especially if previously sedentary. Historically, yoga has been assumed to be a low-intensity activity but studies evaluating the energy expenditure suggest that yoga may be a moderate-intensity activity which satisfy intensity recommendations for physical activity guidelines and may result in greater energy expenditure.<sup>121,122</sup> Many studies do not evaluate or report the intensity of yoga and because there are numerous variations of yoga, it is difficult to measure the intensity. The methods used to evaluate energy expenditure also may not accurately estimate the energy expenditure of yoga. For example, studies report using a device worn on the back (Oxycon mobile) and/or a wrist or hip worn accelerometer.<sup>121,122</sup> However, many yoga poses are performed on the back, unilaterally, and many static holding positions are utilized throughout class making it difficult for these devices to capture movement. The caloric expenditure of prenatal yoga has not yet been determined but if practiced at a moderate pace, prenatal yoga may be an also be a physical activity that can be performed at a moderate-intensity that increases energy expenditure and perhaps prevent EGWG.

Studies in non-pregnant populations testing the effects of yoga on weight outcomes are promising. In a cohort study by Kristal et al., (2005), researchers examined the effects of yoga on weight in 15,550 adults.<sup>75</sup> Results of this study revealed that

regular yoga practice (30 minutes once per week for four or more years) reduced weight by 3.1 lbs and 18.5 lbs in normal and overweight individuals, respectively. Findings suggest that yoga may contribute to long-term weight maintenance or weight loss. A review investigating yoga on the management of overweight and obesity suggest that yoga may assist with behavioral change, weight loss, and maintenance particularly through increasing energy expenditure, reducing back/joint pain, heightening mindfulness, improving mood, reducing stress and food intake, and allowing individuals to be more connected to their bodies (more aware of satiety and overeating).<sup>249</sup> However, there is a lack of consistency between yoga studies concerning type, duration, frequency, and methodological rigor. Yoga (and prenatal yoga) may have the potential to increase physical activity levels and subsequently energy expenditure which may have a positive impact on weight-related outcomes. However, more research is needed to evaluate these relationships.

### *Sleep quality*

Poor sleep quality (e.g., disturbed sleep, short sleep duration) is not uncommon during pregnancy with a recent meta-analysis reporting 46% of pregnant women experience poor sleep (scores of  $\geq 5$  on the Pittsburgh Sleep Quality Index).<sup>250</sup> Pregnant women often experience poor sleep quality in the first trimester and report even worse sleep in the third trimester.<sup>250,251</sup> Poor sleep quality has been associated with an increased risk of preterm birth,<sup>252</sup> cesarean section and longer labor duration,<sup>253</sup> and has been reported to be a risk factor for depression in both the prenatal and postpartum periods.<sup>254–</sup>  
<sup>257</sup> The relationship between sleep quality and birth/maternal health outcomes during pregnancy is not fully understood, as there is a dearth of literature in this area.

Several studies, in non-pregnant adult populations, have investigated the impact of sleep quality on weight outcomes with findings supporting a strong link between sleep restriction and weight gain or the development of obesity.<sup>126-129</sup> In pregnant women, this relationship remains undetermined in part due to the poor amount of published literature related to sleep quality and weight gain during pregnancy. In a large cohort study investigating the impact of sleep duration on the development of diabetes in non-pregnant women enrolled in the Nurses Health Study (N=70,026), findings suggest both short ( $\leq 5$  hours) and long ( $\geq 9$  hours) sleep durations were associated with an increased risk of diabetes diagnosis.<sup>258</sup> This association was no longer significant in short duration sleepers after controlling for BMI which may suggest that weight gain plays an important role between the relationship among sleep restriction and the development of diabetes. In other words, sleep restriction may predispose women to weight gain and thus contribute to the development of diabetes.

Interestingly, an observational study in pregnant women suggested that longer sleep durations ( $\geq 9$  hours) reported by women were found to be protective against EGWG.<sup>259</sup> Another study found that women who were overweight or obese before pregnancy and had EGWG had poorer sleep quality compared to normal and underweight women.<sup>260</sup> Sleep quality in the last month of pregnancy was inversely associated with EGWG regardless of pre-pregnancy BMI. However, these studies in pregnant women were observational, weight was self-reported, and the sample size was low. Poor sleep quality during pregnancy has also been reported as a predictor of postpartum weight retention (PPWR). Findings in one study reported women who had a PPWR of at least 5kgs of weight at 16-weeks postpartum were more likely to experience disturbed sleep,

later sleep times, and sleep disordered breathing during pregnancy compared to women who did not retain excess weight.<sup>261</sup> An association with shorter sleep duration and higher PPWR has also been reported in some studies.<sup>262</sup> There is a need for more intervention studies to investigate the relationship between sleep quality and EGWG in pregnant women.

### *Sleep quality and prenatal yoga*

Currently few studies have investigated the impact of prenatal yoga on sleep quality in pregnant women. One randomized control trial tested a combined 12-week Tai chi/prenatal yoga intervention in depressed pregnant women (N=46) on depressive and anxiety symptoms and sleep disturbances compared to a wait-list control group (N=46).<sup>124</sup> Pregnant women randomized to the Tai chi/prenatal yoga intervention experienced significantly greater reductions in depression, anxiety, and sleep disturbances compared to the control group. However, this study did not report on weight outcomes. Similar findings were reported in a pilot study investigating the impacts of a mindfulness-based yoga intervention on sleep in pregnant women.<sup>125</sup> Pregnant women (N=15) in their second or third trimester were asked to attend a weekly mindfulness meditation and prenatal yoga class for seven weeks. Findings suggest women had less sleep disturbance, fewer nighttime awakenings, and less wake time at night at post-intervention only for women who began the intervention in their second trimester. Though these findings are promising, this study was limited by a small sample size and did not report weight outcomes.

Because sleep quality is impaired during pregnancy and may be related to weight outcomes, it is important to investigate strategies such as prenatal yoga to improve sleep

behaviors during pregnancy. There is also an important link between sleep quality, depressive symptoms and weight gain such that poor sleep quality has been associated with depressive symptoms<sup>263</sup> and depressive symptoms have been associated with a higher risk of obesity.<sup>171,222</sup> This potential relationship is illustrated in our model as an important pathway through which prenatal yoga may prevent EGWG. This relationship deserves further exploration in future studies. Though limited studies exist on the impact of prenatal yoga on sleep and weight outcomes, there are promising findings to demonstrate the potential for prenatal yoga to improve sleep outcomes. Prenatal yoga may be a strategy to improve sleep and thereby influence weight gain during pregnancy. However, more research to establish these relationships are needed.

### **Discussion**

The overwhelming amounts of pregnant women who gain above and beyond the IOM's recommendation for healthy gestational weight underscores an urgent need to identify effective strategies to reduce or attenuate the rapid rates of weight gained during pregnancy. However, emerging evidence highlighted throughout this paper suggests the complexities involved in EGWG during pregnancy. The model proposed here challenges the status quo regarding weight management strategies (i.e., typical diet/physical activity models). Behavioral, psychological/emotional, and physiological factors may all play major roles in the pathway to preventing EGWG. Prenatal yoga, or yoga in the general population, has not been widely regarded as a weight management tool like other physical activities (e.g., walking, running, swimming) and deserves further exploration.

Our model proposes several different pathways through which yoga may prevent EGWG. The first pathway is through behavioral factors including improved sleep and

diet behavior and mindfulness. These improvements alone may directly influence EGWG or may affect psychological/emotional factors which then impact EGWG or may influence physiological factors that may then affect EGWG. The second pathway is through psychological/emotional factors including increased self-awareness, emotion regulation, and mood and reduced stress. These factors may directly influence EGWG or may influence the behavioral factors that thereby affect EGWG. Finally, the third pathway is through physiological factors including reduced pregnancy discomforts and increased energy expenditure. These changes may directly influence EGWG or may influence behavioral factors that affect EGWG. We suggest further testing of this model to confirm pathways.

Other behavioral models have been developed to explain the pathway to EGWG in an effort to identify ways to promote optimal health during pregnancy. However, none have attempted to explain the potential mechanisms of yoga to prevent EGWG. One conceptual model developed by Hill et al., (2013) was created to explain the psychosocial risk and protective factors for EGWG.<sup>66</sup> Similar to our model, Hill's model describes several maternal psychological factors that influence GWG including self-esteem, anxiety and depression, stress, and past psychiatric history. They also included maternal physical activity and eating behaviors and suggest these behaviors are directly impacted by self-efficacy and motivation to change weight management behaviors during pregnancy. In a model developed by Gard et al., (2014), researchers aimed to propose aspects of yoga that affect self-regulation.<sup>93</sup> While this model was not developed to explain EGWG, the self-regulatory behaviors explained in the model may be related to weight outcomes. Their complex model outlines how yoga may influence stress responses, which influence



brain networks that inhibit factors such as negative appraisal, emotional reactivity, rumination, inflammation, muscle tension and pain, which ultimately lead to improved psychological and physical well-being. While no two models are the same, each can guide future research to begin to identify important mechanisms not only in the development of EGWG but also the mechanisms of strategies (especially prenatal yoga) to prevent EGWG. Effectiveness trials with strong methodological rigor are needed to test these relationships especially in pregnant women as a large amount of existing evidence is based on small pilot or preliminary studies.

### **Conclusion**

Excessive gestational weight gain (EGWG) is an important factor that may negatively impact maternal and child health outcomes. With the high proportions of pregnant women with EGWG and adverse risks associated with EGWG, it is imperative for researchers to identify effective strategies to prevent EGWG to encourage optimal maternal and child health outcomes. Though the literature supporting prenatal yoga as a weight management tool during pregnancy is lacking, there is considerable evidence to support the use of prenatal yoga to prevent EGWG. The model proposed here highlights important gaps in the literature and important areas for future exploration to confirm model pathways.

## CHAPTER 3

MANUSCRIPT #2: Investigating the feasibility and preliminary efficacy of a prenatal yoga intervention to prevent excessive gestational weight gain: A randomized controlled trial

### **Introduction**

Nearly 50% of pregnant women experience excessive gestational weight gain (EGWG) during pregnancy.<sup>1</sup> EGWG is weight gain above and beyond the Institute of Medicine (IOM) guidelines for healthy weight gain in pregnant women.<sup>4</sup> There are a wide range of negative health implications resulting from EGWG including delivery complications,<sup>9</sup> shorter duration of breast feeding,<sup>264</sup> prenatal hypertensive disorders,<sup>13</sup> gestational diabetes,<sup>11,12</sup> and large for gestational age infants.<sup>12</sup>

Not only are there immediate and short-term negative health implications, but there are also long-term negative health implications that can affect the mother and infant for years to come. EGWG is a predictor of post-partum weight retention and can lead to long-term obesity in the mother and child.<sup>265-267</sup> Infants born to mothers with EGWG are more likely to develop childhood obesity and have impaired cognition (i.e., executive functioning).<sup>17,268</sup> A study by Oken et al., (2007) found that women who had EGWG, compared with inadequate GWG (i.e., gestational weight gain below the healthy range), had nearly a 4-fold increased odds of having an overweight child at age three.<sup>269</sup> It is recommended that pregnant women (with normal pregnancies) engage in 20-30 minutes of moderate-intensity physical activity on all or most days of the week to help prevent EGWG and promote optimal birth outcomes.<sup>53</sup> However, studies report most pregnant women do not meet these guidelines and are highly sedentary (e.g., engaged in sitting

activities).<sup>54,55</sup> The negative health implications of EGWG (and a lack of physical activity) across the lifespan for the mother and child highlights a need to investigate strategies to help pregnant women prevent EGWG.

To date, interventions to prevent EGWG have had mixed findings. A 2015 Cochrane review examined randomized controlled trials testing diet or exercise (or a combination) to prevent EGWG and associated pregnancy complications.<sup>27</sup> Based on pooled data from 24 studies (7,096 participants), there was an average reduced risk of EGWG by 20% [average risk ratio (RR) 0.80, 95% confidence interval (CI) 0.73 to 0.87] for diet or exercise (or combined) interventions. Though this high-quality evidence demonstrates a positive effect, there was large heterogeneity among studies concerning type of intervention, type of participant, delivery of intervention, timing of measurement, commencement of intervention (i.e., trimester), intensity of intervention, and methods of monitoring or supervision. Some researchers suggest mental health factors (e.g., stress, depression) may impact the success of GWG interventions.<sup>28</sup> Mental health factors such as stress may affect maternal behaviors that contribute to EGWG (e.g., poor diet, lack of physical activity). Additionally, the IOM has suggested that psychosocial factors (e.g., mental and emotional health) be considered in weight management interventions to improve their success during pregnancy.<sup>4</sup> Identifying approaches that include physical activity while also addressing psychosocial health appears to be an appropriate next step in research that examines novel options for preventing EGWG.

Yoga may be a feasible weight management strategy to help prevent EGWG and has yet to be explored as such during pregnancy. In the US, yoga is known as a form of exercise that includes physical postures, breath control, and meditation.<sup>240</sup> There are

many types of yoga but yoga designed specifically for pregnant women is often referred to as prenatal yoga. Currently, there are no studies investigating the efficacy of prenatal yoga on EGWG. The bulk of the literature related to prenatal yoga highlights its benefits for mental health (e.g., improved mood, decreased depression and stress)<sup>43,72</sup> and labor outcomes (e.g., shorter labor duration, decreased pain perception)<sup>73,74</sup> but not for weight related outcomes during pregnancy. Additionally, qualitative research related to prenatal yoga suggests pregnant women enjoy the self-care and physical strength aspects of prenatal yoga and are particularly enthusiastic about prenatal yoga and its benefits (physical, mental, and emotional).<sup>46</sup>

Though no studies have explored the utility of prenatal yoga to prevent EGWG, the data to support the use of yoga for weight management in non-pregnant populations are promising. A recent systematic review and meta-analysis on the effects of yoga on weight related outcomes concluded that yoga is a safe and effective intervention to reduce BMI in overweight/obese individuals.<sup>47</sup> One study conducted in healthy middle-aged adults found that regular yoga practice (at least once per week for one year) was associated with attenuated weight gain.<sup>75</sup> Similarly, other studies have found that increased yoga practice was associated with a lower body mass index (BMI)<sup>76-78</sup> and lower body weight.<sup>79,80</sup>

The aforementioned studies underscore promising effects for yoga and weight management in non-pregnant populations, however studies in pregnant women are lacking. Therefore, prenatal yoga may provide potential advantages above and beyond other EGWG prevention strategies as it may increase mindfulness and self-regulatory behaviors that may address mental health concerns while concurrently providing a

moderate level of physical activity (i.e., 3-6 METs).<sup>40,41</sup> Promoting optimal health during pregnancy is critical for the future health of the mother and child. As such, there is a need for studies to investigate weight management strategies that include physical activity (i.e., prenatal yoga) and effects on mental/emotional health parameters during pregnancy.

As there are no prior studies examining prenatal yoga as a strategy for preventing EGWG, this study was designed to explore the feasibility (i.e., acceptability, demand) and preliminary efficacy of a 12-week prenatal yoga intervention on EGWG and mental/emotional health parameters in pregnant women. In a randomized controlled trial comparing prenatal yoga to a pregnancy education comparison group, we assessed 1) acceptability (defined as satisfaction, intent to continue use, perceived appropriateness), 2) demand (defined as attendance/adherence), and 3) preliminary efficacy on GWG and factors expected to be putative mediators of GWG effects: mindfulness, emotion regulation, self-awareness, sleep quality, depression, anxiety, and perceived stress. We hypothesized that 1) at least 70% of the sample will report the intervention to be a satisfactory, useful, safe and appropriate modality to reduce EGWG (acceptability), 2) at least 60% of participants in each group will attend 50% of classes (demand), and 3) pregnant women in the intervention group will experience less EGWG, have higher levels of mindfulness, emotion regulation, self-awareness, better sleep quality and lower levels of depression, anxiety, and perceived stress compared to pregnant women in the pregnancy education comparison group. Data from this study may inform future studies in this area.

## **Methods**

This study was a two-group, parallel, randomized feasibility trial of a 12-week prenatal yoga intervention vs. a pregnancy education comparison group with assessments at baseline (week 0) and post-intervention (week 12). The Institutional Review Board of a large university in the southwestern United States approved this study and all participants provided their consent to participate. Data collection occurred June 2018-May 2019.

#### *Power Calculations for Planned Sample Size*

An a priori power analysis was calculated to demonstrate statistical significance with a power of 80% based on a previous study that tested a nutrition and exercise intervention on EGWG in normal weight pregnant women (effect size .74, mean difference of 7.48 lbs between groups).<sup>270</sup> The power analysis was conducted using G\*power and after assuming a 20% attrition rate, 58 participants (N=29/arm) were needed to observe a significant effect.

#### *Recruitment*

Participants were recruited from local perinatology and OBGYN clinics, WIC clinics and non-for profits. Women were notified by posted flyers or referrals from their health care provider. Participants were also recruited through paid and unpaid advertisements through social media (i.e., Facebook, Instagram) and email listservs of pregnancy organizations (e.g., MomDoc, Embry Women's Health). Recruitment occurred June 2018-February 2019. See table 2 for eligibility criteria.

## **Table 2. Eligibility Criteria**

---

### Inclusion:

- Primiparous women 18-46 years of age
- 12-24 weeks gestation at onset of intervention
- Reside in the phoenix metropolitan area
- Singleton pregnancy
- English speaking
- Willing to sign a HIPAA release form for birth outcome information to research staff
- Can attend at least one yoga or educational session per week for majority of intervention (i.e., at least 70% of sessions)
- Do not plan on moving during intervention duration

### Exclusion:

- Current alcohol or substance abuse
  - Engage in  $\geq 150$  min of physical activity
  - Participation in  $\geq 30$  min of yoga/week for previous six months
  - Pre-pregnancy BMI  $\geq 40$
  - Considered by healthcare provider to be "High-risk" and advised not to exercise
    - High risk conditions: unexplained bleeding, placenta previa, preeclampsia, membrane rupture, incompetent cervix, cardiac or pulmonary disease, or pre-term labor
-

## *Procedures*

All interested participants were directed to complete a web-based eligibility screener (~15 minutes) via Qualtrics (Provo, UT). Eligible participants were asked to complete a phone appointment to be given additional information about the study. If they agreed to participate, women were sent an electronic informed consent and baseline questionnaires via Qualtrics and asked to schedule an in-person enrollment appointment. During the in-person enrollment appointment, the research team then allocated the participant to either the prenatal yoga or pregnancy education comparison group and provided women with study materials.

A random number list with 1:1 allocation was generated by an independent researcher (not involved in data collection or analysis) using an online randomization tool to assign each eligible participant to a treatment condition. To conceal randomization, sequentially numbered, opaque sealed envelopes were opened to reveal study arm assignment at the time randomization. The lead researcher (JG) assigned participants to a treatment condition during the in-person enrollment appointment.

Also during the enrollment appointment, participants were provided with study materials including: 1) study instructions, 2) schedule and location of classes, and 3) pregnancy safety handout (i.e., contraindications to yoga during pregnancy if in prenatal yoga group). Those assigned to the prenatal yoga group were given a Physical Activity Readiness Medical Examination for Pregnancy (PARmed-X for Pregnancy) form to complete with a physician prior to beginning the yoga classes. The PARmed-X for Pregnancy determines the safety or possible risk of exercising and if the individual needs



permission from their physician before engaging in an exercise program (i.e., prenatal yoga).

Participants entered the study on a continual basis. Once women were enrolled in the study (despite group allocation), they were asked to sign up for classes using an online appointment scheduler. If participants were not signed up for class, the research team sent participants an email reminder to attend and sign-up for classes. At the end of the study (week 12), women were emailed a satisfaction survey via Qualtrics to assess the feasibility of the intervention. Participants in both groups received \$10 at the completion of baseline assessments and \$15 after completion of post-intervention assessments. Women were also provided with a small bag of diapers or wipes at each session that was attended.

### *Interventions*

*Prenatal yoga intervention group (YG).* The research team including one MS-level 500-hour registered yoga teacher (RYT) and one PhD-level 200-hour RYT developed six 75-minute manualized prenatal yoga classes. Six classes were developed so that each class was repeated twice to enhance familiarity with the poses and prevent boredom. Each class was outlined as follows: 1) opening greeting/intention setting, 2) pranayama (i.e., breathing exercises), 3) warm-up/sun salutations (i.e., flowing sequence), 4) prenatal yoga sequence (e.g., combination of sun salutations, vinyasa (i.e., movement between poses), and standing, seated, and/or balancing poses), 5) cool-down 6) Savasana (i.e., final resting pose), and 7) class closing. Meditation and breath awareness (e.g., linking each movement with breath) were emphasized throughout each class. All classes focused on safety and alignment and incorporated modifications to poses/exercises as necessary (e.g., using a

yoga block, strap, or chair).<sup>271,272</sup> Four certified yoga instructors (had at least a 200-hour Yoga Teacher Training (YTT) certificate) with experience teaching pregnant women instructed the manualized prenatal yoga classes. Each yoga instructor had a 1-hour training with the lead researcher (JG) and were provided with an outline of each class to use when teaching. The classes were offered at a local community wellness center with access to free parking. Two classes (one weekday evening and one weekend morning) were offered weekly. Women were asked to attend one class per week but could attend both if they wish. Additionally, women were provided with a yoga mat.

*Pregnancy education comparison group (CG).* Women in the control group were asked to attend a weekly 75-minute group-based pregnancy education class. The class format included a didactic portion followed by group discussion. Women were given the book, *Your Pregnancy and Childbirth, Month to Month, Revised Sixth Edition by the American College of Obstetricians and Gynecologists (ACOG)*.<sup>273</sup> The research team developed 12 classes based on educational materials published and publically available by ACOG and expertise from two OB/GYN's. Class topics were developed for primiparous women and included (but were not limited to): fetal development, labor and delivery, developing a birth plan, financial considerations, and breast and formula feeding. A certified labor and delivery nurse and doula/lactation educator taught all pregnancy education classes. The classes were offered in a conference room on campus with access to free parking. Two classes (one weekday evening and one weekend morning) were offered weekly. Women were asked to attend one class per week but could attend both if they wish.

