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## The Energy Expenditure and Feasibility of Two Prenatal Yoga Programs

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To the Graduate Council:

I am submitting herewith a thesis written by Doree Lynn Gardner entitled "The Energy Expenditure and Feasibility of Two Prenatal Yoga Programs." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Kinesiology.

Dawn P. Coe, Major Professor

We have read this thesis and recommend its acceptance:

Katie Kavanagh, Dixie L. Thompson

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

# The Energy Expenditure and Feasibility of Two Prenatal Yoga Programs

A Thesis Presented for the  
Master of Science  
Degree  
The University of Tennessee, Knoxville

Doree Lynn Gardner

August 2014

## **Dedication**

This thesis is dedicated to Taylor, for all his continuing love and support. Together  
we can achieve anything!

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## Abstract

**Purpose:** To determine the energy expenditure and feasibility of two different DVD-based prenatal yoga programs (static yoga practice and vinyasa practice). **Methods:** Participants were 25 women in their second trimester (13-28 weeks) who were screened for pregnancy-related risk factors. The two DVDs used were “Prenatal Yoga with Shiva Rea” (DVD A) which is a static yoga practice, and “Jennifer Wolfes Prenatal Vinyasa Yoga” (DVD B) which is a flow yoga practice. Both DVDs were approximately 50-55 minutes, and included three phases (warm up, main, cool down). Each subject completed both prenatal DVD routines approximately two weeks apart. The energy expenditure ( $\text{VO}_2$ , METs, and Kcals) was measured using the Viasys Jaeger Oxycon Mobile system. Enjoyment and feasibility were measured using an adapted version of the PACES questionnaire. **Results:** DVD B had significantly greater average total energy expenditure than DVD A ( $p < 0.001$ ). There was a significant interaction between phase, type of yoga, and  $\text{VO}_2$ ,  $F(3,21) = 61.15$ ,  $p < .001$ . DVD B had significantly greater average total bout heart rate (HR) than DVD A ( $p < 0.001$ ). There was a significant interaction between phase, type of yoga, and HR,  $F(1,16) = 10.318$ ,  $p = 0.005$ . There were no differences between yoga DVD program type for feasibility ( $p = 0.397$ ) or enjoyment ( $p = 0.886$ ). The rating of perceived exertion (RPE) was significantly higher for DVD B compared to DVD A (14.12 vs. 11,  $p < 0.001$ ). **Conclusion:** The energy expenditure of “vinyasa” style prenatal yoga (DVD B) was significantly higher than standard prenatal yoga. Additionally, both DVDs were found to be equally enjoyable and feasible. These

results provide data regarding energy expenditure and can be useful in providing options for activity during pregnancy.



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# **CHAPTER 1**

## **INTRODUCTION**

Exercise during pregnancy provides many health benefits for the mother and the fetus<sup>1-3</sup>. These benefits include reduced risk for maternal complications such as preeclampsia and gestational diabetes mellitus (GDM) and reduced fetal complications such as unfavorable fetal birth weight, hyperinsulinemia, and hypoglycemia<sup>2,4,5</sup>. The 2008 Physical Activity Guidelines for Americans recommends that during pregnancy women should engage in at least 150 minutes of moderate-to-vigorous intensity physical activity per week<sup>6</sup>. However, recent research suggests that only about 23% of pregnant women engage in the recommended amount of physical activity<sup>7,8</sup>. Pregnancy is associated with a decline in the frequency and duration of physical activity<sup>7</sup>. Inactivity during pregnancy is cause for concern because pregnant women who do not engage in exercise forgo numerous health benefits<sup>7</sup>.

The type of exercise most beneficial during pregnancy is still unclear; however, many pregnant women turn to less strenuous forms of physical activity during gestation such as walking, water aerobics, and yoga<sup>1</sup>. A possible reason for yoga's growing popularity in the pregnant population may be health benefits associated with the practice in reducing stress, anxiety, insomnia, depression, back pain, and relief of muscular tension or pain<sup>9</sup>. Prenatal yoga practice has also been correlated to more favorable birth outcomes<sup>10</sup>. Limited research has focused on yoga during pregnancy despite the popularity of prenatal yoga programs and classes<sup>11</sup>.

Despite prenatal yoga's growing popularity<sup>12</sup> and the evidence supporting both the psychological and physical benefits, there is a lack of research in this area. Specifically, research investigating the energy expenditure and feasibility of prenatal yoga programs have yet to be reported. The lack of literature may explain the hesitance of some health professionals to recommend prenatal yoga for general well being during pregnancy. In fact, the American College of Obstetricians and Gynecologists (ACOG) does not even mention the word yoga in their committee opinion entitled "Exercise during Pregnancy and the Postpartum Period"<sup>1</sup>. Pregnancy is an important time in women's lives that may promote decreased physical activity<sup>13</sup>. For many women, being physically active during pregnancy is compromised by the physical and psychological demands that occur during this time<sup>13</sup>. Most commonly, women report barriers to physical activity during pregnancy due to physical limitations, restrictions, and lack of time<sup>13</sup>. Researchers have identified that low impact and less strenuous exercise options may be more feasible for women during pregnancy<sup>7</sup>. Yoga may be attractive as an alternative to traditional aerobic and strength training programs because it requires little space, virtually no equipment, has limited harmful side effects, and with its focus on relaxation, body awareness, and meditation provides a qualitatively different exercise experience which may be perceived as less strenuous and more pleasurable<sup>14</sup>. At this point, no studies have reported the energy expenditure or feasibility of prenatal yoga, leaving a fundamental gap in the research on this topic. Therefore, the purpose of this research study is to investigate both the energy expenditure and the feasibility of two different DVD-based prenatal yoga programs.

**Objectives:**

The current study has two main objectives:

1. Investigate the energy expenditure of two DVD prenatal yoga routines.
2. Determine the feasibility (defined by use and enjoyment) of two different DVD-based prenatal yoga programs.

Hypothesis: There will be differences in energy expenditure between the two types of DVD based yoga programs.

## **CHAPTER 2**

### **REVIEW OF LITERATURE**

#### **INTRODUCTION**

Pregnancy is often a time when women take steps to improve their lifestyle habits in order to provide the healthiest environment for the fetus. Decades of scientific evidence have demonstrated that physical activity during pregnancy is not only safe, but also beneficial for both women and their developing fetus<sup>1,7,15-20</sup>. The 2008 Physical Activity Guidelines for Americans state: “Unless a women has medical reasons to avoid physical activity during pregnancy, she can begin or continue moderate-intensity aerobic physical activity during her pregnancy and after the baby is born”<sup>6</sup>. Furthermore, the American College of Obstetricians and Gynecologists Committee Opinion on Exercise During Pregnancy and the Postpartum Period, updated in 2009, states: “In the absence of either medical or obstetric complications, 30 minutes or more of moderate exercise a day on most, if not all, days of the week is recommended for pregnant women, and pregnant women should be encouraged to engage in regular, moderate intensity physical activity to continue to derive the same associated health benefits during their pregnancies as they did prior to pregnancy”<sup>21</sup>. These guidelines are clear that women should stay active during pregnancy; however, a majority of women do not meet the recommended levels of physical activity before and during pregnancy<sup>16</sup>. This may be due to reported barriers to physical activity during pregnancy such as rapid physical changes and lack of feasibility of more traditional physical activities



used before pregnancy<sup>13</sup>. Further research is needed on benefits of more non-traditional physical activity programs such as yoga.

The purpose of this literature review is to provide a detailed description of physical activity trends during pregnancy, benefits of physical activity during pregnancy, and specifically current research on prenatal yoga.

## **HISTORY OF PHYSICAL ACTIVITY DURING PREGNANCY AND RECOMMENDATIONS**

In 1985, the American College of Obstetricians and Gynecologists (ACOG) released a bulletin regarding exercise and pregnancy advising women to reduce physical activity during pregnancy<sup>1</sup>. The bulletin suggested that maximum heart rate during pregnancy should not exceed 140 beats per minute and women should not take part in strenuous exercise for more than 15 minutes<sup>1</sup>. This advice was based on concerns that exercise could have negative effects on the mother and the fetus due to increased stress hormones, increased core temperature during embryogenesis, biomechanical stress and increased risk of maternal musculoskeletal injury due to changes in posture and ligament laxity, and by shunting the transport of oxygen and nutrients to maternal skeletal muscles rather than to the developing fetus<sup>4,22</sup>. These recommendations were mostly based on expert opinion due to the lack of scientific research of exercise during pregnancy available at that time<sup>4</sup>.

Following the original ACOG physical activity guidelines in 1985, research over the next decade focused on safety and the potential benefits of physical activity

performed during the gestational period. Results from these studies showed that any effects of physical activity on the mother and the fetus were likely to be beneficial, and not harmful as previously thought<sup>4</sup>. Specifically, retrospective studies of women who participated in leisure time physical activity throughout their pregnancies were less likely to develop pregnancy-related disorders such as preeclampsia, gestational diabetes, and gestational hypertension<sup>19</sup>. In 1994 ACOG revised the bulletin no longer recommending that women reduce physical activity during pregnancy and removing limitations and prohibitions regarding exercise during pregnancy; however, they still recommended that women avoid exercising to exhaustion<sup>23</sup>. In 2002, the current ACOG Committee Opinion #267 was released encouraging women without any contraindications to engage in at least 30 minutes of moderate intensity physical activity on most, if not all days of the week to continue to derive the health benefits of activity during their pregnancy<sup>21</sup>. In 2003 the Society of Obstetricians and Gynaecologists of Canada and the Canadian Society for Exercise Physiology released joint recommendations stating “all women without contraindications should be encouraged to participate in aerobic and strength conditioning exercises as part of a healthy lifestyle during their pregnancy”<sup>22</sup>. The Office of Disease Prevention and Health Promotion, within the U.S. Department of Health and Human Services, led the development of the first ever “Physical Activity Guidelines for Americans” in 2008. These guidelines complement the “Dietary Guidelines for Americans” as well as other national health promotion and disease prevention efforts, and include a section recommending physical activity specifications to pregnant women<sup>6</sup>. The guidelines specify that healthy pregnant

women who are not already doing vigorous intensity exercise, should get at least 150 minutes of moderate intensity aerobic activity per week.

