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Coherence-Based Resilience Effects on Antenatal Autonomic Nervous System Stress Markers Controlled

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This is to certify that the doctoral dissertation by

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Walden University
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Abstract

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by

Patrice Fortune

MS, Drexel University, 2004

MA, Marylhurst University, 2000

BS, University of Washington, 1996

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

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Abstract

Antenatal stress disrupts autonomic nervous system (ANS) equilibrium within the neuro-cardio-utero-placental (NCUP) structure perpetuating treatable conditions of depressive-based gestational hypertension disorders. The present ANS-based study of the NCUP system investigated the effect of coherence-based stress resilience (CBSR) post-4-week intervention. This quasi-experimental research design involved experimental (n = 8) and waitlist control (n = 3) conditions. Controlling for pretest values, quantitative pre-post methodology was used to assess the effect of CBSR to evaluate change in variables. Resultant of small sample size, significant findings are considered tentatively. Heart rate variability (p = 0.044), dehydroepiandrosterone/ dehydroepiandrosterone sulfate (p = 0.142), Pregnancy Experience Scale (p = 0.155), Edinburgh Postnatal Depression Scale (p = 0.171), positive reappraisal (p = 0.117), systolic (p = 0.102) and diastolic (p = 0.084) maternal blood pressure (MBP) yielded statistical significance (p < .20) for pre-post variables and large substantive significance. Stress index (p = 0.068), parasympathetic (p = 0.149) and sympathetic (p = 0.015) nervous systems, and low frequency (p = 0.185) yielded statistical significance for pre-post variables and large substantive significance. The current study supports prior findings that higher sympathetic and lower parasympathetic control may increase MBP of gestational hypertensive disorders such as preeclampsia. Continued study of noninvasive treatment for gestational hypertension, stress, and depression is imperative because a generational feedback loop of sequential depression is connected with the leading cause of antenatal death. Consequently, NCUP equilibrium resultant of CBSR is positive social change for global generations.

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Dedication

Unshakable concentration of a warrior monk

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Chapter 1: Introduction to the Study

Depression, a noncommunicable chronic disease, is a serious illness with 4%-41% prevalence rates of occurrence during pregnancy (Bonari et al., 2004; Marcus, 2009; Periera et al., 2011; Stein et al., 2008). However, 50%-70% of pregnant women remain undiagnosed during a critical time of life (Tegethoff et al., 2011). Normal pregnancy-related fluctuations in hormones that lead to depression have potentially fatal outcomes when not treated adequately (American Psychiatric Association [APA], 2000; Bloom et al., 2011; Bonari et al., 2004; Boutayeb et al., 2013; Chand, 2012; Weinstock, 2005). Untreated antenatal depression can result in lifelong disabling symptoms that began in utero. A generational feedback loop can occur when a mother, herself exposed in utero, continues the sequential depressive cycle by exposing her fetus (Bonari et al., 2004; Field et al., 2004; Weinstock, 2005). Consequently, perpetuation of the depressive reproduction cycle increases the risk of physical and social disability (Bennett et al., 2004a; Mathers et al., 2004). Depression is the main precursor of suicide and the underlying basis of comorbidity in cardiovascular diseases that include gestational hypertension and preeclampsia (Boutayeb et al., 2013; Mathers et al., 2004). The economic consequences are $30 to $44 billion dollars annually (Barrio & Burt, 2000; Bennett et al., 2004a; Karavidas et al., 2007; Pariante, 2003).

The cost of depression involves decreased productivity, missed workdays, and lost lifetime earnings. Hidden costs that further affect individuals, families, and the community are medical resource consumption in outpatient office and inpatient hospital related medical care, as well as pharmaceuticals (Barrio & Burt, 2000; Bennett et al.,

2004b). As the level of stress to patients increases, visits to physicians increase, accounting for 75%-90% of all doctor's office visits (Childre & Cryer, 2004).

The leading cause of death during the reproductive years is gestational hypertension, which is associated with antenatal depression, a treatable condition (Faber et al., 2004; Jahic et al., 2008; Leeners et al., 2007). The autonomic nervous system (ANS) is intricately associated with heart rate variability (HRV) is intrinsic to the neural circuitry of the neuro-cardio-utero-placental (NCUP) system (Dayan et al., 2006; Diego et al., 2006; Gayasen et al., 2003; Kurki et al., 2000; Mulder et al., 2002; Nelson & Nelson, 2013; O'Mahony et al., 2006; Quinn, 2005). This ANS process within the NCUP organism determines the quality of the uteroplacental-heart-brain connection. Risk for gestational hypertension, preeclampsia, and uterine artery resistance has been found to be associated with antenatal depression (Dayan et al., 2006; Diego et al., 2006; Gayasen et al., 2003; Kurki et al., 2003; Mulder et al., 2002; O'Mahony et al., 2006). This study aimed to identify the effect in Week 4 posttest biological, psychological, natural- and social-environmental (BPNSE) aspects between the coherence-based stress resilience (CBSR) training and waitlist group on the NCUP system of second trimester pregnant women while controlling for pretest differences and maternal blood pressure (MBP). Antenatal depression precipitated by stress may disrupt ANS equilibrium and thereby may dysregulate NCUP homeostasis. CBSR is expected to have a significant effect on stress and depression during pregnancy thereby promote NCUP homeostasis.

Given the multidimensional nature of pregnancy, synthesis of the divisions that separate the inherently integrated nature of pregnancy is necessary as part of an

integrated approach to antenatal depression and subsequent high-risk complications (Bacidore et al., 2009; Chen et al., 2004; Evans, 2007; Hui, 2012; Ji & Han, 2010; Plastow, 2009; Vrekousis et al., 2010). Accordingly, awareness of the effect CBSR may have on HRV rhythm, Adrenal Stress Index (ASI) hormones (cortisol, dehydroepiandrosterone/dehydroepiandrosterone sulfate [DHEA/DHEAS], 17-hydroxyprogesterone [17-OHP], secretory immunoglobulin A [sIgA] antenatal stress), symptoms of depression, and coping responses within the BPNSE framework is critical for an effective response to antenatal depression (Ho, 2008; Hui, 2012; McCraty et al., 2009; Thomas, 2010). Therefore, noninvasive, integrated methods to address depression during pregnancy are essential to homeostasis within the NCUP ANS. However, there is no literature to date evaluating nonintrusive CBSR training that synchronizes ANS communication within the uteroplacental-heart-brain connection to reduce antenatal stress and improve symptoms of depression during pregnancy (Ho, 2008; McCraty et al., 2009; McCraty & Childre, 2010; Sutarto et al., 2010; Thomas, 2010).

Uteroplacental-heart-brain communication may lead to NCUP homeostasis, akin to individual neurocardiac equilibrium, while social coherence similarly transpires from a stable foundation of partner, family, and community interaction (McCraty et al., 2009; McCraty et al., 2012; Schwerdtfeger & Friedrich-Mai, 2009; Thomas, 2010; Vrekousis et al., 2010). Genuine partner, family, and community interconnectedness based in harmonious intraindividual heart-brain communication are aspects of social coherence that promote positive social-environmental change (Adewuya et al., 2007; Hippman et al., 2009; Hoffman & Hatch, 1996; McCraty & Childre, 2010). More people in a state of

coherence increase the sustainability of positive social-environmental change (Bastiampillai et al., 2012; Hoffman & Hatch, 1996; McCraty & Childre, 2010; Schwerdtfeger & Friedrich-Mai, 2009). Subsequently, positive social coherence has psychophysiologic qualities that improve overall health, antenatal outcomes, and mortality.

The role that antenatal stress plays in depression during pregnancy and the severity of gestational hypertensive disorders necessitate that research focused on antenatal depression receive high priority (Tegethoff et al., 2011). Integrative approaches to antenatal stress, depression, and hypertension with a strong emphasis on the NCUP connection and its relationship with the environment compose an introductory presentation. Chapter 1 presents a brief summary of the topic, describes the gap in knowledge, and discusses the rationale for the study as background to the research.

Delineation of the current, relevant, and significant aspects of this antenatal health dilemma forms the problem statement. The purpose of the study is followed by connecting the problem, focus, and intent of the study. Outline of the research questions and hypotheses included the null and alternative hypotheses. A review of the basis for the theoretical foundation includes an explanation of the relationship between the theory and study approach. The nature of the study's rationale for the research design, key variables, and a brief overview of the methodology come next. Definition of variables along with technical terms follows. Presentation of assumptions, scope of delimitations, and limitations of the study occurred after which significance of the study complete Chapter 1.

Theoretical Background

The basis of this study was the central position of ANS activity to NCUP health within an integrated BPNSE framework (Ho, 2008; Hui, 2012; McCraty et al., 2009; Plastow, 2009; Vrekousis et al., 2010). Inherently integrated ANS function within the NCUP system is intrinsic to the viability of life and crucial to the interconnection of antenatal stress, depression, gestational hypertension, and preeclampsia (Ho, 2008; Hui, 2012; McCraty et al., 2009; Thomas, 2010; Plastow, 2009). The ANS intricately associated with HRV rhythm is fundamental to neural circuitry of the NCUP system and determines the quality of hematological communication of the uteroplacental-heart-brain connection (Dayan et al., 2006; Diego et al., 2006; Marques et al., 2010; O'Mahony et al., 2006; Sutarto et al., 2010; Thomas, 2010). Coherence, a living system's defining quality through synchronization of regular and repeated fluctuation, occurs within and between organisms (Ho, 2008; McCraty & Childre, 2010; McCraty et al., 2012). Consequently, an integrated approach focused on uteroplacental-heart-brain coherence is necessary to the connection between antenatal stress, depression, and psychoneurocardiovascular health (Ho, 2008; Hui, 2012; McCraty et al., 2009; Plastow, 2009; Thomas, 2010; Vrekousis et al., 2010).

An integrated theoretical approach provided a framework to explore BPNSE differences that occur within the NCUP reproductive system and its effect on HRV rhythm and thereby quality of the ANS during pregnancy. I examine the potential effect of CBSR training on BPNSE aspects during pregnancy with provision of further explanation of this theoretical description in Chapter 2. Examination of specific

associations between CBSR training and waitlist groups occurred in this study, controlling for pretest values and MBP. The antenatal BPNSE aspects include:

1. Neuroendocrine and immune system components of 17-OHP, cortisol, DHEA/DHEAS, and sIgA during pregnancy
2. Psychological intensity of antenatal stress and symptoms of depression
3. Positive reappraisal coping responses
4. Heart Rate Variability rhythm during pregnancy
5. Maternal blood pressure

Focus of the Study

The cascade of intricately entwined BPNSE change is a fundamentally integrated characteristic of pregnancy (Bacidore et al., 2009; Evans, 2007; Hui, 2012; McCraty & Childre, 2010; Plastow, 2009). Given the multidimensional nature of pregnancy, collapsing barriers is necessary to an integrated approach for antenatal depression and high-risk complications of gestational hypertension that may arise (Bacidore et al., 2009; Chen et al., 2004; Evans, 2007; Hui, 2012; Ji & Han, 2010; Plastow, 2009; Vrekousis et al., 2010). Inherently multidimensional qualities of antenatal stress and depression comprise integrative characteristics of BPNSE dynamics within the NCUP system (Hui, 2012; Thomas, 2010; Vrekousis et al., 2010). Stress during pregnancy directly related to the activity within the ANS results in disequilibrium within the NCUP reproductive system (Bunevicius et al., 2009a; Paz-Filho et al., 2010; Stewart, 2011; Thomas, 2010). Antenatal depression magnified by stress during pregnancy involves sympathetic and parasympathetic dysfunction within the ANS and pronounced change in reproductive

neuroendocrine function (Gold & Chrousos, 2002; Hippman et al., 2009; Paz-Filho et al., 2010; Schwerdtfeger & Friedrich-Mai, 2009). Accordingly, awareness of the effect that CBSR has on BPNSE aspects is critical for an effective response to antenatal depression (Ho, 2008; Hui, 2012; McCraty et al., 2009; Thomas, 2010). An integrative approach is necessary to effectively address stress and depression during pregnancy (Hui, 2012; Plastow, 2009).

An integrated NCUP process intricately associated with ANS activity maintains homeostasis within the reproductive system during pregnancy, thereby necessitating awareness of antenatal depression in the relationship to stress (Marques et al., 2010; Sutarto et al., 2010; Thomas, 2010; Vrekousis et al., 2010). Gestational health, the NCUP reproductive system, and ANS activity are interrelated as evidenced by associated shifts in the quality of HRV rhythm (Buss et al., 2012; McCraty & Childre, 2010; Sergerie et al., 2008). The ANS intricately associated with HRV rhythm that is intrinsic to the neural circuitry of the NCUP system determines the quality of the uteroplacental-heart-brain connection (Dayan et al., 2006; Diego et al., 2006; Gayasen et al., 2003; Kurki et al., 2000; Mulder et al., 2002; O'Mahony et al., 2006). Heart rate variability rhythm is an effective biomarker of integrated treatment efficacy, ANS function, and the susceptibility and severity of disease during pregnancy such as antenatal depression, gestational hypertension, and preeclampsia (Buss et al., 2012; Marques et al., 2010; Shea et al., 2008).

A balanced NCUP process is integral to the development of ANS activity during pregnancy (Thomas, 2010; Wallwitz et al., 2012). For example, ANS disequilibrium

resultant of antenatal depression adversely affects the entire NCUP system through heart rhythms and hematological communication at a deep cellular level that permeates the entire maternal/fetal system (Marques et al., 2010; Sutarto et al., 2010; Thomas, 2010). Connection between antenatal depression and preeclampsia's ANS origin shows promise for preventative care through NCUP homeostatic regulation (Kurki et al., 2000; McCraty et al., 2009; Paz-Filho et al., 2010; Sutarto et al., 2010; Thomas, 2010; Vrekousis et al., 2010). Given the interconnected nature of pregnancy, the necessity for maintenance of homeostasis, and the essential role that the ANS has in gestational viability, review of NCUP coherence, HRV rhythm, and the benefits of stress resilience training on antenatal depression composes an integrated reproductive model (Ho, 2008; Hui, 2012; McCraty et al., 2009; Plastow, 2009; Sutarto et al., 2010; Thomas, 2010).

Neuro-cardio-utero-placental connection and coherence, intricately associated with ANS activity, affects antenatal hematological communication between the uteroplacental-heart-brain connection (Marques et al., 2010; Sutarto et al., 2010; Thomas, 2010). There is no literature to date evaluating nonintrusive CBSR training that synchronizes ANS communication within the uteroplacental-heart-brain connection to reduce antenatal stress and improve symptoms of depression during pregnancy (Ho, 2008; McCraty et al., 2009; McCraty & Childre, 2010; Sutarto et al., 2010; Thomas, 2010). The leading cause of death during the reproductive years is gestational hypertension, which is directly related to antenatal depression, a treatable condition (Diego et al., 2006; Jahic et al., 2008; McCraty & Childre, 2010; Pavithran et al., 2008; Siepmann et al., 2008). Preeclampsia, recently found to originate in the ANS and central

nervous system in nonpregnant women, provides researchers with a further route to pursue the cause of preeclampsia (Kurki et al., 2000). An integrated NCUP approach focused on uteroplacental-heart-brain coherence, therefore, is necessary to respond to the connection between antenatal stress, depression, and neurocardio pregnancy-related disease such as gestational hypertension and preeclampsia (Ho, 2008; Hui, 2012; McCraty et al., 2009; Thomas, 2010; Vrekousis et al., 2010).

Problem Statement

The severity and course of antenatal depression precipitated by stress disrupts ANS equilibrium and thereby dysregulates NCUP homeostasis and further perpetuates depressive based disorders during pregnancy (Bunevicius et al., 2009a; Paz-Filho et al., 2010; Stewart, 2011; Thomas, 2010). These multidimensional dynamics of antenatal stress and depression adversely affect NCUP HRV rhythm within an integrated BPNSE framework disrupting ASI function; yet conventionally, antenatal depression goes unnoticed or compartmentalized (Hui, 2012; Plastow, 2009; Thomas, 2010; Vrekousis et al., 2010). The onset of pregnancy and subsequent change in reproductive neuroendocrine function associated with it leads to depression when stress persists without treatment (Bonari et al., 2004; Gold & Chrousos, 2002; Hippman et al., 2009; Paz-Filho et al., 2010; Schwerdtfeger & Friedrich-Mai, 2009). With constant and repeated exposure to stress during pregnancy, along with neuroendocrine hyperactivity associated with antenatal depression, natural suppressors of stress reactions become desensitized, thereby diminishing their efficacy (Bonari et al., 2004; Paz-Filho et al., 2010; Weinstock, 1997, 2005).

Untreated stress during pregnancy leads to a significant imbalance within the NCUP system, antenatal depression, gestational hypertensive disorders, detrimental cardiovascular consequences, and gestational mortality that stem from treatable conditions (McCraty & Tomasino, 2004; Nam et al., 2011; Pavithran et al., 2008; Thayer & Sternberg, 2006; Vrekousis et al., 2010). Heart rate variability rhythm intricately associated with hematological communication between the uteroplacental-heart-brain connections is integral to NCUP reproductive wellbeing (Marques et al., 2010; Sutarto et al., 2010; Thomas, 2010). The essential benefits of nonintrusive CBSR within the uteroplacental-heart-brain connection remain unexplored (Ho, 2008; McCraty et al., 2009; McCraty & Childre, 2010; Sutarto et al., 2010; Thomas, 2010). The integrated nature of CBSR training approach on stress, depression, and NCUP-related disease such as gestational hypertension is necessary in an effort to disrupt the perpetuation of antenatal depressive disorders (Ho, 2008; Hui, 2012; McCraty et al., 2009; Thomas, 2010; Vrekousis et al., 2010).

Purpose of the Study

The purpose of this quantitative study was to identify the effect of CBSR training over a 4-week period on the NCUP system of second trimester pregnant women. For this quantitative study, the course of antenatal depression precipitated by stress that occur over time may disrupt NCUP homeostasis during pregnancy. The expected effect of CBSR training on the NCUP relationship between antenatal stress and depression within the BPNSE framework was explored. I examined the effect of CBSR in the NCUP

system over a 4-week period between a group of pregnant women who received training and practice in CBSR and a group that received no training or practice.

Nature of the Study

Compartmentalizing separate aspects of the uteroplacental-heart-brain connection during pregnancy fragments the inherently integrated NCUP system that is intrinsic to the viability of life (Ho, 2008; Hui, 2012; McCraty et al., 2009; Plastow, 2009). Nonintrusive CBSR synchronizes the ANS of nonpregnant individuals, which shows promise for stress resilience and improvement of depression through ANS homeostasis within the uteroplacental-heart-brain connection of pregnancy (Ho, 2008; McCraty et al., 2009; McCraty & Childre, 2010; Sutarto et al., 2010; Thomas, 2010). For example, when exposed to stress and depression, decreased HRV rhythm disrupts NCUP homeostasis, which results in gestational milieu incoherence, uteroplacental hemodynamic dysregulation, and hypertensive disorders of pregnancy (Childre et al., 2000; Ho, 2008; McCraty et al., 2003; Stein et al., 2008; Vrekousis et al., 2010). Considering the necessity for uteroplacental-heart-brain coherence and pregnancy viability, it is important to evaluate the effect of CBSR within the NCUP system (Ho, 2008; Lehrer et al., 2010; McCraty et al., 2009; Plastow, 2009; Thomas, 2010).

The independent variable for this study was CBSR training. Nine dependent variables included HRV rhythm measure of autonomic function responsive to antenatal stress and four ASI functions of cortisol, DHEA/DHEAS, 17-OHP, and sIgA in addition to measures of MBP, antenatal depression, pregnancy stress experience, and positive cognitive reappraisal coping strategy. Clinical covariates for this study were systolic

maternal blood pressure (SMBP), diastolic maternal blood pressure (DMBP), and pretest values (Carnethon et al., 2002; Snigh et al., 1999; Windham et al., 2012).

I examined the effect of CBSR that occurred over a 4-week period within the NCUP system of second trimester pregnant women who received training and practiced CBSR. I explained the effect of CBSR within the NCUP system over a 4-week period between a group of second trimester pregnant women who received training and practiced CBSR and a group that received no training or practice. Chapter 3 further explained implementation and analyses of this study's methodology.

Research Questions and Hypotheses

Below are research questions and hypotheses for this study.

RQ1: While controlling for MBP and any pretest differences, what is the effect of posttest HRV rhythms between training and waitlist groups?

$H_0$1: While controlling for MBP and pretest values, there will be no significant effect in Week 4 posttest HRV rhythms between the CBSR trained group and the waitlist group.

H_a1: While controlling for MBP and pretest values, there will be a significant effect in Week 4 posttest HRV rhythms between the CBSR trained group and the waitlist group.

RQ2: While controlling for MBP and any pretest differences, what is the effect of posttest stress response in cortisol levels between training and waitlist groups?

$H_0$2: While controlling for MBP and pretest values, there will be no significant effect in Week 4 posttest stress response in cortisol levels between the CBSR trained group and the waitlist group.

H_a2: While controlling for MBP and pretest values, there will be a significant effect in Week 4 posttest stress response in cortisol levels between the CBSR trained group and the waitlist group.

RQ3: While controlling for MBP and any pretest differences, what is the effect of posttest DHEA/DHEAS stress adaptation levels between training and waitlist groups?

$H_0$3: While controlling for MBP and pretest values, there will be no significant effect in Week 4 posttest DHEA/DHEAS stress adaptation levels between the CBSR trained group and the waitlist group.

H_a3: While controlling for MBP and pretest values, there will be a significant effect in Week 4 posttest DHEA/DHEAS stress adaptation levels between the CBSR trained group and the waitlist group.

RQ4: While controlling for MBP and any pretest differences, what is the effect of posttest 17-OHP adrenal reserve indicators between training and waitlist groups?

$H_0$4: While controlling for MBP and pretest values, there will be no significant effect in Week 4 posttest 17-OHP adrenal reserve indicators between the CBSR trained group and the waitlist group.

H_a4: While controlling for MBP and pretest values, there will be a significant effect in Week 4 posttest 17-OHP adrenal reserve indicators between the CBSR trained group and the waitlist group.

RQ5: While controlling for MBP and any pretest differences, what is the effect of posttest sIgA levels between training and waitlist groups?

$H_0$5: While controlling for MBP and pretest values, there will be no significant effect in Week 4 posttest sIgA levels between the CBSR trained group and the waitlist group.

H_a5: While controlling for MBP and pretest values, there will be a significant effect in Week 4 posttest sIgA levels between the CBSR trained group and the waitlist group.

RQ6: While controlling for MBP and any pretest differences, what is the effect of posttest intensity of symptoms in antenatal stress between training and waitlist groups?

$H_0$6: While controlling for MBP and pretest values, there will be no significant effect in Week 4 posttest on intensity of symptoms of antenatal stress between the CBSR trained group and the waitlist group.

H_a6: While controlling for MBP and pretest values, there will be a significant effect in Week 4 posttest on intensity of symptoms of antenatal stress between the CBSR trained group and the waitlist group.

RQ7: While controlling for MBP and any pretest differences, what is the effect of posttest symptoms of antenatal depression between training and waitlist groups?

$H_0$7: While controlling for MBP and pretest values, there will be no significant effect in Week 4 posttest on symptoms of antenatal depression between the CBSR trained group and the waitlist group.

H_a7: While controlling for MBP and pretest values, there will be a significant effect in Week 4 posttest on symptoms of antenatal depression between the CBSR trained group and the waitlist group.

RQ8: While controlling for MBP and any pretest differences, what is the effect of posttest positive reappraisal coping responses between training and waitlist groups?

$H_0 8$: While controlling for MBP and pretest values, there will be no significant effect in Week 4 posttest on positive reappraisal coping responses between the CBSR trained group and the waitlist group.

$H_a 8$: While controlling for MBP and pretest values, there will be a significant effect in Week 4 posttest on positive reappraisal coping responses between the CBSR trained group and the waitlist group.

RQ9: While controlling for any pretest differences, what is the effect of posttest MBP between training and waitlist groups?

$H_0 9$: While controlling for pretest values, there will be no significant effect in Week 4 posttest on MBP between the CBSR trained group and the waitlist group.

$H_a 9$: While controlling for pretest values, there will be a significant effect in Week 4 posttest on MBP between the CBSR trained group and the waitlist group.

Independent Variable

Coherence-Based Stress Resilience Training is a self-regulated stress management technique that balances the ANS via synchronized breath (HeartMath, 2012; Sutarto et al., 2010; Thomas, 2010; Vrekousis et al., 2010).

Dependent Variables

Heart rate variability is the variation that occurs within the maternal beat-to-beat intervals between each heartbeat as measured by the emWavePro (Marques et al., 2010; McCraty & Childre, 2010) for the purpose of this study.

Adrenal Stress Index is a noninvasive salivary hormone test that assesses endocrine function with a combination of hormone levels (Diagnos-Techs, 2013a, 2013b). The ASI salivary hormone values collected for the purpose of this study were cortisol, DHEA/DHEAS, 17-OHP, and sIgA.

Adrenal Stress Index Cortisol is a glucocorticoid stress hormone measure employed as a biomarker for antenatal stress and depression (Jones et al., 2006; Field et al., 2006; Diagnos-Techs, 2013a, 2013b).

Adrenal Stress Index DHEA/DHEAS is an endogenous steroid hormone that converts to DHEAS, the sulfate ester of DHEA, on an as needed basis and is associated with shifts in stress and depression (Gallagher, 2002; Markopoulou et al., 2009; Diagnos-Techs, 2013a, 2013b).

Adrenal Stress Index 17-OHP Salivary 17-OHP a natural hormone building block of cortisol produced during the synthesis of two or more glucocorticoids and sex hormones, increases understanding of the underlying causes that contribute to abnormal fluctuation in cortisol (Diagnos-Techs, 2013a, 2013b).

Adrenal Stress Index sIgA Salivary sIgA is an antibody in mucus secretion with a critical function of immune health and maintenance of pregnancy that relies on immunoglobulin properties of sIgA within gestational mucous membranes and plays a

key role in understanding effects of stress (Negril et al., 1995; Diagnos-Techs, 2013a, 2013b).

Antenatal stress is integrated dysregulated homeostasis combined with the intensity of antenatal stress symptoms that pose a threat to NCUP coherence (McCraty et al., 2009; Vrekousis et al., 2010).

Antenatal depression is a condition that occurs during pregnancy within the NCUP system involving integrated characteristics of BPNSE processes (Bennett et al., 2004a; McCraty et al., 2009; Simone & Pun, 2007; Vrekousis et al., 2010).

Positive reappraisal represents cognitive focused coping assessed with a process-oriented approach that identifies shifts in cognitive reappraisal, which reframes negative thought via mind integration processes resultant of positive reappraisal (Childre & Cryer, 2004; Gold & Chrousos, 2002; Folkman & Lazarus, 1988).

Covariates

The first covariate was MBP. Maternal blood pressure is exerted pressure of the pregnant woman's blood on the inside walls of her blood vessels (American College of Obstetrics and Gynecology [ACOG], 2013; Carnethon et al., 2002; Snigh et al., 1999; Windham et al., 2012). The first or maximum number is the systolic pressure, and the second or minimum number is the diastolic pressure, which occurs when the heart relaxes during the cardiac cycle's resting phase. Pretest values was the second covariate. These are data values collected during the pretest phase of the study.

Definition of Terms

Biological, psychological, natural-, and social-environmental framework: An integrative system in which the antenatal stress process occurs (Hui, 2012; McCraty et al., 2009; Vrekousis et al., 2010). Biological elements are antenatal cortisol, DHEA/DHEAS, 17-OHP, and sIgA as measured by the salivary ASI test. Psychological factors are symptoms of depression during pregnancy as measured by the Edinburgh Postnatal Depression Scale (EPDS). Natural-environmental aspects are symptoms of antenatal stress as measured by the Pregnancy Experience Scale (PES). Social-environmental components are positive reappraisal coping responses as measured by the Ways of Coping (WOC) Questionnaire.

Circadian oscillation: Cardiological electromagnetic communication (Connell et al., 2013; Ritz et al., 2013).

Coherence: A living system's very defining quality via synchronization of regular and repeated fluctuation that occurs within and between organisms at deeply molecular and cellular levels as evidenced by consistent HRV rhythms that adhere to smooth wavelike rhythms as measured by the emWave Pro (Ho, 2008; McCraty et al., 2012; Sutarto et al., 2010).

Coherence ratio: Indicates the cumulative percentage of time that the participant was in a state of coherence.

Gestational hypertension: Newly diagnosed blood pressure equal to or greater than 140/90 with no protein in the urine (Iwase & Misumida, 2011; Siddiqui et al., 2010).