*Measures*

See Table 3 for a Summary of Data Collection. Participants in both groups received identical measurements. All baseline and post-intervention (week 12) assessments were self-reported online via Qualtrics. Attendance and weight using a research grade scale (Tanita WB-800S digital weight scale) were collected weekly prior to class. Pre-pregnancy weight was self-reported at study entry. Total GWG during the intervention was determined as the difference between week 1 and week 12 weight measurements. Weekly rate of GWG was determined by calculating the difference between weekly collected weights (e.g., week 2 – week 1, week 3 – week 2) and comparing the values to IOM guidelines (weekly rate of GWG). Participants were also asked to submit weekly logs to track physical activity, medication and/or psychotherapy use, pregnancy complications and adverse events.

**Table 3. Summary of Data Collection**

<b>Outcome Measure</b>	<b>Measurement Tool</b>	<b>Baseline</b>	<b>12-Weeks Post</b>
<b>Acceptability</b>			
Satisfaction	Overall satisfaction survey		X
Safety	Overall satisfaction survey		X
Perceived appropriateness	Overall satisfaction survey		X
Intent to continue to use	Overall satisfaction survey		X
<b>Demand</b>			
Adherence	Attendance		Weekly
<b>Preliminary effects</b>			
Gestational weight gain	TANITA scale		Weekly
Mindfulness	Mindful Attention Awareness Scale	X	X
Emotion regulation	Emotion Regulation Questionnaire	X	X
Self-awareness	Self-Awareness Outcomes Questionnaire	X	X
Sleep quality	Pittsburgh Sleep Quality Index	X	X
Depression	Edinburgh Postnatal Depression Scale	X	X
Anxiety	State-Trait Anxiety Inventory	X	X
Perceived Stress	Perceived Stress Scale	X	X

### *Mindfulness*

The Mindful Attention Awareness Scale (MAAS) is a valid and reliable measure with good internal consistency ( $\alpha=.80-.87$ ).<sup>274</sup> This scale includes 15-items and measures the extent to which individuals are able to maintain awareness of present-moment experience. Scores range between 1-6 with higher scores reflect higher levels of mindfulness. The internal consistency for the current study was within good ranges ( $\alpha=.86$ )

### *Emotion regulation*

The Emotional Regulation Questionnaire (ERQ) is a valid 10-item scale used to measure an individual's tendency to regulate their emotions by two strategies (i.e., cognitive reappraisal and expressive suppression).<sup>275</sup> Scores range from 1-7. The higher the scores, the greater the use of the emotional regulation strategy. The internal consistency for the current study was within good ranges for both subscales ( $\alpha=.84-.89$ )

### *Self-awareness*

The Self-Awareness Outcomes Questionnaire (SAOQ) consists of 38 items measuring 4 subscales (reflective self-development, acceptance, proactive at work, emotional costs).<sup>276</sup> The SAOQ assesses the frequency with which respondent's experience outcomes related to the development of self-awareness and identifies the main impacts of self-awareness on people's day-to-day lives. All four subscales are reliable with Cronbach alphas ranging from  $\alpha=0.77-.87$ . Scores range from 1-5 with higher scores representing a greater frequency of experienced outcomes. The internal consistency for the current study was within good ranges for the reflective self-development and

acceptance subscales ( $\alpha=.80-.83$ ) and below acceptable ranges for the proactive at work and emotional costs subscales ( $\alpha=.60-.68$ ).

### *Sleep quality*

The Pittsburgh Sleep Quality Index (PSQI) is a 19-item questionnaire that includes subscales for subjective sleep quality, sleep latency, sleep duration, sleep disturbance, habitual sleep efficiency, daytime dysfunction and use of sleep medications.<sup>277</sup> The PSQI is a reliable measure ( $\alpha=0.74$ ) in pregnant women.<sup>278</sup> The PSQI includes a range of question types such as: 1) fill in the blank and 2) Likert scales with four ordinal answers (e.g., not during the past month to three or more times a week; no problem at all to a very big problem; very good to very bad). Seven component scores are produced to calculate a final global score ranging from zero to 21. Higher global PSQI scores indicate worse sleep quality. The internal consistency for the current study was within acceptable ranges ( $\alpha=.74$ ).

### *Depression*

Edinburgh Postnatal Depression Scale (EPDS) is a 10-item scale used to assess participants at risk for perinatal depression and is a reliable ( $\alpha=.87$ ) and valid tool.<sup>279</sup> Scores range from 0-30 with scores of 12 or greater indicating probable depression. The internal consistency for the current study was within excellent ranges ( $\alpha=.90$ ).

### *Anxiety*

The State Trait Anxiety Inventory (STAI) yields scores indicating levels of both trait (Form Y-1) and state anxiety (Form Y-2) and is reliable and valid measure of anxiety in pregnant population.<sup>280</sup> Both forms of the STAI include 20 statements on a four-point Likert scale. Form Y-1 instructs participants to select the appropriate answer

concerning how they feel right now. Response types on Form Y-1 include: 1=not at all, 2=somewhat, 3=moderately so, and 4=very much so. Form Y-2 instructs participants to select the appropriate answer concerning how they generally feel. Response types on Form Y-2 include: 1=almost never, 2=sometimes, 3=often, and 4=almost always. Scores range from 20 to 80 with higher scores indicating greater anxiety. The internal consistency in the current study for Form Y1 and Y2 were in excellent ranges ( $\alpha=.93-.94$ ).

### *Perceived stress*

The Perceived Stress Scale (PSS) includes 10-items that measure the degree of self-appraised stress in one's life within the past month.<sup>281,282</sup> The PSS is a reliable and valid measure that has demonstrated Cronbach's  $\alpha=.84$  and good construct validity in pregnant women. Scores range from 0-40 with higher scores indicating higher levels of perceived stress. The internal consistency for the current study was within excellent ranges ( $\alpha=.90$ ).

### *Statistical Analysis*

Data were analyzed following intention to treat (ITT) principles and completer only analyses (i.e., those who completed at least 50% of sessions). After data were confirmed as normally distributed, we used chi-square analyses and t-tests to analyze demographic and participant characteristics. To assess feasibility, we produced descriptive statistics and frequencies reports to estimate the acceptability and demand of the prenatal yoga intervention. The average number of prenatal yoga sessions completed and the proportion of withdrawals determined adherence to the program. Independent t-tests were used to examine change in total GWG and average weekly change in rate of GWG (compared to

IOM guidelines) between intervention and control groups. For the second and third trimesters, the IOM recommends an average rate of weight gain of 1lb/week for normal weight, .6 lbs/week for overweight, and .5 lbs/week for obese individuals.<sup>283</sup>

We used linear mixed models (LMM) to analyze pre-post changes in primary (i.e., weight gain during pregnancy) and secondary (i.e., mindfulness, emotion regulation, self-awareness, sleep quality, depression, anxiety, and stress) outcomes. Mixed models are an extension of linear regression that allows for the analysis of repeated measures (e.g., weight) without excluding cases with missing data due to multiple imputation. For weight outcomes, model building steps included entering stepwise into the model: time (weeks 1-12), group (intervention vs control), and group x time interaction to assess whether overall weight varied by group membership across time. We also tested for quadratic (time) trends in the model. For our secondary outcomes, model building steps included entering stepwise into the model: time (pre- and post-intervention), group (intervention vs control), and group x time interaction to assess whether mental/emotional health indices varied by group membership across time. We used the maximum likelihood estimation procedures and all models were adjusted for age, race, ethnicity, income, education, gestational age at enrollment, and pre-pregnancy BMI. All statistical procedures and analyses were conducted using SPSS 25.0.

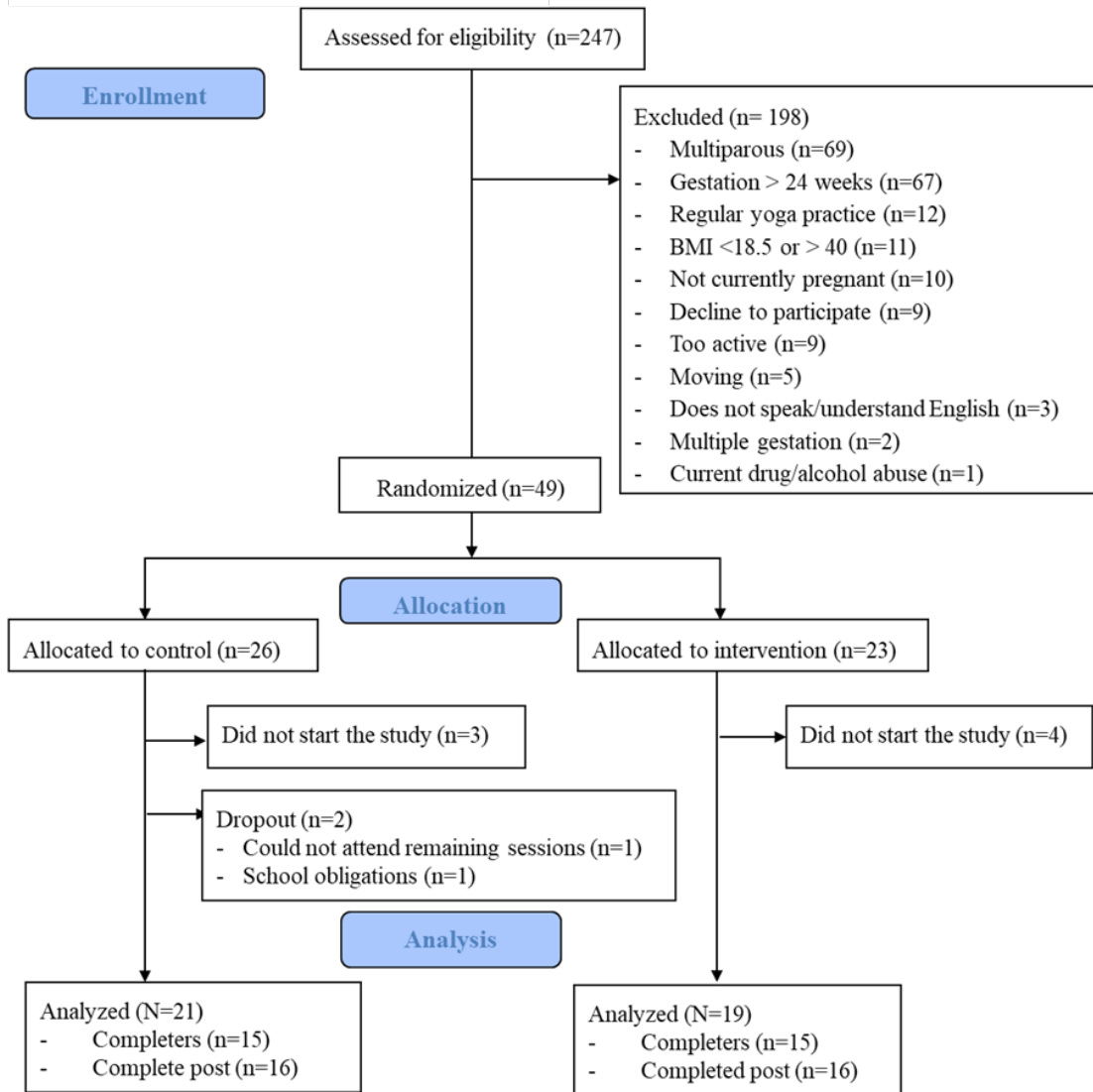
## **Results**

A total of 247 participants were assessed for eligibility (See Figure 2 for Enrollment Flow Diagram) and 198 were excluded from the study. The most common reason for ineligibility (n=69) was women being multiparous (i.e., giving birth to more than one child). Forty-nine participants were randomized to the control (N=26) or



intervention (N=23) groups. It is unknown why women chose to not participate in the study after allocation. Women would sign up for classes and no show and/or were not responsive to outreach by the research team. Fifteen participants in each group were considered completers (attended at least 50% of sessions) and 16 participants in each group completed post-intervention assessments.

**Figure 2. Enrollment Flow Diagram**



### *Participant characteristics*

Table 4 describes the demographics and participant characteristics of study participants by group allocation. There were no significant differences between groups on any variable. The majority of the sample was White, European-American, or Caucasian, had a normal weight pre-pregnancy BMI, held full-time employment, and was married.

**Table 4. Demographic Characteristics of Study Participants (N=49)**

Variable	Control (N=26)		Intervention (N=23)		P
	N	%	N	%	
Age M (SD)	27.21	(5.15)	26	(3.96)	0.43
Ethnicity					
Hispanic	10	38.5	12	52.2	0.34
Race					0.29
American Indian or Alaskan Native	2	7.7	2	8.7	
Asian or Asian American	3	11.5	0	0.0	
White, European-American, or Caucasian	15	57.7	17	73.9	
Black, African-American, or Native African	1	3.8	1	4.3	
Bi-racial or Multi-racial	2	7.7	3	13.0	
Prefer not to respond	3	11.5	0	0.0	
Income					0.16
<\$20,000 per year	9	34.6	4	17.4	
\$20,000 - \$34,999 per year	4	15.4	6	26.1	
\$35,000 - \$49,999 per year	1	3.8	5	21.7	
\$50,000 - \$74,999 per year	4	15.4	5	21.7	
\$75,000 - \$99,999 per year	6	23.1	3	13	
>\$100,000 per year	2	7.7	0	0	
Education					0.91
Less than high school	1	3.8	0	0	
High school diploma	2	7.7	1	4.3	
Some college	7	26.9	7	30.4	
Associates/2-year degree	2	7.7	3	13	
Bachelors/4-year degree	11	42.3	9	39.1	
Graduate school or above	3	11.5	3	13	
Marital status					0.40
Single	4	15.4	2	8.7	
Partnered/In a relationship	10	38.5	6	26.1	
Married	12	46.2	15	65.2	
Employment status					0.25
Employed full time (40+ hours/week)	14	53.8	13	56.5	
Employed part-time (up to 39 hours/week)	2	7.7	6	26.1	
Unemployed and currently looking for work	2	7.7	0	0	
Unemployed and not currently looking for work	0	0	1	4.3	
Student	6	23.1	2	8.7	
Self-employed	1	3.8	1	4.3	
Other	1	3.8	0	0	
Pre-pregnancy BMI					0.97
Normal	15	57.7	14	60.9	
Overweight	7	26.9	6	26.1	
Obese	4	15.4	3	13	

### *Acceptability*

See table 5 for Satisfaction Survey Responses. Approximately 94% (N=15/16) of intervention group participants indicated that they somewhat or very much enjoyed the prenatal yoga sessions. All intervention group participants (N=16) agreed or strongly agreed that they were satisfied with participating in the prenatal yoga sessions and the majority (87.5%, N=14/16) agreed or strongly agreed that they were satisfied with the teachers of the prenatal yoga sessions. Seventy-five percent (N=12/16) agreed or strongly agreed that prenatal yoga helped them to better regulate their emotions, increased their self-awareness, and made them more mindful. Approximately 56% (N=9/16) of intervention group participants agreed or strongly agreed that prenatal yoga helped them manage their weight during pregnancy and 25% were neutral (N=4/16). No injuries or adverse events related to participation in prenatal yoga were reported.

**Table 5. Satisfaction Survey Responses (N=16)**

	N	%
Overall, how much did you enjoy the prenatal yoga sessions?		
Very much	11	68.8
Somewhat	4	25.0
Not at all	1	6.3
I felt that 75 minutes per week of prenatal yoga was:		
About right	14	87.5
Too little	2	12.5
I am satisfied with participating in the prenatal yoga sessions.		
Strongly Agree	13	81.3
Agree	3	18.8
I am satisfied with the teachers of the prenatal yoga sessions.		
Strongly Agree	12	75.0
Agree	2	12.5
Neutral	1	6.3
Disagree	1	6.3
The prenatal yoga sessions were easy to follow.		
Strongly Agree	11	68.8
Agree	3	18.8
Neutral	2	12.5
Prenatal yoga has helped me to regulate my emotions better (e.g., feelings of stress, anxiety, or depression).		
Strongly Agree	8	50.0
Agree	4	25.0
Neutral	3	18.8
Disagree	1	6.3
Prenatal yoga increased my self-awareness.		
Strongly Agree	7	43.8
Agree	5	31.3
Neutral	3	18.8
Disagree	1	6.3
Prenatal yoga has made me more mindful.		
Strongly Agree	7	43.8
Agree	5	31.3
Neutral	3	18.8
Disagree	1	6.3
The prenatal yoga helped to manage my weight gain during pregnancy.		
Strongly Agree	3	18.8
Agree	6	37.5
Neutral	4	25.0
Disagree	1	6.3
Strongly Disagree	2	12.5
Prenatal yoga helped me sleep better.		
Strongly Agree	5	31.3

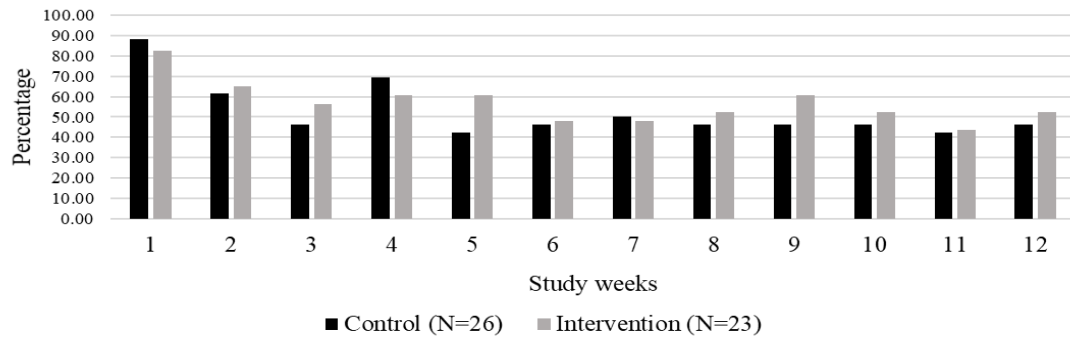
Agree	6	37.5
Neutral	3	18.8
Disagree	2	12.5
Participating in prenatal yoga helped me make healthier choices overall.		
Strongly Agree	4	25.0
Agree	4	25.0
Neutral	7	43.8
Disagree	1	6.3
Prenatal yoga helped me feel more connected to my baby.		
Strongly Agree	6	37.5
Agree	6	37.5
Neutral	4	25.0
It was easy to find the time to do prenatal yoga.		
Strongly Agree	5	31.3
Agree	4	25.0
Neutral	6	37.5
Disagree	1	6.3
I will continue participating in prenatal yoga in the future.		
Strongly Agree	8	50.0
Agree	6	37.5
Neutral	1	6.3
Disagree	1	6.3
I recommend participating in prenatal yoga to other pregnant women.		
Strongly Agree	13	81.3
Agree	3	18.8
The weekly log was easy to complete.		
Strongly Agree	11	68.8
Agree	4	25.0
Neutral	1	6.3
Did you participate in prenatal yoga at home?		
Yes	5	31.3
No	11	68.8
Did you enjoy doing prenatal yoga at home?		
Yes	5	100
What barriers kept you from attending the prenatal yoga sessions?		
None	2	12.5
Work	12	75.0
Travel related	8	50.0
Pregnancy related symptoms (i.e. nausea, fatigue)	7	43.8
Other	2	12.5

### *Demand*

In both the intervention and control groups, 75% (N=15/20) of participants attended at least 50% of classes (6/12) after removing dropouts or those who never started the study. The number of participants attending weekly sessions by group is depicted in Figure 3. On average, the control group attended 7.09 (SD = 3.46) classes and the intervention group attended 8.84 (SD = 3.85) classes. The majority of intervention group participants (N=14/16) felt that the 75 minutes per week of prenatal yoga was ‘about right’. Approximately, 88% of intervention group participants (N=14/16) plan on participating in prenatal yoga in the future and all agreed or strongly agreed that they would recommend prenatal yoga to other pregnant women.



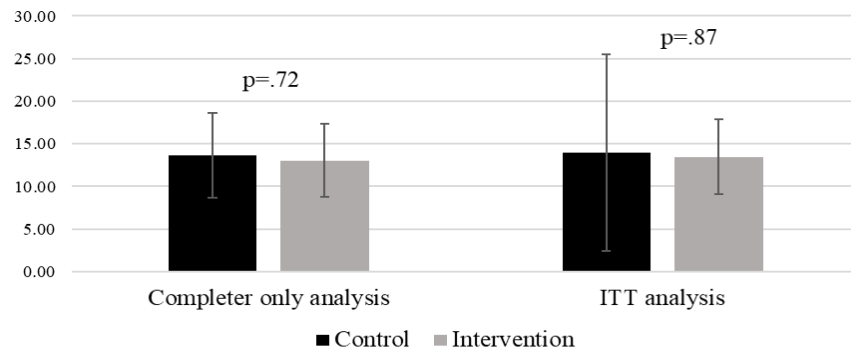
**Figure 3. Percentage of Participants Attending Weekly Sessions by Group**



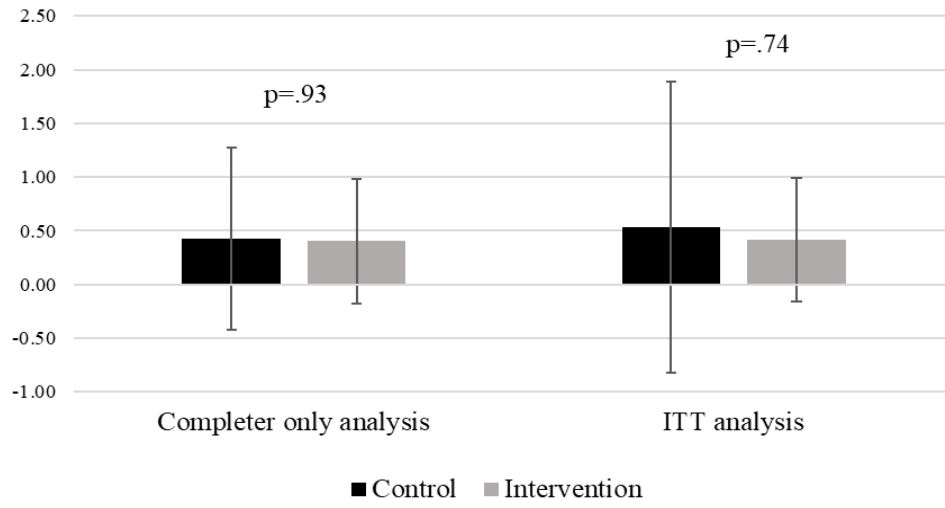
### *Preliminary efficacy*

Findings from both ITT and completer-only analysis testing group differences on total GWG and rate of GWG throughout the 12-week intervention were not significant (See Figure 4 and 5). Findings from completer-only analysis demonstrated no significant difference in total GWG in the control group ( $M 13.65 \pm 4.93$ ) compared to the intervention group ( $M 13.04 \pm 4.26$ ,  $p=.72$ ,  $d=.13$ ) and no significant difference in average rate of GWG change between groups ( $p=.93$ ). Similarly, findings from ITT analysis demonstrated no significant difference in total GWG in the control group ( $M 13.97 \pm 11.51$ ) compared to the intervention group ( $M 13.48 \pm 4.42$ ,  $p=.87$ ,  $d=.06$ ) and in average rate of GWG change between groups ( $p=.74$ ). Note that rate of GWG change is the weekly amount of weight above/below the recommended guidelines (e.g., a positive value indicates GWG above the recommended value).