With the high prevalence of overweight and obesity in America, it is important that all people participate in physical activity<sup>24-26</sup>. This is also true for pregnant women. Many women wish to continue to pursue an active lifestyle during pregnancy, while the pregnancy itself may provide the motivation for more sedentary women to begin an exercise program for the sake of improved health and fitness<sup>20</sup>. Although for many years physician groups advised against exercise during pregnancy, today, American physician groups encourage women with uncomplicated pregnancies to follow the current Physical Activity Guidelines for Americans<sup>6</sup>.

## **BENEFITS OF PHYSICAL ACTIVITY DURING PREGNANCY**

There is evidence that suggests that exercise positively affects pregnancy, labor, and pregnancy outcomes. For example, research has shown that women who are physically active during their pregnancies have decreased risk for conditions such as preeclampsia and gestational diabetes, faster labors, decreased excessive gestational weight gain, and decreased anxiety<sup>4,20,24,27</sup>. Additionally, women who exercise during pregnancy are more likely to continue to exercise postpartum<sup>28</sup>. Furthermore, with the mother's health choices during pregnancy having an enormous impact on the health of the growing baby, it is crucial for the mother to be proactive with her health habits especially during this time.

## **Healthy Body Weight**

Maintaining a healthy body weight and avoiding excess fat accumulation are frequently stated goals of women who choose to exercise during pregnancy<sup>29</sup>. Excessive gestational weight gain is a public health concern in many developed nations<sup>30</sup>. Women who gain excessive weight during pregnancy are more likely to develop gestational diabetes mellitus, deliver a baby by cesarean section, become obese postpartum, and put their child at risk of childhood overweight or obesity<sup>24,30</sup>. Research has shown that overall, weight and fat gain was significantly lower in a group of experienced exercisers who were active both before and during their pregnancies compared to a control group of previously active women who quit exercising before or during early pregnancy<sup>31</sup>. Additionally, objectively measured walking is significantly associated with reduced risk of excessive gestational weight gain in both the 2<sup>nd</sup> and 3<sup>rd</sup> trimesters<sup>30</sup>.

## **Prevention of Pregnancy Induced Complications**

Gestational Diabetes Mellitus (GDM) is defined by the American Diabetes Association as a form of glucose intolerance first diagnosed during pregnancy<sup>32</sup>. As obesity rates have increased, so has the prevalence of GDM with approximately 10% of all pregnant women developing this condition<sup>33,34</sup>. GDM is one of the most common complications of pregnancy and is associated with a substantially elevated risk of adverse health outcomes for both mothers and offspring<sup>35</sup>. Physical activity has been shown to be effective in preventing and managing GDM<sup>35</sup>. The responsible mechanisms are that glucose tolerance and insulin sensitivity is improved, while

muscle and liver glycogen storage is enhanced, thus reducing the incidence of hyperglycemia and hypoglycemia<sup>36</sup>. Higher levels of physical activity before and during early pregnancy are associated with significantly decreased risk for developing GDM<sup>35</sup>. Furthermore, physical activity can be used as an adjunctive therapy for women with GDM as a way to control blood glucose levels without the use of pharmacological intervention<sup>37</sup>.

Preeclampsia is characterized by hypertension and protein in the urine after 20 weeks of pregnancy<sup>15</sup>. It is the leading cause of perinatal morbidity and mortality in the developed world, and to date, the only means of treating the disease is by inducing delivery<sup>15,38</sup>. The incidence of preeclampsia has risen to 3-6% in the past 20 years<sup>38</sup>, and will likely keep climbing as a result of the obesity epidemic and incidence of hypertension<sup>39</sup>. The impact of exercise on reducing the risk of preeclampsia has long been debated; therefore, ACOG has yet to support the prescription of exercise training to women at risk for developing the disease<sup>15</sup>. There is, however, a significant body of research that supports the protective roles of physical activity against preeclampsia<sup>38</sup>. Epidemiological and clinical studies have shown that the rate of pregnancy-induced hypertension and preeclampsia may be lowered in women who engage in regular physical activity<sup>18,19,38</sup>. Most studies investigating the impact of physical activity in early pregnancy have demonstrated a significant decrease in preeclampsia risk compared with sedentary women<sup>15,18,19,38</sup>. Conversely, some studies have shown no protective role, or a non-significant decreased risk of preeclampsia with physical activity during pregnancy; however,

this may be attributable to the small number of cases, or the short evaluation period<sup>15,40,41</sup>.

### **Relief of Pregnancy Related Discomforts**

Some evidence supports that exercise may assist with many of the discomforts of a normal pregnancy. Women who are physically active have reported decreased incidence of constipation, improved bladder control, decreased incidence of varicose veins, improved sleep, less heartburn, and fewer leg cramps<sup>42</sup>. Additionally, women who are regularly physically active before and during pregnancy experience less pelvic girdle and low back pain<sup>43,44</sup>.

### **Ease of Labor and Delivery**

There is substantial evidence that suggests that physical activity may make pregnancy more comfortable, shorten labor, and reduce the need for obstetric interventions<sup>3</sup>. Compared with sedentary women, well-conditioned pregnant women were found to have significantly shorter labors, less need for obstetric intervention, and fewer signs of fetal compromise<sup>3,45</sup>. Consistent maternal exercise is also correlated with decreased requests for anesthetic and decreased perceived exertion during labor<sup>46</sup>.

### **Psychological Benefits**

Physical activity provides numerous psychological benefits as well as physiological benefits<sup>20</sup>. Although few studies have investigated the effect of

physical activity interventions on mental health during pregnancy, available evidence supports a beneficial effect<sup>20</sup>. Moderate physical activity during the third trimester has been associated with lower depression scores at six-week postpartum checkups<sup>27</sup>. Furthermore, postpartum exercise interventions have been shown effective in reducing symptoms of depression<sup>47</sup>.

## **YOGA**

Yoga is an ancient mind-body practice that originated in India and is becoming increasingly recognized and used in developed nations as a health practice<sup>48,49</sup>. The word yoga comes from the Sanskrit word “yug”, which directly translates as “to unite”; more broadly, it means to work towards a more unified experience of the self and improved health<sup>48</sup>. The physical practice of yoga postures (asanas) was originally intended to prepare the body for meditation; however, the practice of the postures has become synonymous with “yoga” in the Western world<sup>50</sup>. Traditionally, the practice of postures is one of eight different branches of the yoga framework: bhakti (devotion), karma (service), raja (meditation), mantra (chanting), laya (abstract thought), tantra (ritual), vedanta (philosophy), and hatha (physical)<sup>50,51</sup>.

Hatha yoga is the most common form of yoga practiced in North America<sup>50</sup>. Specifically, hatha yoga uses a combination of postures to enhance strength, flexibility, balance, and mind-body coordination<sup>52</sup>. Additionally, meditation and breathing exercises (pranayama) are practiced to focus and calm the mind while developing self-awareness<sup>50</sup>. Hatha yoga involves participants to hold and move

between a series of static postures. Main classifications of the different types of postures are standing, forward bends, backward bends, twists, balancing, inversions, and restoratives<sup>50,53</sup>. These postures require focused effort in completing the poses, controlling the body, and breathing at a steady rate<sup>50</sup>. Generally, a yoga pose requires isometric muscle contractions to stabilize the body in the posture. Depending on the style of yoga, the posture may be held for 30 seconds to several minutes<sup>54</sup>. The styles of hatha yoga are characterized by the rate at which the postures are performed, temperature and environment of the class, emphasis on body awareness, alignment, and breathing, physical intensity, and difficulty level of the postures selected<sup>50</sup>. Some of the many forms of hatha yoga popular in the United States are Hatha flow, Iyengar, restorative, Vinyasa, Bikram or “hot yoga”, Ashtanga, and Kundalini<sup>54</sup>. To meet the particular needs of the wide variety of individuals that practice yoga the use of props (straps and blocks) and posture modifications enables those of most functional abilities to practice yoga<sup>50</sup>. For the sake of this review, the term “yoga” will refer to Hatha yoga.

### **Metabolic Response to Hatha Yoga**

Unlike other traditional modes of physical activity, yoga is a hybrid form of activity that combines stretching, isometric muscle contractions, breathing exercises, and meditation. Despite yoga being an ancient practice, scientific research investigating the effects of this type of physical activity is relatively new. Although some studies have shown that yoga demonstrates significant musculoskeletal and metabolic health benefits, the degree to which the physical activity component of



the yoga may have contributed to these benefits has received very little attention<sup>49</sup>. Few studies have attempted to quantify the metabolic costs of yoga compared to more traditional forms of physical activity. Of the few studies that have investigated the intensity of yoga, most reported the average energy cost to be in the low to moderate range based on percentage of maximal heart rate and oxygen consumption ( $\text{VO}_2$ )<sup>14</sup>.