Neuro-cardio-utero-placental coherence: A biomedical phenomenon whereby synchronized internal reproductive systems interact individually, harmoniously in step as a whole in an effortless flow of uteroplacental-heart-brain communication evidenced by smooth HRV rhythms (Brown et al., 2009; Ho, 2008; McCraty 2006; McCraty et al., 2009; Sutarto et al., 2010; Thomas, 2010).

Normotensive: A stable blood pressure (Risberg et al., 2009).

Peripartum cardiomyopathy: Pregnancy-related heart failure during the last month of gestation, although symptoms may develop during early pregnancy (Ntusi & Mayosi, 2009; Pyatt & Dubey, 2011).

Preeclampsia: Pregnancy-specific hypertensive disease similar to gestational hypertension, although with protein in the urine (Moreira et al., 2009; Siddiqui et al., 2010; Veillon et al., 2009; Vrekousis et al., 2010).

Social coherence: Occurs when partner, family, and community interactions transpire from a stable foundation (McCraty & Childre, 2010; McCraty et al., 2012; Schwerdtfeger & Friedrich-Mai, 2009).

Suprachiasmatic nucleus: The master oscillator is a pinecone-shaped structure approximately five millimeters in size located within the hypothalamus (Mohawk et al., 2012).

Uterine artery resistance: The effect of increased hypertension experienced during pregnancy (Carpenter & Cooper, 2001).

Uterus-placenta-heart-brain coherence: Neuro-cardio-utero-placental homeostasis akin to individual neurocardiac equilibrium (McCraty et al., 2009; McCraty et al., 2012; Thomas, 2010; Vrekousis et al., 2010).

Assumptions, Limitations, Scope, and Delimitations

Assumptions

While the framework of the study was integrative, an assumption was that the investigator was independent of the study and that findings were both independent and objective. To maintain the investigator's independence, clinical providers adhered to a scripted presentation of the training. Presentation of measures were consistent. It was assumed that participants had an education level that permitted them to accurately read and understand materials presented in this study. Another assumption was that participants thoroughly read, understood, and responded correctly to all directions. It was assumed that participants completed questionnaires in an unbiased, consistent manner and made an honest effort to respond accurately to data collection procedures. Voluntary and confidential participation were assumed to elicit truthful response. Given that the participant's physician calculated gestational stage, an assumption of this study was that the obstetrician calculated gestational age accurately. It was assumed that the sample was representative of the population from which it was drawn. Replicability and generalizability were assumptions of this quantitative study.

Limitations

The quantitative research design limited the kind of information collected for this study. Structured data may be generalizable to the population, and the sample can be

selected to represent the study's population. Self-report questionnaire limitations may result in inaccurate and incomplete data. For example, participants may respond with attribution and exaggeration biases, intentional deception, or stress related health problems. During statistical analysis, box plot graphs may detect extreme outliers that might result from limitations of self-report. It was assumed that participants gave their best effort to complete questionnaires in a thoughtful and truthful manner.

Due to time and resource limitations of this study, rather than implement a randomized experimental design, this study used a quasi-experimental design with a waitlist as the control condition in order to uphold methodological rigor (Handley et al., 2011). Chapter 3 contains further information regarding quantitative research-based limitations that may lead to external, internal, construct, and statistical validity.

The ASI comprises biosynthesis of the corticosteroids salivary cortisol, DHEA/DHEAS, and progesterone along with production of immunoglobulin sIgA (Diagnos-Techs, 2010; Guilliams & Edwards, 2010). Each respective component of the ASI has wide interindividual variability (Thomson et al., 2007; Wust et al., 2000). Limitations of the ASI are considerable individual variations in saliva flow with more expansive secretion differences than previously understood (Diagnos-Techs, 2010; Gann et al., 2001; Guilliams & Edwards, 2010). Minimum and maximum levels of individual cortisol show vast differences and while DHEA/DHEAS is a more stable biomarker, large interindividual variation remains present (Euler et al., 2005; Jung et al., 2014; Kalimi & Regelson, 2000; Soldin et al., 2005; Thomson et al., 2007; Wust et al., 2000). Interindividual variance of salivary progesterone is 2 to 3 times greater than within

individual differences (Caritis et al., 2011; Gann et al., 2001; Jasienska & Jasienski, 2008). Interindividual sIgA salivary profiles result in extremely high variability, which make analysis of two different individual measures impossible (Schedlowski & Tewes, 1999; Yi & Moochhala, 2013). Measurements of biochemical mechanisms within the mouth need to consider interindividual variability of salivary biomarkers (Quintana et al., 2009). Given high sensitivity of individual corticosteroids biosynthesis and immunoglobulin production, each participant was their own pre-/postmatch further described in Chapter 3 methods (Soldin et al., 2005).

Scope and Delimitations

A delimitation of this study was the inability to generalize the effects of CBSR outside the second and third trimesters of pregnancy. Antenatal depression precipitated by stress disrupts ANS equilibrium and thereby dysregulates NCUP homeostasis further, which perpetuates depressive-based antenatal disorders (Bunevicius et al., 2009a; Paz-Filho et al., 2010; Stewart, 2011; Thomas, 2010). The integrated dynamics of stress and depression that adversely affect NCUP symmetry remain unnoticed or compartmentalized within a conventional approach (Hui, 2012; Plastow, 2009; Thomas, 2010; Vrekousis et al., 2010). However, the potential stabilizing effects of CBSR training intended to calibrate ANS equilibrium and NCUP homeostasis may instead result from the gestational maturation nature of pregnancy itself and maternal change that occurs over a 4-week period (Kazdin, 2003). Consequently, the scope of this study may be specific to the second and third trimesters of gestation with further research necessary to investigate the effects of CBSR training on the earlier stage of pregnancy. Potential

generalizability may be specific to outpatient pregnant women in their second and third trimesters of pregnancy.

Significance of the Study

This study's contributions to the field of clinical psychology involves improved understanding of antenatal based fluctuations within an integrated BPNSE framework, which affect ANS equilibrium and NCUP homeostasis, thereby perpetuating depressive based disease during pregnancy (Bunevicius et al., 2009a; Paz-Filho et al., 2010; Stewart, 2011; Thomas, 2010). Raised awareness involved the relationship between antenatal depression and stress, antenatal stress between the NCUP relationship and antenatal depression, and the relationship between NCUP stress and depression within the BPNSE framework. The NCUP connection and coherence intricately associated with ANS activity affect antenatal hematological communication of the uteroplacental-heart-brain connection (Ho, 2008; Marques et al., 2010; McCraty et al., 2009; McCraty & Childre, 2010; Sutarto et al., 2010; Thomas, 2010). Research needs to explore nonintrusive CBSR training that synchronizes ANS communication within the uteroplacental-heart-brain connection to reduce antenatal stress and improve depressive symptoms during pregnancy. Contributions to advanced clinical practice with antenatal stress, depression, and depressive based disorders during pregnancy are increased understanding of the effect of CBSR that occur over a 4-week period within the NCUP system of second trimester pregnant women who receive training and practice CBSR.

Like the reproductive effects of NCUP coherence, social coherence affects psychophysiologic components of HRV and the ANS (Ho, 2008; McCraty & Childre,

2010; Vrekousis et al., 2010). Given that coherence is a living system's very defining quality that involves synchronization of regular and repeated fluctuation between organisms, CBSR has the potential for significant social change in quality of coherence (Ho, 2008; McCraty & Childre, 2010; McCraty et al., 2012). Positive social-environmental coherence may in turn have important psychophysiologic benefits on antenatal stress, depression, and mortality rates (Adewuya et al., 2007; Hippman et al., 2009; Hoffman & Hatch, 1996; McCraty & Childre, 2010).

Summary and Transition

I identified the effect of CBSR that occur over 4 weeks in the NCUP system of second trimester pregnant women. I explored the effect of CBSR that occur in the NCUP system over a 4-week period between a group of second trimester pregnant women who receive training and practice CBSR and a group that receives no training or practice. The NCUP coherence strengthens a coherence feedback loop between the pregnant woman, her offspring, the social community, and global generations to come (Ho, 2008; McCraty & Childre, 2010; McCraty et al., 2012; Sutarto et al., 2010; Thomas, 2010; Vrekousis et al., 2010). The positive social change benefits, therefore, have potential to reach beyond the immediate antenatal, familial, and social effects to global future generations.

The following chapters more thoroughly explore aspects introduced in Chapter 1. Chapter 2 provides a detailed literature review examining the integrated BPNSE aspects of the NCUP connection and coherence. These are intricately associated with ANS activity, hematological communication of the uteroplacental-heart-brain connection, and the benefits of CBSR (Ho, 2008; Hui, 2012; McCraty et al., 2009; Plastow, 2009; Sutarto

et al., 2010; Thomas, 2010). Chapter 3 is an explanation of the quantitative research design, setting and sample, study procedures, the CBSR training technique, measures and materials, operational definitions of variables, statistical analyses, threats to validity, and ethical procedures. Chapters 4 and 5 present the findings, limitations, and provide concluding remarks.

Chapter 2: Literature Review

Medical and mental health professionals have opposing views about the communicable status of depression (Bastiampillai et al., 2013; Joiner, 1994). Nonetheless, depression is identified as a noncommunicable disease by medical definition because disruption in normal bodily function occurs (Bloom et al., 2011; Boutayeb et al., 2013; Chand, 2012). However, untreated maternal depression during pregnancy has potential for lifelong disabling symptoms of depression in offspring, beginning in utero (Bonari et al., 2004; Field et al., 2004; Weinstock, 2005). Categorization of all disease is important to identify rates of occurrence and economic impact, and the lifelong effects of antenatal depression need to be included. Noncommunicable disease is currently the largest cause of all death worldwide at 36 million, 63% of all deaths (Boutayeb et al., 2013). Deaths due to noncommunicable disease are expected to reach 44 million by 2020.

Depression was declared the 21st century's major cause of morbidity by the World Health Organization (Bennett et al., 2004a; Mathers et al., 2004). Besides being the main precursor of suicide globally, depression is the leading cause of death for women between the ages of 15 to 44 during the reproductive years. It was estimated that by 2020, depression would be second only to coronary heart disease around the world as a cause of mortality (Bennett et al., 2004a; Mathers et al., 2004). Stress and depression are the underlying bases of comorbidity, conditions that occur concurrently in a patient, in 48% of cardiovascular diseases (heart disease, hypertension, and stroke), 12% of chronic respiratory diseases, 4% of and diabetes cases (Boutayeb et al., 2013). Largely

preventable, 9 million non-communicable cases occur before the age of 60 (Boutayeb et al., 2013). Unipolar depression, an episode of depression without a manic phase, significantly poses the highest disruptive function to life at 151.2 million worldwide, 22.7 million in the Americas with higher rates of unipolar depression in higher-income countries (Mathers et al., 2004). Depression greatly increases the risk of physical and social disability in developing and developed regions worldwide (Bennett et al., 2004a; Mathers et al., 2004).

The cumulative cost of noncommunicable disease is estimated at $47 trillion worldwide over the next two decades per the World Economic Forum and the Harvard School of Public Health macroeconomic simulation (Bloom et al., 2011). This represents a $63 trillion loss, which was 75% of the global gross domestic product. The multi-trillion-dollar loss comprises personal medical and nonmedical care costs, nonpersonal costs, and loss of income (Bloom et al., 2011; Chand, 2012). Approximately 10.8 million individuals experience unipolar depression daily in North and South America, which is 7.5% of the total daily burden that disease poses to society at large (Barrio & Burt, 2000; Dennis et al., 2010a, Mathers et al., 2004; Pariante, 2003). The effects of depression cost a combined economic burden of approximately $30 to $44 billion dollars annually in the United States alone (Barrio & Burt, 2000; Bennett et al., 2004a; Karavidas et al., 2007; Pariante, 2003). The cost of depression involves decreased productivity, missed workdays, and lost lifetime earnings. Hidden costs that further affect individuals, families, and the community are medical resource consumption in outpatient office and inpatient hospital related medical care, as well as pharmaceuticals (Barrio & Burt, 2000;

Bennett et al., 2004b). As the level of stress to patients increases, visits to physicians increase, accounting for 75%-90% of all doctor's office visits (Childre & Cryer, 2004).

Consequences of disease status, mortality, disability, and cost of depression in the general population effect nonpregnant and pregnant women. Stress as a construct is often ambiguously defined in current literature, further complicating identification of antenatal stress and depression due to normal aspects of pregnancy that mimic symptoms of depression (Bennett et al., 2004a; Spinelli, 1997). Severity and course of antenatal depression precipitated by stress range from 10%-47% of women throughout pregnancy (Flynn et al., 2007; Hatton et al., 2007; Manber et al., 2008; Skouteris et al., 2008; Wallis et al., 2012). In 70%-86% of antenatal women, outcomes of pregnancy can range from mild to severe and involve BPNSE aspects of stress and depression (Bonari et al., 2004; Hippman et al., 2009; Tegethoff et al., 2011). Such multidimensional aspects of stress that lead to depression compound the relationship between stress and depression during pregnancy. Nonetheless, 50%-70% of pregnant women remain undiagnosed during a critical time of life (Tegethoff et al., 2011).

Pregnancy is not a disease, although antenatal depression, depression that occurs during this period, is a serious biological illness with potential for development of depression-based diseases (APA, 2000). Psychophysiologic response to antenatal stress within the natural and social environments consequently have potential adverse effects on pregnancy outcomes (Davis et al., 2011; Harville et al., 2010; Meinlschmidt et al., 2010; Parcells, 2010). The interconnected NCUP relationship and the environment, therefore, determine the quality of the pregnancy experience. Awareness of differences within an

integrated framework of BPNSE stress during pregnancy is critical for an effective response to antenatal depression (Ho, 2008; Hui, 2012; McCraty et al., 2009; Thomas, 2011).

Risk for depression-based disease within the NCUP system results from untreated antenatal depression. Maternal factors adversely affected by untreated antenatal depression are HRV, inflammatory illnesses, gestational hypertension, preeclampsia, uterine artery resistance, and the uteroplacental vascular system (Dayan et al., 2006; Diego et al., 2006; Gayasen et al., 2003; Kurki et al., 2000; Mulder et al., 2002; O'Mahony et al., 2006). Symptoms of pregnancy specific disease can be invisible or mild to critically severe, potentially lethal, and when left untreated or diagnosed late stage, potentially fatal maternal effects (Chen et al., 2004; Gayasen et al., 2003; Kurki et al., 2000; Lowenkron, 1999; McCraty et al., 2003; Sheffield et al., 1998). A well-balanced NCUP system is necessary to respond effectively to environmental demands during pregnancy that surpass the gestational milieu's capacity to process stress. Conversely, the majority of stressful life events do not result in illness but rather produce positive outcomes (Brunton, 2010). An antenatal example of this phenomena involves fetal exposure to stress hormones that prepare the fetus for the environment in which they are about to be born (Brunton, 2010). Considering the severe consequences of untreated stress during pregnancy, it is important to explore interconnected aspects of antenatal stress and depression.

Gestational hypertension complicated pregnancy has a direct relationship with antenatal depression (Faber et al., 2004; Jahic et al., 2008; Leeners et al., 2007). The

relationship between hypertension and depression during pregnancy affects 5%-10% of pregnant women. Gestational hypertensive disorders are the leading cause of death during pregnancy (Faber et al., 2004; Jahic et al., 2008; Leeners et al., 2007). Preeclampsia is a severe hypertensive disorder, which occurs primarily during pregnancy despite being one of the most preventable causes of maternal death (Bacidore et al., 2009; Beddoe & Lee, 2008; Jahic et al., 2008). Despite advanced medical care in the United States, birth outcomes are not improved from before the development of the healthcare advances. Consequently, 50,000+ pregnant women die annually worldwide (Bacidore et al., 2009; Beddoe & Lee, 2008; Jahic et al., 2008). An integrated NCUP approach focused on uterus-placental-heart-brain coherence, therefore, is necessary to respond to the connection between antenatal stress, depression, and neurocardio pregnancy related disease such as gestational hypertension and preeclampsia (Ho, 2008; Hui, 2012; McCraty et al., 2009; Thomas, 2012; Vrekousis et al., 2010). The basis of this study is the centrality of ANS activity to the reproductive system and antenatal psychoneurocardiovascular health within an integrated BPNSE framework (Ho, 2008; Hui, 2012; McCraty et al., 2009; Plastow, 2009; Vrekousis et al., 2010).

Given the severity of antenatal depression and the role maternal stress plays in the disease process during pregnancy, the World Health Organization recommends that research on antenatal depression receive high priority (Tegethoff et al., 2011). A review of the literature encompassing an integrative approach to antenatal stress with a strong emphasis on the NCUP connection and its relationship with the environment was described. Chapter 2 presents an analysis of peer-reviewed articles that explain the

intricately entwined aspects of antenatal stress and depression together with their effect on pregnancy outcome. Stress resilience training that may restore homeostasis within the NCUP system was described.

In this manuscript, definitions and rates of antenatal stress and depression are presented first, followed by a description of NCUP integrated effects of stress and antenatal depression. The integrated aspects of antenatal stress and depression are considered. These considerations include BPNSE aspects of the pregnancy experience. Biological components describe the role of hypothalamic-pituitary-adrenal (HPA) axis in antenatal depression, corticotropic-releasing hormone together with the effect of CBSR on 17-OHP, cortisol, DHEA/DHEAS, and sIgA during pregnancy. Effects of the maternal physiologic stress response within the natural environment of the NCUP gestational milieu and the effect of CBSR on the intensity of symptoms in antenatal stress were explained. Psychological effects, risk factors, and symptoms in relation to the integrated NCUP experience of the pregnant woman with differences in symptoms of depression were examined. Next, Social environmental change, NCUP coherence, and antenatal depression were explored.

Neuro-Cardio-Utero-Placental coherence, HRV rhythms, and stress resilience training were reviewed. The definition, consequence, benefits of NCUP coherence, and the effect of CBSR on positive reappraisal coping responses was illustrated. A discussion of HRV, brain stress response, and corticosteroids effect on antenatal stress and depression was demonstrated. Maternal HRV, gestational hypertension, and maternal/fetal HRV followed by a review of untreated stress consequences, antenatal

depression interventions, and barriers to treatment was presented. Finally, NCUP CBSR, benefits to antenatal depression, and the effect of CBSR on HRV rhythm coherence during pregnancy were explored.

Peer-reviewed journal articles from 2000 through 2014 were obtained through a variety of processes. Medical and psychology databases were searched through Walden University EBSCO including MEDLINE, PsycINFO, PsycARTICLES, CINAHL, and SAGE journals. WorldCat, global library collections, was searched to access a broad range of medical libraries and psychological databases. Google Scholar along with a general online Google search yielded literature reviewed, which lead to an examination of more reference lists of peer reviewed studies. The literature search included the following keywords: *pregnancy, pregnant, perinatal, antenatal, reproductive health, peripartum*, *stress, stressor, distress, depression*, *cortisol*, *DHEA, 17-OHP*, *sIgA, heart rate variability, second trimester, psychiatry, psychology*, *psychotherapy, counseling, coping, Edinburgh Postnatal Depression Scale (EPDS), Pregnancy Experience Scale (PES),* and *measures*.

Definition and Rates of Antenatal Stress and Depression

Stress as a construct is described inconsistently throughout the literature. This lack of standardization produced an ambiguous concept of stress (Hui, 2012; Rondo, 2007). Stress during pregnancy has an inherently multidimensional quality that involves integrative characteristics of BPNSE within the NCUP system (Hui, 2012; Thomas, 2011; Vrekousis et al., 2010). The NCUP process functions to maintain homeostasis within the reproductive system throughout gestation (Thomas, 2012; Vrekousis et al.,

2010). The combined result is an integrative framework that represents the role stress plays in the development of antenatal physical and psychological disease. An integrated perspective of BPNSE traditions of stress provide a framework to evaluate the multidimensional process of stress that occurs during pregnancy (Bonari et al., 2004; Hui, 2012; McCraty et al., 2009; DiPietro et al., 2004; Vrekousis et al., 2010; Weinstock, 2005). Disrupted homeostasis that poses a threat to NCUP coherence, therefore, defines antenatal stress for the purpose of this project (McCraty et al., 2009; Vrekousis et al., 2010).

The BPNSE traditions of stress are individual perceptions, while each tradition within BPNSE is an integral component of an integrative framework within the antenatal stress process (Hui, 2012; McCraty et al., 2009; Vrekousis et al., 2010). The environmental component of stress views stressful life events as the etiologic basis of illness. The psychological component of stress emphasizes perception and evaluation of environmental experience in relationship to maintained homeostasis and protection of equilibrium (Hui, 2012; McCraty et al., 2009; Paz-Filho et al., 2010; Vrekousis et al., 2010). Environmental stressors that a person views as beyond their capacity to adapt to their surroundings results in psychological stress that poses a threat to homeostasis (Paz-Filho et al., 2010; Vrekousis et al., 2010). Environmental stressors have a direct effect on psychophysiologic homeostasis (Hui, 2012; McCraty et al., 2009; van den Bergh et al., 2008).

The biological component of stress presents as a physiological response to stress when exposed to excessive stimulation. Similarly, biological responses evidence stressors

as activated within the NCUP system (Stein et al., 2008; Thomas, 2011; van den Bergh et al., 2008; Weinstock, 2005). Depression precedes increased levels of stress. The comorbidity of stress and depression as well are observed in pregnant populations (Kazi et al., 2009; Parcells, 2010). Consequently, stress not only exacerbates depression but also has an effect on depressive outcomes overall (Gould & Chrousos, 2002). Therefore, the interconnection of antenatal stress and depression requires an integrated approach to the maternal/fetal experience that encompasses NCUP aspects of pregnancy (McCraty et al., 2009; Thomas, 2011; Vrekousis et al., 2010).

Antenatal depression is a serious biological illness with multiple causes that contains BPNSE interactions (APA, 2000, Scheid et al., 2007). For example, antenatal depression's adverse effects on women's functioning in nearly all activities includes a change in appetite, sleep patterns, expression of emotion, cognitive processes, behavioral changes, increased physical pain, level of interest, along with a potential for safety risk. To reduce depression during pregnancy, it is essential to utilize an integrated framework of the antenatal stress process.

Definition and rates of stress during pregnancy was described followed by definition and rates of antenatal depression along with the integrated role that antenatal stress and depression play on each other within the NCUP reproductive system.

Antenatal Stress Definition and Rates

Ancient physician research, dating back to as early as 300BC suggests a significant relationship between stress and women's reproductive health. The ancient physician, Hippocrates of Cos, observed the nomadic tribe of the Scythians, and

attributed their high rate of infertility and impotence to harsh living conditions (Chrousos et al., 1998). The harsh living conditions resulted in an environment where increased tension generated strain on the reproductive system. Excessive levels of stress, when left unattended, reach a breaking point that result in disequilibrium within the NCUP reproductive system (Bunevicius et al., 2009a; Stewart, 2011; Thomas, 2011). As a result, antenatal homeostasis works constantly to stabilize the nature of continuous change within the reproductive environment and increases when confronted by adverse stimuli (Vrekousis et al., 2010). Accordingly, threat to NCUP coherence defines antenatal stress.

Multidimensional aspects of pregnancy encompass different types of stress with not all stress being inherently bad (Hawkley et al., 2005). Stress may be positive or negative and can be either long-term or short-term. Both positive and negative stressful experiences have the capacity to disrupt homeostasis (Hawkley et al., 2005). A positive stressor can even have adverse effects. When pregnancy is a positive experience within finite parameters of approximately 40-weeks, overlooking and enduring stress is more possible. Usually, adaptive responses occur during short-term stress; and chronic, long-term stress has the potential to breakdown physiologic resilience that pose a detriment to health (Hawkley et al., 2005). An adaptive physiologic response tends to result from acute stress, repeated intense bouts of stress challenge the organism beyond its ability to meet demands effectively that result in poor health and reduced physiologic resilience.

Given the inherent multidimensional quality of antenatal stress, like non-pregnant stress, integrative characteristics of antenatal stress involve BPNSE (Hui, 2012). The difference is that a pregnant woman has the potential to experience non-pregnant together

with pregnancy related stress. Antenatal stress is recognition that excessive strain has developed (Hoffman & Hatch, 1996). Due to the natural features of pregnancy, increased strain occurs in each component of stress (Bonari et al., 2004; DiPietro et al., 2004; Leigh & Milgrom, 2008; Scheid et al., 2007; Weinstock, 1997, 2005). Accordingly, an increased risk for gestational distress describes the interplay between stressors during pregnancy and antenatal stress resultant in depression.

Pregnant women report more stress during the most vulnerable fetal stage, the first half of gestation, due to low antioxidant defense in early pregnancy than during later in pregnancy (DiPietro et al., 2004; Stein et al., 2008). Environmental factors unique to pregnancy include bodily changes that affect clothing fit, shift in the ability to complete tasks, change in social status, a readjusting of social and professional networks, and physical intimacy (DiPietro et al., 2004). Pregnant women experience physiologic change related to fetal growth. Pregnancy related physical changes vary from woman to woman and include weight gain, increased uterus and breast size, higher cardiovascular output, greater blood volume, shifts in respiration, posture, and gait (Spinelli, 1997). These physiologic changes have significant negative effects on emotional health (Spinelli, 1997). Differences overlooked in pregnancy specific environmental experiences may further lead to inaccurate appraisal of antenatal stress. Antenatal environmental factors may be experienced adversely, although negative and positive states occur simultaneously, affecting separate biological systems (DiPietro et al., 2004). Stress during pregnancy and negative antenatal outcomes are directly related to activity within the ANS and HPA-axis (DiPietro et al., 2004; Paz-Filho et al., 2010). Conversely,

positive stress is unrelated rather than inversely related to depressive symptoms (DiPietro et al., 2004).

Antenatal stress reactions are dynamic because of the continuous interplay that occurs between pregnant women and their environment (Lowenkron, 1999). The self-evaluated ability to cope determines the level of stress experienced (Folkman & Lazarus, 1988). Consequently, the antenatal capacity to cope directly affects the quality of the pregnancy outcome (Dole et al., 2004; Duncan & Bardacke, 2010). Pregnant women who experience increased stress are more likely to attribute difficult outcomes as not within their control and develop distancing as a style of coping to reduce stress. Feelings of responsibility for maladaptive situations lead to avoidance strategies that result in adverse birthing complications (Lowenkron, 1999). Ineffective forms of coping, as a result, comprise psychological components of stress.

The biological component of stress involves activation of the affective and physiologic systems. Peripheral signals such as visual and auditory stimuli, as well the ANS and central nervous system, are involved in the stress response (Paz-Filho et al., 2010). Actual or perceived threat to homeostasis and wellbeing define psychological stress, although antenatal stress involves the interplay of numerous factors of functioning beyond biological and psychological aspects of stress. Psychophysiologic aspects of stress involve peripheral signals integrated between complex systems within the ANS and central nervous system (Paz-Filho et al., 2010). Depressive symptoms correlate with the relationship between the autonomic and cardiac systems (McCraty et al., 2001; Schwerdtfeger & Friedrich-Mai, 2009). An increased risk of depression involves

sympathetic and parasympathetic dysfunction within the ANS (Schwerdtfeger & Friedrich-Mai, 2009). Therefore, it is necessary to be aware of antenatal depression in relationship to stress within the NCUP system.

Antenatal Depression Definition and Rates

Antenatal depression is a condition, which occurs during pregnancy within the NCUP system and involves physiological, emotional, and cognitive processes (Bennett et al., 2004a; Simone & Pun, 2007). Much is unknown about antenatal depression, leaving women unprotected from the development of depressive symptoms and may leave them more vulnerable to emergence or reemergence of depression during pregnancy (Adewuya et al., 2007; Alshulter et al., 2008; Ryan et al., 2005). The shift in the levels of antenatal hormones places women at an increased risk for development of depression during pregnancy. Symptoms of antenatal depression that affect appetite, sleep patterns, self-worth, energy level, concentration, and mood are the same as within non-pregnant women (Alshulter et al., 2008; APA, 2000; Bowen & Muhajarine, 2006b; Marcus, 2009; Osborne & O'Keane, 2009). Concurrently, normal symptoms of pregnancy such as change in appetite, sleep patterns, and fatigue may mask or be confused with symptoms of depression.