**Figure 4. Total GWG During the Intervention in Completer Only and ITT Analysis**



**Figure 5. Rate of GWG Change in Completer Only and ITT Analysis**



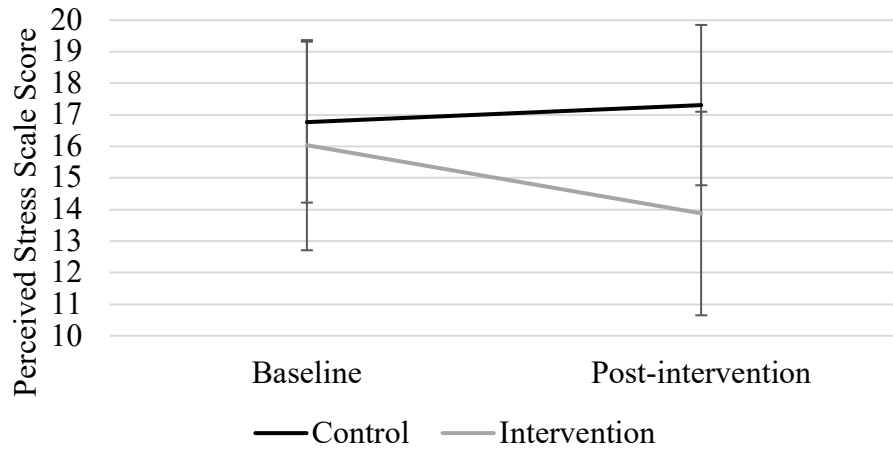
Findings from the mixed models analysis testing the difference in weight by group across time were not significant for both completer only and ITT analyses (See Table 6). There was no difference in weight by group ( $p=0.21$ ) or time x group interaction ( $p=0.70$ ) for completer only analysis. There was no difference in weight by group ( $p=0.70$ ) or time x group interaction ( $p=0.76$ ). Additionally, there was not a significant quadratic trend found for either analysis.

**Table 6. Mixed Model Analysis of Differences in Weight by Group Across Time**

	<u>Completer Only Analysis</u>				<u>ITT Analysis</u>			
	$\beta$	SE	p	95% CI	$\beta$	SE	p	95% CI
Intercept	146.36	6.38	0.00	(133.33, 159.39)	154.15	5.67	0.00	(142.71, 165.59)
Time (linear)	1.24	0.11	0.00	(1.02, 1.46)	1.23	0.10	0.00	(1.03, 1.43)
Group	11.65	9.02	0.21	(-6.78, 30.08)	3.23	8.43	0.70	(-13.77, 20.24)
Time * Group	-0.06	0.15	0.70	(-0.37, 0.25)	-0.05	0.14	0.76	(-0.34, 0.25)
Time (quadratic)	0.00	0.01	0.64	(-0.02, 0.03)	0.00	0.01	0.72	(-0.02, 0.02)

Findings from the mixed models analysis testing the difference in secondary outcomes (i.e., mindfulness, emotion regulation, self-awareness, sleep quality, depression, anxiety, and stress) were not significant for all outcomes with the exception of a time x group interaction effect for perceived stress ( $\beta=-2.85$ ,  $SE=1.29$ ,  $p=0.03$ ) in the ITT analysis (See Figure 6 and Table 7). When computing the completer only analysis, the time x group interaction effect for perceived stress became insignificant ( $p=0.06$ ). Though differences between groups were not significant, pre-post changes were moving in the expected directions for all outcomes in the intervention group (See Table 8).

**Figure 6. Pre-post Differences in Stress by Group Across Time**





**Table 7. Mixed Model Analysis of Differences in Stress by Group Across Time**

	<u>Completer Only Analysis</u>				<u>ITT Analysis</u>			
	$\beta$	SE	p	95% CI	$\beta$	SE	p	95% CI
Intercept	14.47	1.89	0.00	(10.68, 18.25)	15.43	1.72	0.00	(12.01, 18.85)
Time (linear)	1.33	0.82	0.11	(-0.34, 3.00)	1.34	0.91	0.15	(-0.51, 3.19)
Group	2.24	2.68	0.41	(-3.13, 7.61)	2.12	2.49	0.40	(-2.83, 7.07)
Time * Group	-2.31	1.17	0.06	(-4.71, 0.09)	-2.85	1.29	0.03	(-5.47, -0.22)

**Table 8. Baseline and Post-Intervention Mean Scores of Secondary Outcomes by Group**

	Baseline				Post-intervention				<i>d</i>
	Control		Intervention		Control		Intervention		
	<i>M</i>	SD	<i>M</i>	SD	<i>M</i>	SD	<i>M</i>	SD	
Mindfulness	4.39	0.71	4.39	0.85	4.33	0.81	4.55	0.91	0.26
Emotion regulation									
Cognitive reappraisal	5.35	1.10	4.68	1.15	5.21	0.91	4.86	1.16	0.34
Expressive suppression	3.21	1.48	2.99	1.41	3.03	1.32	2.91	1.29	0.10
Self-awareness									
Reflective self-development	3.86	0.44	3.84	0.53	3.81	0.35	3.88	0.59	0.14
Acceptance	3.96	0.48	3.94	0.61	3.94	0.45	4.08	0.54	0.28
Proactive at work	3.81	0.49	3.83	0.49	3.70	0.47	3.75	0.65	0.09
Emotional costs	3.14	0.59	3.08	0.50	3.02	0.33	2.96	0.43	0.16
Depression	9.31	5.19	8.78	5.02	8.06	4.51	5.75	4.43	0.52
Stress	16.77	6.31	16.04	7.70	17.31	4.77	13.88*	6.05	0.63
Anxiety									
State	34.62	10.23	35.57	11.73	37.75	10.82	33.00	10.25	0.45
Trait	37.12	9.78	36.17	10.46	39.13	9.98	33.13	9.61	0.61
Sleep quality	7.65	4.15	6.35	2.89	7.00	3.50	6.00	3.33	0.29

\*Significant time x group interaction for ITT analysis (p=.03)

## Discussion

The results of this pilot randomized feasibility trial demonstrated that prenatal yoga may be an acceptable modality to reduce EGWG during pregnancy. Our findings suggest high acceptability with nearly all participants indicating enjoyment and satisfaction in prenatal yoga. The majority of participants attended at least half of the sessions offered during the intervention and indicated that they plan to participate in prenatal yoga in the future and would recommend prenatal yoga to other pregnant women. We did not find any significant effect of our intervention on GWG during pregnancy. Perceived stress scores were lower in the intervention group at post-intervention compared to the control group but this finding was not significant in the completer-only analysis. Though we were only able to observe a minimal effect across our outcomes, we did see changes in the expected directions. The findings in this study was limited by insufficient power and further efficacy testing is warranted.

### *Acceptability*

We met our benchmark of having at least 70% of the sample report prenatal yoga was a satisfactory and useful modality to reduce EGWG with no reports of injury or adverse events. Approximately 94% of participants enjoyed prenatal yoga and all participants were satisfied with participating in prenatal yoga. These findings are similar to a 10-week prenatal yoga intervention to treat clinical depression in pregnant women (N=34).<sup>82</sup> Women were asked to attend a weekly 75-minute prenatal yoga class and reported high satisfaction with no injuries reported at the end of the intervention. However, this study did not report where the yoga classes were conducted. Another study tested the impact of an 8-week prenatal yoga intervention (75-minute classes) compared

to a treatment as usual group on depression and anxiety during pregnancy (N=46). Findings suggest high levels of satisfaction (*M* score of 28.15/32 on the client satisfaction questionnaire) and credibility (*M* score of 40.95/49 on the credibility scale) with the prenatal yoga classes.<sup>284</sup> No adverse outcomes relating to prenatal yoga were reported in this study and information on where the class was offered was not provided. A study by Beddoe et al. (2009) tested the feasibility of a 7-week mindfulness yoga intervention (75-minute classes) on pain, stress, and anxiety in pregnant women (N=16).<sup>271</sup> Approximately 94% of women in this study reported being satisfied with the class, 50% reported they were taking better care of themselves, and 50% thought attending class was easy. This study also did not report where the yoga classes were conducted. Though our study was the first to test the feasibility of prenatal yoga on weight outcomes during pregnancy, our findings are similar to other prenatal yoga interventions for pregnant women. Prenatal yoga appears to be a highly accepted activity during pregnancy with high satisfaction rates and no safety concerns. However, more studies testing prenatal yoga on weight outcomes are needed to replicate these findings.

### *Demand*

We met our benchmark for demand with 75% of the sample having attended at least 50% of classes (6/12) throughout the intervention. These findings are similar to the aforementioned 10-week prenatal yoga intervention to treat clinical depression during pregnancy.<sup>82</sup> On average, participants attended 50% of sessions (5/10). The attrition rate in this study was approximately 35%, which is comparable to the attrition rate in our study (30%). The 8-week prenatal yoga intervention on symptoms of depression and anxiety described above, reported much lower attrition rates and had better attendance to

the intervention compared to our study.<sup>284</sup> The study reported a 13% attrition rate and participants attended an average of 72% (5.76/8) of classes. However, Davis et al. (2015) intervention was shorter than our current study (8 weeks vs 12 weeks). Beddoe et al. (2009) study testing a 7-week mindfulness yoga intervention (75-minute classes) on pain, stress, and anxiety in pregnant women did not report attendance or attrition rates.<sup>271</sup> Implementing interventions during pregnancy can be challenging partially because of the unique challenges (e.g., fatigue, weight gain, joint/ligament pain, nausea, mood swings) that pregnant women face and may limit their ability to attend classes. It is also important to consider where the prenatal yoga classes are offered (e.g., hospital/clinic, wellness center, yoga studio, fitness center) as this may influence participant adherence. None of the studies described above reported where the prenatal yoga classes were conducted. Future studies evaluating prenatal yoga may benefit from investigating evidence-based strategies to encourage adherence to the intervention such as enhancing motivation, providing education, goal setting, and self-monitoring. Additionally, studies are encouraged to report information regarding the location of implementation of the intervention.

#### *Preliminary efficacy*

We hypothesized that participants in the prenatal yoga group would have less overall GWG, higher levels of mindfulness, emotion regulation, self-awareness, better sleep quality and lower levels of depression, anxiety, and perceived stress compared to those in the control group. However, we did not observe any significant effect on any outcomes with the exception of perceived stress (ITT analysis only).

To our knowledge, there have been no studies conducted to test the impact of prenatal yoga on weight outcomes during pregnancy. We did not find a significant difference between groups on total GWG or rate of GWG during the 12-week intervention. Perhaps comparing the difference in total GWG across pregnancy (i.e., difference in pre-pregnancy weight from last weight prior to delivery) would provide a more complete representation of GWG. However, the current study did not have these data available. Interestingly, while our statistical analysis demonstrated no effect on GWG outcomes, the majority of women reported otherwise on the post-intervention satisfaction survey. When asked if prenatal yoga helped to manage weight gain during pregnancy, 56.3% of participants strongly agreed or agreed that prenatal yoga helped to manage weight gain during pregnancy. Additionally, half of participants reported that participation in prenatal yoga helped them to make healthier choices overall. Conducting long-term studies across the entire pregnancy time course as well as during the post-partum period are highly warranted to examine the impact of prenatal yoga on weight outcomes before and after pregnancy.

When testing for effects on mindfulness, emotion regulation, self-awareness, sleep quality, depression and anxiety, we did not observe a significant difference between groups and/or across time. Several studies testing these outcomes in pregnant samples have reported significant differences favoring the yoga intervention.<sup>42,73,74,166</sup> Though the lack of power (post-hoc analysis determined power of .05) in our study limits the potential to observe an effect across these outcomes, there were improvements or reductions in outcomes in the expected direction with moderate effect sizes on some variables. On average at post-intervention, we observed the following changes:

mindfulness scores were higher; cognitive reappraisal was higher and expressive suppression was lower (emotion regulation); reflective self-development and acceptance of self-and others was higher and emotional costs were lower (self-awareness); sleep quality was better; depression was lower (moderate effect size); and anxiety (small to moderate effect sizes) was lower. Furthermore, on the post-intervention satisfaction survey women were asked if they felt that prenatal yoga helped to regulate their emotions better (e.g., feelings of depression, anxiety, and stress), increase self-awareness and mindfulness, and improve their sleep. The majority of women answered favorably with 75% indicating that prenatal yoga helped to regulate their emotions, increased self-awareness and mindfulness, and 69% reported that prenatal yoga helped them sleep better. These findings support further testing of these outcomes, particularly those with moderate effect sizes (depression and anxiety), in future fully powered studies as they may have important implications on GWG outcomes during pregnancy.

Finally, our mixed model results indicated a significant decrease in stress in the prenatal yoga group at post-intervention compared to the control group. We also observed a moderate effect size ( $d=.63$ ). These findings are similar to other prenatal yoga studies.<sup>73,74,101</sup> The aforementioned study by Beddoe et al. (2009) also found greater reductions in stress for women in their third trimester.<sup>271</sup> However, this study did not have a control group and had a small sample size. Another study conducted in India investigated the effects of prenatal yoga on stress and found a 31.57% reduction in the yoga group (N=45) compared to an increase in 6.6% in the control group (N=45).<sup>214</sup> However, this was a fairly intensive intervention. For the first four weeks of the intervention, women were asked to attend two-hour sessions three days/week. After the

first month, they continued to practice at home for one hour using a prerecorded instruction cassette. Participants had one-hour refresher classes every four weeks up to 28 weeks gestation and every two weeks up to 36-weeks gestation. Stress outcomes have also been evaluated objectively in pregnancy via salivary cortisol. In a RCT conducted in Taipei, 94 pregnant women were randomized to prenatal yoga (N=48) or a routine care control (N=46) group for 20-weeks (70-minute sessions).<sup>100</sup> Findings suggest a significant reduction in cortisol levels after yoga practice compared to controls. These data and ours reported here highlight that prenatal yoga may have the potential to reduce both objective and self-report measures of stress. Stress levels may play a particularly important role in GWG during pregnancy as there has been evidence to suggest that high stress is related to poor diet<sup>144</sup> and pregnant women reporting higher stress have been shown to consume energy-dense and nutrient-poor comfort foods<sup>145,146</sup> which may promote central fat distribution.<sup>147</sup> This increase in central fat distribution has been linked to cortisol production from chronic stress levels.<sup>147</sup> There is a need to further explore these relationships in future trials.

### *Limitations*

Though this study provides important insights related to GWG during pregnancy, there are several limitations that should be noted. First, our sample was homogeneous and from a middle-high socio-economic background and therefore our results may not be generalizable to the wider pregnant population. Future studies may consider including samples that are more diverse. Second, we did not have data on total GWG across pregnancy (i.e., difference between pre-pregnancy weight and last weight prior to delivery). At the time this study was conducted, not all women in the study had given



birth and the last weight prior to delivery was not yet available. Analyzing total GWG across pregnancy may better reflect the impact of the intervention on GWG. Third, this trial was not targeted to women who were at risk for EGWG (e.g., overweight or obese pre-pregnancy BMI) and may have limited the potential effectiveness of the trial. Future studies may consider targeting recruitment for at risk participants in order to observe a change in weight and/or make group comparisons by BMI status. Fourth, we had a small sample size in our study and therefore had insufficient power to detect a significant effect. Results of a post-hoc analysis confirmed lack of power ( $1-\beta$ ) with a value of .05. Though we utilized mixed models, which improved power, there is a need for more rigorous studies that are fully powered to observe an effect. The results presented here should be interpreted based on low recruitment and not meeting power requirements. Finally, self-reported data used in this study presents inherent limitations including biased results, participant burden, potential data errors, and incorrect interpretation of survey question. Adding objective measures in addition to self-report measures may be less subject to bias.

#### *Future research suggestions*

Based on the findings and important insights gained from our study, we offer suggestions for future research in this area. First, increase the frequency of prenatal yoga practice (e.g., 2-3 x per week) or encourage more home practice. Based on our study and others mentioned here, 75-minute sessions appear to be highly acceptable. However, it is unknown the optimal dose of prenatal yoga in order to reduce or attenuate EGWG but weight management studies in non-pregnant populations suggest a dose-response with higher activity levels associated with higher weight loss. Perhaps increasing the

frequency of prenatal yoga practice will have greater influence GWG outcomes. Second, a longitudinal design across the entire pregnancy time course may also have a greater influence on GWG and related mental/emotional health outcomes. GWG and mental/emotional health fluctuates across pregnancy and utilizing a longitudinal design may provide a better understanding of the change in these parameters across pregnancy and how prenatal yoga practice might influence these outcomes. Third, examine potential mechanisms of action on both a biologic/physiological (e.g., heart rate variability) and psychological (e.g., mindfulness) level concerning GWG outcomes. Fourth, test various settings (e.g., hospital/clinic, fitness center, community wellness center, yoga studio, online) of delivery of prenatal yoga on GWG and related outcomes. Many studies do not report where the intervention was delivered. Preferences of pregnant women and study outcomes may vary depending on the location used to deliver the intervention and may affect adherence. Finally, examine pregnancy and birth outcomes among pregnant women practicing prenatal yoga with and without EGWG. These findings may be especially important for clinicians, which can be used to establish guidelines and recommendations to improve pregnancy and birth outcomes.

### **Conclusions**

This was the first study to test the feasibility and preliminary efficacy of prenatal yoga on EGWG during pregnancy. Pregnant women report high satisfaction with participation in prenatal yoga and report that prenatal yoga helps them to manage weight and make healthier choices overall. However, our findings not observe a significant effect on GWG outcomes. Importantly, this study highlights the impact of prenatal yoga on stress, which may have important implications for improving maternal and fetal health

outcomes. More studies with high methodological rigor are needed to test the effect of prenatal yoga on EGWG. The information provided here may inform future yoga research and study design concerning GWG outcomes during pregnancy.

## CHAPTER 4

### MANUSCRIPT #3: An exploratory qualitative analysis of pregnant women's experiences in a weight management prenatal yoga intervention

#### **Introduction**

Over 36 million Americans in the United States practice yoga.<sup>285</sup> Yoga is a system of physical postures and breathing exercises that aims to unite the mind, intellect, and self.<sup>286</sup> Of late, yoga has been popularized in the United States as a form of exercise and has received attention in the media and among researchers in part due to the many documented benefits. Yoga has been investigated as a modality to treat a wide range of health problems including depression,<sup>287</sup> cardiovascular disease,<sup>288</sup> pain,<sup>289</sup> diabetes,<sup>290</sup> and cancer<sup>291</sup> in a variety of populations. Yoga may even have a positive effect on obesity,<sup>249</sup> and other weight outcomes.<sup>47,75,79</sup> During pregnancy, studies suggest that yoga (i.e., prenatal yoga) is safe and may improve mental health (e.g., depression, anxiety)<sup>42,292</sup> and birth and labor outcomes (e.g., pain, labor duration, preterm birth).<sup>293</sup>

Despite the positive outcomes resulting from prenatal yoga, there is a lack of studies exploring pregnant women's experiences of prenatal yoga especially concerning weight management during pregnancy. Qualitative research may provide further insight for the utility of interventions to because it may capture additional information that is overlooked in quantitative research including data related to attitudes, perceptions, beliefs, experiences, motivations, facilitators and barriers that may underlie behaviors. A bulk of the current qualitative research related to prenatal yoga is largely related to mental health. In depressed pregnant women, one study reported that prenatal yoga improves their mental health (e.g., depressive symptoms, stress) and that the physical

benefits (addressing pregnancy discomforts) provided contributed to their improvements.<sup>46</sup> Women also reported that prenatal yoga was more beneficial for them than other types of physical activity because of the combination of mindfulness and feeling strong.<sup>46</sup> Findings in another qualitative study reported that prenatal yoga helped pregnant women connect with their baby, build their mental health and well-being, and prepare them for birth.<sup>50</sup> This data highlights that prenatal yoga provides benefits related to mental health, well-being, and even physical outcomes including a perceived ease of preparation for birth. However, there remains a gap in the literature related to pregnant women's experiences and specific barriers/facilitators of prenatal yoga related to weight management. The experiences of pregnant women and an understanding of factors that contribute to program adherence are important for designing effective weight management programs during pregnancy. A qualitative inquiry exploring this phenomenon is warranted.

We recently conducted a 12-week randomized pilot trial to determine the feasibility and preliminary efficacy of a prenatal yoga intervention on excessive gestational weight gain (EGWG; findings reported elsewhere).<sup>294</sup> The findings contributed to our understanding of prenatal yoga as a weight management intervention to prevent EGWG. However, the contextual factors of a prenatal yoga intervention to prevent EGWG have not yet been explored. This information may inform future research to design appropriate and more successful programs to help pregnant prevent EGWG. As part of a larger study,<sup>294</sup> we conducted interviews with pregnant women at the end of a 12-week prenatal yoga intervention. The objectives of this study were to 1) examine and describe pregnant women's experiences in a prenatal yoga intervention to prevent

EGWG, 2) explore pregnant women's perceptions of prenatal yoga as a tool to help with weight management during pregnancy, and 3) identify facilitators and barriers to participation in a weight management prenatal yoga intervention during pregnancy.