Two studies that investigated intensity of individual static Hatha yoga postures found that the postures elicited a light metabolic response correlating to less than three METs<sup>55,56</sup>. These two studies suggest that the intensity of Hatha yoga postures may not be vigorous enough to be considered adequate for increasing aerobic capacity according to the American College of Sports Medicine (ACSM) guidelines (e.g. 50 to 85% of maximum oxygen uptake reserve)<sup>55,57,58</sup>. Another study that investigated the metabolic response of a standard 30 minute Hatha yoga routine compared the yoga to sitting in chair and walking on the treadmill at a moderate pace (3.5 mph)<sup>57</sup>. This study found that the intensity of Hatha yoga was lower than walking on the treadmill at 3.5 mph at approximately 57% of maximum heart rate (MHR). The average MET value for the hatha yoga session was reported to be 2.17 METs, the average MET value for the treadmill walk was 4.62, and the average MET value for the resting in the chair was reported as 1.03 METs<sup>57</sup>. Furthermore, this study demonstrated the variability in metabolic responses of static yoga postures versus flow yoga postures done in the sun salutation series. The sun salutation is a continuous flow of floor and standing postures, which results in an initial rise followed by sustained elevated heart rate and  $\text{VO}_2$ , whereas static

postures are performed intermittently with rest postures in between. Therefore, on average, heart rate and  $\text{VO}_2$  responses are higher during the flow portion or sun salutation than during the other static postures<sup>54</sup>. The flow type postures executed during the portion of the routine that included the sun salutation series resulted in an average heart rate equivalent of 67% MHR, whereas the static yoga postures resulted in an average of 56% MHR<sup>57</sup>. Another study demonstrated that 32 minutes of Iyengar style hatha yoga, limited to only standing postures, required approximately 4 METs or 34%  $\text{VO}_2$  max. The MET value demonstrated in the study is categorized as “moderate intensity” which would fall into the basic guidelines for physical activity as recommended by “Physical Activity Guidelines for Americans;” however, this is still lower than the recommended ACSM guidelines for increasing aerobic capacity<sup>57</sup>.

The structure of yoga classes that is unique to this type of physical activity may greatly affect the measured intensity. Typical yoga sessions include postures held from 30 seconds to one minute with frequent breaks in between consisting of resting postures lying in the supine position<sup>54</sup>. Therefore, when the intensity across the entire session is averaged, it includes the intensity of these frequent rest postures called “savasanas” or corpse pose. A study investigating the acute physiological responses to hatha yoga postures in advanced practitioners reported the range of responses various yoga postures elicit<sup>59</sup>. The type of posture and duration of the posture significantly determines the physiologic responses such as heart rate,  $\text{VO}_2$ , and blood pressure<sup>59</sup>. There is a large difference in energy expenditure between common hatha yoga postures and savasana (rest posture)<sup>54</sup>.

For example, warrior III, a common standing yoga posture, elicits a  $\text{VO}_2$  of 14.6 mL/kg/min or 4 METs, whereas a common rest posture, savasana, elicits a  $\text{VO}_2$  of 3.6 mL/kg/min or 1 MET<sup>54,59</sup>. The researchers also reported that the physiological responses were significantly greater in standing postures and inversions versus supine and seated asanas<sup>59</sup>.

### **Health Benefits of Yoga**

Yoga programs have been rapidly gaining popularity as a form of exercise and a means of enhancing general health in the United States. In 2008, 15 million Americans reported that they practiced yoga<sup>11</sup>. Furthermore, yoga is perceived as a way to develop and maintain a healthy mind and body. Currently, the majority of scientific research investigating yoga emphasizes the mental health benefits, however, there is also growing body of literature that supports the psychological and physiological health benefits of yoga<sup>49,60,61</sup>. The potential health benefits of yoga range from stress reduction, to improved fitness and management of chronic conditions<sup>62</sup>.

Research has shown that yoga can be effective at alleviating depressive symptoms and improving quality of life for those diagnosed with a depressive disorder<sup>63,64</sup>. Compared to sedentary controls, yoga interventions show effectiveness in treating depression<sup>64</sup>. Yoga has also been shown to decrease perceived stress and anxiety<sup>65,66</sup>. Current research on yoga for posttraumatic stress disorder (PTSD) suggests a possible role of yoga in managing PTSD<sup>67</sup>. After a natural disaster, yoga practice was reported to significantly reduce symptoms of PTSD, self-

rated symptoms of stress (fear, anxiety, disturbed sleep, and sadness), and respiration rate<sup>68</sup>. Similarly, yoga interventions were able to improve symptoms of PTSD in persons exposed to combat or terrorism<sup>67</sup>. The mechanisms by which yoga elicits favorable mental health changes are not completely understood, however, there has been an attempt to explore electrophysiological markers and neurotransmitters, such as gamma-amino-butyric acid (GABA), cortisol, and serotonin, which were found to change with yoga<sup>69,70</sup>. Research studies have found that yoga interventions increase GABA and serotonin levels in the brain, while decreasing cortisol. Following a 60-min yoga posture session, a 34% increase in thalamic GABA levels has been shown in experienced yoga practitioners and a 15% increase in novices with 12 weeks of yoga posture training. There is also evidence that yoga promotes a reduction in sympathetic activation, enhancement of cardio-vagal function, and a shift in autonomic nervous system balance from primarily sympathetic to parasympathetic<sup>71</sup>. The autonomic nervous system plays a central role in stress response. Specifically, overly stressed individuals tend to have decreased parasympathetic nervous system activity (PNS) and increased sympathetic nervous system activity (SNS). The therapeutic effects of yoga can be understood in part through its direct effects on the autonomic nervous system and indirect effects on the GABA system<sup>72</sup>. Evidence suggests that yoga interventions increase parasympathetic nervous system activation, restoring optimal homeostasis to the autonomic nervous system<sup>72</sup>.

The efficacy of yoga to induce favorable psychological and physiological health outcomes has been shown in healthy and clinical populations<sup>62</sup>. The unique

combination of flexibility, strength, and motor control demands qualify yoga as a exercise to improve overall fitness<sup>50</sup>. Yoga postures are beneficial for maintaining and increasing flexibility, balance, and muscular strength and endurance<sup>50</sup>. Furthermore, yoga can help reduce risk factors for chronic diseases such as hypertension and inflammation<sup>50,62,73</sup>. In one intervention study, yoga resulted in reductions in body mass, systolic blood pressure, insulin concentrations, and triglycerides in individuals with at least one metabolic syndrome risk factor when performed twice per week for a 3-month period<sup>74</sup>. Another more traditional form of Hatha yoga, Iyengar yoga, has also been shown to reduce 24-hour blood pressures in pre-hypertensive and stage-I hypertensive individuals<sup>75</sup>. Furthermore, research investigating yoga and inflammation has shown that advanced yoga practitioners have significantly lower baseline levels of inflammatory cytokines such as interleukin 6 (IL-6) and C-reactive protein (CRP)<sup>76</sup>. An 8-week Hatha yoga intervention consisting of 3, 70-minute sessions per week reduced the pro-inflammatory cytokines IL-6 and CRP while increasing extracellular antioxidant superoxide dismutase in chronic heart failure patients<sup>77</sup>. Most recently, a randomized control trial investigating yoga's impact on inflammation in breast cancer survivors reported that 12 weeks of 90-minute yoga sessions, twice per week, resulted in significantly lower pro-inflammatory cytokines, specifically interleukin-6, tumor necrosis factor alpha, and interleukin-1 beta<sup>78</sup>.

Although not well established, studies investigating glucose metabolism and insulin have shown yoga to produce favorable outcomes for both lowering fasting blood glucose in individuals with type 2 diabetes, and increasing insulin

sensitivity<sup>62</sup>. Researchers at Harvard found that eight weeks of daily yoga significantly improved sleep quality for people with insomnia, whereas another study found that twice-weekly yoga sessions helped breast cancer survivors sleep better and feel less fatigued<sup>79,80</sup>. Recently, studies have revealed yoga induced physiological changes at the cellular level. One study found that yoga practice results in changes in gene expression that boosts immunity at the cellular level<sup>81</sup>. Yoga interventions have also been found to significantly decrease inflammatory cytokines in clinical and healthy populations<sup>61,81</sup>.

## **PRENATAL YOGA**

Yoga is perceived as a way to develop and maintain a healthy mind and body, and because of its low-impact and relaxing nature it has been gaining popularity as a mode of exercise during pregnancy<sup>82</sup>. A possible reason for yoga's growing popularity in the pregnant population may be health benefits associated with the practice in reducing stress, anxiety, insomnia, depression, back pain, and relief of muscular tension or pain<sup>9,10,73,83,84</sup>. Yoga is also an attainable way to stay fit during pregnancy because almost any yoga pose can be easily modified to fit the pregnant woman's needs and abilities<sup>82</sup>. However, little is known about the potential benefits and metabolic consequences of yoga among the pregnant population.

Pregnancy is a time when physiological and biomechanical changes occur rapidly as the body adapts to support the growing fetus<sup>4</sup>. This is especially true in the third trimester when the weight of the baby almost doubles, adding additional

strain on the low back, pelvic floor, and diaphragm<sup>29</sup>. Common complaints during this time include low back pain, lower extremity edema, urinary incontinence, and heartburn. In addition to the physiological stressors during this time, psychological stressors are often heightened; as there is a need to manage the various physical, emotional, mental, and pain states that arise throughout the stages of pregnancy and labor<sup>4</sup>. Yoga may be effective in the reduction of negative symptoms associated with pregnancy and birth<sup>49</sup>. Given its growing popularity, it is important to evaluate its effects on the maternal experience and to investigate gaps in the literature and direction for future research.