Physician's lack of awareness of their own emotions, deficient education and postgraduate medical training, physiologic shift in antenatal hormones, and symptoms of pregnancy combined, that mimic depression, lead to inadequate diagnosis of antenatal depression (Angoff, 2013; Barrio & Burt, 2000; Bennett et al., 2004a). With difficulty in diagnosis of depression during pregnancy, up to 70% of women who meet criteria for

major depression are untreated (Andersson et al., 2003; Hippman et al., 2009). A clear definition of antenatal depression requires accurate differentiation between the problematic symptoms of depression during pregnancy and those that resemble normal gestational symptoms (Ryan et al., 2005). Screening tools that differentiate symptoms of antenatal depression are necessary. Consequently, it is essential to increase understanding about the connection between fluctuation in stress hormones during pregnancy and development of antenatal depression.

While there is an overlap between the symptoms of depression in pregnant and non-pregnant women, a depressed mood specifically characterizes antenatal depression, increases feelings of guilt, psychomotor retardation, social withdrawal, and diurnal variations in mood (Alshulter et al., 2008). However, the precise physiologic mechanisms are not totally understood. Antenatal depression has been linked with a number of negative outcomes that include lower than normal weight gain during pregnancy, premature births, and low infant birth weight (Andersson et al., 2003; Dayan et al., 2006; Diego et al., 2006; Shea et al., 2008). Symptoms of depression compromise women's abilities to cope with the changes and stressors that accompany pregnancy, which in turn aggravate depressive symptoms, and create a vicious cycle (Hippman et al., 2009; Segre et al., 2004). Experience of antenatal depression leave women more vulnerable to reoccurring postnatal depression (Bowen & Muhajarine, 2006a).

The rate of depression after puberty is three times higher among women than in men and is particularly elevated among women during the childbearing years (van den Bergh et al., 2008). Up to one in four women experience depression during their lives and

most likely experience it during childbearing years (Marcus et al., 2003). The rates of depression during pregnancy range from 10% to 47% (Flynn et al., 2007; Hatton et al., 2007; Manber et al., 2008; Skouteris et al., 2008; Wallis et al., 2012). Similar results held true on a global scale (Department of Health, Government of Western Australia, 2006).

Pregnant women are twice as likely to develop psychiatric disorders, including depression, than nonpregnant women (Kitamura et al., 1996a). The symptoms of Minor Depression (45%) are higher during pregnancy than Major Depression (27%) and are higher during pregnancy than postnatally (Bowen & Muhajarine, 2006b; Alami et al., 2006; Chen et al., 2004). This is true even in women without history of psychiatric disorders (Hippman et al., 2009). Rates of antenatal depression vary trimester-by-trimester and prevalence of depression fluctuates depending on gestational stage (Bennett et al., 2004b). Depressive symptoms during the second and third trimesters are particularly consistent with these findings (Bunevicius et al., 2009a; Hatton et al., 2007). Depression during pregnancy is 7.4% during the first trimester, 12.8% during the second trimester, and 12.0% during the third trimester.

During the second trimester, prevalence of psychiatric disorders had an effect on 14.1% of 1734 participants, and 10.2% met criteria for depression (Andersson et al., 2003). On the other hand, a u-shaped curve in prevalence of antenatal depression, on an intra-individual basis, changed trimester-by-trimester with higher rates in the first and third trimesters (Lee et al., 2007). Whether depression rates fluctuate among the three trimesters is largely inconclusive (Gavin et al., 2005). These shifts in depression on a trimester-by-trimester basis are evidence for the dynamic nature of antenatal depression

(Bennett et al., 2004b; Lee et al., 2007). There are opposing findings regarding whether higher rates of depression occur before, during, or after pregnancy (Bennett et al., 2004b; Lee et al., 2007).

Although depression during pregnancy is higher than depression after pregnancy, the rates of depression during pregnancy are higher than post-partum depression at 17%; depression in women within the general population is 14% to 21% (Alami et al., 2006; Andersson et al., 2003; O'Keane & Marsh, 2007). Conversely, depression occurs frequently during and after pregnancy but is no more prevalent than in non-pregnant women (van Bussel et al., 2006). Regardless of the different rates of depression before, during and after pregnancy, the prevalence of depression during the second trimester of pregnancy develops to substantial rates (Alami et al., 2006; Andersson et al., 2003; Bennett et al., 2004b; Parcells, 2010). For the purpose of this study, the focus was not the stage at which depression occurs at the highest or lowest rates; rather emphasis was on the integrated role that antenatal stress and depression play on each other within the NCUP system along with the effect that treated and untreated depression has on pregnant women.

Neuro-Cardio-Utero-Placental Effect of Stress and Antenatal Depression

A cascade of the intricately entwined BPNSE change that occurs throughout gestation are the fundamentally integrated characteristics of pregnancy (Bacidore et al., 2009; Chen et al., 2004; Evans, 2007; Hui, 2012; McCraty & Childre, 2010; Plastow, 2009). Conventional psychiatry compartmentalizes mind and body, separating the biological, psychological, and social aspects of the individual (Plastow, 2009). Pregnancy

requires an integrated approach within a collaborative framework that collapses barriers necessary to care adequately for pregnant women, the maternal/fetal dyad, and high-risk antenatal complications as they arise (Bacidore et al., 2009; Chen et al., 2004; Evans, 2007; Hui, 2012; Ji & Han, 2010; Vrekousis et al., 2010). Because healthcare professionals care for two patients during pregnancy, conflicting health related interests may arise between mother and fetus due to their susceptibility to psychophysiological distress within the NCUP system (Beddoe & Lee, 2008; Evans & Thomas, 2010).

To recognize comprehensive effects of antenatal stress and depression on pregnant women, it is imperative to have a framework that integrates the various aspects of pregnancy. Integrated reproductive healthcare requires careful consideration of the division between antenatal symptoms within the NCUP system and available care to address antenatal distress related imbalance in the uteroplacental-heart-brain connection (Ho, 2008; Hui, 2012; McCraty & Childre, 2010; Plastow, 2009; Thomas, 2010). For this purpose, BPNSE aspects of pregnancy were reviewed within the NCUP framework.

Accordingly, neuroendocrine and immune system fluctuation of the biopsychological aspect of antenatal stress and depression was discussed next, subsequent to a discussion on the psychological risks and symptoms of antenatal depression unique to pregnancy. After which, maternal psychophysiological response to stress within natural antenatal environment that comprise the gestational milieu was explained. Then, maternal/fetal intrauterine response to stress within the natural antenatal environment was explored. Finally, social environmental change, NCUP coherence and antenatal depression was discussed.

Biopsychological Factors of Antenatal Stress and Depression

As part of an integrated framework, biopsychological components of antenatal stress function to maintain homeostasis within the NCUP system throughout pregnancy (Hui, 2012; Stein et al., 2008; Thomas, 2011; Vrekousis et al., 2010). Neuroendocrine and immune system homeostasis, essential to gestational viability, have impaired regulatory function when triggered by antenatal stress (Arch et al., 2008). When exposed to repeated stress throughout pregnancy amid subsequent neuroendocrine hyperactivity, natural stress suppressors become desensitized. At this point, decreased efficacy contributes to multiple reinforcing feedback loops resultant of increased depression, morbidity, mortality, and suicide (Bonari et al., 2004; Gold & Chrousos, 2002; Weinstock, 2005). Similarly, preexisting symptoms of depression magnified by antenatal stress, lead to recurrence of depression activated by the onset of pregnancy and pronounced change in reproductive neuroendocrine, ANS, and HPA-axis function (Bennett et al., 2004a; Gold & Chrousos, 2002; Paz-Filho et al., 2010).

HPA-axis function as a key factor of psychophysiologic stability within the neuroendocrine system and regulation of stress related gestational homeostasis was discussed first, subsequent to the interrelationship of antenatal stress, depression, and corticotropin-releasing hormone. Second, the unique association that cortisol and DHEA have separately and together as biomarkers for stress and depression within the NCUP system was reviewed. Third, the vital role progesterone plays within the reproductive system, endocrine-immune equilibrium, and depression during pregnancy was explored.

Finally, the relationship between sIgA and ANS function as it pertains to HRV rhythm, along with antenatal depression was discussed.

Hypothalamic-Pituitary-Adrenal Axis and Antenatal Depression

As a major part of the neuroendocrine system, the HPA-axis together with the sympathetic branch of the ANS regulates stress related homeostasis, immune function, mood, and reproductive activity (Guilliams & Edwards, 2010; Hill et al., 2009). HPA-axis activity is a key factor in psychophysiologic stability throughout gestation (Hill et al., 2009; Vrekousis et al., 2010; Weinstock, 2005). During normal pregnancy, maternal HPA-axis shifts dramatically to regulate homeostasis within the maternal/fetal dyadic system (Davis et al., 2011). Due to biopsychological similarities of extreme stress and depression, the effects of both are the same within the immune and hormonal systems (Weinstock, 2005). Half of the responders to stress exhibited HPA-axis activity, which in turn affected immune and cardiovascular function (Fink et al., 2010; Marques et al., 2010).

Antenatal HPA-axis activity shows bottom-up processing to physiological stress in which brainstem nuclei interact directly with the HPA-axis to maintain homeostasis during pregnancy (Brunton, 2010; Hill et al., 2009; Obel et al., 2005). Pregnancy specific neuroendocrine dynamics influence variations within the gestational stress response, which in turn alters neuroendocrine cadence and circadian cycle rhythmicity consequential of the hormonal pulse (Paz-Filho et al., 2010). Elevated antenatal cortisol may reset HPA-axis rhythms that readjust overall physiologic function thus potentially jeopardizing pregnancy outcomes with early gestational activation (Brunton, 2010;

Kalsbeek et al., 2012; Obel et al., 2005). Uterine activity vital to pregnancy regulated by an interconnection of the ANS, HPA-axis and hypothalamic-pituitary-ovarian-axis when imbalanced increases disease, morbidity, and mortality (Barrio & Burt, 2000; Brunton, 2010; Gold & Chrousos, 2002; Thayer & Sternberg, 2006). Dysregulation, abnormal regulation of emotional and physiological process, in antenatal neuroendocrine function associated with HRV's effect on HPA and hypothalamic-pituitary-ovarian-axis regulatory factors, at the pituitary, ovarian, and uterine levels affected by the stress system, potentially lead to fatal outcomes (Brunton, 2010; Thayer & Sternberg, 2006; Vrekousis et al., 2010). The HPA-axis initial response to antenatal stress is secretion of corticotropin-releasing hormone via neurosecretory cells in an effort to maintain normal homeostasis during pregnancy (Guilliams & Edwards, 2010; Hill et al., 2009; Vrekousis et al., 2010).

Corticotropin-Releasing Hormone

Corticotropin-releasing hormone is a first line of stress response neurotransmitter activated by the HPA-axis and produces positive behaviors (Kramer et al., 2010; Vrekousis et al., 2010; Weinstock, 2010). Placental membranes contain corticotropin-releasing hormone that exacerbates throughout gestation (Kramer et al., 2010). Change in corticotropin-releasing hormone at the placental level in turn adversely affects antenatal neuroendocrine responsivity (Weinstock, 2010). Less responsive to episodic life event stress than severe or chronic stress, these changes elicit increased response within the maternal-placental-fetal neuroendocrine axis (Arck et al., 2008; Obel et al., 2005; Weinstock, 2010).

Corticotropin-releasing hormone synthesized in the placenta and HPA-axis are biochemically identical with most corticotropin-releasing hormone processed in the placenta during pregnancy (Fink et al., 2010; Kramer et al., 2010). Antenatal corticotropin-releasing hormone increases gradually at about 7 weeks and reaches near 100 times between the 32nd and 34th weeks gestation with the highest peak at birth (Itoli et al., 2004; Vrekousis et al., 2010). During the second trimester, cortisol and corticotropin-releasing hormone form a regulatory loop in response to psychophysiologic stress (Kramer et al., 2010; Pearce et al., 2010). Consequently, neurochemical, autonomic, and physiologic change leads to major depression due to overexpression of corticotropin-releasing hormone (Dirks et al., 2002).

Elevated stress hormones in the second trimester increase risk for negative outcomes resultant of increased peripheral corticotropin-releasing hormone and high placental cortisol induced positive feedback loop (Fink et al., 2010). Corticotropin-releasing hormone initiates uterine contractions and cervical ripening (Flandreau et al., 2012). Further activation of the HPA-axis process is suggestive of depression subsequent to overexpression of corticotropin-releasing hormone resultant of HPA-axis hyperactivity (Flandreau et al., 2012). These endometrial milieu threats to homeostasis elevate placental corticotropin-releasing hormone and inflammatory cytokines found to induce preeclampsia, a gestational hypertensive disorder (Vrekousis et al., 2010).

Cortisol, Antenatal Stress, and Depression

Salivary cortisol is a glucocorticoid stress hormone recognized as a valid, reliable, frequently used, and widely accepted psychoneuroendocrinological measure employed as

a biomarker for antenatal stress and depression (Jones et al., 2006; Field et al., 2006). Physical and psychological stress during pregnancy significantly increase cortisol compared to non-pregnant women (Weerth et al., 2007). Higher cortisol levels are associated with antenatal stress and significantly correlated with clinical depression, with the strongest relationship occurring during the second trimester (O'Donnell et al., 2009 van den Bergh et al., 2008). Elevated antenatal cortisol is comparable to hypercortisolism in severe depression, anorexia, and Cushing's syndrome. Lower awakening cortisol in pregnant women is consistent with cortisol levels in posttraumatic stress, atypical depression, and chronic fatigue (Kammerer et al., 2006; van den Bergh et al., 2008). Once elevated to significant levels, antenatal cortisol fails to suppress until after birth (Meyer et al., 2001).

Heightened cortisol is related to the natural progression of gestation while afternoon and evening cortisol are significantly associated with gestational week not collection time or parity, number of times a woman has given birth (Jones et al., 2006). There is no significance between second and third trimester cortisol levels possibly due to a ceiling effect at baseline although early and late antenatal cortisol are significantly correlated (Beddoe et al., 2009; Bolten et al., 2011). Conversely, as cortisol became increasingly higher over the course of pregnancy, levels were significantly higher in late versus early pregnancy (Beddoe et al., 2009; Entringer et al., 2010; King et al., 2010). Yet second trimester evening antenatal cortisol was 27% higher than morning levels that were unaffected (Nierop et al., 2006; Obel et al., 2005).

DHEA, Antenatal Stress, and Depression

Similar to cortisol, DHEA is associated with shifts in stress and depression although cortisol was high while DHEA was low in response to stressful events (Gallagher, 2002; Markopoulou et al., 2009). Conversely, second trimester stress and depression related mood disturbance and melancholic depression showed lower levels of DHEA secretion (Gold & Chrousos, 2002). DHEA plays a role in antenatal mood disturbance with better mood secondary to higher levels of DHEA and is associated with decreased stress (Gold & Chrousos, 2002). Likewise, increased heart rate coherence is consistent with significant improvement in mood and 100% increase in DHEA levels (McCraty et al., 1998).

Treatment resistant depression exhibits unaltered DHEA levels whereas low DHEA levels, regardless of the intervention, represent abnormal depression in contrast to the control group (Markopoulou et al., 2009; Michael et al., 2000). DHEA counters adverse effects of cortisol as well as enhances mood with significant implication for depressive pathophysiology (Michael et al., 2000). Benefits of DHEA prevent damaged inflammatory process that result from harmful cortisol effects with cortisol/DHEA ratios distinguishing the level of dysfunction within the HPA-axis (Guilliams & Edwards, 2010). Due to DHEAS interaction with cortisol in the brain, measurement of cortisol alone may represent incomplete results for hypercortisolemia (Gallagher, 2002). Nonetheless, DHEA, unlike levels of cortisol, has less daily fluctuation, and therefore, is a more stable biomarker (Markopoulou et al., 2009). Cortisol/DHEA ratios are a good biomarker of stress. Regardless the stability of cortisol/DHEA ratios, separate

measurements of cortisol and DHEA remain key factors to understand antenatal stress and depression within the NCUP system (Markopoulou et al., 2009; McCraty et al., 1998). Similarly, progesterone and DHEA are protective pregnenolone hormones necessary for gestational viability (Guilliams & Edwards, 2010; Vrekousis et al., 2010).

Progesterone During Pregnancy

One of the foremost steroid hormones, progesterone, stimulates the female reproductive system, supports gestation and embryogenesis, originates within the placenta, and increases throughout pregnancy (Hill et al., 2010; Risberg et al., 2009). Progesterone is vital to endocrine and immunological effects during the first and second trimester (Arck et al., 2007). Progesterone is essential to successful embryo implantation and pregnancy outcome (Arck et al., 2007). Placental progesterone modulates synthesis of stress hormones within the placenta and is integral to the establishment, support, and maintenance of gestational viability, fetal maturation, and delivery date (Bech-Sabat et al., 2010; Tranguc et al., 2007).

Elevated antenatal stress potentially diminishes adequate levels of progesterone upon which antenatal depression ensues; alternatively, heightened progesterone and antenatal mood disturbance are linked (Arck et al., 2007; Buckwalter et al., 1999; Kammerer et al., 2006). However, normotensive women with stable blood pressure experience increased progesterone through 36-weeks-gestation resultant in higher progesterone than found in their hypertensive counterparts (Risberg et al., 2009). Increased antenatal hemodynamic stress is associated with notably reduced levels of progesterone but higher levels of progesterone buffer pregnancy-induced hypertension

(Ansari et al., 2002). Hypothalamic amenorrhea consequences of stress produce an inhibitory effect of reproductive stress hormones that lead to inadequate gestational progesterone resultant in miscarriage (Arck et al., 2008). High and low, progesterone levels occur in relation to preeclampsia (Risberg et al., 2009). Reduced stress-mediated progesterone activates the HPA-axis, which disrupts maternal immune tolerance when disequilibrium of endocrine-immune cross talk arises (Arck et al., 2008). Given progesterone's integral role in NCUP immune health and depression, understanding shifts in antenatal sIgA are necessary (Costa et al., 2010; Yajimav et al., 2007).

Secretory Immunoglobulin A and Antenatal Stress and Depression

Secretory IgA is an antibody in mucus secretion with a critical function of immune health and maintenance of pregnancy that relies on immunoglobulin properties of sIgA within gestational mucous membranes (Negri et al., 1995). Maternal sIgA during pregnancy plays an important role in protecting against neonate pneumococci, autoimmune disorders, and allergies that increase infant mortality (Deubzer et al., 2004). Levels of sIgA are very low in healthy non-pregnant women although significantly higher during pregnancy in the first and second trimesters, in contrast to less elevated sIgA during premature delivery (Fialova et al., 2006; Negri et al., 1995). Adverse maternal/fetal interaction may occur, wherein the mother's immune response toward the fetus may attribute to unexplained spontaneous abortion (Hanson & Silfverdal, 2009; Hudic & Fatusic, 2009).

Secretory IgA is lower with self-report symptoms of depression although acute stress results in higher sIgA (Yajima et al., 2007). Notably, chronic stress type symptoms

and acute stress produce opposing sIgA results. Perceived stress is associated with decreased sIgA in breast milk although increased sIgA and positive events are linked (Kadaoui & Corthesy, 2007; Sakamoto et al., 2007). Sleep deprivation during pregnancy is a common occurrence and when disrupted, two nights sIgA is elevated. (Costa et al., 2010). Two nights sleep deficit alone decreases saliva flow rate regardless if activity is reduced by 90% during the two following days (Costa et al., 2010; Proctor & Carpenter, 2007). Reduced saliva flow, resultant of sleep deprivation, triggers decrease in parasympathetic tone that may adversely affect collection of salivary measures (Costa et al., 2010; Proctor & Carpenter, 2007). Secretory IgA secretion regulated via ANS function, specifically supplied by cholinergic parasympathetic nerves and synchronized by HRV, has an interconnected effect on antenatal depression (Proctor & Carpenter, 2007; Ring et al., 1999; Shea et al., 2008; Yajima et al., 2007). Given the integrated effect that variation in cortisol, DHEA, progesterone, and sIgA has on antenatal stress and depression, increased knowledge of the change in neuroendocrine and immune system hormones during pregnancy are necessary to further understand antenatal stress and depression within the NCUP system. Therefore, assessment of fluctuation in neuroendocrine and immune system hormone levels during pregnancy further increased understanding.

Integration of biological and psychological aspects of stress involves psychophysiologic integration between complex systems within the ANS and NCUP frameworks (Hui, 2012; McCraty et al., 2009; Paz-Filho et al., 2010; Vrekousis et al., 2010). An actual or perceived threat to homeostasis and wellbeing defines psychological

stress, although antenatal stress involves the interplay between numerous factors of function beyond biological and psychological aspects of stress (Paz-Filho et al., 2010; Vrekousis et al., 2010). Psychological perceptions of environmental experience emphasize awareness to maintain homeostasis and protect psychophysiologic equilibrium.

Psychological Correlates of Antenatal Depression

Worldwide, women have a 50% higher risk of depression than men (Mathers et al., 2004). The greatest burden of disease occurs during childbearing years between the ages of 15 and 44, which increases the threat of a first depressive episode during pregnancy (Mathers et al., 2004). Accurate identification of depressive symptoms and effective diagnosis of antenatal depression pose a challenge due to symptoms of depression that mimic normal pregnancy (Gavin et al., 2005; Kelly et al., 2001a; Segre et al., 2004). An integrated framework of antenatal depression could more effectively recognize intricate symptoms of depression specific to pregnancy. As part of an integrated framework, psychological response to antenatal depression functions to maintain homeostasis within the NCUP system throughout pregnancy (Hui, 2012; Stein et al., 2008; Thomas, 2011; Vrekousis et al., 2010). Likewise, a psychological integrative response to antenatal depression occurs through top-down processing whereby afferent signals arise from the limbic forebrain (Hill et al., 2009).

Top-down processing further activates the HPA-axis and amygdala systems to facilitate the neuroendocrine response to antenatal stress and depression (Hill et al., 2009). Similarly, sIgA and cortisol levels increase when exposed to mental stress (Yajima

et al., 2007). A relationship between psychological perception and experience maintains psychophysiologic homeostasis within the NCUP system via integration of the ANS and central nervous system (Hui, 2012; McCraty et al., 2009; Paz-Filho et al., 2010; Vrekousis et al., 2010). To recognize unique symptoms of depression during pregnancy more effectively, it is beneficial to utilize an integrated framework.

Psychological risk of antenatal depression was described followed by a review of psychological symptoms of depression exclusive to pregnancy along with the integrated role that antenatal stress and depression play on each other within the NCUP reproductive system.

Psychological Risk of Antenatal Depression

Risk factors are the increased likelihood for development of antenatal depression. An interconnected biological and psychological system that affects antenatal homeostasis within neuroendocrine pathways when distressed further complicates the physiological stress response during pregnancy (Mutambudzi et al., 2011; Wadhwa et al., 1996). Transient endocrine activity during pregnancy alters neuroendocrine function within placenta, uterine, and fetal-placental-decidual units thus compress hypothalamic-pituitary-target systems (Wadhwa et al., 1996). The resultant build-up of chemicals further stresses an already taxed HPA-axis that produces an increase in stress hormones (Sider et al., 2003; Weinstock, 2005). This neurobiological imbalance untreated during early pregnancy leads to antenatal depression (Meinlschmidt et al., 2010).

More antenatal uplifts (experiences viewed as positive) occur than hassles (experiences viewed as negative) although uplifts are not inversely related to depression

(DiPietro et al., 2004). With a high number of uplifts in relation to hassles, uplifts may mask hassles that pose increased difficulty in identification of antenatal depression. Severe antenatal depression is common, yet although 20% of expectant mothers experience depression, only 14% seek treatment (Bonari et al., 2004; Bunevicius et al., 2009b; Gausia et al., 2009). Given the risk factors of severe antenatal depression, it is essential to assess for suicidality (Bunevicius et al., 2009b; Gausia et al., 2009). Gravely, 40% of pregnant women attempt suicide at least once with suicidality accounting for 20% of deaths during pregnancy, the second most frequent cause of death in pregnant women (Bonari et al., 2004; Bowen & Muhajarine, 2006a; Bunevicius et al., 2009b; Gausia et al., 2009). Lack of adequate treatment of antenatal depression increases maternal/fetal morbidity, mortality, and maternal suicide (Hendrick & Altshuler, 2002).

Psychological Symptoms of Antenatal Depression

Symptoms of antenatal depression are the same as nonpregnant symptoms although diagnosis of depression during pregnancy is complex due to confounding symptoms, natural physiological complaints, and hormonal changes (Bowen & Mauhajarine, 2006a; Bunevicius et al., 2009a; Gavin et al., 2005; Manber et al., 2008). Diagnosis of antenatal depression takes place at lower rates than actually occur due to overlooked symptoms that closely resemble normal pregnancy (Bunevicius et al., 2009a; Chung et al., 2001; Kelly et al., 2001a). Overlooked confounding symptoms dismissed as normal pregnancy may result in serious obstetric outcomes (Bunevicius et al., 2009a; Manber et al., 2008). Significantly more somatic symptoms, from functionally impaired to debilitating, are reported by depressed pregnant woman than depressed nonpregnant

women (Birndorf et al., 2001; Kelly et al., 2001a; Manber et al., 2008). Yet, anhedonia and low mood are indistinguishable between pregnant and non-pregnant women, although suicidality and guilt are lower in pregnant than nonpregnant women (Manber et al., 2008).

Pregnant and nonpregnant women report no significant difference in sleep or appetite, although pregnant women have significantly less difficulty getting to sleep than non-pregnant women, possibly due to increased need for sleep during pregnancy (Manber et al., 2008). Still, pregnant women express more complaints about antenatal energy level, libido, somatic concerns, appetite, and sleep patterns than non-pregnant women (Bunevicius et al., 2009a; Manber et al., 2008). Antenatal sleep disturbance attributed to natural physiological processes of pregnancy with sleep quality in early gestation significantly correlated with increased depression during later phases of gestation in the second and third trimesters (Skouteris et al., 2008). Regardless that disruption in quality of sleep is due to pregnancy related shift in hormones, consequences of antenatal depression ensue nonetheless.

Given the integrated effect of psychological risks on symptoms of antenatal depression, increased knowledge of unique risks and symptoms of depression specific to antenatal depression are necessary to increase understanding of antenatal depression within the NCUP system. Therefore, investigation of the effect of CBSR on symptoms of depression within an integrated NCUP framework increased understanding of antenatal mental health. Maternal psychophysiologic response to antenatal stressors within the NCUP framework was explored.

Maternal Physiologic Stress Response Within a Gestational Environment

Natural environmental components of pregnancy that comprise the gestational milieu function as part of an integrated framework that maintains homeostasis within the NCUP system throughout pregnancy (Hui, 2012; Stein et al., 2008; Thomas, 2011; Vrekousis et al., 2010). The quality of the intrauterine environment during gestation significantly affects disease across the life span (Kelly et al., 2001a). Although, pregnant women may be unaware of the effect that physiologic stress and untreated depression have on the integrated gestational environment within their own bodies (Tegethoff et al., 2011). Increased stress associated with pregnancy, as a result, involves hyperactivity in the secretion and distribution of hormones within the brain, blood stream, and placenta (Carpenter & Cooper, 2001; Dayan et al., 2002; Kurki et al., 2000; Sugiura-Ogasawara et al., 2002; Weinstock, 2005). This pregnancy related neuroendocrine activity within the NCUP system can lead to gestational hypertension, preeclampsia, spontaneous abortions, uterine artery resistance, spontaneous early labor, preterm birth, and a number of similar pregnancy-disrupting reactions. Consequently, antenatal depression associated with increased adverse physical symptoms during pregnancy lead to maternal morbidity and mortality (Bonari et al., 2004; Kelly et al., 2001a).

Peripartum cardiomyopathy, pregnancy-related heart failure associated with antenatal depression and implications of morbidity, mortality, and death was discussed next, subsequent to gestational hypertension, the hidden nature of preeclampsia in relation to elevated psychological stress, and adverse outcomes of antenatal depression. Uterine artery resistance in relation to antenatal hypertension amplified by antenatal

stress and depression within the NCUP system was reviewed. The risks and consequences that antenatal inflammation has on gestational viability were explored. Finally, the relationship between antenatal stress, depression, spontaneous abortion, early labor, and preterm birth related to mortality were discussed.