## **Methods**

### *Research Design*

This study is part of a larger study (i.e., parent study) that aimed to investigate the feasibility and preliminary efficacy of a 12-week prenatal yoga intervention to prevent EGWG.<sup>294</sup> For the current study, we conducted qualitative interviews at post-intervention using a semi-structured interview guide with open-ended questions. Interviews were conducted between October 2018 and May 2019. The Institutional Review Board of a large university in the southwestern United States approved this study and all participants consented to participate.

### *Participants*

All women who participated in the prenatal yoga intervention were asked to participate in an interview to glean further insights about the 12-week prenatal yoga intervention in relation to our aforementioned objectives. Inclusion criteria for the parent study were: 1) women between 18-46 years of age, 2) 12-24 weeks gestation at onset of intervention, 3) reside in the Phoenix Metropolitan area, 4) have a singleton pregnancy, 5) speak English, 6) can attend at least one prenatal yoga or educational session per week for majority of pregnancy (i.e., at least 70% of sessions), and 7) do not plan on moving during intervention duration. Women were included in the current analysis if they were assigned to the prenatal yoga arm of the study and indicated their interest in an interview at study completion.

### *Procedures*

At the end of the study (week 12), women were emailed a satisfaction survey via Qualtrics and were asked to participate (i.e., volunteer) in a brief interview to glean further insights about the feasibility of the intervention. Participants were asked to interview within seven to 10 business days from completion of the intervention.

Participants agreeing to interview were asked to schedule a 20-30 minute phone or in-person appointment (based on preference). Those indicating preference for an in-person interview were interviewed in a private room on-site at the wellness center where the prenatal yoga classes were offered. Prior to the interview participants were informed that the interview was anonymous, would last approximately 20-30 minutes, and would be recorded and transcribed. Women were compensated with \$15 for completing the interview.

### *Prenatal Yoga Intervention*

The details of the prenatal yoga intervention are reported elsewhere.<sup>294</sup> Briefly, classes were 75 minutes in duration and offered twice weekly (one weekday evening class and one weekend morning class). Women were asked to attend one class per week but could attend both if they preferred. Each class included the following components: 1) opening greeting/intention setting, 2) pranayama (i.e., breathing exercises), 3) warm-up/sun salutations (i.e., flowing sequence), 4) Prenatal yoga sequence (e.g., combination of sun salutations, vinyasa (i.e., movement between poses), and standing, seated, and/or balancing poses), 5) cool-down 6) Savasana (i.e., final resting pose), and 7) class closing. Meditation and breath awareness (e.g., linking each movement with breath) was

emphasized throughout each class. The prenatal yoga classes were conducted in a yoga room at a community wellness center (classes were only open to research participants).

### *Measures*

We conducted semi-structured interviews at post-intervention related to our objectives. The semi-structured interview guide explored the following: prenatal yoga during pregnancy, likes and dislikes of prenatal yoga (including duration of session, style, time of day, frequency etc.), the impact of prenatal yoga and GWG, mental state during pregnancy and impact on GWG, challenges and benefits of prenatal yoga during pregnancy, and perceived facilitators barriers to prenatal yoga participation (See Table 9 for the interview guide).



### **Table 9. Semi-structured Interview Guide**

---

1. Can you tell me about your overall experience participating in prenatal yoga during this study?
    - a. Did your ability to practice prenatal yoga change over the course of your pregnancy?
  2. I am going to read a list of items to you and I would like you to tell me about how prenatal yoga has or has not impacted your life in these ways?
    - a. Self-awareness
      - i. How has prenatal yoga impacted your awareness with your body, mind, spirit?
    - b. Physical activity participation
      - i. How has prenatal yoga impacted your physical activity behaviors (outside of the yoga during the 12-week intervention)?
    - c. Eating behaviors
      - i. How has prenatal yoga impacted your eating behaviors?
    - d. Connection with baby
      - i. How has prenatal yoga impacted your connection to your baby?
    - e. Others?
  3. How do you believe that prenatal yoga helps manage weight gain during pregnancy, if at all?
  4. What does mindfulness mean to you?
    - a. How does mindfulness relate to yoga?
    - b. How does mindfulness relate to weight gain during pregnancy?
  5. What were the major challenges or barriers you experienced while practicing prenatal yoga?
  6. What helped or motivated you to practice prenatal yoga?
  7. What are your plans for future participation in yoga after delivery or in a future pregnancy?
    - a. How often will you participate?
  8. Would you recommend prenatal yoga for other pregnant women? Why or why not?
-

### *Analytic procedures*

The interviews were audio recorded, transcribed verbatim, and uploaded and coded with QSR NVivo 12 (Cambridge, MA 2012), a qualitative analysis software package. We summarized interview responses using an inductive approach to thematic analysis. A thematic analysis involves developing themes and categories from the interview transcripts.<sup>295</sup> Generating codes using an inductive approach is a data-driven process that allows the researchers to identify themes without trying to fit into a preexisting coding frame or the researchers analytic preconceptions.<sup>295</sup> After the interviews were transcribed the lead author (JG) “open coded” each transcript and developed a preliminary codebook. Open coding involves reading through the transcripts and recording notes of words, theories or short phrases of what is being said in the transcripts. After JG developed the codebook, she and another author (DJ) used the codebook to assign themes and propose additional themes as necessary. The authors compiled a list of the identified themes and met to discuss findings. Any duplications were removed and overlapping areas and similarities were combined to further refine the list. This process was repeated until authors reached agreement on major themes. A third author (JH) reviewed all themes and made suggestions for coding modifications. The final list of themes was finalized by consensus of all three authors. Descriptive statistics were used to describe the sample demographics using SPSS version 25.

### **Results**

In the parent study 23 women were allocated to the prenatal yoga arm. Of those, 13 women chose to participate in an interview. Two women requested an in-person interview and the remaining women were interviewed over the phone. The interviews

lasted an average of 23.08 minutes. A total of 3 hours and 47 minutes of interview data were analyzed for themes. The average number of prenatal yoga sessions attended among the interview participants was  $M=10.31$ ,  $SD= 2.81$  (Min = 4, Max = 15).

*Participant characteristics*

Table 10 describes the demographics and participant characteristics of the interviewed study participants. The majority of the sample was Hispanic and White, European-American, or Caucasian. Most women had an annual income greater than \$35,000, at least a Bachelors/4-year degree, were married, and employed fulltime. Just under half of the sample had a normal pre-pregnancy BMI.

**Table 10. Demographic Characteristics of Study Participants (N=13)**

Variable	N	%
Age M (SD)	27.6	(3.9)
Ethnicity		
Hispanic	8	61.5
Race		
American Indian or Alaskan Native	2	15.4
White, European-American, or Caucasian	7	53.8
Black, African-American, or Native African	1	7.7
Bi-racial or Multi-racial	3	23.1
Income		
<\$20,000 per year	1	7.7
\$20,000 - \$34,999 per year	3	23.1
\$35,000 - \$49,999 per year	4	30.8
\$50,000 - \$74,999 per year	4	30.8
\$75,000 - \$99,999 per year	1	7.7
Education		
Some college	3	23.1
Associates/2-year degree	2	15.4
Bachelors/4-year degree	6	46.2
Graduate school or above	2	15.4
Marital status		
Single	1	7.7
Partnered/In a relationship	2	15.4
Married	10	76.9
Employment status		
Employed full time (40+ hours/week)	8	61.5
Employed part-time (up to 39 hours/week)	3	23.1
Unemployed and not currently looking for work	1	7.7
Student	1	7.7
Pre-pregnancy BMI		
Normal	6	46.2
Overweight	5	38.5
Obese	2	15.2

### *Emerging themes*

Twelve themes were identified among the data and were organized into the following categories: 1) Experiences of prenatal yoga (positive experience/enjoyment, pain relief, connecting to body), 2) prenatal yoga and weight (increased mindfulness/self-awareness, increased physical activity, weight management), 3) barriers to prenatal yoga (physical body, commute/traffic, schedule), and 4) facilitators of prenatal yoga (healthy pregnancy, support from other pregnant women, the feeling from prenatal yoga).

### *Experiences of prenatal yoga*

#### *Positive experience/enjoyment*

Women expressed having a positive experience participating in prenatal yoga and enjoying the program. Participants talked about looking forward to attending class and wanting to continue participating in prenatal yoga in the future. One woman shared: “So I really really really enjoyed doing yoga, and I'm planning on continuing as many sessions as possible.” Other women said that prenatal yoga has been a “very positive experience” and that they are a “huge fan of it [prenatal yoga]”. Another woman mentioned, “If it wasn't for this specific research, I would've probably not gotten to experience yoga the way I did and gotten to become aware of how beneficial it is.” Other women talked about being “grateful” for the experience and that they “liked everything about it.”

#### *Pain relief*

Women often cited that prenatal yoga helped with pain relief particularly related to their pregnancies. Many women stated that prenatal yoga helped with “pelvis and back aches” and even releasing tense muscles. Some women also mentioned that they were not having as many pain/pregnancy related symptoms compared to other pregnant women

they knew. One woman expressed this as: “So it [prenatal yoga] just really takes tension off the back and expanding your hips was really nice too. And overall, I have actually a couple friends that are pregnant around the same time as I am and they seem to just be having different experiences than I am... I understand pregnancies are different anyways but... They have a lot more pains and aches than I do.” Some women mentioned even practicing the poses at home to help alleviate pressure and pain in their bodies. Most of the women talked about the physical movement of prenatal yoga helping with pain relief but others mentioned that even the breathing techniques benefitted pain relief.

#### *Connecting to body*

Women talked about how prenatal yoga helped them to get “connected” or “in tune” with their bodies. They felt more conscientious of not only their own body but also the baby inside. One woman said, “I loved being challenged and trying to get in tune with my body, as well as being conscientious that there's a baby inside.” Another woman said, “Well you're really in tune with your body while you're practicing yoga. You're in tune to how your body's reacting, how your breathing is changing and how you're feeling.” Women also mentioned this connection to body helped them to “adjust” or “maneuver” their bodies during prenatal yoga to what felt good to their body.

#### *Prenatal yoga and weight*

##### *Increased mindfulness/awareness*

Women mentioned that prenatal yoga increases “self-awareness” or “mindfulness” which helped women pay attention to what they are “putting into their bodies”. One woman said that, “It kind of goes back to that self-awareness of, if you're not paying attention to what you're putting in your body, and you're just eating whatever

you want, then obviously weight gain's going to be an issue. But if you're really intentional with what you eat, and think that through, and what it's going to do for your body, and what things are good and bad for your body". Women also mentioned that increasing awareness or mindfulness also helped them to be more aware of how their eating would affect the health of their baby. Others expressed this increase in mindfulness related to being mindful of how much weight they are gaining and noticing when they are gaining too much or too little. One woman even shared that prenatal yoga helped her become more aware of poor eating behaviors and accepting that "it was not the best health move" and allowing herself to be more aware next time.

#### *Increased physical activity*

Women also spoke about prenatal yoga being a "workout" and that it helped them be more physically active. One woman said, "It [prenatal yoga] is a work out. It's not just stretching. It's definitely a workout. I'm feeling it when I'm sweating and my body's achy because I'm sore from certain stretches and poses." Another said, "Just its physical activity. So that will help in and of itself. ...And so in turn, I'm actually having more physical activity throughout the week." One woman noted that her heart rate was elevated during class and that was "impactful toward weight". Some even suggested that it would be important to practice prenatal yoga at least three times per week to have a greater impact on weight and that prenatal yoga is "good for you" because it is physical activity.

#### *Weight management*

Women mentioned that participation in the prenatal yoga classes helped them to not gain as much weight as they would have if they had not taken the classes. Some even spoke about prenatal yoga helping them to get stronger and that would help manage their

weight during pregnancy. One woman expressed this as, “I knew that I should do something during pregnancy to keep my weight and to be strong and, and I thought that yoga was the best way to do it.” Another talked about how prenatal yoga helped to “balance out weight gain”.

### *Barriers to prenatal yoga*

#### *Physical body*

Women mentioned that at times it was difficult performing some of the poses because of back or hip problems. One woman said, “I think it was just my physical body. Just, my hip pain and just having to put up with it was very irritating.” Another said, “In the beginning with my back problem, I had some difficulty doing some positions.”

Women also mentioned that as their pregnancy progressed the classes became more difficult. One expressed this as, “Toward the end my hips were just not having a lot of the exercises. Because my son had, you know, dropped so early, I just felt it in my hips all the time.”

#### *Commute/traffic*

Some women had difficulty attending class because of a long commute or heavy traffic. One woman said, “I guess the commute, for me, was the biggest barrier.” Another said, “The only thing was on the weekends when the freeway is closed, it was taking me an hour to get there. So on Saturdays I just couldn't do that. It was a lot of traffic. It was a lot of road closures.”

#### *Schedule*

Women spoke about conflicts in their schedule that limited their ability to attend class. Some women mentioned work or doctor’s appointments that got in the way of



attending class. One woman said, “Sometimes the work scheduling, did kind of just go up and down, here and there.” Another woman mentioned “family events” or the “distraction of the holidays” that made it hard to attend class at times.

### *Facilitators of prenatal yoga*

#### *Healthy pregnancy*

Women frequently talked about having a healthy pregnancy was motivation for them to attend class. They mentioned that they knew prenatal yoga was good for their health and it would be good for the baby as well. One woman expressed this as, “My plan was never miss any session because I want everything that I was doing to help me and to help the baby to go healthy together”. Women also said they would attend class even if they were tired because they knew it would be beneficial. One woman stated, “Honestly, like thinking of the baby growing inside of me. So, any time that I did go to class, like I know that I was tired because I just got off work, you know. And I'm just like, well, this is beneficial for him, so I need to go. Just thinking about his well-being pushed me to go a lot of the time when I was, you know, super tired. And then same with like when I practiced at home. Even if it was five minutes, you know? It was definitely thinking about him and his health.” Women even mentioned that they would still try to attend class despite working late because prenatal yoga was “worth it” for them and the baby.

#### *Support from other pregnant women*

Women mentioned that the support received from other pregnant women in class motivated them to attend the prenatal yoga classes. Women liked seeing other pregnant women progressing in their practice. One said, “I think it was just the people. I felt really, I don't know I think that seeing other people that were pregnant going and seeing their

progression, it just motivated me to like want to be with them and progressing at the same time with them.” Other women mentioned that they enjoyed getting a few minutes before/after class to chat with women about their pregnancy and “sharing stories”. One mentioned that it was motivating to have the “peer pressure” of others in class and seeing others “trying their best” to practice prenatal yoga. Some said they were surprised at how much they enjoyed the “social aspect” of the classes.

#### *The feeling from prenatal yoga*

Many women talked about the feeling that they got from prenatal yoga was a major motivation to attend class. Many said that prenatal yoga made them “feel good” and that they appreciated how they felt after each session. One woman said, “I just ... I love the feeling. It makes me feel good. I love the way that I would feel to start my day. Another stated, “Just the way my body was feeling. Overall. I really appreciated how I felt after each session so I wanted to continue to feel like that. And when I didn't go I just felt like I was missing something.” Women who attended morning sessions spoke about how they liked the feeling from prenatal yoga because it “started their day off on the right foot”.

### **Discussion**

The objectives of this study were to 1) examine and describe pregnant women’s experiences in a prenatal yoga intervention to prevent EGWG, 2) explore pregnant women’s perceptions of prenatal yoga as a tool to help with weight management during pregnancy, and 3) identify facilitators and barriers to participation in a weight management prenatal yoga intervention during pregnancy. We identified 12 themes that were organized into four main categories including: 1) Experiences of prenatal yoga

(positive experience/enjoyment, pain relief, connecting to body), 2) prenatal yoga and weight (increased mindfulness/self-awareness, increased physical activity, weight management), 3) barriers to prenatal yoga (physical body, commute/traffic, schedule), and 4) facilitators of prenatal yoga (healthy pregnancy, support from other pregnant women, the feeling from prenatal yoga). The findings of this study provided important insights particularly related to the utility of prenatal yoga as a tool for weight management during pregnancy.

Women frequently spoke about their positive experience practicing prenatal yoga, were enthusiastic about practicing prenatal yoga and expressed a high level of enjoyment. To date, no studies have evaluated the experiences of pregnant women participating in a prenatal yoga program to prevent EGWG. Qualitative studies assessing women's experiences in a prenatal yoga program (not specific to EGWG) cited patient reported outcomes such as decreasing depression or perceived benefits of prenatal yoga, but did not specifically report any findings related to pregnant women's enjoyment.<sup>46,296,297</sup> Satisfaction survey data from the parent study suggests that 94% (N=15/16) of participants enjoyed the prenatal yoga sessions<sup>294</sup> and supports the findings reported here. The high level of enjoyment of prenatal yoga warrants the integration of prenatal yoga into other settings that provide care and/or services for pregnant women including clinics, prenatal care programs, and/or other healthcare facilities caring for pregnant women. There is extensive evidence that pregnant women (and other populations) are more likely to engage in a behavior when they enjoy them.<sup>45,298,299</sup> Compared to other physical activities, prenatal yoga may be an activity that pregnant women are better able to adhere to because of the high level of enjoyment. A systematic review examining dose

of exercise interventions on GWG concluded that successful interventions had higher adherence and lower attrition rates.<sup>300</sup> Perhaps adherence to prenatal yoga interventions may be better when compared to other activities,<sup>301</sup> which would likely contribute to greater benefit especially in regard to preventing EGWG.

Pain relief also emerged as a main theme among interview participants and may contribute to program adherence. Commonly reported discomforts of pregnancy such as nausea, fatigue, back/pelvic pain, swelling, and headache<sup>231</sup> may limit normal daily functioning.<sup>230</sup> Confirmatory studies in pregnant women have reported that prenatal yoga may help with pelvic/back pain and even labor pains.<sup>102</sup> Reducing pain during pregnancy may allow women to engage in more physical activity or may reduce the likelihood of their pain affecting normal daily functioning. Increasing weight gain during pregnancy may also be a contributor to pain and prenatal yoga could perhaps be a way to make the inevitable pain experienced during pregnancy more manageable. In non-pregnant populations, pain is commonly reported in those with greater weight.<sup>113–115,232,233</sup> Future studies could investigate the relationship between pain and GWG in overweight or obese pregnant women.

Connecting to the body was another important theme identified among the data. These findings were similar to a recent qualitative study (analyzing free-text responses) in pregnant women that aimed to understand elements of yoga classes that would be useful or not useful for depressed pregnant women.<sup>296</sup> Women wrote that they were able to “get more in touch” with their bodies and that they learned how to “feel” their body and how to listen to it.<sup>296</sup> Because prenatal yoga draws attention to the present moment, it may provide an opportunity for women to reflect on the messages that their bodies are

sending them.<sup>82</sup> Prenatal yoga may also give women a “safe space” to focus on self-care and their growing baby inside.<sup>302,303</sup> Women in our study also mentioned how prenatal yoga helped them connect not only with the body but also with their breath and how they were feeling inside. A major focus of prenatal yoga (and yoga in general) is to remove distractions from the outside environment and focus internally on the self.<sup>304</sup> Having a greater connection to the body may help women better respond to the somatic cues in their body and attend to their physical needs in a more responsive manner, which may have important implications for weight management during pregnancy.

Another major theme that emerged in relation to weight gain during pregnancy was the increased mindfulness/awareness that women experienced after participating in prenatal yoga. Alexander et al., (2013) reported similar findings in a qualitative study that explored the perceived benefits of yoga in older adults at risk for cardiovascular disease.<sup>305</sup> Participants in this study reported that prenatal yoga helped support their efforts toward improving their diet by increasing their awareness. Participants spoke about how they had an increased awareness of body sensations and ate less and did not overeat when they felt full. Perhaps increasing mindfulness/awareness may be a strategy that to help women manage their weight by simply paying more attention to their health behaviors (e.g., what they are eating, level of activity). Increasing mindfulness/awareness of the behaviors one is engaging in may help pregnant women make healthier choices by paying attention to what their body needs (rather than wants). Women who are more mindful or aware may also be more concerned with how their behaviors are affecting their baby inside. Furthermore, these findings provide insight that prenatal yoga may foster behavioral benefits beyond increasing physical activity levels. Prenatal yoga may

be a more gentle approach to physical activity with an added benefit of increasing mindfulness/awareness that may impact health behaviors.<sup>46,306</sup> Future studies may consider enhancing mindfulness/awareness throughout class by instructing women to focus on the breath and/or sensations in the body.

Interestingly, women in our study specifically talked about how they thought prenatal yoga was helping them manage their weight during pregnancy. Reports from a sample of non-pregnant adults who lost weight from practicing yoga<sup>307</sup> suggest that the increase in strength and muscle tone contributed to their weight loss and others mentioned changes in metabolism. Conversely, one qualitative study investigating barriers and facilitators to yoga in low-income minority adults (non-pregnant) reported that participants didn't practice yoga because it lacks physicality and weight loss benefits.<sup>308</sup> Participants spoke about yoga just being "stretching" and that they had never heard of it being like a workout. There are many styles of yoga practiced in the US and they all vary in regard to the intensity of class. For example, restorative yoga classes are typically slower moving and do not include vinyasas (e.g., flowing sequence between poses) while Ashtanga yoga is a more energetic style of yoga that includes a progressive series of poses and many vinyasas.<sup>309-311</sup> Some styles of yoga may be more prevalent in areas across the US and some people may not have experienced or be aware of the faster paced classes that may have a more pronounced impact on weight. Additionally, as described above, there may be other mechanisms through which prenatal yoga impacts weight gain (e.g., mindfulness, self-awareness). These mechanisms warrant further testing in future research.