### **Prenatal Yoga and Mental Health**

Much of the limited prenatal yoga research focuses on mental health or psychological benefits of prenatal yoga practice during pregnancy. Researchers in India evaluated the effects of prenatal yoga on the quality of life and interpersonal relationships of 102 healthy pregnant women compared to standard antenatal exercises<sup>85</sup>. The program went from the 20<sup>th</sup> to 36<sup>th</sup> weeks of gestation and encompassed lectures, postures (asanas), breathing exercises (pranayama), and meditation. The yoga group had significantly greater improvements on the World Health Organization Quality of Life Inventory and Fundamental Interpersonal Relationships Orientation questionnaire. Specifically, the women in the yoga group reported significantly lower anxiety, depression, and stress when compared to the control group. The authors suggest that yoga may be a cost-effective and non-invasive way to improve mood and quality of life during pregnancy<sup>85</sup>. Another study

used a similar 16-18 week yoga program to investigate maternal stress during pregnancy<sup>73</sup>. A control group that received standard prenatal exercises was used. Stress was measured via questionnaire, and also objectively via heart rate variability. Self-reported perceived stress scores and heart rate variability both decreased significantly in the yoga group compared with the control group<sup>73</sup>. Specifically, perceived stress decreased by 31.6% in the yoga group with significantly lower heart rate variability, whereas the perceived stress increased by 6.6% in the control group<sup>73</sup>. Additional studies have found yoga programs during pregnancy to significantly reduce maternal feelings of anxiety and depression<sup>83,84</sup>. An 8-week prenatal yoga intervention that included 59 pregnant women reported decreased anxiety both subjectively via questionnaire, and physiologically via cortisol levels<sup>84</sup>. Another similar prenatal yoga intervention used three questionnaires, the pregnancy experiences questionnaire, the state trait anxiety inventory, and the hospital anxiety depression questionnaire, to evaluate yoga's impact on anxiety and depression. Compared to a control group, the yoga group reported 15.6% less anxiety and 30.7% less depression compared to 13.7% anxiety increase and 3.5% depression increase in the control group<sup>83</sup>,

### **Prenatal Yoga and Pregnancy Related Discomforts**

Research in Taiwan examined the effects of a 12-14 week prenatal yoga program during the 26<sup>th</sup> to 40<sup>th</sup> weeks of pregnancy on discomfort and childbirth self-efficacy, when compared to standard prenatal education<sup>9</sup>. The yoga group reported less discomfort in the 38-40<sup>th</sup> week of gestation and higher self-efficacy in



both the active and second stages of labor<sup>9</sup>. Additionally, a similar 12-week prenatal yoga intervention in Thailand found that the yoga program resulted in higher maternal comfort at three different assessment points during labor, lower self-reported maternal labor pain scores, and significantly shorter labor times, when compared to a control group<sup>86</sup>. No differences were found in the number of women with induced labors, or newborn APGAR scores<sup>86</sup>. Another prenatal yoga intervention study found that women in the yoga experimental group reported higher levels of comfort during labor and two hours post labor<sup>10</sup>. The experimental group was also found to have shorter duration of the first stage of labor, as well as total time of labor<sup>10</sup>.

### **Limitations to Current Prenatal Yoga Research and Future Directions**

Most of the literature investigating prenatal yoga to date has been conducted in Asian countries (India, Taiwan, Thailand), where yoga is more culturally accepted and common<sup>82</sup>. Thus, the results may not be applicable to other areas of the world where yoga is less prominent. Studies in different cultural settings are necessary to better evaluate the feasibility of yoga as a form of prenatal exercise<sup>82</sup>. Also, studies use a variety of yoga styles, so it is difficult to make comparisons between them. Despite yoga's growing popularity, there are limited numbers of randomized, controlled yoga studies using objective quantitative outcome measures and those studies often have small numbers of subjects<sup>75,87,88</sup>. Yoga interventions studies need to focus on larger participant samples, validated and reliable assessment instruments, specify inclusion and exclusion criteria, and use sound methodology

that is accurately reported. This would improve the usability of the study results and promote growth in the area of yoga research.

It is vital for prenatal yoga programs moving forward that the energy expenditure and feasibility of yoga programs be investigated to open the door for further research in this area. The feasibility of yoga intervention programs has been investigated in a variety of populations, however there is currently no standard protocol or validated questionnaire for assessing feasibility. The dictionary definition of feasibility is “the degree something is capable of being easily or conveniently done.” Previous studies investigating feasibility of yoga programs most often assess feasibility by measuring multiple factors such as program adherence, enjoyment, likeability, and feasibility of the programs<sup>57,87,89,90</sup>. A recent study found that a 12-week yoga intervention study was found to be both effective and feasible in reducing falls and improving mobility in the elderly<sup>87</sup>. Additionally, yoga interventions have been found feasible for individuals with arthritis, chronic obstructive pulmonary disease, breast cancer survivors, veterans with posttraumatic stress disorder, and young adults with intellectual disabilities<sup>58,89,90</sup>. However, the feasibility of yoga programs in the pregnant population has not yet been evaluated. Feasibility of programs is especially important during times of high stress and transition such as pregnancy<sup>13</sup>. Because many women report an increase of barriers to physical activity during pregnancy, it is important that potential exercise programs be both enjoyable and feasible for the participants<sup>13</sup>. For this reason, both the energy expenditure and feasibility of prenatal yoga programs should be evaluated.

## CONCLUSION

The importance of physical activity during pregnancy has been established, and current guidelines recommend that pregnant women participate in 150 minutes of moderate physical activity per week<sup>6</sup>. Pregnancy is associated with a decline in exercise frequency and duration<sup>7</sup>. Inactivity during pregnancy is cause for concern because prenatal women who do not engage in exercise forgo numerous health benefits<sup>8</sup>. The type of exercise most beneficial during pregnancy is still unclear; however, many pregnant women may turn to less strenuous forms of physical activity during gestation such as water aerobics, yoga, and walking<sup>7</sup>. Yoga programs have been rapidly gaining popularity as a form of exercise and a means of enhancing general health in the United States. Furthermore, yoga is perceived as a way to develop and maintain a healthy mind and body, and because of its low-impact and relaxing nature it has been gaining popularity as a mode of exercise during pregnancy<sup>82</sup>. Research supports that consistent exercise during pregnancy increases numerous health benefits for both the mother and the baby<sup>4,5,8</sup>. Specifically, a few studies have highlighted the benefits of prenatal yoga practice for the pregnant population, however, this research is very limited, and therefore further research in this area is needed<sup>82</sup>. With popularity of prenatal yoga programs on the rise, it is important that there be research quantifying the metabolic and physiological parameters of prenatal yoga.

## Chapter 3

### MANUSCRIPT

#### ABSTRACT

**Purpose:** To determine the energy expenditure and feasibility of two different DVD-based prenatal yoga programs (static yoga practice and vinyasa practice). **Methods:** Participants were 25 women in their second trimester (13-28 weeks) who were screened for pregnancy-related risk factors. The two DVDs used were “Prenatal Yoga with Shiva Rea” (DVD A) which is a static yoga practice, and “Jennifer Wolfes Prenatal Vinyasa Yoga” (DVD B) which is a flow yoga practice. Both DVDs were approximately 50-55 minutes, and included three phases (warm up, main activity, cool down). Each subject completed both prenatal DVD routines approximately two weeks apart. The energy expenditure ( $\text{VO}_2$ , METs, and Kcals) was measured using the Oxycon Mobile system. Enjoyment was measured using an adapted version of the PACES questionnaire. Feasibility was measured using a questionnaire specific to perceived feasibility and an activity log (usage of the DVD). **Results:** DVD B had significantly greater average total energy expenditure than DVD A ( $p < 0.001$ ). There was a significant interaction between phase, type of yoga, and  $\text{VO}_2$ ,  $F(3,21) = 61.15$ ,  $p < .001$ . DVD B had significantly greater average total bout heart rate (HR) than DVD A ( $p < 0.001$ ). There was a significant interaction between phase, type of yoga, and HR,  $F(1,16) = 10.318$ ,  $p = 0.005$ . There were no differences between yoga DVD program type for feasibility ( $p = 0.397$ ) or enjoyment ( $p = 0.886$ ). The rating of perceived exertion (RPE) was significantly higher for DVD B compared to DVD A (14.12 vs. 11,  $p < 0.001$ ). **Conclusion:** The energy expenditure of “vinyasa” style

prenatal yoga (DVD B) was significantly higher than standard prenatal yoga. Additionally, both DVDs were found to be equally enjoyable and feasible. These results provide data regarding energy expenditure and can be useful in providing options for activity during pregnancy.

## **INTRODUCTION**

Exercise during pregnancy provides many health benefits for the mother and the fetus<sup>1-3</sup>. These benefits include reduced risk for maternal complications such as preeclampsia and gestational diabetes mellitus (GDM) and reduced fetal complications such as unfavorable fetal birth weight, hyperinsulinemia, and hypoglycemia<sup>2,4,5</sup>. The 2008 Physical Activity Guidelines for Americans recommends that during pregnancy women should engage in at least 150 minutes of moderate-to-vigorous intensity physical activity per week<sup>6</sup>. However, recent research suggests that only about 23% of pregnant women engage in the recommended amount of physical activity<sup>7,8</sup>. Pregnancy is associated with a decline in the frequency and duration of physical activity<sup>7</sup>. Inactivity during pregnancy is cause for concern because pregnant women who do not engage in exercise forgo numerous health benefits<sup>7</sup>.

The type of exercise that is most beneficial during pregnancy is still unclear; however, many pregnant women turn to less strenuous forms of physical activity during gestation such as walking, water aerobics, and yoga<sup>1</sup>. Yoga is perceived as a

way to develop and maintain a healthy mind and body, and because of its low impact and modifiable nature, yoga is a plausible exercise for pregnant women<sup>82</sup>.

Pregnancy is an important time in women's lives that may encourage decreased physical activity levels<sup>13</sup>. For many women, being physically active during pregnancy is compromised by the physical and psychological demands that occur during this time<sup>13</sup>. Most commonly, women report barriers to physical activity during pregnancy due to physical limitations, medical restrictions, and lack of time<sup>13</sup>. Researchers have identified that low impact and less strenuous exercise options may be more feasible for women during pregnancy<sup>7</sup>. Yoga may be attractive as an alternative to traditional aerobic and strength training programs because it requires little space; virtually no equipment, has limited harmful side effects, and with its focus on relaxation, body awareness, and meditation provides a qualitatively different exercise experience that may be perceived as less strenuous and more pleasurable<sup>14</sup>.