Peripartum Cardiomyopathy

Peripartum cardiomyopathy is heart failure typically diagnosed during the last month of pregnancy although symptoms may develop during early pregnancy, hence the term pregnancy-related cardiomyopathy (Ntusi & Mayosi, 2009; Pyatt & Dubey, 2011). Associated with antenatal depression although, uncommon, peripartum cardiomyopathy poses likely fatal implications of morbidity, mortality, and death (Elkayam, 2011; Goland et al., 2009; Pyatt & Dubey, 2011; Sliwa et al., 2010). At peak hemodynamic stress, peripartum cardiomyopathy presents toward the end of gestation with a high risk of recurrence during a subsequent pregnancy (Bhattacharyya et al., 2012; McGarry & Tong, 2007; Pyatt & Dubey, 2011; Sliwa et al., 2010). Left ventricular systolic dysfunction with decreased contractility and heart failure are characteristics that occur during the last month of pregnancy (Elkayam, 2011; Ramaraj & Sorrell, 2009). The cause is unknown, yet irregular antenatal immune response, hormonal abnormalities, and inflammation are potential causes (Bhattacharyya et al., 2012; Elkayam, 2011; Ramaraj & Sorrell, 2011).

Patients with symptoms of peripartum cardiomyopathy show a significant reduction in progesterone levels compared to asymptomatic pregnant women (Ansari et al., 2002). Lower levels of progesterone further increase maladaptive maternal response to hemodynamic distress during pregnancy, which may further influence the development

of heart disease (Ansari et al., 2002). Heart health, development of coronary heart disease, and cardiac mortality, are associated with symptoms of depression (Goland et al., 2009; Lavoi et al., 2010). Endothelial dysfunction, a form of inner lining malfunction within a blood vessel, likewise triggers cardiac complications linked to depression, although often with the presence of few depressive symptoms (Lavoi et al., 2010). Poor cardiac outcomes during pregnancy are likely the result of combined behavioral and physiologic effects of depression (Lavoi et al., 2010). Preeclampsia, cesarean section, twin pregnancy, teenage pregnancy, and advanced maternal age pose a risk for development of peripartum cardiomyopathy (Bhattacharyya et al., 2012). Hesitation to diagnose peripartum cardiomyopathy early in pregnancy occurs to avoid misdiagnosis of other diastolic dysfunction such as those that may present in preeclampsia (Ntusi & Mayosi, 2009; Pyatt & Dubey, 2011).

Gestational Hypertension and Preeclampsia

Women with gestational hypertension, increased symptoms of preeclampsia, and mild to severe preeclampsia have significantly elevated psychological stress compared to stable pregnancies (Black, 2007). Criteria for gestational hypertension include newly diagnosed blood pressure equal to or greater than 140/90, no protein in the urine, a diagnosis commencing after 20 weeks gestation (Iwase & Misumida, 2011; Siddiqui et al., 2010). Preeclampsia, a pregnancy specific hypertensive disease with similar criteria to gestational hypertension, although with protein in the urine, has an unknown etiology and is the leading cause of maternal/fetal morbidity and mortality (Moreira et al., 2009; Siddiqui et al., 2010; Veillon et al., 2009; Vrekousis et al., 2010). First stage symptoms of

preeclampsia begin as early as 12 weeks gestation with inadequate uteroplacental remodeling of spiral arteries (Bushnell & Chireau, 2011; Keiser et al., 2009). Second stage preeclampsia involves reduced flow of fluids to and from the placenta caused by damaged blood vessels, a term called insufficient placental perfusion that occurs via spiral arteries (Bushnell & Chireau, 2011; Keiser et al., 2009; Siddiqui et al., 2010; Veillon et al., 2009). Likewise, effective maternal-placental blood circulation requires adequate artery spiral remodeling to maintain sufficient uteroplacental blood flow necessary for optimal pregnancy outcomes and may be adversely affected by clinical depression (Bennett et al., 2004a; Bushnell & Chireau, 2011).

Symptoms of mild preeclampsia are invisible; therefore, preeclampsia may occur earlier than 20-weeks gestation and remain undetected due to the hidden nature of the condition (Siddiqui et al., 2010). Together with the silent nature of antenatal depression, preeclampsia poses increased potential for dangerous outcomes (Siddiqui et al., 2010). Depression was found in 30% of pregnant women but preeclampsia was found in 4.5%, and of the preeclamptic women, 32% experienced depression (Kurki et al., 2000). This presents a strong likelihood of elevated risk toward preeclampsia in antenatal depression with a 3.1-fold risk factor. Increased risk of cardiovascular mortality, therefore, is a serious consequence of antenatal depression, a treatable condition (Siepmann et al., 2008). Fetal delivery irrespective of gestational stage has been the only known protective measure that preserves maternal life in cases of preeclampsia (Jahic et al., 2008; Siddiqui et al., 2010).

Pregnant women with hypertensive disorders have a higher incidence of antenatal depression, and depression at 12 weeks gestation poses increased risk for preeclampsia (Chen et al., 2004; Diego et al., 2006; Kurki et al., 2000). A direct relationship between antenatal depression and preeclampsia is consistent with severe antenatal emotional stress and experience of maternal stress during pregnancy (Leeners et al., 2007; Mulder et al., 2002). Depression may trigger vasoconstriction, change vasoactive hormones, and neuroendocrine transmitters that alter vascular function associated with preeclampsia (Kurki et al., 2000).

Preeclampsia, recently found to originate in the ANS and central nervous system in nonpregnant women, provides researchers with a further route to pursue its cause (Kurki et al., 2000). Antenatal depression related abnormalities in both the ANS and HPA-axis adversely affect cardiac regulation during pregnancy (Sheffield et al., 1998). Connection between preeclampsia's ANS and central nervous system origin, together with antenatal depression's dysregulation of ANS and HPA-axis, may show promise for preventative care of conditions through homeostatic regulation of NCUP mechanisms (Kurki et al., 2000; McCraty et al., 2009; McCraty et al., 1998; Sutarto et al., 2010; Thomas, 2010).

Uterine Artery Resistance

Uterine artery resistance is the effect of increased hypertension experienced during pregnancy with higher rates in antenatal depression, uterine contractions, and uterine hypertonus (uterine muscle spasms that remain unrelaxed between contractions; Carpenter & Cooper, 2001). Primary manifestation of preeclampsia may involve

antenatal stress induced uterine artery resistance (Kurki et al., 2000). Intramural pressure increases uterine venous pressure through contractions. Intrauterine pressure may be reduced through maternal systemic hypotension, aortic compression, and restricted uterine blood flow (Carpenter & Cooper, 2001). This reduced blood flow through the placenta restricts umbilical artery blood flow, resulting in severe hypoxia, low oxygen level in the blood, tissue, and organs (Carpenter & Cooper, 2001).

Placental growth and gestational maturation that begin during the first trimester and continue throughout pregnancy produce increased uterine blood flow with possible vasoconstriction that effect peripheral resistance and results in reduce blood pressure (Iwase & Misumida, 2011). Increased maternal stress in turn leads to diminished uterine blood flow, which reduces essential oxygenated nutrition (Mulder et al., 2002). The interrupted process of transplacental maternal hormones results in an increased intrauterine exposure to placental corticotropin-releasing hormone in response to amplified maternal stress that adversely affects the intrauterine environment (Mulder et al., 2002). These stress-induced processes transmit signals of maternal stress to the fetus that pose unfavorable stress effects on the unborn (Mulder et al., 2002). Consequences of intrauterine stress are integral to progression of disease across the life span as the antenatal environment is pivotal in quality-of-life span health (Tegethoff et al., 2011).

Inflammation During Pregnancy

Inflammation is a malfunctioned immune system response to protect the body against invasion of foreign matter (Guilliams & Edwards, 2010). Chronic intermittent and acute stress of increased severity breeds acute and chronic inflammation that signals anti-

inflammatory properties of cortisol (Guilliams & Edwards, 2010). Stress mediated inflammatory pathways pose harmful effects on antenatal vascular and heart health (Brown et al., 2009). Antenatal cardiovascular disorders promote the release of inflammatory cytokines, protein that signal messages between cells, further perpetuating cyclic systemic inflammation. Excessive proinflammatory cytokines alone pose increased risk for antenatal depression and preterm birth (Weinstock, 2010).

Activation of inflammatory processes occurs in relation to depression, even though pathophysiology of antenatal depression may have originated during the mother's own fetal experience (O'Mahony et al., 2006). Antenatal depression plays a possible role in inflammatory activated vaginal infection that increases the risk of premature uterine contractions, ruptured placental membranes, and reduced gestation (Dayan et al., 2006). Inflammation is linked to the quality of blood pressure, preeclampsia, and pathophysiologic development of peripartum cardiomyopathy (Bernardi et al., 2008; Bhattacharyya et al., 2012).

Compared to healthy controls, inflammatory status predicts antenatal outcome secondary to significantly higher pro-inflammatory cytokines or significantly lower anti-inflammatory cytokines (Hudic & Fatusic, 2009). Anti-inflammatory cytokine regulation of the pro-inflammatory process reduces physiological deterioration that otherwise led to declined muscle strength as well as increases morbidity and mortality (Thayer & Sternberg, 2006). Antenatal inflammation poses a severe risk of premature delivery due to chorioamnionitis, inflammation of fetal membranes that occur in 1 to 2% of pregnancies (Goldman & Schmalstieg, 2008).

Spontaneous Abortion

Spontaneous abortion is a naturally occurring loss of the products of conception prior to 20-weeks gestation (Nelson et al., 2003). Often reported alongside antenatal depression spontaneous abortion is nonsignificant (Nelson et al., 2003). Participation in the treatment for antenatal depression was also not reported (Nelson et al., 2003). Treatment status is of particular importance due to pronounced differences between pregnant women with treated and those with nontreated maternal depression. Outcomes for treatment of antenatal depression are more positive with fewer spontaneous abortions (Bonari et al., 2004; Field et al., 2004). Lack of care is associated with increased rates of miscarriage (Sugiura-Ogasawara et al., 2002). However, depression related spontaneous abortion was not significant (Nelson et al., 2003). Nonetheless, spontaneous abortion that correlates with depression is significant in a plethora of other studies (Bonari et al., 2004; Field et al., 2004; Weinstock, 2005).

Pregnant women affected by antenatal stress and depression experience elevated rates of spontaneous abortion (Bunevicius et al., 2009a; Diego et al., 2006). Similarly, higher antenatal stress and depression related cortisol are associated with early miscarriage (Arck et al., 2008; Brunton et al., 2008). Premature birth, adverse pregnancy outcomes, and spontaneous abortion have a direct relationship to high levels of antenatal stress and depression (Arck et al., 2008; Bunevicius et al., 2009a). Potential for a vicious cycle of severe depression and subsequent chronic miscarriages are directly linked to untreated pregnancy related stress and depression (Sugiura-Ogasawara et al., 2002). Consequently, reproductive complications associated with recurrent miscarriage are

stressful and traumatic life events statistically significant for severe pregnancy related depression (Sugiura-Ogasawara et al., 2002).

Spontaneous Early Labor and Preterm Birth

Preterm birth is delivery before 37 weeks gestation in relation to a full-term gestation period of 40 weeks (ACOG, 2008). Exact sources of spontaneous early labor and preterm births are unknown; they may involve psychosomatic processes within the biochemical environment (Meis et al., 2003; Vrekousis et al., 2010). Insight to triggers of early labor related mortality are imperative as premature labor accounts for 80% of preterm births, 8 to 12% of all live births, subsequent to moderate antenatal stress (ACOG, 2008; Beddoe & Lee, 2008; Meis et al., 2003).

Over exposure to stress induced glucocorticoids, stress hormones that facilitate cell release of glucose to combat physical and emotional stress, are intended for stress relief; however, in excess, these stress hormones further increase spontaneous premature birth (Ventura et al., 2011). Additional consequences are antenatal stress induced disorders of preeclampsia and amniotic infection (Ersch et al., 2008). Psychophysiological effects of antenatal stress further impose maternal/fetal distress subjecting them to long-term stress outcomes, chronic stress cycles, and associated preterm births (Ersch et al., 2008; Mulder et al., 2002). Acute stress during early pregnancy, chronic psychological stress throughout pregnancy, and distress in late pregnancy consequently affects maternal/fetal outcomes unfavorably.

Antenatal stress and potential antenatal depression are the leading cause of preterm birth (70%) related morbidity and mortality (Alshulter et al., 2008; Pearce et al.,

2010; Vrekousis et al., 2010). Premature birth is significantly twice as likely in depressed (9.7%) versus non-depressed (4.0%) pregnant women, which subsequently results in unfavorable pregnancy related outcomes (Bunevicius et al., 2009a; Dayan et al., 2002; O'Keane & Marsh, 2007). Preterm birth consequently accounts for 75% of neonatal deaths, which occur within 28 days of life (Douglas, 2010; Vrekousis et al., 2010).

An integrated framework within the gestational milieu maintains NCUP homeostasis, which further affects maternal and fetal health (Hui, 2012; Stein et al., 2008; Thomas, 2011; Vrekousis et al., 2010). Sympathetic modulation manages the quality of hemodynamic function within the placenta and maternal/fetal dyad (Heiskanen et al., 2008; Struijk et al., 2001). Therefore, maternal/fetal morbidity and mortality, are directly affected by the consequence of parasympathetic deactivation resultant of gestational hypertension and preeclampsia (Heiskanen et al., 2008; Jahic et al., 2008; Siddiqui et al., 2010).

Maternal/Fetal Response to Stressors in the Gestational Environment

The maternal/fetal intrauterine connection within the antenatal milieu functions as part of an integrated framework that relies on NCUP homeostasis for gestational viability (Bech-Sabat et al., 2010; Hui, 2012; Stein et al., 2008; Thomas, 2011; Vrekousis et al., 2010). Accordingly, lipophilic properties of stress related reproductive hormones adversely affect intrauterine homeostasis, which in turn affect the quality of embryo attachment, implantation, the wellbeing of both mother and fetus, as well as the maternal/fetal intrauterine relationship (Bech-Sabat et al., 2010; Jones et al., 2006; Tegethoff et al., 2011; Vrekousis et al., 2010; Welberg & Seckl, 2001). Notwithstanding,

natural early intrauterine conditions that are hypoxic due to low oxygen tension are highly sensitive to antenatal stress (Potdar et al., 2009). Intrauterine oxygen levels increase significantly after trophoblastic formation of spiral arteries end of the first trimester (Potdar et al., 2009). However, hypoxia-reoxygenation, increased blood oxygen levels, may increase oxidative stress when exposed to antenatal depression further disrupting NCUP homeostasis (Potdar et al., 2009). When exposure to stress hormones within the intrauterine environment is adverse, the process may be preparation for unpredictable conditions in the external environment after birth (Brunton, 2010). Nonetheless, as brief as gestation is, psychological effects of maternal stress may compromise fetal disease throughout the life span regardless the cause of antenatal depression (Stein et al., 2008; Vrekousis et al., 2010).

Accordingly, maternal/fetal crossover of reproductive hormonal effects on antenatal stress, depression, and homeostasis within the NCUP milieu were discussed next, followed by the effects of maternal depression within the gestational milieu on fetal development. After which, physical symptoms of antenatal depression on the fetus were reviewed. Finally, psychological factors of fetal neurodevelopment and homeostasis within the NCUP environment were explored.

Maternal/Fetal Crossover Effects of Antenatal Stress and Depression

Heightened maternal hormones during pregnancy processed by hyperactive HPA-axis activity accentuate depressive symptoms even when diagnosis of depression is absent (Weinstock, 2005). Antenatal depression has maternal/fetal ramifications beyond pregnancy (Chiba et al., 2010). Reproductive hormonal steroids easily cross the placental

barrier due to their fat solubility that signifies highly lipophilic properties (Mulder et al., 2002; Welberg & Seckl, 2001). Antenatal fat-soluble hormones cross barriers between mother and fetus through the placenta, umbilical cord, and blood plasma, in which 40% of maternal hormones affect fetal development (Bonari et al., 2004; Weinstock, 2005). Placental hormone downregulation is a suppressed response to stimuli. Antenatal stress effects on placental hormone downregulation explains how maternal cortisol crosses the blood barrier and increase amniotic cortisol (Field et al., 2004; O'Donnell et al., 2009; Sarkar et al., 2007). While decreased output of fetal cortisol generates unchanged fetal blood cortisol, further evidence of the stress-induced permeability of placental cortisol (Mulder et al., 2002; O'Donnell et al., 2009).

Stress-associated hormones in placental-umbilical cord blood strongly reflect the quality of the maternal/fetal milieu within the intrauterine environment (Chiba et al., 2010; Tegethoff et al., 2011). Maternal-placental-fetal neuroendocrine physiology shows potential for fetal feedback regulation; as fetal adrenal neurobehaviors become active, larger variations in fetal steroids arise (Buss et al., 2012; Fink et al, 2010). After fetal adrenal glands mature, cortisol within the fetal compartment includes both production of fetal cortisol and maternal cortisol that traverse placental barriers (Buss et al., 2012). Raised 17-OHP may indicate exposure to chronic intrauterine stress as fetal activation of the HPA-axis is a precursor to increased cortisol (Ersch et al., 2008). Naturally, the integrated quality of the gestational milieu functions to maintain NCUP homeostasis within the maternal/fetal dyad throughout pregnancy (Hui, 2012; Stein et al., 2008; Thomas, 2011; Vrekousis et al., 2010). Consequently, maternal hormones within the

intrauterine environment during pregnancy have an effect on fetal disease across the life span of the child (Tegethoff et al., 2011).

Effects of Maternal Hormones on Fetal Development

Antenatal stress and depression have effects beyond the mother that involve the fetus as well (Bolten et al., 2011; Field et al., 2006; Scheid et al., 2007). Maternal depression has the potential to have an effect on fetal brain development as maternal hormones transfer to the fetal system (Stein et al., 2008; Weinstock, 2005). Fetal brains are developmentally sensitive to increased corticotropin-releasing hormone during the early third trimester. Accordingly, fetal suppression of cerebral development and habituation to acoustic signals within the intrauterine environment occur in reaction to maternal depression related corticotropin-releasing hormone (Field et al., 2004; Monk et al., 2004; Weinstock, 2005). Increased corticotropin-releasing hormone secretion may also lead to fetal death prior to delivery secondary to excessive bleeding, inflammation, and infection within the gestational milieu (Field et al., 2006; Weinstock, 2005).

Pregnant women who experience higher morning cortisol with steeper morning decline give birth to smaller neonates in first-born infants although not in subsequent births (Kivlighan et al., 2008). The results of antenatal cortisol stress response change maternal/placental physiology, influencing almost every organ and tissue in maturation of the fetal body and central nervous system (Davis et al., 2011). For example, higher maternal cortisol levels resulted in a nearly 6.5% increase in the volume of a fetal girl's right amygdala, and no effect was seen in the male fetus. A significant correlation between higher maternal cortisol levels during early pregnancy than mid to late

pregnancy links intrauterine stress hormones with affective problems in 7-year-old girls (Buss et al., 2012; van den Bergh et al., 2008). Conversely, amygdala abnormalities and affective problems had no effect on male fetus or boys. Fetal exposure to high maternal cortisol, albeit brief, given the temporary nature of the intrauterine environment, has permanent adverse outcomes. Nonetheless, these intrauterine stress levels may be preparation for an unstable external environment at birth (Brunton, 2010). Maternal hormones within the gestational milieu affect fetal development; antenatal depression may also present lifelong physical symptoms for the fetus.

Physical Symptoms of Antenatal Depression on the Fetus

Fetal exposure to chronic maternal stress and depression increases risk for intrauterine growth retardation, smaller head circumference, low birth weight, low APGARs, as well as increased morbidity and mortality (Bushnell & Chireau, 2011; Schetter, 2011; Ventura et al., 2011; Vrekousis et al., 2010). Fetal growth restriction consequently affects adverse developmental plasticity, molecular and cellular change, gene expression, organ system adaptations, and fetal malformation (Davis et al., 2011; Gluckman et al., 2009; Tegethoff et al., 2011). Antenatal stress has an effect on subclinical fetal abnormalities in metabolic function, ANS, as well as cardiovascular, neurodevelopmental, and brain activity (Monk et al., 2011; O'Donnell et al., 2009; Vrekousis et al., 2011). Fetal reactions to maternal depression involve an increase in sympathetic and a decrease in parasympathetic control that in turn affects cardiac characteristics (Monk et al., 2011). This affect occurs because the fetal heart rate

threshold decreases while response magnitude increases with prolonged deceleration and recovery to baseline.

Maternal blood pressure, heart rate, and HRV rhythms are further associated with perinatal health (Harville et al., 2010). Intrauterine exposure to acceleration and deceleration of maternal heart rate relative to maternal expression of emotion affect fetal respiratory, cardiovascular, and muscular change (Mastropieri & Turkewitz, 1999). Fetal detection of fluctuation in expression of maternal stress is transduced through speech intonation, muscular tension, and heart rate rhythm associated with shift in maternal state of emotion (DiPietro et al., 2002; Mastropieri & Turkewitz, 1999). These acoustical qualities within the intrauterine environment further comprise the integrated nature of the NCUP system and the psychological effect on fetal development (Bonari et al., 2004; Hui, 2012; Stein et al., 2008; Thomas, 2011; Trixler Gati et al., 2005; Vrekousis et al., 2010).

Psychological Factors of Fetal Development

Maternal stress and depression affect fetal psychological development with dramatic effects secondary to the slightest chemical imbalance (Bonari et al., 2004; Trixler et al., 2005). Maternal stress hormone imbalance and positive feedback loops lead to a chemical imbalance within fetal hypothalamic adrenal glands that result in life span affective disorders, which include depression, anxiety, schizoaffective disorder and schizophrenia (Bonari et al., 2004; Trixler et al., 2005). Severe antenatal stress due to the death of a close relative within the first trimester increases risk for diagnosis of schizophrenia (O'Donnell et al., 2009; Welberg & Seckl, 2001). Mid or end gestational

exposure to antenatal bereavement stress shows a higher risk for neurodevelopmental disorders on the autism spectrum.

Infants exposed to antenatal stress and depression have a long-term risk of impaired motor, cognitive, and emotional development, having fewer facial expressions, irritability, and mental and behavioral disorders compared to offspring of mothers who had been successfully treated for antenatal depression (Tegethoff et al., 2011; Vieten & Astin, 2008). A relationship between obstetrics' complications and frontal lobe neurological impairment in the fetus was not gender-specific, but predisposed both male and female fetus for externalizing behavior problems such as impulsive, hyperactive, aggressive, and oppositional defiant behaviors (Marsman et al., 2009). Abnormal amygdala volume, affective problems, and neuropsychiatric disorders were significantly associated with exposure to high levels of intrauterine stress (Buss et al., 2012). Stressful antenatal stimuli regardless its origin may lead to a range of neurodevelopmental and metabolic syndrome disorders that begin before birth within the intrauterine environment as part of the NCUP system and continue into adulthood. The consequences of intrauterine exposure to antenatal stress are suggestive of the fetal programming phenomenon (Vrekousis et al., 2010).

Neuro-Cardio-Utero-Placental homeostasis maintains a relationship beyond the maternal/fetal dyad (McCraty et al., 2009; McCraty & Childre, 2010; McCraty et al., 2012; Thomas, 2011; Vrekousis et al., 2010). Homeostasis within the NCUP system functions to sustain uteroplacental-heart-brain coherence comparable to personal equilibrium of the neurocardiac connection (Hui, 2012; McCraty et al., 2009; McCraty &

Childre, 2010; Thomas, 2011; Vrekousis et al., 2010). Similarly, social coherence occurs wherein family and community interactions that transpire at a stable baseline improve HRV rhythms (McCraty & Childre, 2010; McCraty et al., 2012; Schwerdtfeger & Friedrich-Mai, 2009). Likewise, social and global coherence develops when intricately connected self-reinforced feedback loops form and affect individual, family, and community psychophysiologic health (McCraty & Childre, 2010; McCraty et al., 2012). Neuro-Cardio-Utero-Placental homeostasis in relationship to social coherence and global change consequences of antenatal stress and depression were explored next.

Social Change, Neuro-Cardio-Utero-Placental Coherence, and Antenatal Depression

Coherence is a living system's very defining quality via synchronization of regular and repeated fluctuation that occur within and/or between organisms (Ho, 2008; McCraty & Childre, 2010; McCraty et al., 2012). Uterus-placenta-heart-brain coherence is NCUP homeostasis, which is akin to individual neurocardiac equilibrium (McCraty et al., 2009; McCraty et al., 2012; Thomas, 2010; Vrekousis et al., 2010). Social coherence similarly occurs wherein partner, family, and community interactions transpire from a stable foundation (McCraty & Childre, 2010; McCraty et al., 2012; Schwerdtfeger & Friedrich-Mai, 2009). Social cohesion forms intricately connected self-reinforced feedback loops that further promote coherence.

Individual, reproductive, and social coherence affects psychophysiologic components of HRV rhythm (Ho, 2008; McCraty & Childre, 2010; Vrekousis et al., 2010). Higher depression scores are associated with lower HRV (Schwerdtfeger & Friedrich-Mai, 2009). Nonetheless, regardless the harmful effect that depression has on

HRV rhythm, when moderated by positive interaction with a partner, family, or friends, social coherence buffers adverse health. A shift in HRV rhythm correlated with fluctuation in the ANS related to change in sympathetic activity secondary to anger (McCraty & Childre, 2010). Elevated parasympathetic activity, however, is associated with relaxation and increased coherence. Synchronized relationships between sympathetic and parasympathetic branches of the ANS are consistent with higher HRV (McCraty & Childre, 2010). The experience of social stress results in significantly decreased high-frequency components of HRV and was significant for increased low-frequency/high frequency ratio in the second trimester, third trimester, and in non-pregnant women (Klinkenberg et al., 2009). Whereas there were no significant differences in all three groups, stress during pregnancy generally shows lower levels of high-frequency and low-frequency values than in non-pregnancy women.

Perceived level of spousal support, marital satisfaction, and quality of intimacy contributes to antenatal depression (Adewuya et al., 2007; Kazi et al., 2009; Lau & Keung, 2007). More severe depressive symptoms are further associated with low-level companionship and lack of intimate emotional connection because of marital conflict (Lau & Keung, 2007). Marital distress, perception of low social support, and social discord are features that distinguish non-depressed pregnant women from those who experience antenatal depression (Goodman & Tully, 2009). During the second trimester, pregnant women with 60% higher rate of depression have less supportive partners compared to a 20% rate of depression in pregnant women whose partners offer positive support (Kitamura et al., 1996b).

Maintenance of psychological equilibrium within the family consequently is necessary to healthy family interrelations that promote optimal pregnancy outcomes (Hippman et al., 2009; Hoffman & Hatch, 1996; Rubertsson et al., 2003). Quality of family dynamics and support have an effect on antenatal depression; the entire family, in turn, may experience the serious consequences of depression during pregnancy (Bennett et al., 2004a; Hippman et al., 2009; Rubertsson et al., 2003). Befriending behaviors, therefore, have important psychophysiologic benefits that counter ill effects of stress as well as improve overall health, antenatal outcomes, and mortality rates, all of which are essential to promoting positive social environmental change (Adewuya et al., 2007; Hippman et al., 2009; Hoffman & Hatch, 1996; McCraty & Childre, 2010).

Integrated BPNSE characteristics of pregnancy interwoven throughout the reproductive system affects homeostasis of the uteroplacental-heart-brain connection (Bacidore et al., 2009; McCraty et al., 2009; McCraty & Childre, 2010; McCraty et al., 2012; Plastow, 2009). The defining qualities of NCUP coherence as they relate to stress and depression during pregnancy were discussed next, subsequent to a review of the synchronization of regular and repeated fluctuation of antenatal HRV rhythm within the NCUP system. After which, the potential for CBSR training during pregnancy was further explored.

Neuro-Cardio-Utero-Placental Coherence, Heart Rate Variability, and Stress Resilience Training

Within the BPNSE integrative framework during pregnancy, NCUP coherence, HRV rhythm, and stress resilience training was reviewed (Hui, 2012; McCraty &

Childre, 2010; Plastow, 2009). Neuro-cardio-utero-placental coherence is synchronized communication between the uteroplacental-heart-brain connection toward the common goal of gestational viability to ensure a life-sustaining milieu during pregnancy (Ho, 2008; McCraty et al., 2009; Sutarto et al., 2010; Thomas, 2011). Antenatal stress and depression, however, trigger NCUP incoherence, which increases dysregulation within the NCUP system. This disruption leads to severe physiologic disorders such as peripartum cardiomyopathy, organ failure, preeclampsia, elevated liver functions, seizure, stroke, cerebral overregulation, cerebral autoregulation loss, intracerebral hemorrhage, reduced uteroplacental perfusion pressure, and placental ischemia (hypoxia) (McCraty et al., 2009; Thomas, 2011; Vrekousis et al., 2010). The connection between multidimensional systems combined for the sole purpose of sustaining gestational life for embryo-fetal development show evidence of inherently integrated disorders of the NCUP system (Ho, 2008; Thomas, 2011).