Overall, barriers and facilitators reported in our study are not different from what has been reported in other yoga or prenatal exercise studies.<sup>301,312,313</sup> Findings in qualitative and non-qualitative studies suggest that pregnant women experience barriers including physical limitations (e.g., fatigue, pain), or a lack of time, motivation, and/or social support.<sup>314,315</sup> A qualitative study exploring experiences of pregnant and postpartum women practicing prenatal yoga reported that a major benefit of prenatal yoga was the community building and that they enjoyed being in class with other pregnant women.<sup>46</sup> Women also liked the sense that “they were all in this together”. Contrary to our findings, a qualitative study reporting on the facilitators of yoga participation in low-income minority adults (non-pregnant) suggested that a major facilitator for engagement in yoga was having positive yoga instructors characteristics, beginner level class, and positive messaging in class related to relaxation or stress reduction.<sup>308</sup> Future studies should consider designing interventions to minimize barriers and enhance common facilitators reported by pregnant women. These strategies may also be improve program adherence, which also has important implications for GWG management during pregnancy.

### **Limitations**

Though the findings presented here provide important insights related to pregnant women’s experiences in a prenatal yoga intervention to prevent EGWG, several limitations should be noted. First, the sample was small and relatively homogenous with the majority of pregnant women being Hispanic and White, European-American, or Caucasian. Therefore, the generalizability of these findings are limited to these populations. More studies should focus on recruiting more diverse populations including

those at risk for EGWG (e.g., overweight or obese pregnant women). Second, qualitative research has inherent limitations such that these analyses are hypothesis generating rather than confirmatory but are more useful to understand human experiences as compared to quantitative research. Qualitative research is also highly subjective. However, we included a team of three independent researchers who contributed to theme development and agreement was met between all researchers. Finally, the nature of recruitment in this study presents self-selection bias, which may have resulted in a sample that does not well represent the target population.

### **Implications for future research**

Importantly, the findings from this study shed light on the potential benefit of prenatal yoga in regard to weight management. Future studies that aim to test prenatal yoga as a tool to manage weight during pregnancy may consider the following:

- Ensure the prenatal yoga classes focus on implementing breath awareness and mindfulness to help women develop a deeper connection to the body and potentially increase awareness of behaviors related to weight gain (e.g., eating, physical activity, or weight monitoring).
- Incorporate yoga poses that increase heart rate but are also safe for pregnant women.
- Add more frequent number of sessions to have a greater perceived (or actual) benefit on weight gain.
- Incorporate strategies to minimize barriers or enhance facilitators such as offering multiple class times, provide transportation or incentives for travel, and create a supportive environment with women attending class.



- Explore both qualitatively and quantitatively the potential mechanisms through which prenatal yoga may affect weight gain (e.g., mindfulness, self-awareness).
- Examine the impact of prenatal yoga on weight gain and pain in at-risk populations including overweight or obese pregnant women.
- Integrate prenatal yoga into a variety of settings (e.g., clinics, prenatal care programs, other healthcare facilities, online) and investigate 1) the perceptions of pregnant women practicing prenatal yoga in various settings and 2) differences in GWG among women practicing prenatal yoga in various settings.

## **Conclusion**

The findings presented here demonstrated that prenatal yoga is highly regarded as a positive experience during pregnancy. Prenatal yoga may be particularly helpful for relieving pain associated with pregnancy and may help women be more connected to their bodies. Prenatal yoga may also have important implications for weight management during pregnancy as it may help women become more self-aware and/or mindful of their health behaviors and provides an opportunity to increase their physical activity. Though these insights are promising, EGWG is a complex issue and more research in this area is needed especially in more ethnically diverse pregnant women or those at risk for EGWG. The information provided in this study may inform future studies testing the utility of yoga for weight management in among pregnant women.

## CHAPTER 5

### DISCUSSION

The purpose of this three-article dissertation was to investigate the feasibility and preliminary efficacy of a 12-week prenatal yoga intervention to prevent EGWG. To our knowledge, this is the first study to test the impact of prenatal yoga on EGWG in pregnant women. This study was designed to provide data to inform future research testing the utility of prenatal yoga as a tool to prevent EGWG. The aim of manuscript one was to review the literature and propose a model that explains how prenatal yoga may provide a novel way to prevent EGWG in pregnant women through behavioral, psychological/emotional, and physical mechanisms. The aim of manuscript two was to investigate the feasibility (i.e., acceptability, demand) and preliminary efficacy of a prenatal yoga intervention to prevent EGWG. Finally, the aims of manuscript three was to 1) examine and describe pregnant women's experiences in a prenatal yoga intervention to prevent EGWG, 2) explore pregnant women's perceptions of prenatal yoga as a tool to help with weight management during pregnancy, and 3) identify facilitators and barriers to participation in a weight management prenatal yoga intervention during pregnancy. The findings from the three manuscripts in this dissertation provide important insights that may be applied to future research studies in this area.

Strong evidence supports that diet and/or exercise interventions reduce the risk of EGWG by 20%.<sup>27</sup> However, physical activity and/or exercise levels declines across pregnancy and many women replace more strenuous activities with lighter intensity activities.<sup>55,245,316</sup> In the first manuscript presented, we provided an in-depth review of the literature supporting the pathways through which we believe prenatal yoga (a low impact

and low-moderate intensity exercise) may prevent EGWG. Prenatal yoga may be an innovative way to potentially address the pervasive issue of EGWG in the United States. Because prenatal yoga is a low impact and low-moderate intensity activity, this may be a form of exercise that pregnant women are capable of doing throughout their pregnancies.<sup>40,41</sup> As we describe in manuscript one, prenatal yoga is a unique type of exercise as it cultivates mindfulness through meditation, breath focus, and physical movement. Our model describes various pathways of how prenatal yoga may prevent EGWG via behavioral factors including sleep and diet quality and mindfulness, psychological/emotional factors including self-awareness, emotion regulation, stress, and mood, and physical factors including pregnancy discomforts and energy expenditure. Though some of the proposed pathways have limited evidence specifically related to pregnant women, the promising findings in non-pregnant women warrants further investigation among pregnant women. Understanding the mechanisms of prenatal yoga on EGWG may inform the design of future research studies to further evaluate the effectiveness of prenatal yoga to prevent EGWG. Identifying the mechanisms may also inform yoga programs designed to manage weight in both pregnant and non-pregnant populations.

The findings presented in manuscript two suggest that prenatal yoga was an acceptable, enjoyable, and well-attended intervention with no study-related injuries to report. Women reported being satisfied and had an intent to continue participating in prenatal yoga in the future and the majority of women were able to attend at least half of the classes. Other studies have reported prenatal yoga as a highly acceptable activity with no adverse outcomes.<sup>82,271,284</sup> There may be several explanations for why pregnant

women have such high regard for prenatal yoga. Some studies report that pregnant women stop or limit exercise during pregnancy because of physical limitations (e.g., back/pelvic pain) or perceived risks/dangers they believe are associated with exercise during pregnancy.<sup>74,317,318</sup> Clarke et al., (2004) reported that women believed that participation in exercise would lead to increased falls or muscular strain, and many were concerned for the health of their unborn baby (risk of miscarriage and/or premature birth).<sup>317</sup> Prenatal yoga has been shown to improve pregnancy discomforts such as back/pelvic pain which may reduce pregnant women's physical limitations and encourage women to maintain participation throughout pregnancy.<sup>111,319</sup> In addition, prenatal yoga is a low impact and low-moderate intensity exercise that may not be as susceptible to the risks of more rigorous exercise regimes<sup>74</sup> which may be perceived as a safer activity among pregnant women.

Findings in manuscript two did not report any significant effect of prenatal yoga on the rate of GWG or total GWG during the intervention but did report lower perceived stress scores at post-intervention among the prenatal yoga group participants. We did however observe changes in the expected direction (i.e., rate of GWG was lower in prenatal yoga group compared to controls albeit not significant). The lack of significance may have been due to the small sample size that was not efficient to observe an effect. It may also be possible that the effects of prenatal yoga will be more profound beyond the 12-week intervention. There may still be a potential for the rate of GWG to increase/decrease until a woman delivers her baby but we did not collect weekly weight beyond the 12-week intervention. We also did not have total GWG (difference between pre-pregnancy weight and weight prior to delivery) data available for this dissertation.

Total GWG is an additional parameter that is important to determine the adequacy of GWG during a woman's pregnancy. Both the rate of GWG and total GWG should be collected in future examinations.

Interestingly, even though we did not find significance in relation to our GWG outcomes, the majority of women reported in the satisfaction survey that they felt that prenatal yoga helped to manage their weight gain during pregnancy and that prenatal yoga helped them to make healthier choices overall. These findings justify the need to follow-up beyond the 12-week study to investigate changes in total GWG. Despite observing actual reductions in rate of GWG or total GWG during the intervention, perhaps women may be experiencing changes in their metabolic profiles as many state making healthier changes because of prenatal yoga. Therefore, future studies should explore other weight-related health outcomes including glucose tolerance, blood pressure, or lipid profiles and/or even birth outcomes (e.g., preterm birth, length of labor, infant birthweight). International studies exploring the efficacy of prenatal yoga on birth outcomes have reported improvements in birth weight, decreased preterm labor, and less subjective labor pain, and shorter total length of labor.<sup>44,320</sup> More research in this area is warranted.

Finally, the findings presented in manuscript three, provide support that prenatal yoga may influence weight through mechanisms that promote healthier behaviors. Importantly, women often described an increase in mindfulness or self-awareness that helped them to control their weight. Women felt that by just being more aware of their bodies and what they are putting into their bodies can influence the amount of weight they gain during pregnancy. These data may indicate that women choose to make better

dietary choices by simply being more aware of their behaviors. Other more intensive and time-consuming weight loss strategies such as self-monitoring (e.g., counting calories) may actually reduce motivation for weight change, is not enjoyable, and is overwhelming.<sup>321,322</sup> Increasing mindfulness or self-awareness may be a less stigmatizing approach to weight management in pregnant women. This partially supports our proposed model pathways introduced in manuscript one. We proposed that prenatal yoga might prevent EGWG through behavioral factors, one of which is mindfulness, as well as psychological/emotional factors, one of which is self-awareness. The data presented in our study support further investigation of these factors as mediators on the effect of prenatal yoga on EGWG.

#### *Future Directions*

While this dissertation provides significant insights, there remains important questions to be investigated in future research. The mechanisms of change of prenatal yoga in regard to preventing EGWG are not currently understood. Identifying the putative mediators of prenatal yoga may inform future research studies and the design of yoga programs for weight management in both pregnant and non-pregnant populations. This discovery may help researchers to develop programs that incorporate the effective factors driving change in GWG outcomes (e.g., mindfulness, self-awareness). As our study is the first to test the preliminary efficacy of prenatal yoga on EGWG, there is a need for more empirical studies of prenatal yoga including those with sufficient power and rigorous methodology to confirm pathways as described in our model proposed in manuscript one.

The optimal amount of prenatal yoga to attenuate GWG is not currently understood. Low doses of prenatal yoga (e.g., 75 minutes 1/week) may be effective to improve mental health outcomes such as depression<sup>82</sup> but data from our study may suggest that this may be too low of an amount to observe a change in GWG. There are limited studies in non-pregnant populations to suggest that increasing yoga practice is associated with lower weight gain.<sup>75,323,324</sup> More studies are needed to evaluate the optimal dose of prenatal yoga in the context of GWG outcomes.

As mentioned previously, our data did not report significant changes in GWG outcomes but qualitative reports from pregnant women suggest otherwise. Because our data did not capture follow-up data (e.g., GWG until delivery or last weight prior to delivery), it is difficult to determine whether prenatal yoga had a long-term rather than acute effect on GWG. It would be useful to conduct a study to 1) collect weight beyond the initial intervention, 2) collect final weight prior to delivery (e.g., medical records), and/or 3) collect other weight-related health outcome data. These outcomes may provide a broader picture of GWG across pregnancy and may have important clinical implications.

We also know little about the effects of prenatal yoga on pregnancy and birth outcomes. We do have a better understanding of the potential negative effects of EGWG on pregnancy and birth outcomes including increased risk of cesarean section, prematurity, and gestational diabetes.<sup>51,52</sup> However, more rigorous controlled trials are needed to investigate the impact of prenatal yoga on birth outcomes. A dismantling approach to identify the critical components of prenatal yoga (i.e., meditation, breath

focus, physical movement) to improve birth outcomes would also provide important clinical value.

Lastly, our current study included women with normal-obese pre-pregnancy BMI's. However, evidence suggests that pregnant women with an overweight or obese pre-pregnancy BMI are at a higher risk of EGWG.<sup>7</sup> Additionally, low-income and racial/ethnic minorities are particularly vulnerable to EGWG.<sup>325</sup> Future studies are encouraged to target at-risk groups for EGWG.

### *Conclusions*

The studies presented here in this preliminary investigation provide important insight related to the potential for prenatal yoga to prevent EGWG. Our model identifies several potential pathways through which prenatal yoga may prevent EGWG and warrants testing in future research. Though our findings related to EGWG may have been limited, the data here provides important information for crucial adjustments needed for a future study. Despite not observing an effect on EGWG, women in our study report a beneficial effect of prenatal yoga on their weight due to an increase in mindfulness and/or self-awareness. This contextual data supports the need for more research to explore these factors as putative mediators on the effect of prenatal yoga and EGWG. As our study is the first to explore the efficacy of prenatal yoga on EGWG, researchers are encouraged to conduct fully powered empirical studies to confirm or dispute our findings.



## REFERENCES

1. Deputy NP, Sharma AJ, Kim SY. Gestational Weight Gain - United States, 2012 and 2013. *MMWR Morbidity Mortal Wkly Rep.* 2015;64(43):1215.
2. Curtin SC, Abma JC, Ventura SJ, Henshaw SK. Pregnancy rates for U.S. women continue to drop. *NCHS Data Brief.* 2013;(136):1-8.
3. Statistics NC for H. *Births: Final Data for 2014 : National Vital Statistics Reports;2015 ASI 4146-5.439;National Vital Statistics Rpt. Vol. 64, No. 12.;* 2015.
4. Yaktine AL, Rasmussen KM. *Weight Gain During Pregnancy:: Reexamining the Guidelines.* National Academies Press; 2009.
5. Council NR, Health C on the I of PW on M and C, (U.S.) NRC, et al. *Influence of Pregnancy Weight on Maternal and Child Health: Workshop Report.* Washington, D.C: National Academies Press; 2007.
6. Mamun AA, Kinarivala M, O'Callaghan MJ, Williams GM, Najman JM, Callaway LK. Associations of excess weight gain during pregnancy with long-term maternal overweight and obesity: evidence from 21 y postpartum follow-up. *Am J Clin Nutr.* 2010;91(5):1336-1341. doi:10.3945/ajcn.2009.28950
7. Restall A, Taylor RS, Thompson JM, et al. Risk factors for excessive gestational weight gain in a healthy, nulliparous cohort. *J Obes.* 2014;2014:148391. doi:10.1155/2014/148391
8. US Department of Health and Human Services. Maternal, Infant, and Child Health | Healthy People 2020. <https://www.healthypeople.gov/2020/topics-objectives/topic/maternal-infant-and-child-health>. Published 2014. Accessed June 25, 2019.
9. Viswanathan I, Siega-Riz MA, Merry-K Moos R, et al. Evidence Report/Technology Assessment Outcomes of Maternal Weight Gain.; 2008. [www.ahrq.gov](http://www.ahrq.gov). Accessed June 25, 2019.
10. Fraser A, Macdonald-Wallis C, Lawlor DA, et al. Associations of gestational weight gain with maternal body mass index, waist circumference, and blood pressure measured 16 y after pregnancy: The Avon Longitudinal Study of Parents and Children (ALSPAC). *Am J Clin Nutr.* 2011;93(6):1285-1292. doi:10.3945/ajcn.110.008326
11. Bogaerts A, Devlieger R, den Bergh BRH, Witters I. Obesity and pregnancy, an epidemiological and intervention study from a psychosocial perspective. *Facts, views Vis ObGyn.* 2014;6(2):81.
12. Guelinckx I, Devlieger R, Beckers K, Vansant G. Maternal obesity: pregnancy complications, gestational weight gain and nutrition. *Obes Rev.* 2008;9(2):140-

150. doi:10.1111/j.1467-789X.2007.00464.x
13. Thorsdottir I, Torfadottir JE, Birgisdottir BE, Geirsson RT. Weight gain in women of normal weight before pregnancy: complications in pregnancy or delivery and birth outcome. *Obstet Gynecol.* 2002;99(5):799-806. doi:10.1016/S0029-7844(02)01946-4
  14. Bodnar LM, Siega-Riz AM, Simhan HN, Himes KP, Abrams B. Severe obesity, gestational weight gain, and adverse birth outcomes. *Am J Clin Nutr.* 2010;91(6):1642-1648. doi:10.3945/ajcn.2009.29008
  15. Di Fabio DR, Blomme CK, Smith KM, Welk GJ, Campbell CG. Adherence to physical activity guidelines in mid-pregnancy does not reduce sedentary time: an observational study. *Int J Behav Nutr Phys Act.* 2015;12(1):27. doi:10.1186/s12966-015-0191-7
  16. Huberty JL, Buman MP, Leiferman JA, Bushar J, Adams MA. Trajectories of objectively-measured physical activity and sedentary time over the course of pregnancy in women self-identified as inactive. *Prev Med Reports.* 2016;3:353-360. doi:10.1016/j.pmedr.2016.04.004
  17. Ensenauer R, Chmitorz A, Riedel C, et al. Effects of suboptimal or excessive gestational weight gain on childhood overweight and abdominal adiposity: results from a retrospective cohort study. *Int J Obes (Lond).* 2013;37(4):505. doi:10.1038/ijo.2012.226
  18. Wrotniak BH, Shults J, Butts S, Stettler N. Gestational weight gain and risk of overweight in the offspring at age 7 y in a multicenter, multiethnic cohort study. *Am J Clin Nutr.* 2008;87(6):1818.
  19. Pligt P, Willcox J, Hesketh KD, et al. Systematic review of lifestyle interventions to limit postpartum weight retention: implications for future opportunities to prevent maternal overweight and obesity following childbirth. *Obes Rev.* 2013;14(10):792-805. doi:10.1111/obr.12053
  20. Gore SA, Brown DM, West DS. The role of postpartum weight retention in obesity among women: A review of the evidence. *Ann Behav Med.* 2003;26(2):149-159. doi:10.1207/S15324796ABM2602\_07
  21. Moll U, Olsson H, Landin-Olsson M. Impact of Pregestational Weight and Weight Gain during Pregnancy on Long-Term Risk for Diseases. *PLoS One.* 12(1):e0168543. doi:10.1371/journal.pone.0168543
  22. Skouteris H, Hartley-Clark L, McCabe M, et al. Preventing excessive gestational weight gain: a systematic review of interventions. *Obes Rev.* 2010;11(11):757-768. doi:10.1111/j.1467-789X.2010.00806.x

23. Campbell F, Johnson M, Messina J, Guillaume L, Goyder E. Behavioural interventions for weight management in pregnancy: a systematic review of quantitative and qualitative data. *BMC Public Health*. 2011;11(1):491. doi:10.1186/1471-2458-11-491
24. Streuling I, Beyerlein A, von Kries R. Can gestational weight gain be modified by increasing physical activity and diet counseling? A meta-analysis of interventional trials. *Am J Clin Nutr*. 2010;92(4):678-687. doi:10.3945/ajcn.2010.29363
25. Hui A, Back L, Ludwig S, et al. Lifestyle intervention on diet and exercise reduced excessive gestational weight gain in pregnant women under a randomised controlled trial: Exercise and dietary intervention on gestational weight gain. *BJOG An Int J Obstet Gynaecol*. 2012;119(1):70-77. doi:10.1111/j.1471-0528.2011.03184.x
26. Evenson KR, Savitz A, Huston SL. Leisure-time physical activity among pregnant women in the US. *Paediatr Perinat Epidemiol*. 2004;18(6):400-407. doi:10.1111/j.1365-3016.2004.00595.x
27. Muktabhant B, Lumbiganon P, Ngamjarus C, Dowswell T. Interventions for preventing excessive weight gain during pregnancy. *Cochrane database Syst Rev*. 2012;(4).
28. Walker LO. Managing Excessive Weight Gain During Pregnancy and the Postpartum Period. *J Obstet Gynecol Neonatal Nurs*. 2007;36(5):490-500. doi:10.1111/j.1552-6909.2007.00179.x
29. Duncombe D, Wertheim EH, Skouteris H, Paxton SJ, Kelly L. How Well Do Women Adapt to Changes in Their Body Size and Shape across the Course of Pregnancy? *J Health Psychol*. 2008;13(4):503-515. doi:10.1177/1359105308088521
30. Clark A, Skouteris H, Wertheim EH, Paxton SJ, Milgrom J. The Relationship between Depression and Body Dissatisfaction across Pregnancy and the Postpartum: A Prospective Study. *J Health Psychol*. 2009;14(1):27-35. doi:10.1177/1359105308097940
31. Clark A, Skouteris H, Wertheim EH, Paxton SJ, Milgrom J. My baby body: A qualitative insight into women's body-related experiences and mood during pregnancy and the postpartum. *J Reprod Infant Psychol*. 2009;27(4):330. doi:10.1080/02646830903190904
32. Rallis S, Skouteris H, McCabe M, Milgrom J. A prospective examination of depression, anxiety and stress throughout pregnancy. *Women and Birth*. 2014;27(4):e36-e42.
33. Currie S, Gray C, Shepherd A, Mcinnes R. Antenatal physical activity: a