Despite prenatal yoga's popularity and the evidence supporting both the psychological and physical benefits, scientific research in this area is scarce. It is important for prenatal programs moving forward that the energy expenditure during the yoga practice be investigated in order to create future research opportunities in this area. The energy expenditure during yoga practice in non-pregnant individuals has been investigated; however, prenatal energy expenditure has yet to be reported. Furthermore, because many women report increased barriers to physical activity during pregnancy, it is important that potential exercise programs be both enjoyable and feasible for participants<sup>13</sup>. Feasibility is defined by

the ease and convenience that a task can be completed. For the purposes of this study, feasibility was evaluated based on rated enjoyment, perceived feasibility, and DVD usage. The lack of prenatal yoga research leaves a fundamental gap in the research on this topic. Therefore, the purpose of this research study is to investigate both the energy expenditure and the feasibility of two different DVD-based prenatal yoga programs.

## **METHODS**

### **Participants**

Twenty-five pregnant women in their second trimester (13-28 weeks) participated in the current study. Participants were recruited from the Knoxville area by word of mouth, flyers, internet postings, and emails. All participants were at least 18 years of age, between 13 and 28 weeks gestation, had physician approval to participate in the study, and were inexperienced yoga practitioners. Participants were excluded from the study if these criteria were not met or if they had one or more contraindications for exercise, as outlined by the American College of Obstetricians and Gynecology. Each participant provided informed consent (Appendix A) prior to participating in the study. The University of Tennessee Institutional Review Board approved the protocol (Appendix B).

### **Protocol**

Participants reported to the laboratory on three separate occasions, with approximately two weeks between each visit. Using a randomized design,

participants completed two DVD-based prenatal yoga programs “Shiva Rea’s Prenatal Yoga” (DVD A) and “Prenatal Vinyasa Yoga & Short Forms” (DVD B). DVD A is a standard Hatha yoga practice where static postures are performed separated by frequent rest breaks. DVD B is a vinyasa or yoga flow based practice where postures are synchronized with breathing which turn static postures into a dynamic flow. Each of these routines was performed on a separate visit. Energy expenditure was assessed while the participant performed the routines contained on each yoga DVD. After completion of visit 1, the participants had a two-week period to practice the yoga DVDs on their own. During this two-week period, the participants recorded any structured physical activity and prenatal yoga DVD usage on an activity log (Appendix C). After the two-week period, when the participants returned for visit 2, they completed a questionnaire (Appendix D) to determine the feasibility of practicing the yoga DVDs at home.

#### Visit 1

Each participant’s height and weight was measured. Participants were fitted with mask covering the mouth and nose, the Oxycon portable metabolic unit, and a Polar heart rate monitor. The Oxycon Mobile respiratory gas exchange analysis system (CareFusion, Inc.) was used to determine values of oxygen consumption and energy expenditure during the sessions. This portable system weighs approximately two pounds and is worn on the participant’s chest using a fitted vest. The polar heart rate monitor is a strap placed around the participant’s chest, just below the breast tissue, that determines heart rate during the session. Energy expenditure during 10



minutes of rest and the entire yoga session was assessed. Table 1 outlines the specific phase lengths for each DVD. The participant was asked to rate their perceived exertion (RPE) using the Borg Scale (6-20) four times throughout the yoga session. After the initial visit, the participant was sent home with the yoga DVD and an activity log (Appendix C) for two weeks. The participant was instructed to record any structured physical activity on the log, including prenatal DVD usage. After the two-week period (at Visit #2), the participant completed assessment questionnaires of enjoyment and feasibility (Appendix D) after each of these activities.

## Visit 2

Upon returning for visit two, the participant completed assessment questionnaires of enjoyment (PACES) and feasibility. Explicit instructions were given to the participant instructing them to fill out the questionnaires relative to the specific yoga DVD that was evaluated during visit one and the two-week period. The procedures were held consistent between visit one and visit two. Each participant's weight was measured again. As in Visit #1, the participants were fitted with the portable metabolic unit and a heart rate monitor. Another 10-minute resting period was conducted. The participant performed the alternate prenatal yoga program DVD. After completing the prenatal yoga program, filled out the enjoyment and feasibility questionnaires. The participant was once again sent home with the DVD for two weeks. After the two weeks the participant returned to the lab to complete the final questionnaires and return the activity logs.

## **Questionnaires**

An adapted version of the PACES questionnaire was used to measure enjoyment of the yoga DVDs. The participants were given direct instruction to fill out the questionnaire for each specific DVD. The measure was scored from 7-35, with a higher score indicating greater enjoyment. Perceived feasibility questions created for the purpose of this study were scored from 2-10, with a lower score indicating higher rated feasibility.

## **Statistical Analyses**

Descriptive statistics are reported as mean  $\pm$  standard deviation. Energy expenditure was expressed as VO<sub>2</sub>, METs, and Kcals. These values were derived from breath by breath data averaged over 30-second intervals. Heart rate (bpm) was also averaged over 30-second intervals. Total bout energy expenditure and heart rate were determined by averaging the data over all four phases of the yoga routine (rest, warm up, main activity, cool down). Paired t-tests were used to examine total bout differences (VO<sub>2</sub>, METs, and Kcals) and enjoyment, feasibility and usage (number of times the yoga DVD was performed) between the two different yoga DVD types. Repeated measures ANOVA was used to compare interactions for energy expenditure (VO<sub>2</sub>, METs, and Kcals) and heart rate between the type of yoga DVD and the phase (rest, warm up, main, cool down). All data were analyzed using SPSS version 17.0 (SPSS, Inc., Chicago IL). An alpha level of 0.05 was used to indicate statistical significance for all analyses.

## RESULTS

Participant characteristics are shown in Table 2. The results of the repeated measures ANOVA indicated that there was a significant interaction between phase and type of yoga for energy expenditure ( $\text{VO}_2$ , METs, and Kcal)  $F(3,21)= 61.15$ ,  $p<0.001$ . To examine this interaction, the energy expenditure during the different types of yoga was compared at each individual phase using paired samples t-test (Table 3). For all phases, except rest, DVD B had significantly higher average energy expenditure ( $p<0.001$ ). Figure 1 illustrates the average  $\text{VO}_2$  values for each phase (rest, warm up, main, cool down) for DVD A and DVD B. The results of the paired samples t-test for  $\text{VO}_2$  indicated that DVD B had a significantly higher average  $\text{VO}_2$  for the total bout ( $9.30 \pm 1.13$  vs.  $6.50 \pm 1.01 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ ),  $t(23)= -14.76$ ,  $p< 0.001$ . All phases were significantly greater than rest.

For both DVDs, the average total bout heart rate was compared using paired samples t-tests. The results of the paired samples t-test for heart rate indicated that DVD B had a significantly higher average heart rate for the total bout ( $115 \pm 13.3$  vs.  $100 \pm 9.8 \text{ bpm}$ ),  $t(23)= -8.80$ ,  $p<0.001$ . The results of the repeated measures ANOVA indicated that there was a significant interaction between phase, type of yoga, and heart rate,  $F(1,16)=10.318$ ,  $p=0.005$ . To examine this interaction, the heart rates during the different types of yoga were compared at each individual phase using paired samples t-tests (Table 4). DVD B had significantly higher heart rates during the main portion of the yoga workout and during the cool down ( $p<0.001$ ), however, there were not significant differences in heart rate between the two programs

during the rest and warm up (Table 4). Figure 2 illustrates the average heart rates during each phase (rest, warm up, main, cool down) for DVD A and DVD B.

Additionally, the feasibility, enjoyment, and RPE were compared for each DVD yoga program using paired samples t-tests (Table 5). The RPE was significantly higher for DVD B compared to DVD A (14.12 vs. 11,  $p < 0.001$ ). No significant differences were found for either yoga DVD program type for feasibility ( $p = 0.397$ ) or enjoyment ( $p = 0.886$ ). DVD usage was significantly higher for DVD B versus DVD A ( $p < 0.05$ ). Over the two week period where the women used the DVDs at home, DVD B had an average usage of 1.5 times, whereas DVD A had an average reported usage of 0.59.

Table 1. DVD phase length

<b>Phase</b>	<b>DVD A time (minutes)</b>	<b>DVD B time (minutes)</b>
Warm up	7	7
Main	40	35
Cool down	5	4
Total bout	52	46

Table 2. Participant characteristics (N=25)

<b>Variable</b>	<b>Mean <math>\pm</math> SD</b>	<b>Range</b>
Age (y)	29.76 $\pm$ 2.33	21 – 37
Gestational Age (wk)	21.86 $\pm$ 4.94	13 – 28
Weight (kg)	70.25 $\pm$ 9.96	54.36 – 92.72
Height (m)	1.66 $\pm$ 0.06	1.52 – 1.80

Table 3. Mean  $\text{VO}_2$  ( $\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ ) MET value, and caloric expenditure (Kcal/day) at each phase (rest, warm up, main, cool down, and total bout) for each yoga type (DVD A and DVD B).

Phase	DVD A $\text{VO}_2$	DVD B $\text{VO}_2$	DVD A MET	DVD B MET	DVD A Kcal	DVD B Kcal	Sig. ( <i>p</i> )
Rest	3.57 ± 0.54	3.55 ± 0.47	1.02 ± 0.29	1.01 ± 0.29	1795 ± 302	1770 ± 255	0.730
Warm up	6.20 ± 0.97	7.01 ± 0.86	1.77 ± 0.51	2.00 ± 0.57	3119 ± 581	3431 ± 483	<0.001
Main	6.84 ± 1.09	10.08 ± 1.23	1.95 ± 0.55	2.88 ± 0.82	3424 ± 596	5055 ± 632	<0.001
Cool down	5.31 ± 1.24	7.50 ± 1.02	1.52 ± 0.43	2.14 ± 0.61	2662 ± 646	3731 ± 490	<0.001
Total bout	6.50 ±1.01	9.30 ± 1.13	1.86 ± 0.53	2.66 ± 0.76	3267 ± 546	4656 ± 577	<0.001

Table 4. Mean heart rate (beats per minute) at each phase for each type of yoga.