Condition of HRV rhythm shows quality of connection within and between systems (Ho, 2008). Healthy HRV rhythm is higher and maintains communication between the cardiovascular system and other systems within the body (Ho, 2008). Reduced HRV predicts grave illness, death, and has no intercommunication with the rest of the body (Ho, 2008; Lehrer et al., 2010). Minimally invasive, stress resilience training, in which HRV rhythm measures quality of NCUP intercommunication and coherence shows promise for safe, effective, integrative care of stress and depression during pregnancy (Ho, 2008; McCraty et al., 2009; Plastow, 2009; Thomas, 2010).

The defining qualities of NCUP coherence as they relate to stress and depression during pregnancy was discussed next, subsequent to HRV and biological factors of NCUP stress and depression. Heart Rate Variability and gestational hypertensive disorders were reviewed, and maternal/fetal HRV was explained. Finally, stress resilience training during pregnancy and NCUP CBSR was explored.

Neuro-Cardio-Utero-Placental Coherence

Coherence involves harmonious interaction between systems within the body that occur at deeply molecular and cellular levels (Ho, 2008; McCraty & Tomasino, 2004; Sutarto et al., 2010). Heart-brain synchronization, which is at the core of psychophysiologic coherence, correlates directly with the equilibrium that exists between the sympathetic and parasympathetic branches of the ANS (McCraty & Tomasino, 2004). Resultant physiological coherence improves cognitive function and emotional stability (McCraty & Tomasino, 2004). Stress exposure activates the physiological stress system including the sympathetic nervous system and HPA-axis (Mulder et al., 2002). Furthermore, a wide range of psychological and physical diseases is significant for dysregulation of the ANS (Thayer & Sternberg, 2006). For example, shifts in HRV and ANS activity change correlates with fluctuation in emotional processes (Kobele et al., 2010).

Neuro-cardio-utero-placental coherence is a synchronized reproductive system that has a direct effect on gestational progression and pregnancy outcomes (McCraty et al., 2009; McCraty & Childre, 2010; Sutarto et al., 2010; Thomas, 2010). The NCUP connection and coherence are intricately associated with ANS activity that affects

antenatal hematological communication throughout the maternal/fetal system (Marques et al., 2010; Sutarto et al., 2010; Thomas, 2010). Antenatal psychophysiologic health, is directly related to heart-based reappraisal of stress that maintains ANS equilibrium, decreases doctor visits, improves pregnancy outcomes, and increases mortality (McCraty et al., 2009; Moreno & Lau, 2007; Oz et al., 2009; Ritz et al., 2013).

NCUP coherence definition and NCUP connection and coherence was discussed further, subsequent to positive reappraisal. After which, consequences and benefits of NCUP coherence were explored.

Definition of Neuro-Cardio-Utero-Placental Coherence

Neuro-cardio-utero-placental coherence is a biomedical phenomenon whereby synchronized internal reproductive systems interact individually, harmoniously in step as a whole, in effortless flow of uteroplacental-heart-brain communication evidenced by smooth HRV rhythms (Brown et al., 2009; Ho, 2008; McCraty, 2006; McCraty et al., 2009; Sutarto e al., 2010; Thomas, 2010). The strongest rhythms of circadian oscillation, cardiological electromagnetic communication, flow through every molecule and cell within the body that encompass gestational progression in the amniotic fluid as stem cells, embryo, and fetus develop (Colwell, 2000; Connell et al.,2013; Ho, 2008; Ritz et al., 2013). Response time varies within the ANS and HPA-axis. Accordingly, the heart works in tandem with the ANS and HPA-axis to manage the body's stress response (Marques et al., 2010; Paz-Filho et al., 2010; Thayer & Sternberg, 2006).

Antenatal hormonal coherence affects the elaborate interconnected maternal/fetal immune, cardiovascular, and nervous systems (Bech-Sabat et al., 2010; Nader et al.,

2010). Cardiac coherence is established when electrical mechanical heart systems operate effectively to enhance immune function necessary to maintain an intrauterine environment fit for fetal survival (Arck et al., 2008; Bech-Sabat et al., 2010; Hudic & Fatusic, 2009; Nader et al., 2010.). Increased rates of mortality regardless the cause involve lower HRV notwithstanding health status (Ritz et al., 2013; Samuels, 2007). Implications that the effect coherence and the heart-brain connection have during pregnancy involve maternal/fetal health via the uteroplacental-heart-brain connection (Thomas, 2010).

Neuro-Cardio-Utero-Placental Connection and Coherence

Pregnancy characteristics have strong uteroplacental-mind-body connections, and thus present significant psychophysiologic challenges that require multidisciplinary collaboration (Bacidore et al., 2009; Evans, 2007; Plastow, 2009). Optimized physiologic response to stress that improves psychophysiologic coherence is likely due to balanced breath that entrains heart rhythms and increases HRV (Courtney et al., 2011; McCraty et al., 2009). When the heart-brain connection is out-of-sync, reduced parasympathetic function, with increased sympathetic activity, and lower HRV, are consistent with depression (Courtney et al., 2011; Siepmann et al., 2008; Sutarto et al., 2010). A spontaneous electrical pulse contracts the heart, which pumps blood throughout the pregnant woman's NCUP system with every heartbeat (Armour, 2008; Thomas, 2011). The cardiophysiologic nervous system responds to hormone and neurotransmitter processes within the brain via complex intrinsic neurocardiac ganglia pathways (Armour, 1991, 2004; Childre et al., 2000). Consequently, the ANS and intricately interconnected

NCUP blood vessel communication systems carry emotional antenatal depressive information throughout the pregnant woman's body that ultimately have an adverse effect on the maternal/fetal dyad (Childre et al., 2000; McCraty et al., 2009; Thomas, 2011). Autonomic nervous system disequilibrium from antenatal depression has an adverse effect on the entire NCUP unit through heart rhythms, and hematological communication at a deep cellular level that permeates the entire maternal/fetal system (Marques et al., 2010; Sutarto et al., 2010; Thomas, 2011). Optimized coherence is heart based, which begins in the cardiac system rather than through cognitive processes.

Positive Reappraisal and Neuro-Cardio-Utero-Placental Coherence

Cognitive reappraisal reframes negative thought via mind integration processes (Childre & Cryer, 2004; Gold & Chrousos, 2002). Inaccurate perception and skewed emotional reaction trigger reflexive physiologic and metabolic reactivity that led to an irrelevant stress response, thus maladjusted coping (Duncan & Bardacke, 2010; Gold & Chrousos, 2002; Obel et al., 2005; Urizar et al., 2004). Appraisal represents cognitive focused coping assessed with a process-oriented approach that identifies shifts in cognitive reappraisal (Folkman & Lazarus, 1988). Adequate coping, nonetheless, necessitates factors beyond cognitive reappraisal for efficient regulation of internal stability required for ANS, neuroendocrine, and immune health (Hawkley et al., 2005; Wallwitz et al., 2012).

A balanced NCUP process is integral to human genetic ANS activity developed during pregnancy (Thomas, 2011; Wallwitz et al., 2012). The quality of these genetic factors involves every heartbeat, coordinated breath, and regulation of HRV (Wallwitz et

al., 2012). Reappraisal of emotion that originates within the cardiac ANS connection improves mood via synchronized heart-brain interaction (Schneider et al., 2008; McCraty et al., 2009; Wallwitz et al., 2012). Deep cellular memory within the heart significantly influences perception via intracellular communication transmitted to brain processes through the ANS (McCraty et al., 2009; Moreno & Lau, 2007; Ritz et al., 2013; Tirziu et al., 2010). Heart based reappraisal of stress and mood, therefore, maintains ANS balance essential to psychophysiologic health (McCraty et al., 2009; Moreno & Lau, 2007; Ritz et al., 2013). Incoherence results when the NCUP process is out of sync.

Consequences of Neuro-Cardio-Utero-Placental Incoherence

A low capacity to cope is statistically significant for a negative feedback loop of stress-exacerbated incoherence (McCraty et al., 2009). Psychophysiologic disequilibrium related to ineffective coping increases physician visits. Dysfunctional breath results in lower HRV, which results in an ANS imbalance, leads to NCUP incoherence exacerbated by antenatal complications (Courtney et al., 2011; Oz et al., 2009; Thomas, 2011). Decreased resilience, respiratory, cardiovascular, and autonomic disease affected by maladjusted breath, low HRV, and negative emotion results in 40% increased mortality (Courtney et al., 2011). Gestational consequences of NCUP incoherence ensue despite cognitive reappraisal of negative emotions as the body does not rationalize, but rather simply experiences (Childre et al., 2000; Oz et al., 2009; Thomas, 2011).

Benefits of Neuro-Cardio-Utero-Placental Coherence

The consequences of incoherence occur in the wake of recirculated disturbed flow of HRV rhythm. However, the reestablishment of homeostasis within the NCUP system

results in benefits of coherence (McCraty et al., 2009). Depression was significantly improved (Beck Depression Inventory 5.5) post HRV biofeedback compared to baseline (Beck Depression Inventory 21.5) (Siepmann et al., 2008). Autonomic equilibrium of vascular resonance further shows improved mood, hypertension, and parasympathetic cardiac input that are benefits of psychophysiologic coherence (McCraty & Tomasino, 2004; Nierop et al., 2008; Siepmann et al., 2008). Regulated breath, resultant of psychophysiologic coherence, promotes effective coping, emotional stability, positive health, internal self-regulation, and physiologic resilience (Courtney et al., 2011; Engelhard et al., 2003; McCraty et al., 2009; Nierop et al., 2008). Breath exercise and positive visualization decreased depressive symptoms and increased NCUP interconnectedness, thereby positively improving antenatal health (Evans, 2007; Ji & Han, 2010). Psychophysiologic coherence and antenatal wellbeing positively correlated are predictive of uncomplicated vaginal delivery and low antenatal morbidity (Engelhard et al., 2003; Oz et al., 2009). For this purpose, HRV rhythm within the BPNSE aspects of pregnancy was reviewed within the NCUP system.

Heart Rate Variability and Biological Factors of Neuro-Cardio-Utero-Placental Stress and Depression

Heart Rate Variability is the beat-to-beat variation within the interval between each heart beat (Marques et al., 2010; McCraty & Childre, 2010). Low HRV, resultant of antenatal stress and depression, is significant for reproductive hormonal imbalance, immune function deficits, increased disease, morbidity, and mortality (Childre et al., 2000; Marques et al., 2010). Conversely, hormonal balance and immune function

improvement lead to increased HRV and balance between the sympathetic and parasympathetic branches of the ANS when emotions are positive (Childre et al., 2000; McCraty & Childre, 2010). Overall, reduced sympathetic activity affects shifts in stress hormones, while decreased cortisol, lower stress, and increased relaxation is resultant of parasympathetic activity (Childre et al., 2000).

Gestational health, the reproductive system, amygdala and ANS activity are interrelated as evidenced by associated shifts in the quality of HRV rhythm (Buss et al., 2012; McCraty & Childre, 2010; Sergerie et al., 2008). The ANS and HPA-axis are two main stress-related systems directly interconnected with the immune function responsible for NCUP health and viability of pregnancy (Marques et al., 2010). Heart Rate Variability rhythm is an effective biomarker in treatment efficacy, ANS function, and the susceptibility and severity of disease such as gestational hypertension and preeclampsia (Marques et al., 2010). Change in HRV rhythm, significant for fluctuation in cortisol, DHEA, progesterone, and sIgA levels, is further evidence of integrated function within the NCUP system and quality of reproductive emotional health (Bai et al., 2009; DiPietro et al., 2012; Dogru et al., 2010; Rockliff et al., 2008; Yajima et al., 2007).

Amygdala, circadian rhythm, HPA-axis, and HRV's interrelationship with NCUP quality of health was discussed next, subsequent to cortisol, HRV rhythm, and antenatal emotional health. DHEA, HRV, and emotional health during pregnancy was explained. Then, progesterone, HRV rhythm, stress, and antenatal depression were explored. Finally, sIgA, HRV rhythm, stress and gestational mood was discussed.

Amygdala, Heart Rate Variability, and the Neuro-Cardio-Utero-Placental Interrelationship

The amygdala is a forebrain structure the size and shape of an almond with electrical cellular activity synchronized to cardiac change in heartbeat (Black, 2001; Childre et al., 2000; Thayer & Sternberg, 2006). Together amygdala and ANS activity maintains psychophysiologic homeostasis (Thayer & Sternberg, 2006). Positive and negative stressors trigger amygdala response with left-right functional dissociation (Sergerie et al., 2008). The amygdala's left side was approximately 15% smaller in unipolar depression than controls without depression (Black, 2001). Consequently, excitotoxicity is a process that occurs, in overactive amygdala of individuals with depression, which reduces amygdala size, due to cell death from the lethal effects of excessive activity (Black, 2001).

The resting amplitude signature of the heart dependent on the calibration pulse correlates with the cardiac signature of emotionality (Koelsch et al., 2007). Emotional memory, psychological stress response, and depression, regulated in part by amygdala activity, significantly reduces HRV and increases the risk of cardiac based disease (Black, 2001; Buss et al., 2012; Childre et al., 2000; Hill et al., 2009; Koelsch et al., 2007; McCraty et al., 2009; Nierop et al., 2006; Sergerie et al., 2008). Cardiac signature correlated with amygdala activity is further associated with HRV rhythm time and frequency, an intricate heart-brain-emotionality connection that responds to psychological treatment (Koelsch et al., 2007; McCraty et al., 2009). Activity within the woman's reproductive system has a significant effect on the responsiveness of the

amygdala related to gestational health (Sergerie et al., 2008). An intrauterine stress-related milieu increases maternal cortisol levels that adversely affect neurodevelopment trajectory in the fetal amygdala (Buss et al., 2012).

Circadian Rhythm, Heart Rate Variability, and the NCUP Interrelationship

Psychophysiologic change follows a 24-hour cycle known as a circadian rhythm and when disrupted by internal or external stress during pregnancy increases potential for antenatal depression (Brunton et al., 2008; Nader et al., 2010; Paz-Filho et al., 2010). The antenatal HPA-axis circadian rhythm is attenuated, which reduces the stress response during pregnancy (Brunton et al., 2008). Blunted antenatal stress response during pregnancy may be a reproductive mechanism that physically shields offspring from adverse effects of stress (Brunton et al., 2008). Rhythmicity of the HPA-axis circadian cycle that controls cortisol secretion activates the ANS, which coordinates psychophysiologic homeostasis (Kalsbeek et al., 2012; Nader et al., 2010).

While the HPA-axis and heart rhythms interrelate, they are peripheral clock systems; the master oscillator is the central suprachiasmatic nucleus, a pinecone-shaped structure approximately five millimeters in size, located within the hypothalamus (Mohawk et al., 2012). The suprachiasmatic nucleus remains consistent as the master clock regardless the external stimuli while circadian rhythms of peripheral clocks adjust for effective stress response. However, as the ill effects of stress advance toward depression, functionality of the suprachiasmatic nucleus circadian clock is significantly impaired in depressed patients (Nader et al., 2010; Reghunandanan & Reghunandanan, 2006). To maintain psychophysiologic equilibrium, ANS cardiac balance adjusts in an

effort to manage stress (Matveev et al., 2007). Heart rate variability's measure of the ANS cardiac balance is the universally accepted method for evaluating shifts in rhythm. The sleep-wake cycle does not entirely mediate the heart's rhythm, but rather is influenced by local and extended ANS circadian rhythms that fluctuate throughout the 24-hour day (Vandewalle et al., 2007). As a result, day-night sleep cycle disturbance has a direct effect on rhythmicity of the HPA-axis circadian cycle that further balances psychophysiologic equilibrium (Kalsbeek et al., 2012).

Hypothalamic-Pituitary-Adrenal-Axis, HRV, and the NCUP Interrelationship

Neuroendocrine properties activated by the HPA-axis and sympathetic neural mechanisms are two main pathways wherein psychological stress affects physical health (Marques et al., 2010). Regulation of the two systems is intricately associated with HRV rhythm (Marques et al., 2010). The HPA-axis, sympathetic, and parasympathetic branches of the ANS in connection with HRV during pregnancy shows increased activity as an adaptive response to internal and external antenatal stress (Shea et al., 2008). Regulation of the HPA-axis and ANS exhibits dysregulation in women with antenatal depression (Shea et al., 2008; Sheffield et al., 1998). A vagus nerve comprised of two nerves that pass from the brainstem through organs in the neck, chest, and abdomen on each side of the body, communicates information from the organs to the central nervous system. An inhibitory function of the vagus nerve affects HPA-axis regulation of stress that lowers HRV increases the risk of antenatal hypertensive and cardiac disease (Marques et al., 2010; Weber et al., 2010). Fluctuation in HPA-axis and HRV interaction significantly influences change in antenatal cortisol levels (DiPietro et al., 2012).

Cortisol, Heart Rate Variability, and Antenatal Emotional Health

Cortisol level significantly increased in depression is associated with decreased HRV and elevated sympathetic nerve activity (Brown et al., 2009; Rockliff et al., 2008; Thayer & Sternberg, 2006). Conversely, inhibition of emotion, such as a lack of self-compassion, has lower HRV without a significant change in cortisol levels (Rockliff et al., 2008). This decreased maternal HRV results in a lack of cortisol response during pregnancy (DiPietro et al., 2012). Heart Rate Variability rhythm influences decreased cortisol levels with improved mood after emotional self-management practice with re-experienced positive sensations (McCraty et al., 1998). Elevated HRV showed significantly decreased cortisol after viewing compassion-focused imagery while a negative response showed reduced HRV with no change in cortisol (Rockliff et al., 2008).

DHEA, Heart Rate Variability, and Emotional Health During Pregnancy

Cortisol/ DHEA ratios adverse fluctuation during the second trimester result in stress and depression that demonstrate significant improvement to emotion management techniques (Gold & Chrousos, 2002; McCraty et al., 1998). Consequences of the stress hormone imbalance improve after HRV biofeedback training (McCraty et al., 1998). Heart Rate Variability is significantly affected by DHEAS, a metabolite derivative of DHEA, although gonadal steroids have less effect on HRV (Dogru et al., 2010). DHEAS have significant regulatory effects on ANS activity but reverse effects on parasympathetic and sympathetic correlated negatively (Dogru et al., 2010). Increased

HRV and DHEA are also consistent with improved antenatal mood and decreased stress (Buckwalter et al., 1999; Gold & Chrousos, 2002; McCraty et al., 1998).

Progesterone, Heart Rate Variability, Stress, and Antenatal Depression

Progesterone fluctuates throughout the reproductive cycle although consistent levels are vital during the second trimester (Arck et al., 2007; Zambotti et al., 2013). Autonomic control and sympathetic activity correlate positively with progesterone; consequently, a negative feedback loop of stress and depression adversely affects these rhythms during pregnancy (Ansari et al., 2002; Kammerer et al., 2006; Leicht et al., 2003; Zambotti et al., 2013). Low-frequency HRV components increase whereas high-frequency HRV components decrease during the luteal phase (immediately after ovulation) of the female reproductive cycle subsequent to corpus luteum (matured ovary follicle) formation (Leicht et al., 2003; Zambotti et al., 2013). When the uterus begins preparation for implantation of the blastocyst in early pregnancy progesterone is significantly higher. Fluctuation of HRV in relation to reproductive phase progesterone shifts as it affects autonomic tone (Bai et al., 2009; Leicht et al., 2003). Accordingly, ANS activity mediates between HRV and progesterone within the ovarian cycle and throughout pregnancy (Bai et al., 2009).

Secretory Immunoglobulin A, Heart Rate Variability, Stress and Gestational Mood

Immunoglobulin properties of sIgA are critical to pregnancy, although acute stress lowers HRV, increased cardiac disease and sIgA are unexpectedly higher (Negri et al., 1995; Ring et al., 1999). Doubled HRV with improved parasympathetic tone differentiates breath of consistent rate and rhythm from imbalanced breath, which

increases sIgA (Ring et al., 1999). In contrast, sympathetic activity increased while parasympathetic activity decreased during mental tasks as evidenced by low-frequency and high-frequency HRV parameters (Isowa et al., 2006). Still, women with antenatal depression and lower HRV have lower sIgA although women with improved mood have higher HRV and higher sIgA during pregnancy (Yajima et al., 2007). Acute stress that triggers adaptive survival mechanisms improve immune function and sIgA concentrations (Isowa et al., 2006).

The integrated nature of biological and psychological components of stress and depression during pregnancy are similarly associated with change in HRV rhythm (DiPietro et al., 2012; Kobele et al., 2010; McCraty et al., 2009). The shift in psychological stress and emotion intricately interconnects with biological aspects of NCUP homeostasis, which affects reproductive viability (McCraty & Childre, 2010; Vrekousis et al., 2010). The role that antenatal stress and depression has in homeostasis of the NCUP system as evidenced by a shift in HRV rhythm was explored.

Heart Rate Variability, Antenatal Stress and Depression During Pregnancy

Symptoms of depression and impaired HRV are interconnected (Siepmann et al., 2008). Parasympathetic and sympathetic balance are essential to quality of HRV, although both branches of the ANS do not have an equal effect on HRV (Pavithran et al., 2008; Siepmann et al., 2008). Sympathetic activity was not significant for change post biofeedback in depressed or non-depressed individuals; therefore, parasympathetic activity is suggestive of increased HRV. Analysis of HRV biofeedback reflects synchronized activity in both sympathetic and parasympathetic branches of the ANS

(McCraty & Tomasino, 2004). Increased HRV is consistent with emotional stability but low HRV is significant for antenatal depression, sudden cardiac death and cardiovascular morbidity (McCraty & Tomasino, 2004; Nam et al., 2011; Pavithran et al., 2008; Sharpley et al., 2000; Thayer & Sternberg, 2006).

Antenatal stress response and HRV rhythm were explored next, followed by a discussion of antenatal depression and HRV rhythm. Heart Rate Variability rhythm and suicide during pregnancy was then reviewed.

Antenatal Stress Response and Heart Rate Variability

Heart rate variability's sensitivity to shifts within the female reproductive system predicts one's capacity to respond effectively to stress (Nam et al., 2011). Reduced HRV, secondary to antenatal stressors, lead to physical vulnerability during pregnancy due to impaired parasympathetic modulation, and the consequences of this reduction in HRV lead to a diminished ANS stress response (McCraty et al., 2001; Shea et al., 2008). Decreased parasympathetic responsivity related to diminished flexibility in the high-frequency component of HRV further compromise the quality of emotional health (Shinba et al., 2008). Additionally, elevated high-frequency HRV parameters and decreased negative emotional reactivity correlated in response to stress (Egizio et al., 2008). High-frequency HRV with a slight decrease in response to stress, maintained higher quality interpersonal functioning than did significantly decreased high-frequency HRV (Egizio et al., 2008).

Antenatal Depression and Heart Rate Variability

Significant reduction in HRV is common in pregnant women with higher scores of depressive symptoms (Karavidas et al., 2007; Lao et al., 2009; Schwerdtfeger & Friedrich-Mai, 2009; Shea et al., 2008). Elevated sympathetic and reduced parasympathetic activity evidence disrupted autonomic equilibrium within the reproductive milieu during antenatal depression (Brown et al., 2009; McCraty et al., 2001; Shea et al., 2008). Increased symptoms of depression during pregnancy, endorsed on the EPDS, were positively associated with low-frequency/high-frequency HRV ratio (Shea et al., 2008). A relationship between the autonomic and cardiac systems correlated with the level of depressive symptoms (McCraty et al., 2001; Schwerdtfeger & Friedrich-Mai, 2009).

Pregnant women with expression of prominent negative affect have lower HRV than pregnant women with positive affect (Karavidas et al., 2007; Lao et al., 2009; Schwerdtfeger & Friedrich-Mai, 2009). Autonomic tone and increased depressive symptoms correlate with increased psychological stress and decreased HRV (Kobele et al., 2010; Sheffield et al., 1998). Similarly, elevated symptoms of depression were significantly correlated with decreased ANS responsiveness, HRV, high-frequency, and parasympathetic activity, important indicators of psychological dysfunction (Shinba et al., 2008). Clinical depression and decreased HRV show increased risk of mortality resultant of cardiac complications and sudden cardiac death (Kobele et al., 2010). Sympathetic and parasympathetic dysfunctions within the ANS pose an increased risk of depression (Schwerdtfeger & Friedrich-Mai, 1998). Given the increased potential for

serious pregnancy outcomes in women with deregulated ANS activity, lower HRV, and an unrecognized cycle of depression, monitoring pregnant women for thoughts of self-harm and risk of suicide are essential (Andersson et al., 2003; Gausia et al., 2009 Hippman et al., 2009; Segre et al., 2004; Shea et al., 2008).

Heart Rate Variability and Suicide During Pregnancy

Antenatal depression involves shifts in HRV that when acute, chronic, or severe result in dysregulated (an impaired regulatory process) mood and depressive symptoms that have an adverse effect on cognition which may include suicidal thoughts (Bennett et al., 2004a; Bowen & Muhajarine, 2006b; Manber et al., 2008; Simone & Pun, 2007; Severus, 2006). Life-threatening aspects of depression may include coronary artery disease, sudden cardiac death, impaired endothelial dysfunction, decreased HRV, and suicide (Severus, 2006). One in 10 individuals with recurrent depression dies of complications due to the disorder (Severus, 2006). Suicidal ideation or thoughts of self-harm commonly accompany severe symptoms of antenatal depression (Gausia et al., 2009). A protective factor for symptoms of suicide may be present during pregnancy although antenatal risk of suicide is low with reports of suicidal ideation between 5% and 14% (Gausia et al., 2009; Manber et al., 2008). Conversely, around 40% of pregnant women who exhibited symptoms of extreme maternal depression with psychosis disclosed suicidal ideation (Bowen & Muhajarine, 2006b). Pregnant women who experience loss of consciousness due to attempted suicide expose the fetus to cardiac abnormalities, delayed neonatal peristalsis (consistent, surging, progressive

gastrointestinal contractions), maternal mortality, and commonly result in death of the maternal/fetal dyad (Novikova et al., 2009).

Heart Rate Variability and Gestational Hypertension

Significant cardiovascular adaptation occurs to meet the gestational circulatory need for hemodynamic change however little is known about HRV rhythm effects on NCUP coherence (Baumert et al., 2010; McCraty & Childre, 2010). Homeostasis in the NCUP system maintains coherence, although when exposed to stress and depression, decreased HRV evidence NCUP incoherence, dysregulated uteroplacental hemodynamics (blood flow), endothelial dysfunction, gestational hypertension, and preeclampsia occurs (Childre et al., 2000; Ho, 2008; McCraty et al., 2003; Stein et al., 2008; Vrekousis et al., 2010). Gestational hypertensive disorders nonetheless are the leading cause of maternal morbidity and mortality (Faber et al., 2004; Pavithran et al., 2008; Sugiura-Ogasawara et al., 2002). Placenta removal is the only reported cure for hypertension during pregnancy, resulting in pregnancy termination. Increased HRV decreases gestational hypertension and improves antenatal depression (Faber et al., 2004; Pal et al., 2009; Pavithran et al., 2008; Sugiura-Ogasawara et al., 2002).

Severity of impaired cardiovascular ANS control with increased sympathetic and decreased parasympathetic activity are early indicators of gestational hypertension, chronic hypertension, and preeclampsia (Metsaars et al., 2006; Mussalo et al., 2001). Autonomic dysfunction with reduced parasympathetic activity is consistent with reduced HRV (Alter et al., 2009). Severe hypertension showed reduced HRV compared to healthy controls, although reduced HRV was not significant in symptoms of mild hypertension

(Mussalo et al., 2001). Reduced HRV may be a predictor for gestational hypertensive disease and preeclampsia, which may have an adverse effect on antenatal depression (Bushnell & Chireau, 2011; Diego et al., 2006; McCraty & Childre, 2010; Mussalo et al., 2001). Reduced HRV effects of cardiovascular reactivity to antenatal stress that result in adverse NCUP physiological responses to depression during pregnancy are predictors of gestational hypertensive disorders (Bushnell & Chireau, 2011; Christian, 2012). Given the inseparable NCUP consequences of stress, gestational hypertensive disorders, and antenatal depression being the leading cause of maternal morbidity and mortality, peripartum cardiomyopathy and HRV was further discussed. Preeclampsia and HRV were explored. Finally, uterine-intrauterine response to HRV was reviewed, subsequent to placental effects of HRV.