- qualitative study exploring women's experiences and the acceptability of antenatal walking groups. *BMC Pregnancy Childbirth*. 2016;16(1). doi:10.1186/s12884-016-0973-1
34. Bennett HA, Einarson A, Taddio A, Koren G, Einarson TR. Prevalence of depression during pregnancy: systematic review. *Obstet Gynecol*. 2004;103(4):698-709. doi:10.1097/01.AOG.0000116689.75396.5f
  35. Woods SM, Melville JL, Guo Y, Fan M-Y, Gavin A. Psychosocial stress during pregnancy. *Am J Obstet Gynecol*. 2010;202(1):61.e1-61.e7. doi:http://dx.doi.org/10.1016/j.ajog.2009.07.041
  36. Claesson I-M, Josefsson A, Sydsjö G, et al. Prevalence of anxiety and depressive symptoms among obese pregnant and postpartum women: an intervention study. *BMC Public Health*. 2010;10(1):766. doi:10.1186/1471-2458-10-766
  37. Dunkel Schetter C. Psychological science on pregnancy: stress processes, biopsychosocial models, and emerging research issues. *Annu Rev Psychol*. 2011;62:531-558.
  38. Ross LE, McLean LM. Anxiety disorders during pregnancy and the postpartum period: A systematic review. *J Clin Psychiatry*. 2006;67(8):1285-1298.
  39. National Center for Complementary and Integrative Health. Complementary, Alternative, or Integrative Health: What's In a Name? | NCCIH. <https://nccih.nih.gov/health/integrative-health>. Published 2018. Accessed June 25, 2019.
  40. Ainsworth BE, Haskell WL, Herrmann SD, et al. 2011 Compendium of Physical Activities: a second update of codes and MET values. *Med Sci Sports Exerc*. 2011;43(8):1575. doi:10.1249/MSS.0b013e31821ece12
  41. Larson-Meyer DE. A Systematic Review of the Energy Cost and Metabolic Intensity of Yoga. *Med Sci Sport Exerc*. 2016:1. doi:10.1249/MSS.0000000000000922
  42. Gong H, Ni C, Shen X, Wu T, Jiang C. Yoga for prenatal depression: a systematic review and meta-analysis. *BMC Psychiatry*. 2015;15(1):14. doi:10.1186/s12888-015-0393-1
  43. Bribiescas S. Yoga in pregnancy. *Int J Childbirth Educ*. 2013;28(3):99.
  44. Chuntharapat S, Petpichetchian W, Hatthakit U. Yoga during pregnancy: Effects on maternal comfort, labor pain and birth outcomes. *Complement Ther Clin Pract*. 2008;14(2):105-115. doi:10.1016/j.ctcp.2007.12.007
  45. Hegaard HK, Kjaergaard H, Damm PP, Petersson K, Dykes A-K. Experiences of

physical activity during pregnancy in Danish nulliparous women with a physically active life before pregnancy. A qualitative study. *BMC Pregnancy Childbirth*. 2010;10. doi:10.1186/1471-2393-10-33

46. Kinser P, Masho S. Yoga Was My Saving Grace: The Experience of Women Who Practice Prenatal Yoga. *J Am Psychiatr Nurses Assoc*. 2015;21(5):319-326. doi:10.1177/1078390315610554
47. Lauche R, Langhorst J, Lee MS, Dobos G, Cramer H. A systematic review and meta-analysis on the effects of yoga on weight-related outcomes. *Prev Med (Baltim)*. April 2016. doi:S0091-7435(16)30036-6
48. Rioux JG, Ritenbaugh C. Narrative review of yoga intervention clinical trials including weight-related outcomes. *Altern Ther Health Med*. 2013;19(3):32-46.
49. Ross A, Thomas S. The health benefits of yoga and exercise: a review of comparison studies. *J Altern Complement Med*. 2010;16(1):3-12. doi:10.1089/acm.2009.0044
50. Doran F, Hornibrook J. Women's experiences of participation in a pregnancy and postnatal group incorporating yoga and facilitated group discussion: a qualitative evaluation. *Women Birth*. 2013;26(1):82. doi:10.1016/j.wombi.2012.06.001
51. Siega-Riz AM, Viswanathan M, Moos M-K, et al. A systematic review of outcomes of maternal weight gain according to the Institute of Medicine recommendations: birthweight, fetal growth, and postpartum weight retention. *Am J Obstet Gynecol*. 2009;201(4):339--e1.
52. Goldstein RF, Abell SK, Ranasinha S, et al. Association of gestational weight gain with maternal and infant outcomes: a systematic review and meta-analysis. *Jama*. 2017;317(21):2207-2225.
53. Practice CO. Physical Activity and Exercise During Pregnancy and the Postpartum Period. *Obstet Gynecol*. 2015;126(6):e135-e142. doi:10.1097/AOG.0000000000001214
54. Hesketh KR, Evenson KR. Prevalence of U.S. Pregnant Women Meeting 2015 ACOG Physical Activity Guidelines. *Am J Prev Med*. 2016;51(3):e87-9. doi:10.1016/j.amepre.2016.05.023
55. Evenson KR, Wen F. Prevalence and correlates of objectively measured physical activity and sedentary behavior among US pregnant women. *Prev Med (Baltim)*. 2011;53(1-2):39-43. doi:10.1016/j.yjmed.2011.04.014
56. Tanentsapf I, Heitmann BL, Adegboye ARA. Systematic review of clinical trials on dietary interventions to prevent excessive weight gain during pregnancy among normal weight, overweight and obese women. *BMC Pregnancy Childbirth*.

2011;11(1):81.

57. Brown MJ, Sinclair M, Liddle D, Hill AJ, Madden E, Stockdale J. A systematic review investigating healthy lifestyle interventions incorporating goal setting strategies for preventing excess gestational weight gain. *PLoS One*. 2012;7(7):e39503.
58. Gardner B, Wardle J, Poston L, Croker H. Changing diet and physical activity to reduce gestational weight gain: a meta-analysis. *Obes Rev*. 2011;12(7):e602-e620. doi:10.1111/j.1467-789X.2011.00884.x
59. Ho M, Garnett SP, Baur LA, et al. Impact of dietary and exercise interventions on weight change and metabolic outcomes in obese children and adolescents: a systematic review and meta-analysis of randomized trials. *JAMA Pediatr*. 2013;167(8):759-768.
60. Wu T, Gao X, Chen M, Van Dam RM. Long-term effectiveness of diet-plus-exercise interventions vs. diet-only interventions for weight loss: a meta-analysis. *Obes Rev*. 2009;10(3):313-323.
61. Franz MJ, Boucher JL, Rutten-Ramos S, VanWormer JJ. Lifestyle weight-loss intervention outcomes in overweight and obese adults with type 2 diabetes: a systematic review and meta-analysis of randomized clinical trials. *J Acad Nutr Diet*. 2015;115(9):1447-1463.
62. Poobalan AS, Aucott LS, Precious E, Crombie IK, Smith WCS. Weight loss interventions in young people (18 to 25 year olds): a systematic review. *Obes Rev*. 2010;11(8):580-592.
63. Craemer KA, Sampene E, Safdar N, Antony KM, Wautlet CK. Nutrition and Exercise Strategies to Prevent Excessive Pregnancy Weight Gain: A Meta-analysis. *Am J Perinatol Reports*. 2019;9(01):e92--e120.
64. Ruchat S-M, Mottola MF, Skow RJ, et al. Effectiveness of exercise interventions in the prevention of excessive gestational weight gain and postpartum weight retention: a systematic review and meta-analysis. *Br J Sport Med*. 2018;52(21):1347-1356.
65. Hartley E, McPhie S, Skouteris H, Fuller-Tyszkiewicz M, Hill B. Psychosocial risk factors for excessive gestational weight gain: A systematic review. *Women and Birth*. 2014. doi:10.1016/j.wombi.2015.04.004
66. Hill B, Skouteris H, McCabe M, et al. A conceptual model of psychosocial risk and protective factors for excessive gestational weight gain. *Midwifery*. 2013;29(2):110-114. doi:10.1016/j.midw.2011.12.001
67. DiPietro JA, Millet S, Costigan KA, Gurewitsch E, Caulfield LE. Psychosocial

- influences on weight gain attitudes and behaviors during pregnancy. *J Am Diet Assoc.* 2003;103(10):1314-1319.
68. Thomas M, Vieten C, Adler N, et al. Potential for a stress reduction intervention to promote healthy gestational weight gain: Focus groups with low-income pregnant women. *Women's Heal Issues.* 2014;24(3):e305-e311.
  69. Davis EM, Stange KC, Horwitz RI. Childbearing, stress and obesity disparities in women: a public health perspective. *Matern Child Health J.* 2010;16(1):109-118. doi:10.1007/s10995-010-0712-6
  70. Tomiyama AJ, Dallman MF, Epel ES. Comfort food is comforting to those most stressed: evidence of the chronic stress response network in high stress women. *Psychoneuroendocrinology.* 2011;36(10):1513-1519.
  71. Cramer H. Prevalence, Patterns, and Predictors of Yoga Use. *Am J Prev Med.* 2016;50(2):230; 230-235; 235.
  72. Battle CL. Prenatal Yoga and Depression During Pregnancy. *Birth.* 2010;37(4):353; 353-354; 354.
  73. Babbar S, Parks-Savage AC, Chauhan SP. Yoga during pregnancy: a review. *Am J Perinatol.* 2012;29(6):459.
  74. Curtis K, Weinrib A, Katz J. Systematic review of yoga for pregnant women: current status and future directions. *Evid Based Complement Alternat Med.* 2012;2012:715913-715942. doi:10.1155/2012/715942
  75. Kristal A, Littman A, Benitez D, White E. Yoga practice is associated with attenuated weight gain in healthy, middle-aged men and women. *Heal Med.* 2005;11(4):28-33.
  76. Moliver N, Mika EM, Chartrand MS, Burrus SWM, Haussmann RE, Khalsa SBS. Increased Hatha yoga experience predicts lower body mass index and reduced medication use in women over 45 years. *Int J Yoga.* 2011;4(2):77-86. doi:10.4103/0973-6131.85490
  77. Palasuwan A. Dietary intakes and antioxidant status in mind-body exercising pre- and postmenopausal women. *J Nutr Heal Aging.* 2011;15(7):577-585.
  78. Sivasankaran S, Pollard-Quintner SFAU, Sachdeva RFAU, Pugada J FAU - Hoq M. S, FAU HSM, Zarich SW. The effect of a six-week program of yoga and meditation on brachial artery reactivity: do psychosocial interventions affect vascular tone? *Clin Cardiol JID - 7903272.* 109AD.
  79. Gokal R, Shillito L, Maharaj SR. Positive impact of yoga and pranayam on obesity, hypertension, blood sugar, and cholesterol: A pilot assessment 3]. *J Altern*

- Complement Med.* 2007;13(10):1056-1057. doi:10.1089/acm.2007.0679
80. Mahajan AS, Reddy KS, Sachdeva U. Lipid profile of coronary risk subjects following yogic lifestyle intervention. *Indian Heart J.* 1999;51(1):37-40.
  81. Watts AW, Rydell SA, Eisenberg ME, Laska MN, Neumark-Sztainer D. Yoga's potential for promoting healthy eating and physical activity behaviors among young adults: a mixed-methods study. *Int J Behav Nutr Phys Act.* 2018;15(1):42. doi:10.1186/s12966-018-0674-4
  82. Battle CL, Uebelacker LA, Magee SR, Sutton KA, Miller IW. Potential for prenatal yoga to serve as an intervention to treat depression during pregnancy. *Womens Health Issues.* 2015;25(2):134-141. doi:10.1016/j.whi.2014.12.003
  83. Muzik M, Hamilton SE, Lisa Rosenblum K, Waxler E, Hadi Z. Mindfulness yoga during pregnancy for psychiatrically at-risk women: Preliminary results from a pilot feasibility study. *Complement Ther Clin Pract.* 2012;18(4):235-240. doi:10.1016/j.ctcp.2012.06.006
  84. Vieten C, Astin J. Effects of a mindfulness-based intervention during pregnancy on prenatal stress and mood: results of a pilot study. *Arch Womens Ment Health.* 2008;11(1):67-74. doi:10.1007/s00737-008-0214-3
  85. Kabat-Zinn J. Mindfulness. *Mindfulness (NY).* 2015;6(6):1481-1483.
  86. Olson KL, Emery CF. Mindfulness and weight loss: a systematic review. *Psychosom Med.* 2015;77(1):59.
  87. O'Reilly GA, Cook L, Spruijt-Metz D, Black DS. Mindfulness-based interventions for obesity-related eating behaviours: a literature review. *Obes Rev.* 2014;15(6):453-461.
  88. Vieten C, Laraia BA, Kristeller J, et al. The mindful moms training: development of a mindfulness-based intervention to reduce stress and overeating during pregnancy. *BMC Pregnancy Childbirth.* 2018;18(1):201.
  89. Fiori F, Aglioti SM, David N. Interactions between body and social awareness in yoga. *J Altern Complement Med.* 2017;23(3):227-233. doi:10.1089/acm.2016.0169
  90. Tihanyi BT, Bö\Hor P, Emanuelsen L, Köteles F. "Mediators between Yoga Practice and Psychological Well-Being: Mindfulness, Body Awareness and Satisfaction with Body Image." *Eur J Ment Heal.* 2016;11(1-2):112.
  91. Boutelle KN, Kirschenbaum DS. Further support for consistent self-monitoring as a vital component of successful weight control. *Obes Res.* 1998;6(3):219-224.
  92. Baker RC, Kirschenbaum DS. Self-monitoring may be necessary for successful



- weight control. *Behav Ther.* 1993;24(3):377-394.
93. Gard T, Noggle JJ, Park CL, Vago DR, Wilson A. Potential self-regulatory mechanisms of yoga for psychological health. *Front Hum Neurosci.* 2014;8:770. doi:10.3389/fnhum.2014.00770
  94. Menezes CB, Dalpiaz NR, Kiesow LG, Sperb W, Hertzberg J, Oliveira AA. Yoga and emotion regulation: A review of primary psychological outcomes and their physiological correlates. *Psychol Neurosci.* 2015;8(1):82.
  95. Leehr EJ, Krohmer K, Schag K, Dresler T, Zipfel S, Giel KE. Emotion regulation model in binge eating disorder and obesity-a systematic review. *Neurosci Biobehav Rev.* 2015;49:125-134.
  96. Macht M, Simons G. Emotional eating. In: *Emotion Regulation and Well-Being.* Springer; 2011:281-295.
  97. Zeeck A, Stelzer N, Linster HW, Joos A, Hartmann A. Emotion and eating in binge eating disorder and obesity. *Eur Eat Disord Rev.* 2011;19(5):426-437.
  98. Levitan RD, Davis C. Emotions and eating behaviour: Implications for the current obesity epidemic. *Univ Toronto Q.* 2010;79(2):783-799.
  99. Konttinen H, Männistö S, Sarlio-Lähteenkorva S, Silventoinen K, Haukkala A. Emotional eating, depressive symptoms and self-reported food consumption. A population-based study. *Appetite.* 2010;54(3):473-479.
  100. Chen P-J, Yang L, Chou C-C, Li C-C, Chang Y-C, Liaw J-J. Effects of prenatal yoga on women's stress and immune function across pregnancy: A randomized controlled trial. *Complement Ther Med.* 2017;31:109-117.
  101. Jiang Q, Wu Z, Zhou L, Dunlop J, Chen P. Effects of yoga intervention during pregnancy: a review for current status. *Am J Perinatol.* 2015;32(06):503-514.
  102. Kawanishi Y, Hanley SJ, Tabata K, et al. Effects of prenatal yoga: a systematic review of randomized controlled trials. *Nihon Kosshu Eisei Zasshi.* 2015;62(5):221-231.
  103. Adam TC, Epel ES. Stress, eating and the reward system. *Physiol Behav.* 2007;91(4):449-458.
  104. Ng QX, Venkatanarayanan N, Loke W, et al. A meta-analysis of the effectiveness of yoga-based interventions for maternal depression during pregnancy. *Complement Ther Clin Pract.* 2019;34:8-12.
  105. Goyal M, Singh S, Sibinga EMS, et al. Meditation programs for psychological stress and well-being: a systematic review and meta-analysis. *JAMA Intern Med.*

- 2014;174(3):357-368.
106. Matvienko-Sikar K, Lee L, Murphy G, Murphy L. The effects of mindfulness interventions on prenatal well-being: A systematic review. *Psychol Health*. 2016;31(12):1415-1434.
  107. Taylor BL, Cavanagh K, Strauss C. The effectiveness of mindfulness-based interventions in the perinatal period: a systematic review and meta-analysis. *PLoS One*. 2016;11(5):e0155720.
  108. Hall HG, Beattie J, Lau R, East C, Biro MA, Anne Biro M. Mindfulness and perinatal mental health: A systematic review. *Women and Birth*. 2015;29(1):62-71. doi:10.1016/j.wombi.2015.08.006
  109. Manber R, Blasey C, Allen JJB. Depression symptoms during pregnancy. *Arch Womens Ment Health*. 2008;11(1):43-48.
  110. Matthews J, Huberty J, Leiferman J, Buman M. Psychosocial predictors of GWG by trimester and the role of mindfulness. *Midwifery*. 2018;56:86-93.
  111. Sun Y-C, Hung Y-C, Chang Y, Kuo S-C. Effects of a prenatal yoga programme on the discomforts of pregnancy and maternal childbirth self-efficacy in Taiwan. *Midwifery*. 2010;26(6):e31-e36.
  112. Martins RF, e Silva JL. Treatment of pregnancy-related lumbar and pelvic girdle pain by the yoga method: a randomized controlled study. *J Altern Complement Med*. 2014;20(1):24-31.
  113. Mogren IM. BMI, pain and hyper-mobility are determinants of long-term outcome for women with low back pain and pelvic pain during pregnancy. *Eur spine J*. 2006;15(7):1093-1102. doi:10.1007/s00586-005-0004-9
  114. Katonis P, Kampouroglou A, Aggelopoulos A, et al. Pregnancy-related low back pain. *Hippokratia*. 2011;15(3):205. <http://www.ncbi.nlm.nih.gov/pubmed/22435016>. Accessed June 24, 2019.
  115. Sabino J, Grauer JN. Pregnancy and low back pain. *Curr Rev Musculoskelet Med*. 2008;1(2):137-141. doi:10.1007/s12178-008-9021-8
  116. Pain H, Wiles R. The experience of being disabled and obese. *Disabil Rehabil*. 2006;28(19):1211-1220.
  117. Vincent HK, Raiser SN, Vincent KR. The aging musculoskeletal system and obesity-related considerations with exercise. *Ageing Res Rev*. 2012;11(3):361-373.
  118. Larsson UE, Mattsson E. Functional limitations linked to high body mass index, age and current pain in obese women. *Int J Obes*. 2001;25(6):893.

119. Garver MJ, Focht BC, Dials J, et al. Weight status and differences in mobility performance, pain symptoms, and physical activity in older, knee osteoarthritis patients. *Arthritis*. 2014;2014.
120. Rimmer JH, Hsieh K, Graham BC, Gerber BS, Gray-Stanley JA. Barrier removal in increasing physical activity levels in obese African American women with disabilities. *J Women's Heal*. 2010;19(10):1869-1876.
121. Sherman SA, Rogers RJ, Davis KK, et al. Energy expenditure in vinyasa yoga versus walking. *J Phys Act Heal*. 2017;14(8):597-605. doi:10.1123/jpah.2016-0548
122. Huberty JL, Matthews JL, Toledo M, et al. Vinyasa Flow: Metabolic Cost and Validation of Hip-and Wrist-Worn Wearable Sensors. *J Meas Phys Behav*. 2018;1(4):174-180. doi:10.1123/jmpb.2017-0010
123. Hall KD, Heymsfield SB, Kemnitz JW, Klein S, Schoeller DA, Speakman JR. Energy balance and its components: implications for body weight regulation. *Am J Clin Nutr*. 2012;95(4):989-994. doi:10.3945/ajcn.112.036350
124. Field T, Diego M, Delgado J, Medina L. Tai chi/yoga reduces prenatal depression, anxiety and sleep disturbances. *Complement Ther Clin Pract*. 2013;19(1):6-10. doi:10.1016/J.CTCP.2012.10.001
125. Beddoe AE, Lee KA, Weiss SJ, Powell Kennedy H, Yang C-PP. Effects of mindful yoga on sleep in pregnant women: a pilot study. *Biol Res Nurs*. 2010;11(4):363-370.
126. Knutson KL, Van Cauter E. Associations between sleep loss and increased risk of obesity and diabetes. *Ann N Y Acad Sci*. 2008;1129(1):287-304.
127. Gangwisch JE, Malaspina D, Boden-Albala B, Heymsfield SB. Inadequate sleep as a risk factor for obesity: analyses of the NHANES I. *Sleep*. 2005;28(10):1289-1296.
128. Wright Jr KP. Too little sleep: a risk factor for obesity? *Obs Manag*. 2006;2(4):140-145.
129. Wu Y, Zhai L, Zhang D. Sleep duration and obesity among adults: a meta-analysis of prospective studies. *Sleep Med*. 2014;15(12):1456-1462.
130. Zhu Y, Hedderson MM, Sridhar S, Xu F, Feng J, Ferrara A. Poor diet quality in pregnancy is associated with increased risk of excess fetal growth: a prospective multi-racial/ethnic cohort study. *Int J Epidemiol*. 2019;48(2):423-432. doi:10.1093/ije/dyy285
131. Mokdad AH, Ballestros K, Echko M, et al. The State of US Health, 1990-2016.