Phase	DVD A	DVD B	Sig. ( <i>p</i> )
Rest	84 ± 9.84	81 ± 11.22	0.211
Warm up	98 ± 10.72	99 ± 10.57	0.716
Main	100 ± 11.24	118 ± 15.89	<0.001
Cool down	91 ± 14.50	102 ± 13.58	<0.001
Total bout	100 ± 9.75	115 ± 13.32	<0.001

Table 5. Feasibility, Enjoyment (PACES), Rate of Perceived Exertion (RPE), and Usage for each type of yoga.

Variable	DVD A	DVD B	Sig. ( <i>p</i> )
RPE (6-20 scale)	11 ± 2.08	14.12 ± 1.45	<0.001
Feasibility (scored 2-10)	3.28 ± 1.90	3.80 ± 2.16	0.397
PACES (scored 7-35)	29.52 ± 5.29	29.76 ± 5.27	0.886
DVD use (# of times used)	0.59 ± 0.96	1.50 ± 1.57	<0.05

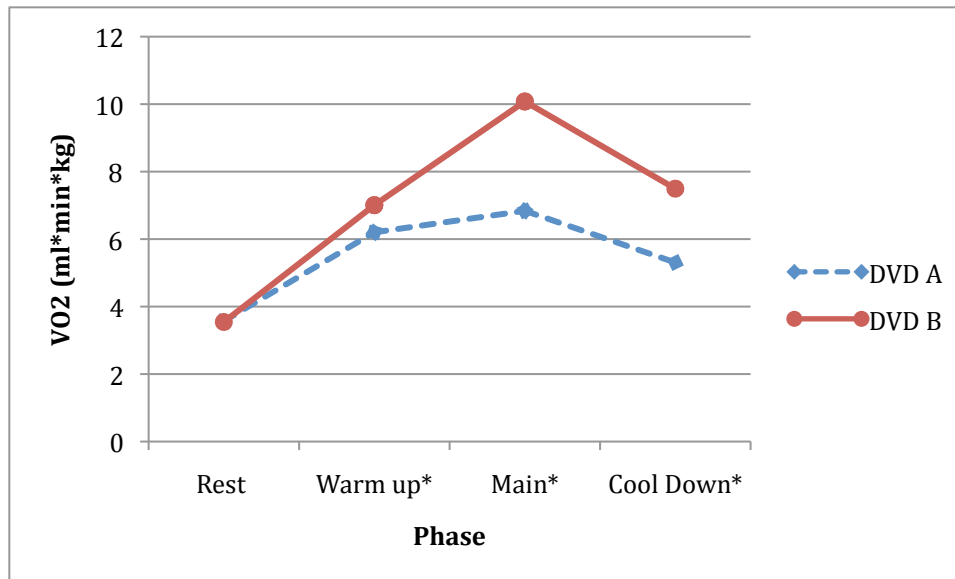


Figure 1. VO<sub>2</sub> values for each phase and each DVD program.

\* p<0.005

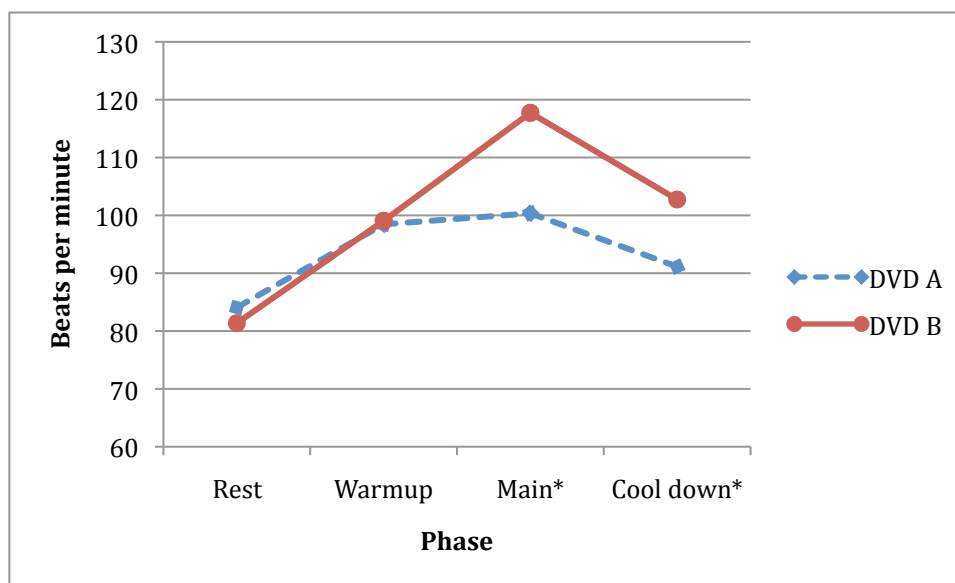


Figure 2. Heart rate values for each phase and each DVD program.

\*p<0.005

## DISCUSSION

Many women experience discomforts during pregnancy, which may act as barriers and contribute to the decline in physical activity during pregnancy. Research suggests that participating in prenatal yoga can relieve many pregnancy related discomforts, sleep disturbances, and perceived stress<sup>9,10</sup>. The current study is the first to examine the energy expenditure and feasibility of prenatal yoga. The primary finding of this study is that vinyasa style prenatal yoga (DVD B) has higher energy expenditure, expressed as  $\text{VO}_2$ , METs, and Kcal, and RPE compared to standard prenatal yoga (DVD A). The current study showed no difference in rated enjoyment or feasibility between the two yoga programs; however, based on activity logs the vinyasa-based program (DVD B) was used approximately three times as frequently at home compared to DVD A (1.50 vs. 0.59).

The current study showed that the vinyasa-based prenatal practice (DVD B) had a higher  $\text{VO}_2$  and heart rate compared to the practice that used static postures followed by rest periods (DVD A). Previous Hatha yoga research has shown that vinyasa or “flow” yoga typically has higher energy expenditure than static yoga postures<sup>59</sup>. Typically, vinyasa yoga is a continuous flow of standing and floor postures that results in a sustained elevated heart rate and  $\text{VO}_2$ . This is in contrast to typical static yoga practice that consists of a posture held for 30 seconds to one minute, followed by rest postures<sup>54</sup>. Therefore, when the entire yoga session is averaged, the low intensity of the frequent rest postures may contribute to the differences in average energy expenditure and heart rate values when comparing the two types of yoga. The RPE was higher in DVD B when compared to DVD A. This

compares favorably with DVD B having higher oxygen consumption ( $\text{VO}_2$ ) and heart rate. Given that vinyasa type yoga requires greater energy expenditure and is quantified to have greater intensity, it would be expected that the RPE would be higher with DVD B.

The feasibility of yoga intervention programs has been shown in various populations; however, the current study was the first to investigate the feasibility of yoga programs in the pregnant population<sup>58,87</sup>. Vinyasa-type yoga tends to have greater intensity and be rated as more difficult when compared to static-based yoga programs<sup>59</sup>. For novice yoga practitioners, static yoga programs may be perceived as more feasible and less difficult. Since vinyasa-type yoga tends to result in greater energy expenditure and intensity, this type of yoga may have great appeal to more fit individuals. The current study showed no difference in rated enjoyment or feasibility between the two yoga programs; however, based on activity logs the vinyasa-based program (DVD B) was used three times as frequently at home compared to DVD A. This may be due to the nature of the program differences. DVD B had higher energy expenditure and RPE, therefore, because the activity involved in DVD B had a higher intensity level, it may have been perceived as a more effective use of time.

The 2008 Physical Activity Guidelines for Americans recommend that pregnant women who are not already doing vigorous-intensity activity should get at least 150 minutes of moderate intensity aerobic activity per week during pregnancy and the postpartum period<sup>6</sup>. The current study showed that energy expenditure was greater for all phases of the yoga programs compared to rest. On average the total



bout  $\text{VO}_2$  was  $6.50 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$  for DVD A and  $9.30 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$  for DVD B, correlating to 1.8 and 2.6 METs, respectively, according to MET value. Light intensity activities are defined as 1.1 to 2.9 METs, whereas moderate intensity activities are defined as 3.0 to 5.9 METs. Therefore, both yoga programs used in the current study fall into the light intensity metabolic equivalent category, although DVD B was on the high end of light intensity. The reported RPE value for DVD B was 14, which in terms of perceived exertion categorizes this DVD in the moderate intensity range. RPE is a subjective measure used to assess intensity, however, previous research has suggested that the RPE system may not always be an accurate prediction of heart rates during pregnancy<sup>91</sup>.

Even though these yoga programs do not fall into the recommended intensity relative to MET values, there are still benefits to this type of exercise training. Previous research supports that yoga practice has positive effects on other components of physical fitness and health such as, flexibility, muscle strength, and mental health variables<sup>61,62</sup>. Additionally, women who may not be able to exercise at a moderate intensity can participate in lower intensity practices such as yoga and still see health benefits<sup>92</sup>. Furthermore, yoga is a mind body practice that incorporates multiple integrated elements such as relaxation techniques, postures, breath control, and meditation. The relative interaction of these elements on health outcomes is unknown. Therefore, yoga may convey health benefits that are unrelated or only partially related to the physical activity component of the practice.

The current study has several strengths and limitations. A notable strength was that the  $\text{VO}_2$  was objectively measured using indirect calorimetry, a valid and

reliable technique. Furthermore, two popular types of yoga programs were investigated. The fact that a DVD-based yoga routine was used is also strength, given that in many other studies where the class is instructed in person, there is room for error in the variety of instruction and differences in the classes from day-to-day which can affect the study results. Additionally, activity logs were used during the study to prevent recall bias. Limitations of the current study include the short time frame of the study and the sample only included participants who were in their second trimester (13 to 28 weeks gestation). Therefore, our findings may not be applicable to pregnant women in all stages of their pregnancy.