Peripartum Cardiomyopathy and Heart Rate Variability

Moderate to severe disruption in HRV resultant of antenatal stress and depression have high rates of cardiomyopathy and mortality (Birsner & Graham, 2011; Elkayam, 2011; Pyatt & Dubey, 2011; Rashba et al., 2006; Sliwa et al., 2010). There is an approximate 50% survival rate of 5-years regardless of the asymptomatic state although the majority of women who develop peripartum cardiomyopathy die within three months (Birsner & Graham, 2011). Compared to controls, significantly reduced HRV was consistent in symptomatic dilated cardiomyopathy (Biswas et al., 2000). Conversely, prognosis is good with preserved HRV compared to a high mortality in severely depressed HRV (Rashba et al., 2006; Birsner & Graham, 2011). Heart rate variability with abnormal RR intervals (space between heart rate R waves, peak amplitude from

baseline), associated with sudden cardiac death, is the significant sole predictor of moderate to severe heart failure (Bilchick et al., 2002). Likewise, acute myocardial infarction triggers depressed RR intervals, the main predictor of mortality (Bilchick et al., 2002).

Preeclampsia and Heart Rate Variability

Preeclampsia, a pregnancy-induced hypertensive disorder with a high rate of depression, shows elevated sympathetic and parasympathetic parameters of autonomic activity (Eppes, & Witter, 2011; Faber et al., 2004; Leeners et al., 2007). In contrast, preeclampsia exhibits increased sympathetic though decreased parasympathetic activity (Metsaars et al., 2006). Regardless the level of parasympathetic activity, sympathetic activity is elevated in preeclampsia (Baumert et al., 2010). Although HRV was significantly impaired in pregnancy-induced hypertensive, it was unaltered in preeclampsia (Faber et al., 2004). Still, preeclampsia has an additional decline in HRV beyond the normal antenatal decreased HRV of gestational hemodynamic shift (Pavithran et al., 2008).

Uterine-Intrauterine Response to Heart Rate Variability

The quality of intrauterine milieu connected to health, disease, and mortality correlated with change in HRV (Shinba et al., 2008; Tegethoff et al., 2011). Sympathetic activity in a healthy pregnancy increases second trimester onward and declines just prior to delivery though was unchanged in mild preeclampsia, elevated in moderate preeclampsia, and decreased in chronic hypertension (Khlybova et al., 2008). Healthy antenatal controls had diminished HRV trimester-by-trimester in contrast to significantly

altered HRV in abnormal uterine perfusion with unchanged HRV the last half of pregnancy (Voss et al., 2006). The uterine artery supplies nourishment to the placenta although pathologic uterine profusion (blood flow to the uterus) results in exacerbated HRV (Voss et al., 2006). Thereby, an impaired blood supply has adverse effects on fetal growth. Regardless the outcome, abnormal uterine perfusion significantly affects cardiovascular control and electrical cardiac activity evidenced by change in HRV (Baumert et al., 2010; Voss et al., 2006).

Placental Effects of Heart Rate Variability

Maternal heart rate influences vascular pressure changes that adversely affect maternal hemodynamic adaptation, and placental health (Bushnell & Chireau, 2011; Shea et al., 2008). Impaired ANS development may be womb originated secondary to placental thinness adversely affected by inadequate spiral artery remodeling that decreases maternal blood flow to the placenta (Barker et al., 2012). Severe outcomes of later life sudden cardiac death may ensue. Serious consequence of inadequate placental spiral artery remodeling led to insufficient placental profusion resultant of reduced blood flow secondary to damaged blood vessels (Bushnell & Chireau, 2011; Keiser et al., 2009; Siddiqui et al., 2010; Veillon et al., 2009). Restored sympathetic modulation response previously affected by depression is responsible for improving placental blood supply when conditions are re-stimulated (Bushnell & Chireau, 2011; Heiskanen et al., 2008). The quality of the maternal/fetal dyadic relationship involves uteroplacental hemodynamics and umbilical blood flow (Heiskanen et al., 2008; Struijk et al., 2001). Antenatal stress and depression had an effect on maternal/fetal hemodynamic

interconnection and HRV (DiPietro et al., 2004; Shea et al., 2008). Maternal/fetal HRV and depression during pregnancy was further explored.

Maternal/Fetal Heart Rate Variability

Quality of maternal HRV rhythm is essential to NCUP homeostasis and gestational viability (Bech-Sabat et al., 2010; McCraty & Childre, 2010; Zambotti et al., 2013). Notwithstanding the highly sensitive nature of early intrauterine gestational conditions, the initial phase of pregnancy is when embryonic cardiovascular function must first begin beating (Kikuchi et al., 2008; Wenink, 2009). Maternal HRV rhythm fluctuates relative to the level of stress and depression experienced during pregnancy along with autonomic activity within the NCUP system (Heiskanen et al., 2008; McCraty & Childre, 2010). Normal pregnancy alone, void of external distress or complication, is a stressful life event (Geller, 2004). Additionally, antenatal stress and depression significantly affects cardiovascular function as well as early spontaneous abortion (Arck et al., 2008; Monk et al., 2011; O'Donnell et al., 2009).

Maternal HRV rhythm during pregnancy was discussed next, subsequent to a discussion on the effects of fetal HRV maturation; after which, HRV and the maternal/fetal dyad were further explored.

Maternal Heart Rate Variability During Pregnancy

Maternal HRV during normal healthy pregnancy is decreased (Ekholm & Erkkola, 1996). Similarly, periodic HRV during the second trimester remains unchanged though significant reduction in overall beat-to-beat variability occurs (Ekholm & Erkkola, 1996). Pregnancy related respiratory change does not account for low antenatal

HRV, although increased, not decreased, spontaneous breath is expected (Ekholm & Erkkola, 1996). Cardiovascular adaptation of pregnancy regulated by autonomic activity maintains profound hemodynamic change involving physical factors of blood flow throughout gestation (Ekholm & Erkkola, 1996).

Autonomic activity and hemodynamic control associated with normal cardiovascular function in healthy pregnancies are biomarkers for dysregulated maternal HRV rhythm during pregnancy (Curione et al., 2005; Heiskanen et al., 2008). Mathematical terms explain the unpredictability of human HRV as chaos; likewise, periodicity of gestational HRV in healthy pregnant women is consistent with the rhythmic chaos shown in human HRV (Curione et al., 2005). Healthy pregnant women had significantly higher low/high frequency ratios than healthy non-pregnant women (Curione et al., 2005). Sinus R-R intervals reset within the cyclic structure during early pregnancy, which result in decreased randomness of HRV and consequently increases the homogeneous pattern within a 24-hour cardiac pace (Curione et al., 2005). Unpredictability of random sinus R-R intervals of HRV rhythmicity within healthy non-pregnant women remains present (Curione et al., 2005). Cardiac regulation by sympathetic activity maintains significantly decreased HRV in healthy pregnant women (Curione et al., 2005).

Antenatal day-night tachycardia, heart rate that beats significantly faster than normal, onward from the first trimester in healthy pregnant women may indicate significantly readjusted cardiac characteristics in relation to sympathetic nervous system regulation of HRV activity (Curione et al., 2005). Change in sympathetic activity is not a

mechanism of desynchronization within human HRV, but rather modulates cardiac pacing throughout pregnancy (Curione et al., 2005). A minor change in antenatal hemodynamics occurs during head-up tilt from the supine position, with no influence on low/high frequency HRV parameters, compared to post pregnancy response to postural change (Heiskanen et al., 2008). Sufficient blood supply to the placenta and stable peripheral resistance relies on modest responses of sympathetic modulation (Heiskanen et al., 2008). Resting cardiac output and increased heart rate near term are likely a consequence of parasympathetic deactivation (Heiskanen et al., 2008).

Fetal Heart Rate Variability Maturation Effects

Around 15 days gestation, an unborn heart develops as a flat sheet of mesodermal cells forming a linear embryonic cardiovascular tube that begins self-initiated heartbeats (Wenink, 2009). Increased low/high-frequency ratio in fetal HRV at 15 to 20 weeks shows functional ANS development as fetal HRV significantly influences intrauterine autonomic growth with earlier sympathetic dominance than parasympathetic development (Kikuchi et al., 2008). High-frequency heart rate dominance occurs during intrauterine rest in relation to movement in fetal breath and maturation of the fetal parasympathetic system (Min et al., 2002). Low-frequency parameters of fetal HRV do not develop prior to 15 weeks (Struijk et al., 2001). At this time, combined sympathetic and parasympathetic control is very faint, nearly nonexistent, as evidenced by very low low/high-frequency ratio occurring under 15 weeks (Struijk et al., 2001).

Increased cardiac responsivity and higher fetal HRV develop consistent with stage of fetal maturation simultaneously stable aspects of fetal HRV distinguish intricate

characteristics of ANS function (DiPietro et al., 1996). Phase of fetal ANS evolution has a significant effect on the hemodynamic stress response due to the intricate interrelationship between the two (van Laar et al., 2008). Shift within fetal ANS activity influences change in fetal HRV during intrauterine deprivation of fetal oxygen (van Laar et al., 2008). Fetal health and wellbeing are also representative of normal fetal HRV but increased fetal blood acidity, a low APGAR score of neonate physical function, and perinatal death are associated with low fetal HRV (van Laar et al., 2008). Reduced fetal HRV is associated with the mother's negative emotions along with her perceived antenatal stress and decreased response to her maternal appraisal of stress (DiPietro et al., 2004; DiPietro et al., 1996).

Heart Rate Variability and the Maternal/Fetal Dyad

Maternal depression during pregnancy adversely affects fetal wellbeing due to sympathetic dominance-based imbalance between sympathetic and parasympathetic subsystems within the ANS (Shea et al., 2008). Significant differences between maternal HRV and fetal HRV where fetal HRV one fourth that of maternal HRV is evidence of functional development of fetal ANS parameters (Struijk et al., 2001). Importantly, fetal maturation between 10- and 20-weeks gestation has no effect on the maternal ANS as evidenced by no difference in maternal HRV (Struijk et al., 2001). Change in maternal cardiovascular function and deviation, in fetal cardiovascular activity, affect their respective sides of uteroplacental performance (Struijk et al., 2001). Uterine and placental perfusion affects uterine hemodynamics although placental perfusion directly influences

umbilical blood flow (Struijk et al., 2001). Therefore, change in placental function and health affects haemodynamic quality in the maternal/fetal dyad (Struijk et al., 2001).

Compared to controls, pregnant women with gestational hypertension showed reduced umbilical artery flow velocity (Ursem et al., 1999). Quality of umbilical artery activity and fetal HRV are likely a biomarker for cardiovascular fetal health at 10 to 20 weeks gestation (Ursem et al., 1999). Disruption in uteroplacental circulation associated with significant decreased quality of umbilical hemodynamic velocity may have adversely affected fetal HRV of women with pregnancy-induced hypertension compared to controls (Ursem et al., 1999). Antenatal hypertension related neonatal mortality resultant of hypertensive disorders that occur in 7% of all pregnancies is the most common cause of fetal death (Ursem et al., 1999). Given the severe consequences of stress during pregnancy together with the deeply integrated effects of depression within the NCUP reproductive process, further review of emotional healthcare during pregnancy is imperative to antenatal health and wellbeing.

Stress Resilience Training During Pregnancy

Outcomes of antenatal depression involve integrated BPNSE aspects of pregnancy, when untreated integrated aspects of antenatal depression pose a threat to NCUP function (Hui, 2012; McCraty & Childre, 2010). Psychological stress and emotional fluctuation have adverse effects on the biological aspects of NCUP homeostasis (McCraty & Childre, 2010; Vrekousis et al., 2010). Antenatal emotional health influences the quality of uteroplacental hemodynamic process and maternal wellbeing (Heiskanen et al., 2008; Struijk et al., 2001). Shifts in HRV rhythm show

further evidence of complex pathways that communicate within the uteroplacental-heart-brain connection (McCraty et al., 2009). Amelioration of depression during pregnancy requires maintenance of coherence within an integrated NCUP system (Ho, 2008; McCraty & Childre, 2010).

Conventional mental healthcare's fundamental and inherent division of the patient and the separation of the NCUP organism render the reproductive system functionless and incapable of the viability necessary to sustain life (Arck et al., 2008; Plastow, 2009). Homeostasis, essential to life and intrinsic to the nature of antenatal coherence, is essential for effective maintenance of emotional health during pregnancy (Ho, 2008; McCraty & Childre, 2010).

The consequences of untreated antenatal stress and depression was discussed next, subsequent to intervention for antenatal stress and depression. After which, barriers to treatment of antenatal stress and depression were further explored.

Consequences of Untreated Antenatal Stress and Depression

Because of how difficult it is to identify antenatal depression, 50 to 70% of women are undiagnosed during a critical time of life (Tegethoff et al., 2011). Outcomes can be mild to severe, involve BPNSE aspects of 70 to 86% of pregnant women, and adversely affect NCUP function (Bonari et al., 2004; Hippman et al., 2009; Tegethoff et al., 2011). Furthermore, there remains potential for development of chronic, recurrent disabling depressive symptoms across a lifespan with increased significance for death (Bonari et al., 2004; Pearlstein, 2008). Once diagnosed only 14% of pregnant women seek treatment for depression although consequences persist (Gausia et al., 2009).

Effects of untreated depression during pregnancy are resultant of significant dysregulated NCUP homeostasis secondary to low HRV (McCraty & Childre, 2010). The adverse gestational milieu effects of low HRV involve the cardiovascular and uteroplacental vascular based illnesses of gestational hypertension, preeclampsia, uterine artery resistance, and stroke that lead to death (Dayan et al., 2006; Diego et al., 2006; O'Mahony et al., 2006). In addition to biological imbalance, antenatal depression takes a serious toll on physical health that involves eyes, ears, respiratory, digestion, and immune function (Tegethoff et al., 2011). Psychological repercussions of antenatal depression without intervention, although common, are sleep related disorders, cognitive decline that led to potential termination of even wanted pregnancy, increased risky behaviors, suicide, and mortality (Brunton et al., 2010; Bunevicius et al., 2009b; Pearlstein, 2008). Additionally, beyond insufficient companionship and marital conflict, the social aftermath of depressive symptoms that remain unattended during pregnancy include significantly increased domestic violence and abuse that requires medical care (Bunevicius et al., 2009a; Goodman & Tully, 2009; Vieten & Astin, 2008). Despite severe consequences of untreated depression during pregnancy, conventional treatment for antenatal depression is limited because NCUP homeostasis and the intrinsic nature of antenatal coherence are absent from mental healthcare intervention for pregnant women (McCraty & Childre, 2010).

Intervention for Antenatal Stress and Depression

Psychological care of antenatal depression translates to cost savings for families, healthcare systems, and the whole society due to the financial consequences of untreated

mental health (O'Brien et al., 2009). Although adverse side effects of medication for antenatal depression are a deterrent that prevents pregnant women from seeking necessary emotional support even though nonpharmacological interventions are required before trying more invasive care (Ventura et al., 2011). Ineffective nonpharmacological care subsequently necessitates referral for psychiatric evaluation (O'Keane & Marsh, 2007; Parcells, 2010; Ryan et al., 2005). The origins of depression are varied enough to require a wide range of management strategies to effectively manage antenatal depression (Buist, 2000).

Bereavement arises regardless the absence of death, therefore, early emotional care for antenatal wellbeing is imperative (Balaguer et al., 2012). Nonpharmacological interventions of interpersonal, cognitive behavioral, mindfulness, mind-body, and brief psychotherapies have longer lasting effects than antidepressants (Duncan & Bardacke, 2010; Marc et al., 2011; King et al., 2010; Parcells, 2010; Yonkers et al., 2009). Results failed to show evidence that interpersonal, psychodynamic, and supportive therapies are effective care for antenatal depression although counseling reduces depression and improves mood by 20-25% compared to no treatment (Bowen et al., 2012; Leigh & Milgrom, 2008). Pregnant women may also benefit from supportive therapies such as exercise, behavioral nutrition, sleep hygiene, psychosocial support, and self-help strategies (Battle et al., 2010; Brown et al., 2009). Still, pregnant women who had a combination of antidepressants and counseling reported significantly higher antenatal mood (Bowen et al., 2012).

Nonetheless, some pregnant women prefer nonverbal mood enhancement methods of progressive muscle relaxation, music, reading, yoga, Qi exercise, massage, and meditation (Battle et al., 2010; Beddoe & lee, 2008; Ji & Han, 2010; Ventura et al., 2011). Active relaxation reduces sympathetic response and induces ANS synchronization thereby, physiological coherence, and may have a positive effect on antenatal depression (McCraty et al., 2003). Non-stressed women exhibited significantly lower first trimester cortisol than second and third trimester evening cortisol that unexpectedly increased possibly due to lack of psychophysiological equilibrium during active relaxation (McCraty et al., 2003; Urizar et al., 2004). Heart rate variability stress resilience training significantly reduces depression, and thus holds potential for safe, noninvasive care of antenatal depression (McCraty et al., 2003).

Increased HRV that result from treatment for depression have emotion-focused HRV feedback benefits (Karavidas et al., 2007; McCraty et al., 2003). Resonant frequency breath (slow, balanced, diaphragmatic breathing) maintained between sessions increases HRV, which offers neurovegetative (autonomic based physical, emotional, and cognitive) improvements in sleep hygiene, fatigue, and concentration (Karavidas et al., 2007). Training increases cardiovagal activity, has immediate significant increased HRV, positive long-term effects and is useful non-invasive care for antenatal depression (Karavidas et al., 2007; McCraty et al., 2003). Self-regulation stress resilience training reduces high blood pressure along with the associated stress and negative emotional arousal and may effectively reduce gestational hypertension (McCraty et al., 2003). Hypertensive diseases during pregnancy are of major clinical importance with timely

delivery being the only current effective treatment (Leeners et al., 2007). Therefore, exploring treatment beneficial in resilience to antenatal stress and depression, both early signs of antenatal hypertension, are essential.

Barriers to Treatment of Antenatal Stress and Depression

The view that pregnancy is a happy time in life, the stigma of depression, the opinions of loved ones, the financial burden, and time constraints are barriers to treatment for antenatal depression (Bacidore et al., 2009; Felice et al., 2007). Unfortunately, pregnant women avoid treatment for depression even when referred by their physician; consequently, a barrier forms between referral and psychiatric appointment (Felice et al., 2007; Harvey & Pun, 2007). Fear of antidepressant effects on pregnancy is an obstacle to mental health treatment (Bonari et al., 2004). Between 50 to 77% of antenatal depression remains unrecognized; in addition, 75% of diagnosed depression is untreated due to physician concerns about psychiatric medication and pregnancy (Bennett et al., 2004a). The Food and Drug Administration also warns against antidepressants during pregnancy to avoid undue fetal risk and physicians typically follow Food and Drug Administration advice (Trixler et al., 2005).

Moreover, because most obstetricians are unaware of psychological symptoms of depression prevalent during pregnancy this lack of familiarity with antenatal depression leads to under identified antenatal depression with up to 20% overlooked (Bacidore et al., 2009; Hatton et al., 2007; Weinstock, 2005). To treat antenatal depression effectively, multidisciplinary collaborative care within an integrative framework is necessary to ease barriers that prevent recovery from depression during pregnancy as only about 50% of

physicians refer for antenatal mental healthcare (Bacidore et al., 2009; Coleman et al., 2008; Trixler et al., 2005). Given the multisystemic nature of antenatal depression, integrative obstetrics mental healthcare as a cohesive multidisciplinary approach may improve the quality of treatment for depression during pregnancy.

Neuro-Cardio-Utero-Placental Coherence-Based Stress Resilience

Homeostasis within the NCUP system resultant of uteroplacental-heart-brain coherence is evidence of synchronized rhythms (Ho, 2008; McCraty et al., 2009). In essence, each organ entrains together in sole operation of the harmonious reproductive process (Ho, 2008). Crucial to healthy NCUP function is variability in rhythms for maintained coherence, which ensure flexibility required for effective response to stress as it arises in BPNSE aspects of pregnancy (Ho, 2008; Hui, 2012; McCraty & Childre, 2010). Effective self-initiated management of positive emotion in connection with the ANS that affect hematological communication throughout the NCUP system maintains coherence (Marques et al., 2010; McCraty et al., 2009; Sutarto et al., 2010). For example, stress and depression results in lower HRV whereas improved mood significantly affects increased HRV (McCraty et al., 2009).

Conventional mental healthcare's fundamental and inherent division of systems does not take into account the integrative nature of coherence, and as a result, care focused on separation renders the organism lifeless (Arck et al., 2008; Ho, 2008; Plastow, 2009). Effective maintenance of antenatal emotional health is intrinsically integrative; therefore, psychophysiologic CBSR and HRV were discussed next. After which, CBSR benefits on antenatal depression were further explored.

Psychophysiologic Coherence-Based Stress Resilience and Heart Rate Variability

Heart rate variability, the beat-to-beat change in heart rate, forms new hemodynamic conditions in the cardiovascular system with every heartbeat (Childre et al., 2000; Sutarto et al., 2010). Changes that emerge in HRV rhythm evidence complex pathways that communicate between heart, brain, and body (Childre et al., 2000). Immediate HRV rhythm response to subtle emotional change in turn encodes these messages via heart-mind-body communication throughout the psychophysiologic system (Childre et al., 2000). A dynamic emotional shift in relation to quality of HRV rhythm predicts conditions for future health (Childre et al., 2000). Increased awareness in quality of breath further improves respiration equilibrium and attention to patterns of HRV rhythm (Courtney et al., 2011; Sutarto et al., 2010).

An interrelationship between dysfunction in hemodynamic activity and antenatal hypertension, a major cardiovascular disease, occurs during pregnancy (Sutarto et al., 2010). Heart rate variability biofeedback focused on hemodynamic influence of respiration promotes psychophysiologic coherence (Courtney et al., 2011; Sutarto et al., 2010). Slow, consistent, abdominal breathing increases HRV, respiratory resilience, and response flexibility (Courtney et al., 2011). Self-regulated synchronized breathing patterns and increased HRV influence improvement of psychophysiologic stress, depression, and hypertension (Courtney et al., 2011). Autonomic nervous system balance of HRV rhythm coherence improves the psychological state and enhances physical function (Sutarto et al., 2010). Ability to self-regulate autonomic function upholds psychophysiologic control of affect and cognition (McCraty et al., 2009; Sutarto et al.,

2010). Similarly, self-regulated CBSR training improves antenatal depression (Pakenham et al., 2007).

Coherence-Based Stress Resilience Benefits on Antenatal Depression

Higher levels of depression and mental stress lead to imbalanced autonomic activity with greater sympathetic predominance (McCraty et al., 2003; Sheffield et al., 1998). Disparity in autonomic balance further increases susceptibility to cardiac complications and risk for sudden death compared to controls with fewer symptoms of depression (Sheffield et al., 1998). Disturbance in cardiologic function increases susceptibility to deleterious psychophysiologic health due to deregulated cardiac control (Sheffield et al., 1998). Resultant abnormalities in autonomic and HPA-axis regulation affect depression consequential of a negative feedback loop (McCraty et al., 2003; Sheffield et al., 1998). Moreover, severe long-term health risks linked to depression present an increased threat for cardiovascular related death and higher premature mortality than experience of positive emotional health (McCraty et al., 2003).

Eighty percent of the experimental group participants experienced increased HRV with improved patterns of coherence upon the practice of an emotional self-regulation technique focused on a shift from negative thought loops to positive emotional states (McCraty et al., 1998; Sutarto et al., 2010). Increased heart rhythm coherence improves homeostatic regulation within autonomic, cardiovascular, and neuroendocrine mechanisms (McCraty et al., 1998; Sutarto et al., 2010). There were significant improvements in depression and increased HRV post emotional self-regulation for patients with elevated symptoms of depression (Shinba et al., 2008). Hypertensive

symptoms improved significantly after emotional self-regulation stress management; therefore, antenatal hypertension and depression may benefit from the practice of emotional self-regulation stress management during pregnancy (Chen et al., 2004; Diego et al., 2006; McCraty et al., 2003). Strengthens resultant of the experienced sensation of positive visualization, emotional self-regulation, and synchronized breath are reduced emotional distress, decreased depressive symptoms, improved psychoneuroimmunology, and uteroplacental-heart-brain coherence (McCraty et al., 2003; Sutarto et al., 2010; Thomas, 2011). As expected, healthy participants and depressed controls without training had no change in their state of emotion, HRV rhythm, or physical functioning (McCraty et al., 2003; Shinba et al., 2008).

Given the relative brevity of pregnancy, positive effects of emotional self-regulated breath, positive reappraisal, improved mood, and enhanced physical function of vital systems; in a relatively brief, inexpensive manner, emotional self-regulated breath may benefit antenatal stress and depression (DiPietro et al., 2004; McCraty et al., 1998). Recovery from the stress associated with cardiovascular complications resolve more quickly for those who experience positive emotions of joy and contentment; therefore, it is suggested that intrauterine vasoconstriction distress may be alleviated by self-regulated positive emotion (DiPietro et al., 2004). Psychophysiologic coherence based breathing techniques are safe, nonintrusive, uncomplicated, effective stress management exercises that are easy to implement as antenatal coping strategies (Evans, 2007; Sutarto et al., 2010). Pregnant women on bed rest found these breathing methods to be safe, simple, practical techniques, helpful at stabilizing psychological states and physical function

(Evans, 2007). Therefore, emotional self-regulated stress management may effectively reduce symptoms of antenatal stress, depression, and hypertension, and improve the quality of life during pregnancy with reduced healthcare costs (DiPietro et al., 2004; Evans, 2007; McCraty et al., 2003).

Summary

An exploration of the current literature showed the NCUP effects of antenatal stress and depression during pregnancy within an integrated model of the reproductive experience (Ho, 2008; Hui, 2012; McCraty et al., 2009; Plastow, 2009; Sutarto et al., 2010; Thomas, 2011). The integrative model included the BPNSE aspects of pregnancy (Hui, 2012; Plastow, 2009; Sutarto et al., 2010). Given the interconnected nature of pregnancy, the necessity for maintenance of homeostasis, and the essential role that the ANS has in gestational viability, NCUP coherence, HRV rhythm, and the benefits of stress resilience training were reviewed within the integrated reproductive model (Ho, 2008; Hui, 2012; McCraty et al., 2009; Plastow, 2009; Sutarto et al., 2010; Thomas, 2011).

Neuro-cardio-utero-placental coherence focused on antenatal stress, depression and disrupted homeostasis threat to NCUP coherence (McCraty et al., 2009; Vrekousis et al., 2010). Additionally, NCUP connection and coherence, intricately associated with ANS activity, affects antenatal hematological communication between the uteroplacental-heart-brain connection (Marques et al., 2010; Sutarto et al., 2010; Thomas, 2011). Stress resilience training effects on the management of emotions throughout the NCUP system and consequences of a significant shift in HRV rhythm affects fluctuations of antenatal

mood (Marques et al., 2010; McCraty et al., 2009; Sutarto et al., 2010). The integrative nature of pregnancy and fundamental need for NCUP coherence are not possible within an inherently divided conventional mental healthcare system (Arck et al., 2008; Ho, 2008; Plastow, 2009). Given the severity of antenatal depression and the role maternal stress plays in the disease process during pregnancy, ACOG, the APA, and the World Health Organization recommends further research on safe, minimally invasive treatments for antenatal depression (APA, 2000; ACOG, 2008; Tegethoff et al., 2011).

Rationale for Current Study

Compartmentalization that separates aspects of pregnancy resulted in fragmentation of past literature regarding the integrated NCUP system intrinsic to the viability of life (Ho, 2008; Hui, 2012; McCraty et al., 2009; Plastow, 2009). There is no literature to date evaluating nonintrusive CBSR training that synchronize ANS communication within the uteroplacental-heart-brain connection to reduce stress and improve mood (Ho, 2008; McCraty et al., 2009; McCraty & Childre, 2010; Sutarto et al., 2010; Thomas, 2010). Given recent findings in several research studies that found significant maladaptive differences within the NCUP system, it is necessary to obtain information regarding changes that occur within an integrated antenatal framework (Bacidore et al., 2009; Evans, 2007; Ho, 2008; Hui, 2012; McCraty et al., 2009; Plastow, 2009). For example, NCUP homeostasis when exposed to stress and depression, decrease HRV as shown by gestational milieu incoherence, dysregulated uteroplacental haemodynamics, gestational hypertension, and preeclampsia (Childre et al., 2000; Ho, 2008; McCraty et al., 2003; Stein et al., 2008; Vrekousis et al., 2010). Furthermore, the

APA and ACOG support an integrated and highly individualized approach in response to antenatal stress and depression during pregnancy (Duncan & Bardacke, 2010; Evans, 2007; Yonker et al., 2009). Considering the importance in the quality of connection within and between the uteroplacental-heart-brain connections in conjunction with significant findings regarding safe, effective, integrative stress resilience training, time is overdue to evaluate the effect of CBSR that occur within this area (Ho, 2008; Lehrer et al., 2010; McCraty et al., 2009; Plastow, 2009; Thomas, 2010).