*JAMA*. 2018;319(14):1444. doi:10.1001/jama.2018.0158

132. Borge TC, Aase H, Brantsæter AL, Biele G. The importance of maternal diet quality during pregnancy on cognitive and behavioural outcomes in children: a systematic review and meta-analysis. *BMJ Open*. 2017;7(9):e016777. doi:10.1136/bmjopen-2017-016777
133. Emond JA, Karagas MR, Baker ER, Gilbert-Diamond D. Better Diet Quality during Pregnancy Is Associated with a Reduced Likelihood of an Infant Born Small for Gestational Age: An Analysis of the Prospective New Hampshire Birth Cohort Study. *J Nutr*. 2018;148(1):22-30. doi:10.1093/jn/nxx005
134. Grieger JA, Grzeskowiak LE, Clifton VL. Preconception Dietary Patterns in Human Pregnancies Are Associated with Preterm Delivery. *J Nutr*. 2014;144(7):1075-1080. doi:10.3945/jn.114.190686
135. Kibret KT, Chojenta C, Gresham E, Tegegne TK, Loxton D. Maternal dietary patterns and risk of adverse pregnancy (hypertensive disorders of pregnancy and gestational diabetes mellitus) and birth (preterm birth and low birth weight) outcomes: a systematic review and meta-analysis. *Public Health Nutr*. 2019;22(3):506-520. doi:10.1017/S1368980018002616
136. Rifas-Shiman SL, Rich-Edwards JW, Kleinman KP, Oken E, Gillman MW. Dietary Quality during Pregnancy Varies by Maternal Characteristics in Project Viva: A US Cohort. *J Am Diet Assoc*. 2009;109(6):1004-1011. doi:10.1016/J.JADA.2009.03.001
137. Doyle I-M, Borrmann B, Grosser A, Razum O, Spallek J. Determinants of dietary patterns and diet quality during pregnancy: a systematic review with narrative synthesis. *Public Health Nutr*. 2017;20(6):1009-1028. doi:10.1017/S1368980016002937
138. Stuebe AM, Oken E, Gillman MW. Associations of diet and physical activity during pregnancy with risk for excessive gestational weight gain. *Am J Obstet Gynecol*. 2009;201(1):58. e1-58.
139. Suliga E, Rokita W, Adamczyk-Gruszka O, Pazera G, Cieśla E, Głuszek S. Factors associated with gestational weight gain: a cross-sectional survey. *BMC Pregnancy Childbirth*. 2018;18(1):465. doi:10.1186/s12884-018-2112-7
140. Polley B, Wing R, Sims C. Randomized controlled trial to prevent excessive weight gain in pregnant women. *Int J Obes*. 2002;26(11):1494-1502. doi:10.1038/sj.ijo.0802130
141. Gray-Donald K, Robinson E, Collier A, David K, Renaud L, Rodrigues S. Intervening to reduce weight gain in pregnancy and gestational diabetes mellitus in Cree communities: an evaluation. *CMAJ*. 2000;163(10).

142. Guelinckx I, Devlieger R, Mullie P, Vansant G. Effect of lifestyle intervention on dietary habits, physical activity, and gestational weight gain in obese pregnant women: a randomized controlled trial. *Am J Clin Nutr*. 2010;91(2):373-380. doi:10.3945/ajcn.2009.28166
143. Shin D, Bianchi L, Chung H, Weatherspoon L, Song WO. Is Gestational Weight Gain Associated with Diet Quality During Pregnancy? *Matern Child Health J*. 2014;18(6):1433-1443. doi:10.1007/s10995-013-1383-x
144. Fowles ER, Stang J, Bryant M, Kim S. Stress, Depression, Social Support, and Eating Habits Reduce Diet Quality in the First Trimester in Low-Income Women: A Pilot Study. *J Acad Nutr Diet*. 2012;112(10):1619-1625. doi:10.1016/J.JAND.2012.07.002
145. Borders AEB, Grobman WA, Amsden LB, Holl JL. Chronic Stress and Low Birth Weight Neonates in a Low-Income Population of Women. *Obstet Gynecol*. 2007;109(2, Part 1):331-338. doi:10.1097/01.AOG.0000250535.97920.b5
146. Obel C, Hedegaard M, Henriksen TB, Secher NJ, Olsen J, Levine S. Stress and salivary cortisol during pregnancy. *Psychoneuroendocrinology*. 2005;30(7):647-656. doi:10.1016/J.PSYNEUEN.2004.11.006
147. Epel, ES.; McEwen B, Seeman T, Matthews K, Castellazzo G, Brownell KD, Bell J, Ickovics JR. Stress and Body Shape: Stress-Induced Cortisol Secretion Is Consistently Greater Among Women With Central Fat. *Psychosom Med*. 2000;62(5):623-632.
148. Chiesa A, Serretti A. Mindfulness-Based Stress Reduction for Stress Management in Healthy People: A Review and Meta-Analysis. *J Altern Complement Med*. 2009;15(5):593-600. doi:10.1089/acm.2008.0495
149. Hofmann SG, Sawyer AT, Witt AA, Oh D. The effect of mindfulness-based therapy on anxiety and depression: A meta-analytic review. *J Consult Clin Psychol*. 2010;78(2):169-183. doi:10.1037/a0018555
150. Noordali F, Cumming J, Thompson JL. Effectiveness of Mindfulness-based interventions on physiological and psychological complications in adults with diabetes: A systematic review. *J Health Psychol*. 2017;22(8):965-983. doi:10.1177/1359105315620293
151. Cramer H, Lauche R, Paul A, Dobos G. Mindfulness-based stress reduction for breast cancer-a systematic review and meta-analysis. *Curr Oncol*. 2012;19(5):e343-52. doi:10.3747/co.19.1016
152. Ledesma D, Kumano H. Mindfulness-based stress reduction and cancer: a meta-analysis. *Psychooncology*. 2009;18(6):571-579. doi:10.1002/pon.1400

153. Cramer H, Haller H, Lauche R, Dobos G. Mindfulness-based stress reduction for low back pain. A systematic review. *BMC Complement Altern Med.* 2012;12(1):162. doi:10.1186/1472-6882-12-162
154. Katterman SN, Kleinman BM, Hood MM, Nackers LM, Corsica JA. Mindfulness meditation as an intervention for binge eating, emotional eating, and weight loss: A systematic review. *Eat Behav.* 2014;15(2):197-204. doi:10.1016/J.EATBEH.2014.01.005
155. Olson KL, Emery CF. Mindfulness and Weight Loss. *Psychosom Med.* 2015;77(1):59-67. doi:10.1097/PSY.000000000000127
156. Howell AJ, Digdon NL, Buro K. Mindfulness predicts sleep-related self-regulation and well-being. *Pers Individ Dif.* 2010;48(4):419-424. doi:10.1016/J.PAID.2009.11.009
157. Black DS, O'Reilly GA, Olmstead R, Breen EC, Irwin MR. Mindfulness Meditation and Improvement in Sleep Quality and Daytime Impairment Among Older Adults With Sleep Disturbances. *JAMA Intern Med.* 2015;175(4):494. doi:10.1001/jamainternmed.2014.8081
158. Gong H, Ni C-X, Liu Y-Z, et al. Mindfulness meditation for insomnia: A meta-analysis of randomized controlled trials. *J Psychosom Res.* 2016;89:1-6. doi:10.1016/J.JPSYCHORES.2016.07.016
159. Marchand WR. Neural mechanisms of mindfulness and meditation: Evidence from neuroimaging studies. *World J Radiol.* 2014;6(7):471-479. doi:10.4329/wjr.v6.i7.471
160. Grabovac AD, Lau MA, Willett BR. Mechanisms of Mindfulness: A Buddhist Psychological Model. *Mindfulness (N Y).* 2011;2(3):154-166. doi:10.1007/s12671-011-0054-5
161. Epel E, Laraia B, Coleman-Phox K, et al. Effects of a Mindfulness-Based Intervention on Distress, Weight Gain, and Glucose Control for Pregnant Low-Income Women: A Quasi-Experimental Trial Using the ORBIT Model. *Int J Behav Med.* April 2019:1-13. doi:10.1007/s12529-019-09779-2
162. Salmon P, Lush E, Jablonski M, Sephton SE. Yoga and Mindfulness: Clinical Aspects of an Ancient Mind/Body Practice. *Cogn Behav Pract.* 2009;16(1):59-72. doi:10.1016/J.CBPRA.2008.07.002
163. Gard T, Brach N, Hölzel BK, Noggle JJ, Conboy LA, Lazar SW. Effects of a yoga-based intervention for young adults on quality of life and perceived stress: The potential mediating roles of mindfulness and self-compassion. *J Posit Psychol.* 2012;7(3):165-175. doi:10.1080/17439760.2012.667144

164. Riley KE, Park CL. How does yoga reduce stress? A systematic review of mechanisms of change and guide to future inquiry. *Health Psychol Rev.* 2015;9(3):379-396. doi:10.1080/17437199.2014.981778
165. Uebelacker LA, Epstein-Lubow G, Gaudiano BA, Tremont G, Battle CL, Miller IW. Hatha Yoga for Depression: Critical Review of the Evidence for Efficacy, Plausible Mechanisms of Action, and Directions for Future Research. *J Psychiatr Pract.* 2010;16(1):22-33. doi:10.1097/01.pra.0000367775.88388.96
166. Field T. Yoga clinical research review. *Complement Ther Clin Pract.* 2011;17(1):1-8. doi:10.1016/J.CTCP.2010.09.007
167. Balasubramaniam M, Telles S, Doraiswamy PM. Yoga on Our Minds: A Systematic Review of Yoga for Neuropsychiatric Disorders. *Front Psychiatry.* 2013;3:117. doi:10.3389/fpsy.2012.00117
168. Li, Amber W.; Goldsmith C-AW. The Effects of Yoga on Anxiety and Stress. *Altern Med Rev.* 2012;17(1):21-35.
169. Büssing A, Michalsen A, Khalsa SBS, Telles S, Sherman KJ. Effects of Yoga on Mental and Physical Health: A Short Summary of Reviews. *Evidence-Based Complement Altern Med.* 2012;2012:1-7. doi:10.1155/2012/165410
170. Fabricatore AN, Wadden TA, Higginbotham AJ, et al. Intentional weight loss and changes in symptoms of depression: a systematic review and meta-analysis. *Int J Obes.* 2011;35(11):1363-1376. doi:10.1038/ijo.2011.2
171. Blaine B. Does Depression Cause Obesity?: A Meta-analysis of Longitudinal Studies of Depression and Weight Control. *J Health Psychol.* 2008;13(8):1190-1197. doi:10.1177/1359105308095977
172. Hemmingsson E. A new model of the role of psychological and emotional distress in promoting obesity: conceptual review with implications for treatment and prevention. *Obes Rev.* 2014;15(9):769-779. doi:10.1111/obr.12197
173. Morin A. Self-Awareness Part 1: Definition, Measures, Effects, Functions, and Antecedents. *Soc Personal Psychol Compass.* 2011;5(10):807-823. doi:10.1111/j.1751-9004.2011.00387.x
174. Baumeister RF, Vohs KD. Self-Regulation, ego depletion, and motivation. *Soc Personal Psychol Compass.* 2007;1(1):115-128.
175. Richards K, Campenni C, Muse-Burke J. Self-care and Well-being in Mental Health Professionals: The Mediating Effects of Self-awareness and Mindfulness. *J Ment Heal Couns.* 2010;32(3):247-264. doi:10.17744/mehc.32.3.0n31v88304423806

176. Vago DR. Mapping modalities of self-awareness in mindfulness practice: a potential mechanism for clarifying habits of mind. *Ann NY Acad Sci*. doi:10.1111/nyas.12270
177. Garfinkel M, Schumacher HR. YOGA. *Rheum Dis Clin North Am*. 2000;26(1):125-132. doi:10.1016/S0889-857X(05)70126-5
178. Hindle L, Carpenter C. An exploration of the experiences and perceptions of people who have maintained weight loss. *J Hum Nutr Diet*. 2011;24(4):342-350. doi:10.1111/j.1365-277X.2011.01156.x
179. Heatherton TF, Baumeister RF. Binge eating as escape from self-awareness. *Psychol Bull*. 1991;110(1):86-108. doi:10.1037/0033-2909.110.1.86
180. Mehta UJ, Siega-Riz AM, Herring AH. Effect of Body Image on Pregnancy Weight Gain. *Matern Child Health J*. 2011;15(3):324-332. doi:10.1007/s10995-010-0578-7
181. Skouteris H. Body image issues in obstetrics and gynecology. In: Thomas F. Cash LS, ed. *Body Image: A Handbook of Science, Practice, and Prevention*. 2nd ed. New York: Guilford Press; 2011:342-349.
182. Hill B, Skouteris H, McCabe M, Fuller-Tyszkiewicz M. Body image and gestational weight gain: a prospective study. *J Midwifery Women's Heal*. 2013;58(2):189-194.
183. Bagheri M, Dorosty A, Sadrzadeh-Yeganeh H, Eshraghian M, Amiri E, Khamoush-Cheshm N. Pre-pregnancy body size dissatisfaction and excessive gestational weight gain. *Matern Child Health J*. 2013;17(4):699-707.
184. Gross JJ. The Emerging Field of Emotion Regulation: An Integrative Review. *Rev Gen Psychol*. 1998;2(3):271-299. doi:10.1037/1089-2680.2.3.271
185. Gross JJ. Emotion Regulation: Current Status and Future Prospects. *Psychol Inq*. 2015;26(1):1-26. doi:10.1080/1047840X.2014.940781
186. McRae K, Jacobs SE, Ray RD, John OP, Gross JJ. Individual differences in reappraisal ability: Links to reappraisal frequency, well-being, and cognitive control. *J Res Pers*. 2012;46(1):2-7. doi:10.1016/J.JRP.2011.10.003
187. Kubzansky LD, Park N, Peterson C, Vokonas P, Sparrow D. Healthy Psychological Functioning and Incident Coronary Heart Disease. *Arch Gen Psychiatry*. 2011;68(4):400. doi:10.1001/archgenpsychiatry.2011.23
188. Suri G, Gross JJ. Emotion regulation and successful aging. *Trends Cogn Sci*. 2012;16(8):409-410. doi:10.1016/J.TICS.2012.06.007



189. Joormann J, Gotlib IH. Emotion regulation in depression: Relation to cognitive inhibition. *Cogn Emot.* 2010;24(2):281-298. doi:10.1080/02699930903407948
190. Amstadter A. Emotion regulation and anxiety disorders. *J Anxiety Disord.* 2008;22(2):211-221. doi:10.1016/J.JANXDIS.2007.02.004
191. Wang M, Saudino KJ. Emotion Regulation and Stress. *J Adult Dev.* 2011;18(2):95-103. doi:10.1007/s10804-010-9114-7
192. Szasz PL, Szentagotai A, Hofmann SG. The effect of emotion regulation strategies on anger. *Behav Res Ther.* 2011;49(2):114-119. doi:10.1016/J.BRAT.2010.11.011
193. Evers C, Marijn Stok F, de Ridder DTD. Feeding Your Feelings: Emotion Regulation Strategies and Emotional Eating. *Personal Soc Psychol Bull.* 2010;36(6):792-804. doi:10.1177/0146167210371383
194. Mumford SL, Siega-Riz AM, Herring A, Evenson KR. Dietary Restraint and Gestational Weight Gain. *J Am Diet Assoc.* 2008;108(10):1646-1653. doi:10.1016/J.JADA.2008.07.016
195. Heery E, Wall PG, Kelleher CC, McAuliffe FM. Effects of dietary restraint and weight gain attitudes on gestational weight gain. *Appetite.* 2016;107:501-510. doi:10.1016/J.APPET.2016.08.103
196. Blau LE, Orloff NC, Flammer A, Slatch C, Hormes JM. Food craving frequency mediates the relationship between emotional eating and excess weight gain in pregnancy. *Eat Behav.* 2018;31:120-124. doi:10.1016/J.EATBEH.2018.09.004
197. Hutchinson AD, Charters M, Prichard I, Fletcher C, Wilson C. Understanding maternal dietary choices during pregnancy: The role of social norms and mindful eating. *Appetite.* 2017;112:227-234. doi:10.1016/J.APPET.2017.02.004
198. de Campora G, Giromini L, Larciprete G, Li Volsi V, Zavattini GC. The impact of maternal overweight and emotion regulation on early eating behaviors. *Eat Behav.* 2014;15(3):403-409. doi:10.1016/J.EATBEH.2014.04.013
199. Li H, Bowen A, Bowen R, et al. Mood instability during pregnancy and postpartum: a systematic review. *Arch Womens Ment Health.* March 2019:1-13. doi:10.1007/s00737-019-00956-6
200. Telles S. A theory of disease from ancient yoga texts. *Med Sci Monit.* 2010;16(6):LE9.
201. Menezes CB, Pereira MG, Bizarro L. Sitting and silent meditation as a strategy to study emotion regulation. *Psychol Neurosci.* 2012;5(1):27-36. doi:10.3922/j.psns.2012.1.05

202. Kyrou I, Tsigos C. Stress hormones: physiological stress and regulation of metabolism. *Gastrointestinal/Endocrine Metab Dis*. 2009;9(6):787-793. doi:http://dx.doi.org.ezproxy1.lib.asu.edu/10.1016/j.coph.2009.08.007
203. Kingston D, Sword W, Krueger P, Hanna S, Markle-Reid M. Life Course Pathways to Prenatal Maternal Stress. *J Obstet Gynecol Neonatal Nurs*. 2012;41(5):609-626. doi:10.1111/j.1552-6909.2012.01381.x
204. Austin M, Leader L. Maternal stress and obstetric and infant outcomes: epidemiological findings and neuroendocrine mechanisms. *Aust New Zeal J Obstet Gynaecol*. 2000;40(3):331-337. doi:10.1111/j.1479-828X.2000.tb03344.x
205. Block JP, He Y, Zaslavsky AM, Ding L, Ayanian JZ. Psychosocial stress and change in weight among US adults. *Am J Epidemiol*. 2009;170(2):181-192. doi:10.1093/aje/kwp104
206. Selye H. The Evolution of the Stress Concept: The originator of the concept traces its development from the discovery in 1936 of the alarm reaction to modern therapeutic applications of syntoxic and catatoxic hormones. *Am Sci*. 1973;61(6):692-699.
207. Coussons-Read ME. The psychoneuroimmunology of stress in pregnancy. *Curr Dir Psychol Sci*. 2012;21(5):323-328.
208. Talley L. Stress Management in Pregnancy. *Int J Childbirth Educ*. 2013;28(1).
209. Liou S-R, Wang P, Cheng C-Y. Longitudinal study of perinatal maternal stress, depressive symptoms and anxiety. *Midwifery*. 2014;30(6):795-801. doi:10.1016/j.midw.2013.11.007
210. Hobel CJ, Goldstein A, Barrett ES. Psychosocial stress and pregnancy outcome. *Clin Obstet Gynecol*. 2008;51(2):333-348. doi:10.1097/GRF.0b013e31816f2709
211. Witt WP, Litzelman K, Cheng ER, Wakeel F, Barker ES. Measuring stress before and during pregnancy: a review of population-based studies of obstetric outcomes. *Matern Child Health J*. 2014;18(1):52-63.
212. Urizar Jr GG, Hurtz SQ, Albright CL, Ahn DK, Atienza AA, King AC. Influence of maternal stress on successful participation in a physical activity intervention: the IMPACT Project. *Women Health*. 2006;42(4):63-82.
213. Whitaker K, Young-Hyman D, Vernon M, Wilcox S. Maternal stress predicts postpartum weight retention. *Matern Child Health J*. 2014;18(9):2209-2217.
214. Satyapriya M, Nagendra HR, Nagarathna R, Padmalatha V. Effect of integrated yoga on stress and heart rate variability in pregnant women. *Int J Gynecol Obstet*. 2009;104(3):218-222.

215. Field T, Diego M, Delgado J, Medina L. Yoga and social support reduce prenatal depression, anxiety and cortisol. *J Bodyw Mov Ther.* 2013;17(4):397-403.
216. Breedlove G, Fryzelka D. Depression Screening During Pregnancy. *J Midwifery Womens Health.* 2011;56(1):18-25. doi:10.1111/j.1542-2011.2010.00002.x
217. Vesga-Lopez O, Blanco C, Keyes K, Olfson M, Grant BF, Hasin DS. Psychiatric disorders in pregnant and postpartum women in the United States. *Arch Gen Psychiatry.* 2008;65(7):805-815. doi:10.1001/archpsyc.65.7.805
218. Farr SL, Bitsko RH, Hayes DK, Dietz PM. Mental health and access to services among US women of reproductive age. *Am J Obstet Gynecol.* 2010;203(6):542.e1-542.e9. doi:10.1016/j.ajog.2010.07.007
219. Le Strat Y, Dubertret C, Le Foll B. Prevalence and correlates of major depressive episode in pregnant and postpartum women in the United States. *J Affect Disord.* 2011;135(1-3):128-138. doi:10.1016/j.jad.2011.07.004
220. Grote NK, Bridge JA, Gavin AR, Melville JL, Iyengar S, Katon WJ. A Meta-analysis of Depression During Pregnancy and the Risk of Preterm Birth, Low Birth Weight, and Intrauterine Growth Restriction. *Arch Gen Psychiatry.* 2010;67(10):1012-1024. doi:10.1001/archgenpsychiatry.2010.111
221. Pearlstein T. Depression during Pregnancy. *Best Pract Res Clin Obstet Gynaecol.* 2015;29(5):754-764. doi:10.1016/J.BPOBGYN.2015.04.004
222. Laraia BA, Siega-Riz AM, Dole N, London E. Pregravid Weight Is Associated With Prior Dietary Restraint and Psychosocial Factors During Pregnancy. *Obesity.* 2009;17(3):550-558. doi:10.1038/oby.2008.585
223. Faria-Schützer DB, Surita FG, Nascimento SL, Vieira CM, Turato E. Psychological issues facing obese pregnant women: a systematic review. *J Matern Neonatal Med.* 2017;30(1):88-95. doi:10.3109/14767058.2016.1163543
224. Zuckerman B, Amaro H, Bauchner H, Cabral H. Depressive symptoms during pregnancy: Relationship to poor health behaviors. *Am J Obstet Gynecol.* 1989;160(5):1107-1111. doi:10.1016/0002-9378(89)90170-1
225. Molyneaux E, Poston L, Khondoker M, Howard LM. Obesity, antenatal depression, diet and gestational weight gain in a population cohort study. *Arch Womens Ment Health.* 2016;19(5):899-907. doi:10.1007/s00737-016-0635-3
226. Bodnar LM, Wisner KL, Moses-Kolko E, Sit DK, Hanusa BH. Prepregnancy body mass index, gestational weight gain, and the likelihood of major depressive disorder during pregnancy. *J Clin Psychiatry.* 2009;70(9):1290-1296. doi:10.4088/JCP.08m04651