The main objective of this study was to assess the energy expenditure of two DVD-based yoga programs “Prenatal Yoga with Shiva Rea” (DVD A) and “Prenatal yoga Vinyasa” (DVD B). Results show that the vinyasa-based yoga program (DVD B) had a higher energy expenditure than DVD A. Overall, both of the DVDs were rated as feasible prenatal yoga programs. Pregnancy is a time that is associated with a decline in physical activity, therefore research investigating the feasibility of programs for this population is important. Furthermore, no studies to date have investigated the energy expenditure of prenatal yoga leaving a fundamental gap in the literature. Further research needs to investigate the long-term effects of prenatal yoga programs and health outcomes during pregnancy, labor, and delivery.

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## **APPENDICES**

## **Appendix A: Informed Consent**

**Appendix D**  
**Consent to Take Part in a Research Study**

**Energy expenditure and feasibility of two prenatal yoga programs**

**Principal Investigators:** Doree Lynn Gardner, BS

**Faculty Advisor:** Dawn P. Cne, Ph.D.

You are being asked to take part in a research study. This consent form will tell you about the study. Please read this form carefully. You will be given a chance to ask questions. If you decide to be in the study, you will be given a copy of this consent.

Taking part in this research study is voluntary. You may choose not to take part in the study. You are also free to withdraw from this study at any time.

**Why is this study being done?**

The primary objective of this study is to measure how many calories are burned during two DVD-based yoga routines. We are also interested in learning if the programs are feasible and enjoyable for pregnant women.

**Who is eligible to participate?**

The study subjects will be healthy women, at least 18 years of age, 13-28 weeks pregnant who have little or no experience with yoga.

**How long will the study last?**

The study will be a total of 6 weeks and require 3 visits to the applied physiology lab on University of Tennessee's campus.

**How many people will be in the study?**

Approximately 30 pregnant women will participate in this study.

**What will happen to me during the study?**

During this study you will be asked to come to the Applied Physiology Lab located in room 309 of the HPER building where the yoga will take place. You will do this 3 times, two weeks apart. Visit 1 will consist of signing consent forms, measuring height and weight, measuring resting energy expenditure and energy expenditure during yoga. Visit 2 will consist of filling out questionnaires and measuring energy expenditure during yoga. Visit 3 will be questionnaires and compensation. We will be measuring your breathing and heart rate while performing yoga in order to estimate energy expenditure. You will be sent home with the yoga DVD for two weeks. When you return for your second visit, you will be given a questionnaire asking about the yoga program. During your second visit you will participate a different yoga DVD, heart rate and energy expenditure will again be measured. You will be sent home with this DVD for two weeks and then be asked to return to the lab to fill out final questionnaires and receive the gift card for participating.

\_\_\_\_\_ (Initials)

UTK EXPEDITED Approval:

NOV 20 2013 - NOV 20 2014

**What risks can I expect from being in the study?**

Like any exercise there is a slight chance that you may be injured while participating in the yoga exercises. Injuries may include a muscle sprain or strain, bruising, or a bone fracture from falling. There is also risk of injury to the unborn child in the event that a fall occurs. Modifications of postures will be given in order to ensure comfort and safety during the class. Additional risks from yoga include: dizziness or lightheadedness, increased shortness of breath, rapid heartbeat, uterine contractions or chest pain. You will be advised to stop if you experience any of these conditions. The heart rate belt worn around the chest may rub on the skin, causing irritation. The researcher will instruct the participant on how to adjust the belt to reduce irritation.

**Are there benefits to taking part in the study?**

There are no direct benefits to you from this study. Results from this study may help establish energy expenditure values of yoga for pregnant women.

**What if I am injured in this study?**

The University of Tennessee does not "automatically" reimburse subjects for medical claims or other compensation. If physical injury is suffered in the course of research, or for more information, please notify the investigator in charge Dr. Dawn P. Coe at (865) 974-0294.

**Will anyone know I am in the study and how am I protected?**

A record of your participation in the study will be kept private in a confidential file in a locked cabinet in the office of Dr. Dawn P. Coe, 341 IIPER Bldg. for 3 years following completion of the study. Only the co-investigators will have access to your data. Study results will be prepared for submission to professional meetings and journals. However, no personal information will be used. Therefore, you will not be identified in reports.

**Who do I call if I have questions about the study?**

Questions about the study: Dawn P. Coe, Ph.D.: 865-974-0294 or dcoec@utk.edu. Questions about your rights as a research subject: You may contact the University of Tennessee, Knoxville, Office of Research Compliance Officer at 865-974-3466.

**What will it cost me to be in the study?**

There will be no cost to you to be in the study.

**Will I be paid for taking part?**

You will be given a 30.00 gift card to Target upon completion of the study.

**Is the Investigator paid to do this study?**

No, the investigator is not being paid to enroll people in this study.

**Can I stop being in the study?**

Your participation in this study is voluntary. Your decision whether or not to participate in this study will not affect your current or future relations with the researchers or the University of Tennessee. If you decide to participate, you are free to withdraw at any time without affecting those relationships.

\_\_\_\_ (Initials)

UTK EXPEDITED Approval:

NOV 20 2013 - NOV 20 2014

**Could I be removed from the study?**

You may be withdrawn for the study for any of the following reasons:

- You fail to show up for your appointments.
- You are put on bed rest during the study period.
- You experience any complications that contradict participating in physical activity

**CONSENT OF SUBJECT:**

I have read or have had read to me the description of the research study. The investigator or her representative has explained the study to me and has answered all of the questions I have at this time. I have been told of the potential risks, discomforts and side effects as well as the possible benefits (if any) of the study. I freely volunteer to take part in this study.

\_\_\_\_\_  
Printed Name of Subject

\_\_\_\_\_  
Signature of Subject

\_\_\_\_\_  
Date

\_\_\_\_\_  
Printed name of Investigator

\_\_\_\_\_  
Signature of Investigator

\_\_\_\_\_  
Date

UTK EXPEDITED Approval:

NOV 20 2013 - NOV 20 2014

## **Appendix B: Institutional Review Board Approval**

November 20, 2013

IRB#: 9349 B

TITLE: Energy expenditure and feasibility of two prenatal yoga programs

Gardner, Doree Lynn  
Kinesiology, Rec. & Sport Studies  
136C HPER Building  
Campus - 2700

Coc, Dawn  
Kinesiology, Rec. & Sport Studies  
341 HPER Building  
Campus - 2700

Your project listed above has been reviewed and granted IRB approval under expedited review.

This approval is for a period ending one year from the date of this letter. Please make timely submission of renewal or prompt notification of project termination (see item #3 below).

Responsibilities of the investigator during the conduct of this project include the following:

1. To obtain prior approval from the Committee before instituting any changes in the project.
2. If signed consent forms are being obtained from subjects, they must be stored for at least three years following completion of the project
3. To submit a Form D to report changes in the project or to report termination at 12-month or less intervals.

The Committee wishes you every success in your research endeavor. This office will send you a renewal notice (Form R) on the anniversary of your approval date.

Sincerely,



Brenda Lawson  
Compliances

Enclosure



## **Appendix C: Activity Log**

## Physical Activity Log Sheet

Name \_\_\_\_\_

Dates \_\_\_\_\_

Gestation (wks) \_\_\_\_\_

Date	Activity Description	Duration (minutes)	Intensity (Light, Moderate, Vigorous)	Notes/Comments

**Light Intensity** - Normal daily activity. No increase in heart rate and breathing

**Moderate Intensity** - Activities that cause breathing and heart rate to increase. Still able to talk.

**Vigorous Intensity** - Activities that cause breathing and heart rate to increase. Difficult to talk.

## **Appendix D: Enjoyment and Feasibility of Physical Activity Questionnaires**

**Methods:**

PACES measure (Motl et al., 2001)

WHEN I AM ACTIVE . . .	DISAGREE A LOT	DISAGREE A LITTLE	NEITHER AGREE NOR DISAGREE	AGREE A LITTLE	AGREE A LOT
I feel bored.					
I dislike it.					
it's no fun at all.					
it makes me depressed.					
it frustrates me.					
it's not at all interesting.					
I feel as though I would rather be doing some- thing else.					

Adapted from Motl et al., 2001.

	Disagree a lot	Disagree A little	Neither agree nor disagree	Agree A little	Agree A lot
I feel that this yoga program is a feasible activity that I can do at home					
I would want to do this DVD based yoga program on my own					

## **Appendix E: Recruitment flyer and email**



## **Pregnant Women Needed for a Research Study**

### **Energy Expenditure and Feasibility of Two Prenatal Yoga Programs**

The purpose of this study is investigate the energy expenditure and feasibility of two different DVD based prenatal yoga programs

If you choose to take part, you will come to the Applied Physiology Lab on University of Tennessee campus on three separate occasions. Visits #1 and 2 will last about 1 hour and 45 minutes and visit #3 will last 20 minutes. We will measure your breathing and heart rate as you perform yoga. To be able to take part in this study you must be between 13 and 28 weeks gestation of a healthy pregnancy as documented by your physician.

Completion of study will be compensated with a gift card

Please contact Doree Lynn Gardner if interested

[dgardne7@utk.edu](mailto:dgardne7@utk.edu)

865-974-5091



Subject line: Seeking pregnant women for prenatal yoga research

The Applied Physiology Lab at University of Tennessee is looking for women between 13 and 28 weeks gestation of a healthy pregnancy. The purpose of this study is investigate the energy expenditure and feasibility of two different DVD based prenatal yoga programs

If you choose to take part, you will come to the Applied Physiology Lab on University of Tennessee campus on three separate occasions. Visits #1 and 2 will last about 1 hour and 45 minutes and visit #3 will last 20 minutes. We will measure your breathing and heart rate as you perform yoga. To be able to take part in this study you must be between 13 and 28 weeks gestation of a healthy pregnancy as documented by your physician.

Completion of this study will be compensated with a gift card

If you are interested in participating or have any questions about the study, please email Doree at [dgardne7@utk.edu](mailto:dgardne7@utk.edu).

Thank you.



## **Appendix F: Borg Scale**

**Table 5.2A The original Borg Scale Rating Perception of Effort (RPE)**

Rating	Perception of effort
6	
7	Very, very light
8	
9	Very light
10	
11	Fairly light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Very, very hard
20	

From Borg (1973, p. 92). © by Lippincott, Williams & Wilkins. Adapted by permission.