Obtaining information directly from second and third trimester pregnant women who receive stress resilience provided information regarding the potential for safe, effective, integrative care of stress and depression during pregnancy. The current study further contributed towards better understanding stress, depression, and cardiovascular disorders such as gestational hypertension and preeclampsia within the NCUP integrative framework. Increased awareness necessary to better serve women experiencing stress and depression during pregnancy provided a foundation for further, more extensive, empirical research.

It is essential to collect data from pregnant women in their second and third trimester of pregnancy in an effort to circumvent potentially high participant attrition due to one in four pregnancies ending in miscarriage during the first trimester with the risk of miscarriage dropping significantly after the 12th week (Creinin et al., 2001; Cunningham & Whitridge, 2001). Additionally, pregnant women experiencing depression is at an increased risk for preterm births (Bonari et al., 2004). One of the main purposes of the current study is to evaluate the effect of CBSR that occur within the NCUP gestational

milieu. First, this study examined the potential effect of CBSR on the BPNSE aspects of pregnancy. Specific associations were examined within and between integrated aspects of pregnancy. These integrated pregnancy factors include the effect of CBSR on:

1. neuroendocrine and immune system components of 17-OHP, cortisol, DHEA/DHEAS, and sIgA during pregnancy;
2. psychological intensity of antenatal stress and symptoms of depression;
3. positive reappraisal coping responses;
4. coherence of HRV rhythm during pregnancy; and,
5. maternal blood pressure.

Antenatal stress and depression induced gestational hypertensive disorders during pregnancy are treatable even as they remain the leading cause of maternal morbidity and mortality (Diego et al., 2006; Faber et al., 2004; McCraty & Childre, 2010; Pavithran et al., 2008; Sugiura-Ogasawara et al., 2002). Effective self-initiated management of positive emotions in connection with the ANS affect hematological communication throughout the NCUP system, and may reduce antenatal stress and depression (Marques et al., 2010; McCraty et al., 2010; Sutarto et al., 2010). Subsequently, Chapter 3 focused on the methodology of this study that includes a description of the sample population, recruitment process, measures, and procedures for the study, as well as the data collection and analysis process. Research questions and design for the study were developed through careful consideration and integration of findings within the literature review. Additionally, precautions for protection of participants were detailed in the following section.

Chapter 4 addressed results including data collection and discrepancies, psychometric internal consistency and reliability, covariate justification, and analysis of the study variables together with advanced HRV metrics and physiological phenomena. Chapter 5 presented a recap of this study's findings, interpretation of the biological systems, psychometric indices, HRV stre-recovery, and frequency-domain outcomes. Finally, limitations, recommendations, implications, social change features were illustrated, together with applied risks from untreated antenatal depression and benefits of reduce stress, depression, and gestational hypertensive disorders.

Chapter 3: Research Method

The purpose of this quantitative study was to identify the effects of CBSR that occur over a 4-week period in the NCUP system of second trimester pregnant women in response to CBSR training. For this quantitative study, the course of antenatal stress between the NCUP relationship during pregnancy and antenatal depression and the expected effect of CBSR on the NCUP relationship between antenatal stress and depression within the BPNSE framework were explored. Therefore, the purpose of this quantitative study was to examine the effect of CBSR that occur over a 4-week period within the NCUP system of second trimester pregnant women who receive training and practice CBSR.

Chapter 3 introduces research methods for the current study. This chapter begins with a presentation of the research questions and diagram of the research model. Research design and rationale presentation follows a review of participants, sample size, setting, and recruitment procedures. An explanation of the stress resilience training process and outline the training and practice technique. The methods' section illustrates the questionnaires and measures implemented for data collection. Likewise, discussion of data collection methods proceeds from definitions of the variables and preparation of the statistical analysis process. Description of threats to validity and ethical considerations that involve precautionary information and preventative measures complete the methods.

Research Design

This study employed quantitative research methodology to assess the effect of CBSR on the NCUP gestational milieu to evaluate variables that may change because of

this empirical study. The independent variable for this study was CBSR training. Nine dependent variables included HRV rhythm measure of autonomic function responsive to stress; four ASI functions; and measures of antenatal depression, pregnancy stress experience, and positive reappraisal coping strategy. Clinical covariates for this study were SMBP, DMBP, and pretest values (Carnethon et al., 2002; Snigh et al., 1999; Windham et al., 2012). The stressor, pregnancy as a major life event, is a variable that may disrupt ANS equilibrium and thereby may dysregulate NCUP homeostasis during pregnancy and antenatal depression. CBSR may have a significant effect on stress and the relationship between pregnancy and antenatal depression thereby promoting NCUP homeostasis. Table 1 below lists the variable types along with the research variables of interest for this study.

Table 1

Summary of Variables

Variable type	Research variable
Independent	Training: CBSR
Dependent	Heart rate variable rhythm
	ASI cortisol
	ASI dehydroepiandrosterone/dehydroepiandrosterone sulfate (DHEA/DHEAS)
	ASI 17-hydroxyprogesterone (17-OHP)
	ASI secretory immunoglobulin A (sIgA)
	Antenatal depression
	Antenatal stress
	Positive reappraisal
Covariate	Systolic and diastolic maternal blood pressure
	Pretest values

For this study I implemented a classical quasi-experimental research design to collect data to study specific variables rather than a randomized experiment due to ethical consideration, time, and resource constraints. Randomized experimental design is the

gold standard, although in practice-based research it may be unethical and unacceptable to randomize participants to a control group (Handley et al., 2011). Instead, quasi-experimental design using a waitlist as the control condition uphold methodological rigor (Handley et al., 2011). Therefore, assignment to groups were nonrandom due to the unethical nature of withholding stress resilience training from second trimester pregnant women. Time constraints of conducting a classical randomized experiment involve the capacity to recruit an adequate number of second trimester pregnant women to the study along with the relatively brief finite nature of pregnancy. Monetary resources of a randomized experiment were also prohibitive for this study. The quasi-experimental research design provided a framework of uncompromising precision for investigation necessary to increase knowledge of NCUP stress and depression during pregnancy (Handley et al., 2011).

This study did not assume equivalence between the two groups due to inability to assign second trimester pregnant women randomly to training or a waitlist. Administration of measures occurred in a pre-post repeated manner, before and after stress resilience training, to both the training group and a waitlist control group. A classical quasi-experimental research design upheld ethical standards in the field of psychology for evaluation of the effect of CBSR that occur in the NCUP system over a 4-week period of time between the training group and waitlist control group as represented in the research questions.

Research Questions and Hypotheses

RQ1: While controlling for MBP and any pretest differences, what is the effect of posttest HRV rhythms between training and waitlist groups?

$H_0$1: While controlling for MBP and pretest values, there will be no significant effect in Week 4 posttest HRV rhythms between the CBSR trained group and the waitlist group.

H_a1: While controlling for MBP and pretest values, there will be a significant effect in Week 4 posttest HRV rhythms between the CBSR trained group and the waitlist group.

RQ2: While controlling for MBP and any pretest differences, what is the effect of posttest stress response in cortisol levels between training and waitlist groups?

$H_0$2: While controlling for MBP and pretest values, there will be no significant effect in Week 4 posttest stress response in cortisol levels between the CBSR trained group and the waitlist group.

H_a2: While controlling for MBP and pretest values, there will be a significant effect in Week 4 posttest stress response in cortisol levels between the CBSR trained group and the waitlist group.

RQ3: While controlling for MBP and any pretest differences, what is the effect of posttest DHEA/DHEAS stress adaptation levels between training and waitlist groups?

$H_0$3: While controlling for MBP and pretest values, there will be no significant effect in Week 4 posttest DHEA/DHEAS stress adaptation levels between the CBSR trained group and the waitlist group.

H_a3: While controlling for MBP and pretest values, there will be a significant effect in Week 4 posttest DHEA/DHEAS stress adaptation levels between the CBSR trained group and the waitlist group.

RQ4: While controlling for MBP and any pretest differences, what is the effect of posttest 17-OHP adrenal reserve indicators between training and waitlist groups?

$H_0 4$: While controlling for MBP and pretest values, there will be no significant effect in Week 4 posttest 17-OHP adrenal reserve indicators between the CBSR trained group and the waitlist group.

$H_a 4$: While controlling for MBP and pretest values, there will be a significant effect in Week 4 posttest 17-OHP adrenal reserve indicators between the CBSR trained group and the waitlist group.

RQ5: While controlling for MBP and any pretest differences, what is the effect of posttest sIgA levels between training and waitlist groups?

$H_0 5$: While controlling for MBP and pretest values, there will be no significant effect in Week 4 posttest sIgA levels between the CBSR trained group and the waitlist group.

$H_a 5$: While controlling for MBP and pretest values, there will be a significant effect in Week 4 posttest sIgA levels between the CBSR trained group and the waitlist group.

RQ6: While controlling for MBP and any pretest differences, what is the effect of posttest intensity of symptoms in antenatal stress between training and waitlist groups?

$H_0$6: While controlling for MBP and pretest values, there will be no significant effect in Week 4 posttest on intensity of symptoms of antenatal stress between the CBSR trained group and the waitlist group.

H_a6: While controlling for MBP and pretest values, there will be a significant effect in Week 4 posttest on intensity of symptoms of antenatal stress between the CBSR trained group and the waitlist group.

RQ7: While controlling for MBP and any pretest differences, what is the effect of posttest symptoms of antenatal depression between training and waitlist groups?

$H_0$7: While controlling for MBP and pretest values, there will be no significant effect in Week 4 posttest on symptoms of antenatal depression between the CBSR trained group and the waitlist group.

H_a7: While controlling for MBP and pretest values, there will be a significant effect in Week 4 posttest on symptoms of antenatal depression between the CBSR trained group and the waitlist group.

RQ8: While controlling for MBP and any pretest differences, what is the effect of posttest positive reappraisal coping responses between training and waitlist groups?

$H_0$8: While controlling for MBP and pretest values, there will be no significant effect in Week 4 posttest on positive reappraisal coping responses between the CBSR trained group and the waitlist group.

H_a8: While controlling for MBP and pretest values, there will be a significant effect in Week 4 posttest on positive reappraisal coping responses between the CBSR trained group and the waitlist group.

RQ9: While controlling for any pretest differences, what is the effect of posttest MBP between training and waitlist groups?

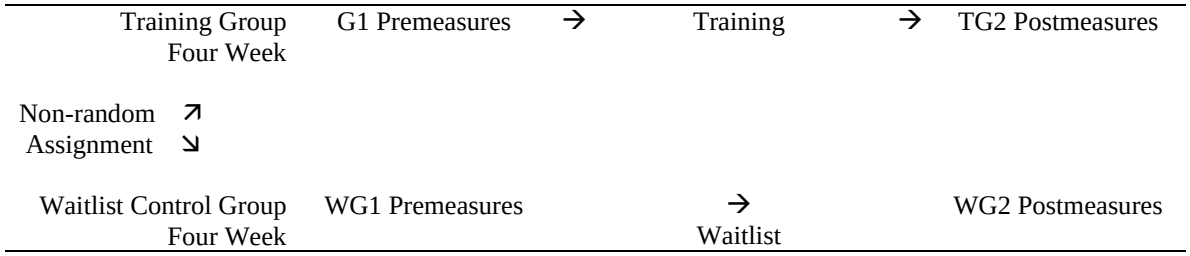
$H_0$9: While controlling for pretest values, there will be no significant effect in Week 4 posttest on MBP between the CBSR trained group and the waitlist group.

H_a9: While controlling for pretest values, there will be a significant effect in Week 4 posttest on MBP between the CBSR trained group and the waitlist group.

Participants comprised two groups of pregnant women in their second trimester of pregnancy. The training group received individual, one-on-one CBSR with a HeartMath provider and the control group was on a waitlist for training. The difference between the two groups is that the training group completed their pre-post measures before and after 4-weeks of training. However, the control group completed their pre-post measures on a 4-week interval as well while on the waitlist. See Figure 1 for a diagram of quasi-experimental research design. Detailed description of the training and practice of stress resilience, which the HeartMath providers presented to the experimental group, followed in the training section later in this chapter. Due to an inability to control for differences that occur within the NCUP gestational milieu and high sensitivity of individual corticosteroids biosynthesis and immunoglobulin production, each pregnant woman was her own pre-post match. A graph of classical quasi-experimental design for this study is depicted in Figure 1.

Figure 1

Difference Between the Two Groups



Note. TG1, WG1: Data collection points for pre-measures, TG2, WG2: Data collection points for post-measures

The training group completes the pre-post measures before and after four consecutive weeks of training. The waitlist control group completes the pre-post measures before and after a four consecutive week waiting period.

The training group received CBSR training, an emotional self-regulated stress management technique, which may improve symptoms of antenatal stress, depression, and hypertension (DiPietro et al., 2004; Evans, 2007; McCraty et al., 2003). Non pregnant individuals within the general population who practiced self-regulated CBSR experienced increased HRV, improved patterns of coherence, and positive emotional states (McCraty et al., 1998; Sutarto et al., 2010). Women exposed to antenatal stress and depression experience imbalanced homeostasis within the NCUP system, gestational milieu incoherence, and dysregulated uteroplacental haemodynamics that further exposes them to gestational hypertension and preeclampsia (Childre et al., 2000; Ho, 2008; McCraty et al., 2003; Stein et al., 2008; Vrekousis et al., 2010). Pregnant women who practice self-initiated management of positive emotion may experience reduced antenatal stress, depression, and improved haematological communication throughout the NCUP system (Marques et al., 2010; McCraty et al., 2003; Sutarto et al., 2010). Stress and

depression during pregnancy remain the leading cause of maternal morbidity and mortality while antenatal stress and depression are treatable (Diego et al., 2006; Faber et al., 2004; McCraty & Childre, 2010; Pavithran et al., 2008; Sugiura-Ogasawara et al., 2002).

The APA and American College of Obstetricians and Gynecologists recommend an integrated approach to addressing stress and depression during pregnancy (Duncan & Bardacke, 2010; Evans, 2007; Yonkers et al., 2009). Investigation of CBSR training may advance understanding of antenatal stress, depression, and cardiovascular disorders such as gestational hypertension and preeclampsia within the BPNSE integrative framework. Obtaining information directly from second trimester pregnant women who receive stress resilience provided information regarding the potential for safe, effective, integrative care of stress and depression during pregnancy. Quasi-experimental methodology evaluated the course of antenatal stress between the NCUP relationship during pregnancy and antenatal depression. Figure 2 illustrates the path between pregnancy as a major life event stressor, antenatal stress, and depression during pregnancy founded in prior research. Past research shows the course of antenatal depression precipitated by stress may disrupt ANS equilibrium thereby may dysregulate NCUP homeostasis. The effects of CBSR on the relationship between antenatal stress and depression was explored as depict in the research model graph in Figure 3. The overall model of this study is the path through which CBSR is expected to have a significant effect on stress and depression during pregnancy thereby NCUP homeostasis.

Figure 2

Path Between Pregnancy Stressors and Antenatal Depression Illustrated

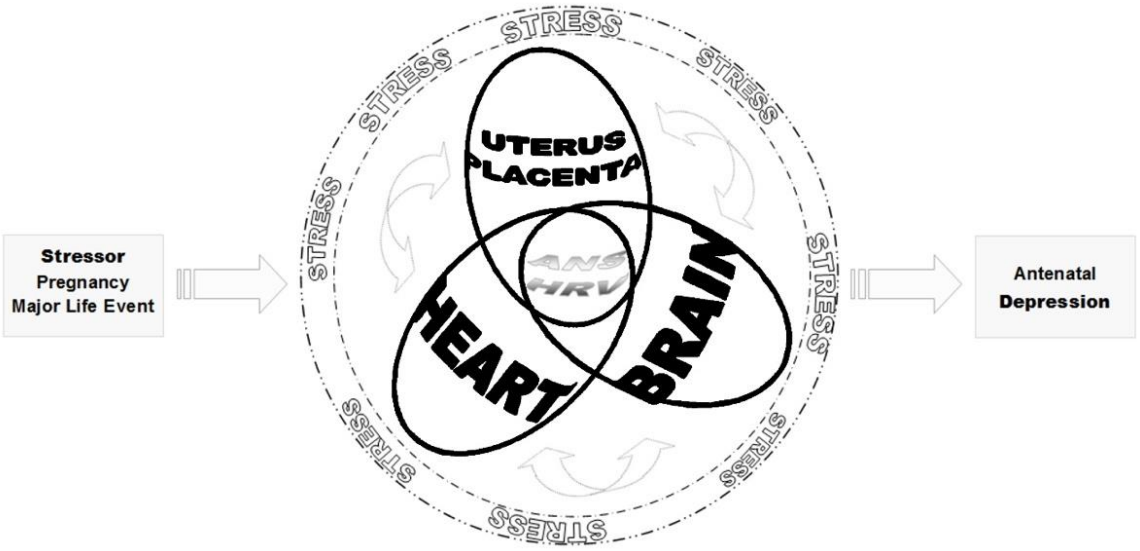
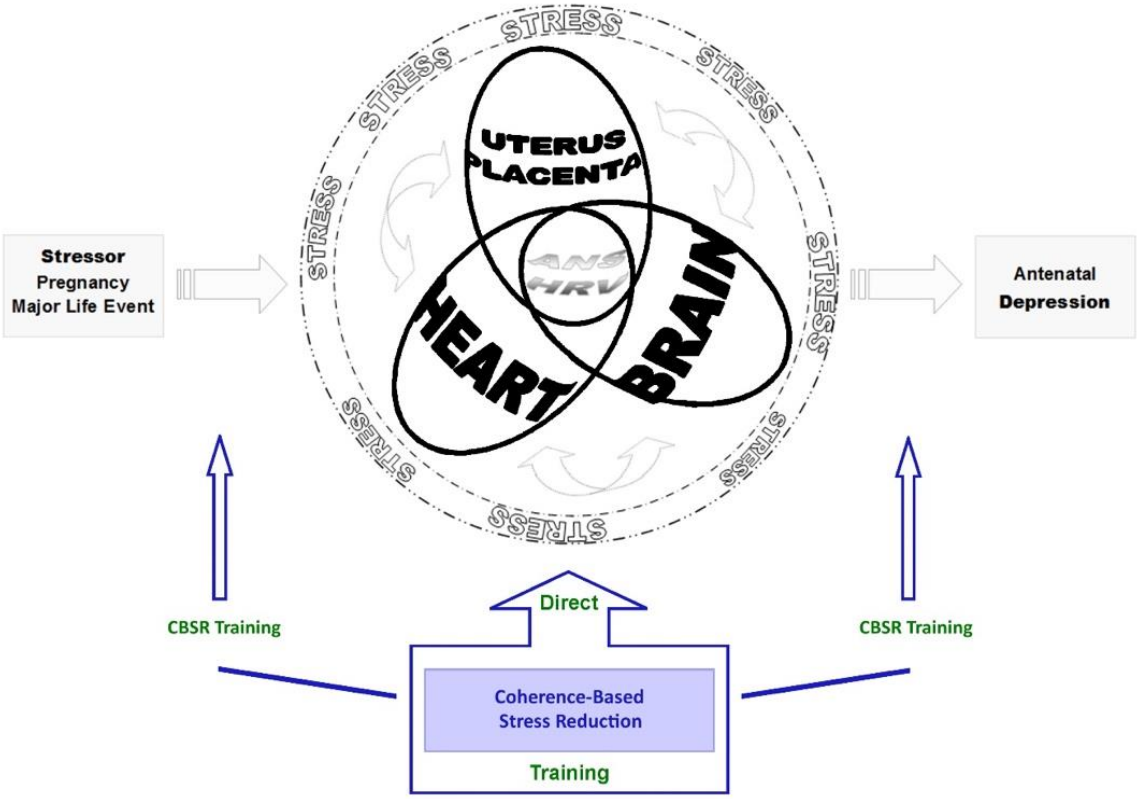


Figure 3

Graph of This Study's Research Model



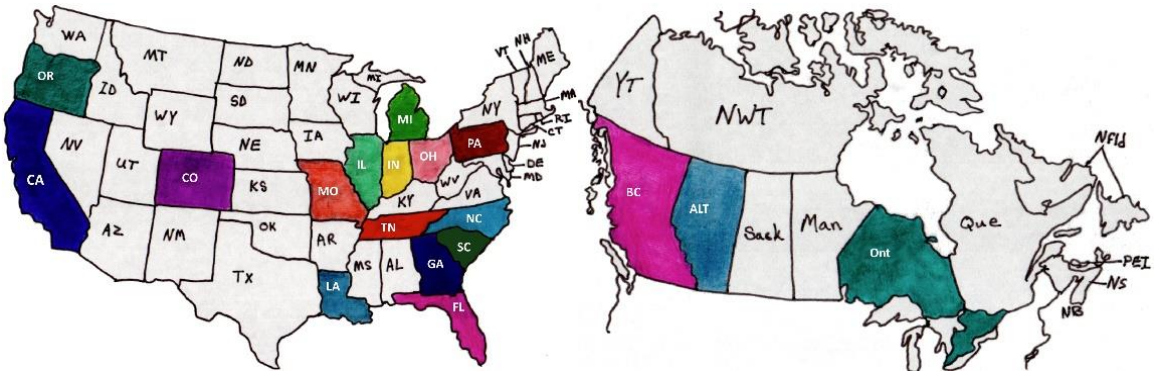
Setting and Sample

This study planned to drew from a sample from a population of adult second trimester pregnant women receiving training from a HeartMath provider. The population was pregnant women of adult childbearing age, approximately 20 to 40-years-old, from week 13 to the end of 22 weeks gestation in their second trimester of pregnancy. The population parameter between 13 to 22 weeks gestation attempted to circumvent high participant attrition due to spontaneous termination of pregnancy and early preterm birth (Creinin et al., 2001; Bonari et al., 2004). The number of pregnant women or clients served by HeartMath providers is currently unknown due to lack of documentation

regarding those statistics, although, following is the number and location of HeartMath providers. There are a total of 626 United States and Canada HeartMath providers of which 554 practice in the United States (excluding Iowa, Mississippi, and West Virginia due to no current providers in those states), and 72 offer services in Canada. Thirty Registered Nurses were HeartMath providers within 16 states, 28 cities across the United States with 5 Registered Nurses in three states, five cities in Canada, as depicted in the geographic area maps in Figure 4 (HeartMath, 2014). The location of HeartMath providers may change as current HeartMath providers relocate and new HeartMath providers are trained.

Figure 4

HeartMath Nurse Provider Location Maps: United States and Canada



Procedures

Sampling Procedures

The sampling method was a nonprobability convenience type due to the time and financial constraints of this study. HeartMath providers offered an invitation for participation in this study to their pregnant clients who are entering training or waiting to enter training and meet inclusion criteria of the population. Inclusion criteria are pregnant

women of adult childbearing age, approximately 20 to 40-years-old, from week 13 to the end of 22 weeks gestation in their second trimester of pregnancy. Due to confounding factors, the following are exclusion characteristics to participation in the study: pregnancy with multiples, pregnancy loss history (e.g., more than one miscarriage, any stillbirth or neonatal death), and current physician care for acute or chronic medical conditions. Exclusion criteria also involve a psychiatric diagnosis, prescribed psychiatric medications, or under current psychological treatment. Additional situations eliminated consist of tobacco use and illicit drug use including marijuana or alcohol.

Sample Size

This study utilized GPower 3.1 to calculate the proposed sample size. Based on statistical analysis of analysis of covariance, alpha = .05, power = .80, medium expected effect size f = .35, and expected average correlation between pre and post scores on each dependent variable of .70 resulted in a total sample size of n = 68 with two groups of 34 participants each. Comparing the treatment for depression during pregnancy with a control group revealed positive average effect (d = .40) (Claridge, 2014). Between 16 - 20 weeks gestation, symptoms of depression were found (β = .42 and p < .05) during pregnancy (Azar & Mercer, 2013).

Recruitment

Enrollment of potential participants to HeartMath provider services may occur directly from the HeartMath provider's own past advertisement efforts, practice referral sources, professional online presence, or directly from HeartMath provider advertisements. Recruitment efforts further involved distribution of advertisement

brochures at complimentary and paid venues, which may include area conventional and alternative healthcare facilities, clinics, and hospitals (e.g., obstetrics, mid-wife, pediatrician, general practitioner, and massage therapist clinics). Participants obtained brochures from local professional associations, conferences, public events, and facilities (e.g., prenatal yoga studios, prenatal shopping venues, prenatal massage studios, religious institutions, libraries, farmer's markets, community colleges, and universities). Likewise, recruitment advertisement used a newspaper, newsletters, and internet websites.

HeartMath providers practicing in the United States enrolled $N = 11$ pregnant women who meet enrollment criteria for participation in this study. HeartMath providers offered an invitation for voluntary participation in this study to their pregnant clients who are entering training or waiting to enter training and meet inclusion criteria of the sampling frame. Allocation of $n = 3$ pregnant women in a HeartMath program waiting for training entered the delayed training control group. The wait list developed naturally according to the order in which clients contacted the HeartMath provider for training. The allocation of $n = 8$ pregnant women entering a HeartMath training program were enrolled in the stress resilience training experimental group. Both groups together comprised $N = 11$ participants total in this study.

Data Collection

Prior to commencement of data collection, A signed copy of the Institute of HeartMath letter of oversight to share a de-identified dataset as described in Appendix B. The HeartMath provider gave the participant their phone number as a point of contact for the study. For study specific questions, the HeartMath provider contacted the investigator

for clarification. The HeartMath provider directly addressed the participant's training specific questions.

The HeartMath provider read general instructions to each participant that explained omission of their name from all materials and measures submitted to the researcher. When confidentiality is upheld, participant apprehension decreases and response integrity increases (Kazdin, 2003). Use of a participation code number maintained participant confidentiality within the research consistently throughout the study. A consistent participation code number coordinated all of each participant's pre and post data collection materials and measures submitted to the researcher from the HeartMath provider together with salivary measures. Description of demographic questionnaire specifics followed in the measures and materials section of this chapter.

Data Collection Phases

Pre-Study Phase

Utilization of an assigned participation code number, for maintenance of confidentiality throughout the study, coordinated all components of participant data. Participants completed demographic and psychological questionnaires, emWavePro measures, and salivary measures processes during the pre-study phase. Completion of the demographic and psychological questionnaires occurred independently at their HeartMath provider's office. The HeartMath provider collected emWavePro measures on all participants in a single-blind manner. The emWavePro computer screen was visible to the HeartMath provider and outside of participant view during the pre-study phase. Diagnos-Techs ASI kits were provided directly to the participants. The participant

collected the salivary sample in their home as directed by John White, M.D., Medical Director at Diagnos-Techs. Participants then return their salivary sample to their HeartMath provider and mailed to Diagnos-Techs for laboratory testing. This research was not financially supported by HeartMath.

Training Phase

Providers scheduled waitlist group participants to return in 4-weeks for post-study measures. The training group return to the site of the HeartMath provider for four consecutive weeks. HeartMath providers conducted training sessions as per sponsor direction of Rollin McCraty, PhD., Institute of HeartMath Executive Vice President and Director of Research and described below in the Quick Coherence technique section. Participants went to the site of their HeartMath provider to complete their emWavePro measures in the beginning and the end of each training session for four consecutive weeks.

Poststudy Phase

At the end of the four consecutive week training phase, both groups completed the same psychological questionnaires, emWavePro measures, and salivary measures during the post-study phase in the same manner as the pre-study phase. Participants had their emWavePro measures completed blindly with the emWavePro computer screen visible to the HeartMath provider and outside of participant view during the post-test phase of the study.

The investigator received data collection results of all measures, directly from providers who collect the information, for the purpose of statistical analysis. HeartMath

providers emailed participants' emWavePro data and Diagnos-Techs emailed the lab results of the ASI measures.

Debrief and Departure

Following completion of the study, HeartMath providers gave participants a brochure describing signs and symptoms of antenatal stress, depression, and risk factors for suicide. The brochure contained referral information for professional support to address any problematic symptoms the participant may have experienced. The pamphlet included the Office of Mental Health 24-hour hotline telephone number in their geographic area of residence. Providers presented an article that described signs and symptoms of antenatal stress and depression that participants can use as a consultation tool to discuss preventative measures with their obstetrician (ACOG, 2012).

Follow-up

The study ends once post-measures are complete. The HeartMath provider then debrief the participant. Debrief procedures involved the HeartMath provider's verbal presentation of content within the debriefing brochure. The debriefing brochure contained HeartMath and ASI information, confidentiality of personal information statement, psychological service and crisis resources. HeartMath providers offered participants an opportunity to ask questions about their CBSR training. Then the participant departed the study. There are no follow-up procedures after the participant departs the study.