227. Webb JB, Siega-Riz AM, Dole N. Psychosocial Determinants of Adequacy of Gestational Weight Gain. *Obesity*. 2009;17(2):300-309. doi:10.1038/oby.2008.490
228. Parcells DA. Women's mental health nursing: depression, anxiety and stress during pregnancy. *J Psychiatr Ment Health Nurs*. 2010;17(9):813-820.
229. Nascimento SL, Surita FG, Cecatti JG. Physical exercise during pregnancy: a systematic review. *Curr Opin Obstet Gynecol*. 2012;24(6):387-394. doi:10.1097/GCO.0b013e328359f131
230. Nazik E, Eryilmaz G. Incidence of pregnancy-related discomforts and management approaches to relieve them among pregnant women. *J Clin Nurs*. 2014;23(11-12):1736-1750. doi:10.1111/jocn.12323
231. Davis DC. The Discomforts of Pregnancy. *J Obstet Gynecol Neonatal Nurs*. 1996;25(1):73-81. doi:10.1111/j.1552-6909.1996.tb02516.x
232. Zdziarski LA, Wasser JG, Vincent HK. Chronic pain management in the obese patient: a focused review of key challenges and potential exercise solutions. *J Pain Res*. 2015;8:63-77. doi:10.2147/JPR.S55360
233. Okifuji A, Hare BD. The association between chronic pain and obesity. *J Pain Res*. 2015;8:399-408. doi:10.2147/JPR.S55598
234. Vincent KR, Vincent HK. Resistance Exercise for Knee Osteoarthritis. *PM&R*. 2012;4(5):S45-S52. doi:10.1016/J.PMRJ.2012.01.019
235. Jiang L, Rong J, Wang Y, et al. The relationship between body mass index and hip osteoarthritis: A systematic review and meta-analysis. *Jt Bone Spine*. 2011;78(2):150-155. doi:10.1016/J.JBSPIN.2010.04.011
236. Jiang L, Tian W, Wang Y, et al. Body mass index and susceptibility to knee osteoarthritis: A systematic review and meta-analysis. *Jt Bone Spine*. 2012;79(3):291-297. doi:10.1016/J.JBSPIN.2011.05.015
237. Prather H, Spitznagle T, Hunt D. Benefits of Exercise During Pregnancy. *PM&R*. 2012;4(11):845-850. doi:10.1016/J.PMRJ.2012.07.012
238. Price BB, Amini SB, Kappeler K. Exercise in Pregnancy: Effect on Fitness and Obstetric Outcomes-A Randomized Trial. *Med Sci Sport Exerc*. 2012;44(12):2263-2269. doi:10.1249/MSS.0b013e318267ad67
239. Posadzki P, Ernst E, Terry R, Lee MS. Is yoga effective for pain? A systematic review of randomized clinical trials. *Complement Ther Med*. 2011;19(5):281-287. doi:10.1016/J.CTIM.2011.07.004
240. Cramer H, Ward L, Steel A, Lauche R, Dobos G, Zhang Y. Prevalence, Patterns,

- and Predictors of Yoga Use: Results of a U.S. Nationally Representative Survey. *Am J Prev Med.* 2016;50(2):230-235. doi:10.1016/J.AMEPRE.2015.07.037
241. Nambi GS, Inbasekaran D, Khuman R, Devi S, Shanmugananth, Jagannathan K. Changes in pain intensity and health related quality of life with Iyengar yoga in nonspecific chronic low back pain: A randomized controlled study. *Int J Yoga.* 2014;7(1):48-53. doi:10.4103/0973-6131.123481
  242. Boroujeni MZ, Marandi SM, Esfarjani F, Sattar M, Shaygannejad V, Javanmard SH. Yoga intervention on blood NO in female migraineurs. *Adv Biomed Res.* 2015;4:259. doi:10.4103/2277-9175.172995
  243. Kisan R, Sujan M, Adoor M, et al. Effect of Yoga on migraine: A comprehensive study using clinical profile and cardiac autonomic functions. *Int J Yoga.* 2014;7(2):126-132. doi:10.4103/0973-6131.133891
  244. Mudd LM, Owe KM, Mottola MM, Pivarnik JM. Health Benefits of Physical Activity during Pregnancy. *Med Sci Sport Exerc.* 2013;45(2):268-277. doi:10.1249/MSS.0b013e31826cebc
  245. Melzer K, Schutz Y, Boulvain M, Kayser B. Physical activity and pregnancy. *Sport Med.* 2010;40(6):493-507.
  246. Caspersen CJ, Powell KE, Christenson GM. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Rep.* 1985;100(2):126-131.
  247. Butte NF, Wong WW, Treuth MS, Ellis KJ, O'Brian Smith E. Energy requirements during pregnancy based on total energy expenditure and energy deposition. *Am J Clin Nutr.* 2004;79(6):1078-1087. doi:10.1093/ajcn/79.6.1078
  248. Thomas DM, Navarro-Barrientos JE, Rivera DE, et al. Dynamic energy-balance model predicting gestational weight gain. *Am J Clin Nutr.* 2012;95(1):115-122. doi:10.3945/ajcn.111.024307
  249. Bernstein AM, Bar J, Ehrman JP, Golubic M, Roizen MF. Yoga in the management of overweight and obesity. *Am J Lifestyle Med.* 2013;8(1):1559827613492097.
  250. Sedov ID, Cameron EE, Madigan S, Tomfohr-Madsen LM. Sleep quality during pregnancy: A meta-analysis. *Sleep Med Rev.* 2018;38:168-176.
  251. Naud K, Ouellet A, Brown C, Pasquier J-C, Moutquin J-M. Is sleep disturbed in pregnancy? *J Obstet Gynaecol Canada.* 2010;32(1):28-34.
  252. Okun ML, Schetter CD, Glynn LM. Poor sleep quality is associated with preterm birth. *Sleep.* 2011;34(11):1493-1498.

253. Naghi I, Keypour F, Ahari SB, Tavalai SA, Khak M. Sleep disturbance in late pregnancy and type and duration of labour. *J Obstet Gynaecol (Lahore)*. 2011;31(6):489-491.
254. Tomfohr LM, Buliga E, Letourneau NL, Campbell TS, Giesbrecht GF. Trajectories of Sleep Quality and Associations with Mood during the Perinatal Period. *Sleep*. 2015;38(8):1237-1245. doi:10.5665/sleep.4900
255. Mellor R, Chua SC, Boyce P. Antenatal depression: an artefact of sleep disturbance? *Arch Womens Ment Health*. 2014;17(4):291-302. doi:10.1007/s00737-014-0427-6
256. Skouteris H, Wertheim EH, Germano C, Paxton SJ, Milgrom J. Assessing Sleep During Pregnancy: A Study Across Two Time Points Examining the Pittsburgh Sleep Quality Index and Associations with Depressive Symptoms. *Women's Heal Issues*. 2009;19(1):45-51. doi:10.1016/J.WHI.2008.10.004
257. Chang JJ, Pien GW, Duntley SP, Macones GA. Sleep deprivation during pregnancy and maternal and fetal outcomes: Is there a relationship? *Sleep Med Rev*. 2010;14(2):107-114. doi:10.1016/J.SMRV.2009.05.001
258. Ayas NT, White DP, Al-Delaimy WK, et al. A prospective study of self-reported sleep duration and incident diabetes in women. *Diabetes Care*. 2003;26(2):380-384. doi:10.2337/diacare.26.2.380
259. Althuisen E, van Poppel MNM, Seidell JC, van Mechelen W. Correlates of Absolute and Excessive Weight Gain During Pregnancy. *J Women's Heal*. 2009;18(10):1559-1566. doi:10.1089/jwh.2008.1275
260. Gay CL, Richoux SE, Beebe KR, Lee KA. Sleep disruption and duration in late pregnancy is associated with excess gestational weight gain among overweight and obese women. *Birth*. 2017;44(2):173-180.
261. Sharkey KM, Boni GM, Quattrucci JA, Blatch S, Carr SN. Women with postpartum weight retention have delayed wake times and decreased sleep efficiency during the perinatal period: a brief report. *Sleep Heal*. 2016;2(3):225-228. doi:10.1016/J.SLEH.2016.05.002
262. Xiao RS, Kroll-Desrosiers AR, Goldberg RJ, Pagoto SL, Person SD, Waring ME. The impact of sleep, stress, and depression on postpartum weight retention: A systematic review. *J Psychosom Res*. 2014;77(5):351-358. doi:10.1016/J.JPSYCHORES.2014.09.016
263. Skouteris H, Germano C, Wertheim Eh, Paxton Sj, Milgrom J. Sleep quality and depression during pregnancy: a prospective study. *J Sleep Res*. 2008;17(2):217-220. doi:10.1111/j.1365-2869.2008.00655.x

264. Hilson JA, Rasmussen KM, Kjolhede CL. Excessive weight gain during pregnancy is associated with earlier termination of breast-feeding among white women. *J Nutr.* 2006;136(1):140-146.
265. Nehring I, Schmoll S, Beyerlein A, Hauner H, Von Kries R. Gestational weight gain and long-term postpartum weight retention: a meta-analysis. *Am J Clin Nutr.* 2011;94(5):1225. doi:10.3945/ajcn.111.015289
266. Robinson SM, Crozier SR, Harvey NC, et al. Modifiable early-life risk factors for childhood adiposity and overweight: an analysis of their combined impact and potential for prevention. *Am J Clin Nutr.* 2015;101(2):368. doi:10.3945/ajcn.114.094268
267. Rooney BL, Schauburger CW. Excess pregnancy weight gain and long-term obesity: one decade later. *Obstet Gynecol.* 2002;100(2):245-252. doi:10.1016/S0029-7844(02)02125-7
268. Pugh SJ, Richardson GA, Hutcheon JA, et al. Maternal Obesity and Excessive Gestational Weight Gain Are Associated with Components of Child Cognition. *J Nutr.* 2015;145(11):2562. doi:10.3945/jn.115.215525
269. Oken E, Taveras EM, Kleinman KP, Rich-Edwards JW, Gillman MW. Gestational weight gain and child adiposity at age 3 years. *Am J Obstet Gynecol.* 2007;196(4):322. e1-322. e8.
270. Ruchat S, Davenport M, Giroux I, et al. Nutrition and exercise reduce excessive weight gain in normal-weight pregnant women. *Med Sci Sports Exerc.* 2012;44(8):1419-1426. doi:10.1249/MSS.0B013E31825365F1
271. Beddoe AE, Paul Yang C-P, Kennedy HP, Weiss SJ, Lee KA. The effects of mindfulness-based yoga during pregnancy on maternal psychological and physical distress. *JOGNN - J Obstet Gynecol Neonatal Nurs.* 2009;38(3):310-319. doi:10.1111/j.1552-6909.2009.01023.x
272. Freedman F. *Yoga for Pregnancy, Birth and Beyond.* New York City, NY: DK Publishing Inc; 2004.
273. American College of Obstetricians and Gynecologists. *Your Pregnancy and Childbirth: Month to Month.* 6th ed. Washington DC: ACOG; 2016.
274. Brown KKW. The benefits of being present: Mindfulness and its role in psychological well-being. *J Pers Soc Psychol.* 2003;84(4):822; 822-848.
275. Gross JJ, John OP. Individual differences in two emotion regulation processes: implications for affect, relationships, and well-being. *J Pers Soc Psychol.* 2003;85(2):348.

276. Sutton A. Measuring the Effects of Self-Awareness: Construction of the Self-Awareness Outcomes Questionnaire. *Eur J Psychol.* 2016;12(4):645.
277. Buysse DJ, Reynolds 3rd CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res.* 1989;28(2):193-213. doi:0165-1781(89)90047-4
278. Qiu C, Gelaye B, Zhong Q-Y, Enquobahrie D, Frederick I, Williams M. Construct validity and factor structure of the Pittsburgh Sleep Quality Index among pregnant women in a Pacific-Northwest cohort. *Sleep Breath.* 2016;20(1):293-301. doi:10.1007/s11325-016-1313-4
279. Cox JL, Holden JM, Sagovsky R. Detection of postnatal depression. Development of the 10-item Edinburgh Postnatal Depression Scale. *Br J Psychiatry.* 1987;150:782-786.
280. Gunning MD, Denison FC, Stockley CJ, Ho SP, Sandhu HK, Reynolds RM. Assessing maternal anxiety in pregnancy with the State-Trait Anxiety Inventory (STAI): Issues of validity, location and participation. *J Reprod Infant Psychol.* 2010;28(3):266-273. doi:10.1080/02646830903487300
281. Cohen J. *Statistical Power Analysis for the Behavioral Sciences.* Lawrence Erlbaum; 1988.
282. Roberti Harrington LN, Storch EA JW. Further psychometric support for the 10-item version of the Perceived Stress Scale. *J Coll Couns.* 2006;9(2):135-147.
283. Council I of M and NR. *Weight Gain During Pregnancy.* Washington, D.C.: National Academies Press; 2009. doi:10.17226/12584
284. Davis K, Goodman SH, Leiferman J, Taylor M, Dimidjian S. A randomized controlled trial of yoga for pregnant women with symptoms of depression and anxiety. *Complement Ther Clin Pract.* 2015;21(3):166-172. doi:10.1016/J.CTCP.2015.06.005
285. Yoga Alliance. The 2016 Yoga in America Study.; 2016. [https://www.yogaalliance.org/Portals/0/2016 Yoga in America Study RESULTS.pdf](https://www.yogaalliance.org/Portals/0/2016%20Yoga%20in%20America%20Study%20RESULTS.pdf). Accessed June 25, 2019.
286. Iyengar BKS. *Light on Yoga: Yoga Dipika.* New York: Schocken Books; 1979.
287. Louie L. The Effectiveness of Yoga for Depression: A Critical Literature Review. *Issues Ment Health Nurs.* 2014;35(4):265-276.
288. Cramer H, Lauche R, Haller H, Steckhan N, Michalsen A, Dobos G. Effects of yoga on cardiovascular disease risk factors: a systematic review and meta-analysis. *Int J Cardiol.* 2014;173(2):170-183.



289. Tekur P, Singphow C, Nagendra HR, Raghuram N. Effect of short-term intensive yoga program on pain, functional disability and spinal flexibility in chronic low back pain: a randomized control study. *J Altern Complement Med*. 2008;14(6):637-644.
290. Kosuri M, Sridhar GR. Yoga practice in diabetes improves physical and psychological outcomes. *Metab Syndr Relat Disord*. 2009;7(6):515-518.
291. Buffart LM, Van Uffelen JGZ, Riphagen II, et al. Physical and psychosocial benefits of yoga in cancer patients and survivors, a systematic review and meta-analysis of randomized controlled trials. *BMC Cancer*. 2012;12(1):559.
292. Satyapriya M, Nagarathna R, Padmalatha V, Nagendra HR. Effect of integrated yoga on anxiety, depression & well being in normal pregnancy. *Complement Ther Clin Pract*. 2013;19(4):230. doi:10.1016/j.ctcp.2013.06.003
293. Riley K, Drake E. The Effects of Prenatal Yoga on Birth Outcomes: A Systematic Review of the Literature. *J Prenat Perinat Psychol Heal*. 2013;28(1).
294. Matthews J. Investigating the feasibility and preliminary effects of a prenatal yoga intervention to prevent excessive gestational weight gain: A randomized controlled trial. (In preparation).
295. Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol*. 2006;3(2):77-101.
296. Uebelacker LA, Kraines M, Broughton MK, et al. Perceptions of hatha yoga amongst persistently depressed individuals enrolled in a trial of yoga for depression. *Complement Ther Med*. 2017;34:149-155. doi:10.1016/J.CTIM.2017.06.008
297. Kinser P, Masho S. "I just start crying for no reason": the experience of stress and depression in pregnant, urban, African-American adolescents and their perception of yoga as a management strategy. *Womens Health Issues*. 2015;25(2):142-148. doi:10.1016/j.whi.2014.11.007
298. Jukic AMZ, Evenson KR, Herring AH, Wilcox AJ, Hartmann KE, Daniels JL. Correlates of Physical Activity at Two Time Points during Pregnancy. *J Phys Act Heal*. 2012;9(3):325-335. doi:10.1123/jpah.9.3.325
299. Evenson KR. Towards an understanding of change in physical activity from pregnancy through postpartum. *Psychol Sport Exerc*. 2011;12(1):36-45. doi:10.1016/J.PSYCHSPORT.2010.04.010
300. McDonald SM, Liu J, Wilcox S, Lau EY, Archer E. Does dose matter in reducing gestational weight gain in exercise interventions? A systematic review of literature. *J Sci Med Sport*. 2016;19(4):323-335.

doi:10.1016/J.JSAMS.2015.03.004

301. Field T. Prenatal exercise research. *Infant Behav Dev.* 2012;35(3):397-407. doi:10.1016/J.INFBEH.2011.10.001
302. Campbell VR, Nolan M. A qualitative study exploring how the aims, language and actions of yoga for pregnancy teachers may impact upon women's self-efficacy for labour and birth. *Women and Birth.* 2016;29(1):3-11. doi:10.1016/J.WOMBI.2015.04.007
303. Kinser PA, Bourguignon C, Taylor AG, Steeves R. "A Feeling of Connectedness": Perspectives on a Gentle Yoga Intervention for Women with Major Depression. *Issues Ment Health Nurs.* 2013;34(6):402-411. doi:10.3109/01612840.2012.762959
304. Bonura KB. Yoga Mind While Expecting: The Psychological Benefits of Prenatal Yoga Practice. *Int J Childbirth Educ* |. 2014;29(4):49-54.
305. Alexander GK, Innes KE, Selfe TK, Brown CJ. "More than I expected": Perceived benefits of yoga practice among older adults at risk for cardiovascular disease. *Complement Ther Med.* 2013;21(1):14-28. doi:10.1016/J.CTIM.2012.11.001
306. McCall M, Thorne S, Ward A, Heneghan C. Yoga in adult cancer: an exploratory, qualitative analysis of the patient experience. *BMC Complement Altern Med.* 2015;15(1):245. doi:10.1186/s12906-015-0738-9
307. Ross A, Brooks A, Touchton-Leonard K, Wallen G. A Different Weight Loss Experience: A Qualitative Study Exploring the Behavioral, Physical, and Psychosocial Changes Associated with Yoga That Promote Weight Loss. *Evidence-Based Complement Altern Med.* 2016;2016:1-11. doi:10.1155/2016/2914745
308. Spadola CE, Rottapel R, Khandpur N, et al. Enhancing yoga participation: A qualitative investigation of barriers and facilitators to yoga among predominantly racial/ethnic minority, low-income adults. *Complement Ther Clin Pract.* 2017;29:97-104. doi:10.1016/J.CTCP.2017.09.001
309. Danhauer SC, Tooze JA, Farmer DF, et al. Restorative Yoga for Women with Ovarian or Breast Cancer: Findings from a Pilot Study. *J Soc Integr Oncol.* 2008;6(2):47-58. doi:10.2310/7200.2008.0008
310. Lasater J. *Relax and Renew: Restful Yoga for Stressful Times.* (Holly Hammond LC, ed.). Boulder: Shambala Publications; 2016.
311. Maehle G. *Ashtanga Yoga: Practice and Philosophy.* Novato: New World Library; 2007.

312. Coll CVN, Domingues MR, Gonçalves H, Bertoldi AD. Perceived barriers to leisure-time physical activity during pregnancy: A literature review of quantitative and qualitative evidence. *J Sci Med Sport*. 2017;20(1):17-25. doi:10.1016/J.JSAMS.2016.06.007
313. Quilty MT, Saper RB, Goldstein R, Khalsa SBS. Yoga in the Real World: Perceptions, Motivators, Barriers, and Patterns of Use. *Glob Adv Heal Med*. 2013;2(1):44-49. doi:10.7453/gahmj.2013.2.1.008
314. Symons Downs D, Hausenblas HA. Women's exercise beliefs and behaviors during their pregnancy and postpartum. *J Midwifery Womens Health*. 2004;49(2):138-144. doi:10.1016/J.JMWH.2003.11.009
315. Evenson KR, Moos M-K, Carrier K, Siega-Riz AM. Perceived Barriers to Physical Activity Among Pregnant Women. *Matern Child Health J*. 2009;13(3):364-375. doi:10.1007/s10995-008-0359-8
316. Streuling I, Beyerlein A, Rosenfeld E, Hofmann H, Schulz T, von Kries R. Physical activity and gestational weight gain: a meta-analysis of intervention trials. *BJOG An Int J Obstet Gynaecol*. 2011;118(3):278-284. doi:10.1111/j.1471-0528.2010.02801.x
317. Clarke PE, Gross H. Women's behaviour, beliefs and information sources about physical exercise in pregnancy. *Midwifery*. 2004;20(2):133-141. doi:10.1016/J.MIDW.2003.11.003
318. Duncombe D, Wertheim EH, Skouteris H, Paxton SJ, Kelly L. Factors related to exercise over the course of pregnancy including women's beliefs about the safety of exercise during pregnancy. *Midwifery*. 2009;25(4):430-438. doi:10.1016/J.MIDW.2007.03.002
319. Martins RF, Pinto e Silva JL, e Silva JL. Treatment of pregnancy-related lumbar and pelvic girdle pain by the yoga method: a randomized controlled study. *J Altern Complement Med*. 2014;20(1):24-31. doi:10.1089/acm.2012.0715
320. Narendran S, Nagarathna R, Narendran V, Gunasheela S, Nagendra HRR. Efficacy of Yoga on Pregnancy Outcome. *J Altern Complement Med*. 2005;11(2):237-244. doi:10.1089/acm.2005.11.237
321. Solbrig L, Jones R, Kavanagh D, May J, Parkin T, Andrade J. People trying to lose weight dislike calorie counting apps and want motivational support to help them achieve their goals. *Internet Interv*. 2017;7:23-31. doi:10.1016/J.INVENT.2016.12.003
322. Guth E. Counting Calories as an Approach to Achieve Weight Control. *JAMA*. 2018;319(3):225. doi:10.1001/jama.2017.21355

323. Camilleri GM, Mejean C, Bellisle F, Hercberg S, Peneau S. Mind-Body Practice and Body Weight Status in a Large Population-Based Sample of Adults. *Am J Prev Med.* 2016;50(4):e101-9. doi:10.1016/j.amepre.2015.10.005 [doi]
324. Ross A, Friedmann E, Bevans M, Thomas S. Frequency of Yoga Practice Predicts Health: Results of a National Survey of Yoga Practitioners. *Evidence-Based Complement Altern Med.* 2012;2012:1-10. doi:10.1155/2012/983258
325. Herring SJ, Nelson DB, Davey A, et al. Determinants of Excessive Gestational Weight Gain in Urban, Low-Income Women. *Women's Heal Issues.* 2012;22(5):e439-e446. doi:10.1016/J.WHI.2012.05.004