## **Appendix G: Confidentiality Agreement**

## **Research Team Member's Pledge of Confidentiality**

### **"Energy Expenditure and Feasibility of Two Prenatal Yoga Programs"**

As a member of this project's research team, I understand that I will be involved in the collection and analysis of sensitive data. The information obtained during data collection was provided by research participants who participated in this project on good faith that their data would remain strictly confidential. I understand that I have a responsibility to honor this confidentially agreement. I hereby agree not to share any information with anyone except the primary researcher of this project or other members of this research team. Any violation of this agreement would constitute a serious breach of ethical standards, and I pledge not to do so.

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Research Team Member (Printed Name)

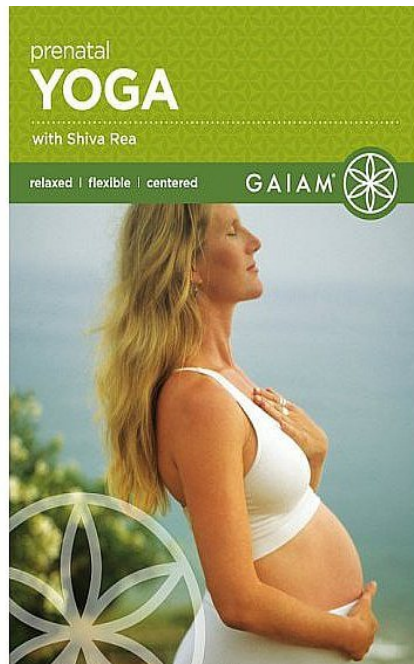
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Date

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Research Team Member (Signature)

## **Appendix H: Yoga DVDs**



## **Appendix I: PAR-MEDX for pregnancy**

# PARmed-X for PREGNANCY

## PHYSICAL ACTIVITY READINESS MEDICAL EXAMINATION

### PARmed-X for PREGNANCY is a guideline for health screening prior to participation in a prenatal fitness class or other exercise.

Healthy women with uncomplicated pregnancies can integrate physical activity into their daily living and can participate without significant risks either to themselves or to their unborn child. Postulated benefits of such programs include improved aerobic and muscular fitness, promotion of appropriate weight gain, and facilitation of labour. Regular exercise may also help to prevent gestational glucose intolerance and pregnancy-induced hypertension.

The safety of prenatal exercise programs depends on an adequate level of maternal-fetal physiological reserve. PARmed-X for PREGNANCY is a convenient checklist and prescription for use by health care providers to evaluate pregnant patients who want to enter a prenatal fitness program and for ongoing medical surveillance of exercising pregnant patients.

Instructions for use of the 4-page PARmed-X for PREGNANCY are the following:

1. The patient should fill out the section on PATIENT INFORMATION and the PRE-EXERCISE HEALTH CHECKLIST (PART 1, 2, 3, and 4 on p. 1) and give the form to the health care provider monitoring her pregnancy.
2. The health care provider should check the information provided by the patient for accuracy and fill out SECTION C on CONTRAINDICATIONS (p. 2) based on current medical information.
3. If no exercise contraindications exist, the HEALTH EVALUATION FORM (p. 3) should be completed, signed by the health care provider, and given by the patient to her prenatal fitness professional.

In addition to prudent medical care, participation in appropriate types, intensities and amounts of exercise is recommended to increase the likelihood of a beneficial pregnancy outcome. PARmed-X for PREGNANCY provides recommendations for individualized exercise prescription (p. 3) and program safety (p. 4).

**NOTE:** Sections A and B should be completed by the patient before the appointment with the health care provider.

## A PATIENT INFORMATION

NAME \_\_\_\_\_

ADDRESS \_\_\_\_\_

TELEPHONE \_\_\_\_\_ BIRTHDATE \_\_\_\_\_ HEALTH INSURANCE No. \_\_\_\_\_

NAME OF \_\_\_\_\_ PRENATAL FITNESS  
PRENATAL FITNESS PROFESSIONAL \_\_\_\_\_ PROFESSIONAL'S PHONE NUMBER \_\_\_\_\_

## B PRE-EXERCISE HEALTH CHECKLIST

### PART 1: GENERAL HEALTH STATUS

In the past, have you experienced (check YES or NO):

- |  | YES                      | NO                       |
|--|--------------------------|--------------------------|
| 1. Miscarriage in an earlier pregnancy?              | <input type="checkbox"/> | <input type="checkbox"/> |
| 2. Other pregnancy complications?                    | <input type="checkbox"/> | <input type="checkbox"/> |
| 3. I have completed a PAR-Q within the last 30 days. | <input type="checkbox"/> | <input type="checkbox"/> |

If you answered YES to question 1 or 2, please explain:

Number of previous pregnancies? \_\_\_\_\_

### PART 2: STATUS OF CURRENT PREGNANCY

Due Date: \_\_\_\_\_

During this pregnancy, have you experienced:

- |   | YES                      | NO                       |
|---|--------------------------|--------------------------|
| 1. Marked fatigue?  | <input type="checkbox"/> | <input type="checkbox"/> |
| 2. Bleeding from the vagina ("spotting")?                 | <input type="checkbox"/> | <input type="checkbox"/> |
| 3. Unexplained faintness or dizziness?                    | <input type="checkbox"/> | <input type="checkbox"/> |
| 4. Unexplained abdominal pain?                            | <input type="checkbox"/> | <input type="checkbox"/> |
| 5. Sudden swelling of ankles, hands or face?              | <input type="checkbox"/> | <input type="checkbox"/> |
| 6. Persistent headaches or problems with headaches?       | <input type="checkbox"/> | <input type="checkbox"/> |
| 7. Swelling, pain or redness in the calf of one leg?      | <input type="checkbox"/> | <input type="checkbox"/> |
| 8. Absence of fetal movement after 6 <sup>th</sup> month? | <input type="checkbox"/> | <input type="checkbox"/> |
| 9. Failure to gain weight after 5 <sup>th</sup> month?    | <input type="checkbox"/> | <input type="checkbox"/> |

If you answered YES to any of the above questions, please explain:

### PART 3: ACTIVITY HABITS DURING THE PAST MONTH

1. List only regular fitness/recreational activities:

INTENSITY	FREQUENCY (times/week)			TIME (minutes/day)		
	1-2	2-4	4+	<20	20-40	40+
Heavy	___	___	___	___	___	___
Medium	___	___	___	___	___	___
Light	___	___	___	___	___	___

2. Does your regular occupation (job/home) activity involve:

	YES	NO
Heavy Lifting?	<input type="checkbox"/>	<input type="checkbox"/>
Frequent walking/stair climbing?	<input type="checkbox"/>	<input type="checkbox"/>
Occasional walking (>once/hr)?	<input type="checkbox"/>	<input type="checkbox"/>
Prolonged standing?	<input type="checkbox"/>	<input type="checkbox"/>
Mainly sitting?	<input type="checkbox"/>	<input type="checkbox"/>
Normal daily activity?	<input type="checkbox"/>	<input type="checkbox"/>
3. Do you currently smoke tobacco?*	<input type="checkbox"/>	<input type="checkbox"/>
4. Do you consume alcohol?*	<input type="checkbox"/>	<input type="checkbox"/>

### PART 4: PHYSICAL ACTIVITY INTENTIONS

What physical activity do you intend to do?

Is this a change from what you currently do? ☐ YES ☐ NO

**\*NOTE: PREGNANT WOMEN ARE STRONGLY ADVISED NOT TO SMOKE  
OR CONSUME ALCOHOL DURING PREGNANCY AND DURING LACTATION.**



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## **Appendix J: Contraindications for Exercise during Pregnancy**

RISK FACTORS:

Contraindications for Exercising During Pregnancy\*

Relative

- Severe anemia
- Unevaluated maternal cardiac dysrhythmia
- Chronic bronchitis
- Poorly controlled type I diabetes
- Extreme morbid obesity
- Extreme underweight [Body mass index (BMI) <12]
- History of extremely sedentary lifestyle
- Intrauterine growth restriction in current pregnancy
- Poorly controlled hypertension
- Orthopedic limitations
- Poorly controlled seizure disorder
- Poorly controlled hyperthyroidism
- Heavy smoker

Absolute

- Hemodynamically significant heart disease
- Restrictive lung disease
- Incompetent cervix / cerclage
- Multiple gestation at risk for premature labor
- Persistent second or third trimester bleeding
- Placenta previa after 26 wk of gestation
- Premature labor during the current pregnancy
- Ruptured membranes
- Preeclampsia / pregnancy-induced hypertension

\*American College of Obstetricians and Gynecologists. Exercise during pregnancy and the postpartum period. ACOG Committee Opinion No. 267. Obstet Gynecol 2002;99:171-173.

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## VITA

Doree Lynn Gardner was born on January 4<sup>th</sup>, 1989 in Sioux City, Iowa to Carter and Donna Gardner. In May of 2007, she graduated from East High School in Sioux City, Iowa. She began her undergraduate education at Arizona State University in Tempe, Arizona in the fall of 2007. At Arizona State, Doree was actively involved in extra curricular and volunteer activities, President of her sorority Kappa Kappa Gamma, and a group fitness instructor at the Student Recreation Center. In 2010, Doree completed an international research internship at The University College Dublin, where she was introduced to working in academia. Upon returning to the United States, she started an undergraduate research assistantship with Dr. Wayne Willis at Arizona State University's Center for Metabolic Biology, which was an exciting and challenging experience that pushed her into continuing her education and research endeavors. She obtained her Bachelor in Science degree from Arizona State in 2012. Doree accepted a graduate teaching assistantship at the University of Tennessee, Knoxville and began her course work in the fall of 2012. Doree graduated from the University of Tennessee with a Master of Science degree in August 2014. She plans to continue her education in the field of Women's Health.