Quick Coherence: Coherence-Based Stress Resilience

Sponsor

Rollin McCraty, PhD., Institute of HeartMath Executive Vice President and Director of Research sponsored the training component of this study. The letter of oversight follows in Appendix B.

Quick Coherence

Quick Coherence, an Institute of HeartMath development, is a CBSR technique that balances the ANS via heart focused synchronized breath conjunct sensation of positive feeling (HeartMath, 2012). As the name of the stress resilience technique implies, Quick Coherence is a rapid method that has the potential to produce stress-reducing results within one minute (HeartMath, 2012). Additionally, an individual may discreetly perform the Quick Coherence procedure during the first signs of stress while in the presence of others (HeartMath, 2012).

HeartMath Providers

The Institute of HeartMath faculty trains healthcare professionals how to use HeartMath tools and techniques within their professional practices with their patients and clients (Childre et al., 2000; McCraty et al., 2009). All HeartMath provider participated in clinician training for healthcare professionals including physicians, Registered Nurses, psychologist, therapists, and other healthcare providers. They completed four one-hour personal sessions with their own HeartMath provider and practiced HeartMath techniques within their own lives. Personal sessions were in preparation for the provider training seminars. The provider course involved 24 hours of face-to-face instruction by Institute

of HeartMath faculty consisting of interactive activities, presentations, a HeartMath manual with in-depth information on HeartMath interventions, techniques, assessment protocols, and emWave technology (Childre et al., 2000; McCraty et al., 2009). HeartMath providers have access to ongoing support of Institute of HeartMath faculty, recorded webinars, an extensive elibrary, and continuing education credits. There was a total of 626 HeartMath trained providers within the United States and Canada.

Quick-Coherence Technique

The HeartMath providers introduced a simple three-step Quick Coherence technique to $n = 8$ training group participants individually, one at a time as follows in Table 2 (Childre et al., 2000; McCraty et al., 2009). Using the emWavePro, HeartMath providers measured participant's HRV at the beginning and end of each training session in a single blind manner in which the emWavePro computer screen was visible to the HeartMath provider while participant was unable to view the computer monitor. Administration of the training sessions occurred during four consecutive weeks, seven days apart, for the duration of one hour each. Each session consisted of a single blind 15-minute pre HRV measure, 30 minutes of Quick Coherence training and practice, followed by a single blind 15-minute post HRV measure.

Table 2

Quick Coherence Technique

Steps	Titles	Directions
1	Heart focus	Focus attention in the area of your heart.
2	Heart breathe	Maintain focus in the area of your heart; breathe slowly and gently at a smooth, balanced, natural rhythm.
3	Heart feeling	While maintaining focused breathing in the area of the heart, re-experience positive feelings of appreciation, care, or compassion involving a person, place, or event. Once you feel the sensation of the re-experienced positive feelings, sustain consistent focused, breathing, and feelings in the area of your heart.

Setting

HeartMath providers see their clients in an outpatient clinical setting. After participant recruitment to the study, they completed self-administered measures during the pre-study period. The provider scheduled the waitlist group to return four consecutive weeks after the pre-study measures were completed and the experimental group entered directly into four consecutive weeks of CBSR training sessions. At the end of the four-week training period, participants in both groups then completed self-administered measures during the post-study period at the site of the HeartMath provider.

Measures and Materials

This study implemented questionnaires and measures for the purpose of data collection including background and demographics, HRV and coherence, antenatal depression, stress experience during pregnancy, positive reappraisal coping, and salivary adrenal stress profile. Following is a summary of measures (see Table 3). A detailed illustration of the instruments, description of each interpretation and scoring process,

along with a review of reliability and validity of each measure proceeded after the summary of measures table in this section.

Table 3

Summary of Measures

Type	Name	Test & subscales
Demographic Questionnaire	Demographic questionnaire	Background & demographics
Psychological Questionnaires	Edinburgh Postnatal Depression Scale Pregnancy Experience Scale Ways of Coping Questionnaire	Antenatal depression Antenatal stress experience Positive reappraisal
Salivary stress measures	ASI panel (Measurements: morning, noon, afternoon, bedtime)	Temporal free cortisol rhythm DHEA/DHEAS 17-OHP Total Salivary sIgA
Coherence measure	EmWavePro	HRV

Demographic Questionnaire

A demographic questionnaire included in the premeasures packet increased the capacity to know characteristics that both the training group and the waitlist control group have in common thereby increasing internal validity (Altshuler et al., 2008; DiPietro et al., 2012). The demographic questionnaire comprised standard information specific to an obstetrics population per ACOG patient addressograph antepartum record and obstetric medical history forms (ACOG, 2011a, 2011b). Information gathered included sociodemographics, geodemographics, obstetrics physical health, and mental health parameters related to ANS and HRV, pregnancy experience, and associated lifestyle elements that cannot be separated (Dayan et al., 2010). American College of Obstetrics and Gynecology did not record reliability or validity scores. Although, founded in 1953 with roots beginning in 1903, they specialize in healthcare for pregnant

women. American College of Obstetrics and Gynecology developed the standard demographic questions specific to pregnant women for clinical and research purposes (ACOG, 2011a, 2011b; Adewuya et al., 2007; Dayan et al., 2010; DiPietro et al., 2012; Marcus et al., 2003). Format of the questionnaire is comprised of checkbox and yes/no responses and were scored by calculating frequencies. The expected completion time of the demographic questionnaire was five minutes although time may vary. Presentation of the demographic questionnaire follows in Appendix D.

Psychological Questionnaires

Psychological questionnaires for this study are the EPDS, the PES, and the WOC Questionnaire (Adewuya et al., 2006; Bunevicius et al., 2009a; DiPietro et al., 2004; Harvey & Pun, 2007; Jomeen & Martin, 2007; Folkman & Lazarus, 1988; Wallis et al., 2012). Following are detailed descriptions of the psychological questionnaires, interpretation of scores, along with validity and reliability.

Edinburgh Postnatal Depression Scale

Sensitive to changes in severity of depression over a 4-week period of time, the EPDS measures the type and number of antenatal and postnatal depressive symptoms (Bunevicius et al., 2009a; Cox et al., 1987; Wallis et al., 2012). Established in 1987, Cox, Holden, and Sagovsky are the original developers of the EPDS. This measure is a 10-item questionnaire that elicits self-report responses with high validity, internal reliability, and test-retest reliability for measuring depression in pregnant women of childbearing age. Response format consists of a 4-point checkbox configuration ranging from all the time to not at all. The expected completion time of the EPDS is five minutes although time

may vary. The EPDS, originally developed for detection of depression post-pregnancy, has a strong sensitivity (100%) and specificity (92%) during the second trimester of pregnancy with a recommended cutoff score of 11 (Bunevicius et al., 2009). Therefore, this instrument is reliable for detecting antenatal depression for the current study. Authorization to reproduce the scale without further permission was printed directly on the assessment form (Cox et al., 1987). A sample question is "I have felt happy" (Cox et al., 1987).

Interpretation of Scores

Participants first select a statement that represents their current state of emotional and cognitive functioning, upon which assignment of scores from 0 - 3, according to the participant's response, follow after completion of the EPDS. Scoring of Questions 1, 2, and 4 occur in a top-down manner starting with a score of 0 for the top box, proceeding in numerical order, with a score of 3 for the bottom box (Cox et al., 1987). Questions 3, and 5-10, however, are reverse scored in a bottom-up manner starting with a score of 3 for the top box, proceeding in retrogressed numerical order, ending with a score of 0 for the bottom box (Cox et al., 1987). There is a maximum score of 30 on the EPDS. Once scores are calculated, the degree of antenatal depression is represented by one total score (Cox et al., 1987). Definition of mild depression is a score of $\geq$ 12 on the EPDS, moderate depression is a score of 13-21, and severe depression is a score of 22-30 (Cox et al., 1987). Question 10 furthermore indicates the potential for suicidal thoughts (Cox et al., 1987). Raw scores were used for statistical analysis.

Reliability and Validity

Clinical depression is not diagnosed with self-report instruments though were found to have sound psychometric properties of reliability and validity for identifying symptoms of depression necessary as a first step in detecting risk for depression during the early stages of pregnancy (Evans et al., 2001). Reliability of the EPDS, originally tested with postnatal women, had a standardized coefficient alpha of .87 (Cox & Holden, 2003; Cox, Holden, & Henshaw, 2014). Nearly all cases of antenatal depression were detected with a cutoff score of 9 or 10 though may be over inclusive, therefore, cutoff scores of 12 or 13 were recommended (Cox & Holden, 2003; Cox et al., 2014). Additionally, validity of the EPDS distinguished depressive symptoms and effectively identified clinical depression between pregnant and non-pregnant women (Cox et al., 1986; Evans et al., 2001). Factor analysis further explained 46% of the variance (Cox et al., 1986). Comparison of the EPDS and the Beck Depression Inventory according to Diagnostics and Statistical Manual, third edition criteria yielded a sensitivity of 95% and specificity of 93% for the EPDS (cut off scores of 10+) though 68% sensitivity and 88% specificity for the Beck Depression Inventory (cut off scores of 11+) post-pregnancy (Harris et al., 1989). The EPDS and Beck Depression Inventory have good convergent validity as evidenced by a correlation result of $r = .68$; $p < .05$ (Teissedre & Chabrol, 2004).

The EPDS was an effective, validated, and widely used tool for detection of depression during pregnancy (Alshulter et al., 2008; Dayan et al., 2002; Murray & Cox, 1990; Evans et al., 2001; Josefsson et al., 2001). Likewise, the EPDS was recommended

as an easy-to-administer tool with robust (α = .89) psychometric properties for screening of antenatal depression in pregnant women (Wallis et al., 2012). Test-retest reliability was evaluated against the Structured Clinical Interview for Diagnostics and Statistical Manual, fourth edition non-Patient during the first, second, and third trimesters of pregnancy were .81 (p < .001) (Bunevicius et al., 2009a). Diagnosis of Major Depressive Disorder during pregnancy found that a cutoff score of $\leq$12 on the EPDS had 92% sensitivity and 95% specificity during the first trimester (Bunevicius et al., 2009a). Second trimester gestation, however, found an EPDS cutoff score of $\leq$11 resultant of 100% sensitivity and 92% specificity (Bunevicius et al., 2009a). An EPDS cutoff score of $\leq$11 was similarly found for the third trimester with sensitivity of 88% and specificity of 92% (Bunevicius et al., 2009a). Therefore, as a screening tool for all periods of pregnancy, including during the second trimester as proposed in this study, the EPDS was resultant of sensitive and accurate screening properties (Bunevicius et al., 2009a).

Pregnancy Experience Scale

Sensitive to magnitude of stress and mood over a 4-week period of time, the PES assesses intensity according to a variety of possible co-occurring positive and negative pregnancy specific stressor experiences. (DiPietro et al., 2004). Created in 2004, DiPietro, Ghera, Costigan, and Hawkins are the original developers of the PES. The PES is a 41-item questionnaire that elicits self-report responses with high internal reliability, test-retest reliability, and convergent reliability for pregnant women of childbearing age. Five areas of specific content measured in preparation for the baby include physical and psychological, self and spouse lifestyle changes, friend and family relationships,

antenatal occurrences and concerns, as well as topics of body image and self. Response format consists of a 4-point Likert scale configuration ranging from 0 (*none*) to 3 (*great deal*) for both hassles (unhappy feelings) and uplifts (happy feelings). The PES instructs examinees to rate both happy and unhappy feelings for each question. The expected completion time of the PES is 10 minutes although time may vary. The PES developed specifically to detect positive and negative aspects of stress during pregnancy is a brief, reliable, nonintrusive method for measuring antenatal stress (DiPietro et al., 2004). The investigator requested permission to reproduce the scale for the purpose of data collection in this study. Permission was provided directly from the developer (DiPietro et al., 2004).

Interpretation of Scores

The participant first ranks their level of negative and positive experience regarding each statement on a scale of 0-3 after which calculation of endorsed items analyzed both hassles and uplifts (DiPietro et al., 2004). The possible range of scores is 0-123 for both subscales. Next, calculation of intensity occurred by adding the ranked scores for hassles and uplifts sections separately then dividing the number of endorsed items for their respective sections (hassles and uplifts), which comprised the mean score (DiPietro et al., 2004). Then, dividing intensity of hassles by the intensity of uplifts resulted in composite ratio (DiPietro et al., 2004). A ratio of one indicates equal intensity of hassle and uplift. A ratio greater than one indicates the experience of more intense hassles than uplifts (DiPietro et al., 2004). Conversely, a ratio less than one indicates the experience of more intense uplifts than hassles (DiPietro et al., 2004).

Reliability and Validity

Psychometrically sound, the PES was an instrument with significant validity and reliability in the detection of pregnancy specific stress and mood in healthy pregnant women, 24 to 38 weeks gestation, with low risk for pregnancy complication (DiPietro et al., 2004). The PES was significant for internal validity with high scale reliability for hassles (α = .95) and uplifts (α = .91) (DiPietro et al., 2004). Test-retest reliability resulted in highly significant and consistent stability over 12 weeks in cohort 1 and 6 weeks in cohort 2 for frequency, intensity, and the ratio (DiPietro et al., 2004). Convergent and discriminate validity had significant positive relations between the PES hassles, depression, and trait anxiety, as evidenced by a medium correlation between the PES and Affective Intensity Measure, Daily Stress Intensity, Depressive Symptoms, and Trait Anxiety with variance between 15-19% (DiPietro et al., 2004). Forced extraction of five factors accounted for 52% of the variance. Uplifts were unrelated rather than inversely related to anxiety and depression (DiPietro et al., 2004). As well, higher intensity and frequency hassles were consistent with increased report of uplifts.

Ways of Coping Questionnaire

Sensitive to methods that people use to relieve stress over time, the WOC Questionnaire evaluates the thoughts and actions that comprise positive reappraisal of life stressors (Folkman & Lazarus, 1988). Formulated in 1988, Folkman and Lazarus are the original developers of the WOC Questionnaire. The WOC Questionnaire has eight subscales totaling 66 items on a 4-point Likert scale that yields raw and relative scores for individuals ages 18 and above (Folkman & Lazarus, 1988). While the entire WOC

Questionnaire including all 7 subscales administered, the results of seven questions within the Positive Reappraisal subscale were the focus for this study. The Positive Reappraisal subscale's central point is personal growth and positive meaning. Response format consists of a 4-point Likert scale configuration ranging from 0 (*none*) to 3 (*great deal*). The expected completion time of the WOC Questionnaire is 10 minutes although time may vary. The WOC Questionnaire was an effective tool for evaluating coping strategies during pregnancy. Aside from problem solving, positive reappraisal was the second lowest form of coping in a pregnant population 95% CI [.36, 1.09] (Faisal-Cury et al., 2012). The investigator requested permission to reproduce the scale for the purpose of data collection in this study. License to reproduce for research purposes was purchased from WOC publisher, Mind Garden.

Interpretation of Scores

Once participants respond to each question, calculation of relative scores described the Positive Reappraisal subscale in relationship to subscales combined as detailed in the calculation of scores description that follows. Exploration first added raw scores for each subscale, after which division of the sum by the total number of items in the subscale that yielded a subscale average (Folkman & Lazarus, 1988). Next, analysis determined the average for subscales combined. Lastly, each subscale average divided by the grand average for the questionnaire derives relative scores for each subscale (Folkman & Lazarus, 1988).

Reliability and Validity

The WOC Questionnaire subscales were averaged over five different events (n = 150) with Caucasian married couples of middle and upper socioeconomic statuses in order to obtain psychometric properties (Folkman & Lazarus, 1988). There was no indication about the gestational status of the woman; therefore, the women may or may not have been pregnant. Due to the variable nature of coping processes, estimates of traditional test-retest reliability were inappropriate (Folkman & Lazarus, 1988). Therefore, internal consistency was determined for each subscale. The Positive Reappraisal section is a 7-item subscale with an internal consistency rating of alpha = .79 (Folkman & Lazarus, 1988).

Each question within the WOC Questionnaire has face validity (Folkman & Lazarus, 1988). Furthermore, construct validity was asserted as evidenced by findings that were consistent with the theoretical predictions that the measure captured both problem-focused and emotional-focused coping, additionally that coping was a process (Folkman & Lazarus, 1988). Subscale assessment verified stability of the Positive Reappraisal subscale, due to variances across different types of coping. Social Support, Confrontive Coping, and Planful Problem Solving were estimated at the lowest mean autocorrelations (r = .17 to .23) suggestive of strongly influenced situational coping (Folkman & Lazarus, 1988). Positive reappraisal though was the most stable of the subscales with the highest average autocorrelation (r = .47) (Folkman & Lazarus, 1988).

The WOC Questionnaire detected maladaptive coping with women in Brazil experiencing antenatal depression. While pregnant women with depression used both

productive and non-productive coping strategies, depression during pregnancy was not statistically associated with the positive coping strategy of positive reappraisal $p = .15$, 95% CI [.29, .95].

Salivary Measures

Sponsor

John White, MD, CM, Senior Medical Director at Diagnos-Techs Laboratory in Kent, WA sponsored the ASI measure process. The Institute of HeartMath letter of oversight to share a de-identified dataset as described in Appendix B

Adrenal Stress Index Panel

As a non-invasive saliva-based hormone test, the ASI assesses endocrine levels of stress that contribute to disease, illness, and mortality (Diagnos-Techs, 2013b). Diagnos-Techs is the original developer of the ASI in 1989 (Diagnos-Techs, 2013b). Diagnos-Techs is an international testing and research laboratory known worldwide for their platinum standards of salivary testing and research. This experiment utilized the ASI to measure four hormone levels including cortisol, DHEA/DHEAS, 17-OHP, and sIgA levels to evaluate the level of stress and potential endocrine abnormalities. Following is a table of hormones that the ASI measures (see table 4). Response format consists of collecting salivary samples between 6am - 8am, 11am - 12pm, 4pm - 5pm, and 11pm - 12am as directed by Diagnos-Tech's instruction. The expected collection time consists of four, 1-minute points, throughout the day though time may vary. Assessment of all four salivary hormone levels occurs from the same swab procedure. Saliva, over blood or urine, is the accepted and preferred, non-invasive method for measuring stress in current

research due to its capacity to capture circadian fluctuations anytime and anywhere (Guilliams & Edwards, 2010; Diagnos-Techs, 2013b). Diagnos-Techs assists with the collection of non-invasive saliva samples via sponsorship of the process. The participant completes the ASI salivary culture swab process as directed by Diagnos-Techs then sends the saliva samples to Diagnos-Tech for the laboratory to run analysis procedures on the saliva cultures (Diagnos-Techs, 2013a, 2013b).

Table 4

ASI Salivary Labs

ASI Labs	Hormone description and values
Cortisol	Description. A glucocorticoid stress hormone, the cortisol load reflects the under the cortisol curve. The area under the curve is an indicator of overall cortisol exposure, where high values favor catabolic state, and low values are a sign of adrenal deterioration.
	Values. Salivary cortisol results yield four free cortisol rhythm values in nanometers (nM), a cortisol load (CL) nM value, in addition to graphs and remarks (i.e., CL = 24, 23 - 42 *nM*).
DHEA/DHEAS	Description. An endogenous steroid hormone, DHEA/DHEAS yield daily averages.
	Values. DHEA/DHEAS results produce one value in nanograms per milliliter (ng/ml) along with a figure that contains the cortisol-DHEA correlation and remarks (i.e., 3 - 10 *ng/ml*).
17-OHP	Description. A natural hormone building block of cortisol, 17-OHP yields daily averages
	Values. 17-OHP results generate one value in picograms per milliliter (pg/ml) (i.e., optimal: 22 - 100 *pg/ml*)
SIgA	Description. An antibody in mucus secretion, sIgA yields daily averages
	Values. Total sIgA results yield one daily average value in milligrams per deciliter (mg/dl) along with remarks (i.e., 25 - 60 *mg/dl*).

Interpretation of Scores

Once participants collect complete Diagnos-Techs salivary samples between 6am - 8am, 11am - 12pm, 4pm - 5pm, and 11pm - 12am they then return the salivary samples back to the laboratory according to Diagnos-Tech's procedures (Diagnos-Techs, 2010).

Diagnos-Techs Laboratory calculated the ASI results for each participant. Diagnos-Techs clinical laboratory sent the investigator each participant's report for the purpose of research analysis procedures. The clinical laboratory report contained a comprehensive assessment of individual results including cortisol, DHEA/DHEAS, 17-OHP, and sIgA throughout the daily cycle.

emWavePro Heart Rate Variability

Sensitive to shifts in HRV, the emWavePro measures real-time HRV affected by stress and related thoughts and emotions (McCraty & Tomasino, 2004; Ginsberg et al., 2010). Manufactured in 1998, Quantum Intech, the original developer of the emWavePro, is a technology powered by HeartMath. The emWavePro model 6030 is manufactured by HeartMath, LLC, Boulder Creek, CA. This mechanical apparatus is a computer software program, used within the Microsoft Windows operating system, and monitors the quality of heart rhythm patterns, a feature of stress relief (Childre, 1998; McCraty & Tomasino, 2004; Lemaire et al., 2011). Response format is psychophysiologic collection of the participants' HRV during the process of teaching self-regulated stress resilience through resonant frequency breath, slow abdominal breathing (i.e., approximately 3 to 7 breaths per minute) (Childre, 1998; McCraty & Tomasino, 2004). This instrument uses a photoplethysmograph sensor that attaches to the finger to gather pulse data by measuring real-time HRV and shows how the heart thereby ANS are affected by stress related thoughts and emotions (McCraty & Tomasino, 2004; Ginsberg et al., 2010). The expected collection time is 15 minutes. The emWavePro, effective in measuring HRV in individuals who breathe and have a heartbeat, (Evans, 2001; McCraty et al., 2003). As a

brief, inexpensive, nonintrusive method of enhancing mood and physical function, the emWavePro is a safe, simple, practical method of measuring HRV in pregnant women who are ambulatory or on bed rest due to physiological complications of pregnancy (Evans, 2001; McCraty et al., 2003). HeartMath providers assist with the collection of non-invasive HRV samples via sponsorship of the process.

Interpretation of Scores

The emWavePro (HeartMath, LLC, Boulder Creek, CA) yields a CR that indicates the cumulative percentage of time that the participant was in a state of coherence. Wave-like HRV rhythm is the bases of coherence scores (Childre, 1998; Morris, 2010)., High, medium, or low-quality coherence is the percentage of time that the participant experiences very, some, or no wave-like HRV rhythms (i.e., *CR* = 71% high) (Childre, 1998; McCraty et al., 2001; Quantum Intech, 2002). An algorithm developed by the Institute of HeartMath and programmed into the emWavePro (HeartMath, LLC, Boulder Creek, CA) measures HRV rhythm at a sample rate of 250hz to calculate the level of CR (Childre, 1998; Morris, 2010). The analysis of HRV rhythm scores involves measuring the level of variability in the HRV amplitude wave and level of coherence, in the heart rhythm pattern. These shifts in HRV amplitude wave and heart rhythm patterns are representative of shifts in the participant's emotional state and mental status directly related to synchronization of the ANS and the dynamics of emotion (McCraty & Tomasino, 2004). The emWavePro (HeartMath, LLC, Boulder Creek, CA) focuses on short-term data collection rather than medical diagnostics (McCraty & Tomasino, 2004).

Operational Definitions of Variables

Dependent Variables

Heart Rate Variability

Variation that occurs within the beat-to-beat intervals between each heartbeat were measured by the emWavePro computer software program using a photoplethysmograph sensor that attaches to the finger for the purpose of data collection (Marques et al., 2010; McCraty & Childre, 2010). The emWavePro measures quality of HRV rhythm by calculating *CR* (i.e., *CR* = 71% high; Quantum Intech, 2002).

Adrenal Stress Index

The ASI is a noninvasive salivary hormone test that increases understanding of stress-related conditions by assessing endocrine function with a combination of hormone levels (Diagnos-Techs, 2013a, 2013b). The ASI salivary hormone values collected for the purpose of this study were cortisol, DHEA/DHEAS, 17-OHP, and sIgA (Diagnos-Techs, 2013a, 2013b). Assessment of all four salivary hormone levels occurs from the same swab procedure. The participant completes the ASI salivary culture swab process as directed by Diagnos-Techs then sends the saliva samples to Diagnos-Tech for the laboratory to run analysis procedures on the saliva cultures (Diagnos-Techs, 2013a, 2013b).

Adrenal Stress Index Cortisol. Salivary cortisol is a glucocorticoid stress hormone recognized as valid, reliable, frequently used, and widely accepted psychoneuroendocrinological measure employed as a biomarker for antenatal stress and depression (Jones et al., 2006; Field et al., 2006). Results of salivary cortisol analysis

procedures, as measured by the ASI test, yield a cortisol load (CL) value and is representative of the area under the cortisol curve (i.e., CL = 24, 23 - 42 *nM*) (Diagnos-Techs, 2013a, 2013b).

Adrenal Stress Index Dehydroepiandrosterone/Dehydroepiandrosterone Sulfate. Salivary DHEA is an endogenous steroid hormone that converts to DHEAS, the sulfate ester of DHEA, on an as need basis (Diagnos-Techs, 2013a, 2013b). As valid and reliable method of detecting quality of adrenal response, DHEA/DHEAS recognize exposure to chronic stress and are associated with shifts in stress and depression (Gallagher, 2002; Markopoulou et al., 2009; Diagnos-Techs, 2013a, 2013b). Results of salivary DHEA/DHEAS analysis procedures, as measured by the ASI test, yield one daily average, the reference value in nanograms per milliliter (*ng/ml*) (i.e., 3 - 10 *ng/ml*) (Diagnos-Techs, 2013a, 2013b).

Adrenal Stress Index 17-OHP. Salivary 17-OHP a natural hormone building block of cortisol, produced during the synthesis of two or more glucocorticoids and sex hormones, increases understanding of the underlying causes that contributes to abnormal fluctuation in cortisol (Diagnos-Techs, 2013a, 2013b). Results of salivary 17-OHP analysis procedures, as measured by the ASI test, yield one daily average, the reference value in picograms per milliliter (*pg/ml*) (i.e., optimal: 22 - 100 *pg/ml*) (Diagnos-Techs, 2013a, 2013b).

Adrenal Stress Index Secretory Immunoglobulin A. Secretory IgA is an antibody in mucus secretion with a critical function of immune health and maintenance of pregnancy that relies on immunoglobulin properties of sIgA within gestational mucous

membranes (Negril et al., 1995; Diagnos-Techs, 2013a, 2013b). Affected by fluctuation in cortisol, Secretory IgA plays a key role in understanding effects of stress. Results of salivary sIgA analysis procedures, as measured by the ASI test, yield one daily average reference value in milligrams per deciliter (*mg/dl*) (i.e., 25 - 60 *mg/dl*) (Diagnos-Techs, 2013a, 2013b).

Antenatal Stress

Integrated dysregulated homeostasis combined with the intensity of antenatal stress symptoms that pose a threat to NCUP coherence define antenatal stress as measured by the emWavePro, ASI, and PES for the purpose of this project (McCraty et al., 2009; Vrekousis et al., 2010; Diagnos-Techs, 2013a, 2013b). The PES measures antenatal stress by calculating an intensity score (DiPietro et al., 2004).

Antenatal Depression

Antenatal depression is a condition that occurs during pregnancy within the NCUP system involving integrated characteristics of BPNSE processes as measured by the emWavePro, ASI, and EPDS for the purpose of this project (Bennett et al., 2004a; McCraty et al., 2009; Simone, & Pun, 2007; Vrekousis et al., 2010; Diagnos-Techs, 2013a, 2013b). The EPDS measures antenatal depression by calculating a score ranging from 0 to 30 (Cox et al., 1987).

Positive Reappraisal

Appraisal represents cognitive focused coping assessed with a process-oriented approach that identifies shifts in cognitive reappraisal, which reframes negative thought via mind integration processes resultant of positive reappraisal (Childre & Cryer, 2004;

Gold & Chrousos, 2002; Folkman & Lazarus, 1988). Cognitive reappraisal coping is measured by the WOC Questionnaire and positive reappraisal is necessary to maintain quality coherence in HRV as measured by the emWavePro (Childre & Cryer, 2004; Folkman & Lazarus, 1988). The WOC Questionnaire measures cognitive reappraisal coping by calculating a relative score (Folkman & Lazarus, 1988).

Covariates

Maternal Blood Pressure

A covariate of this study, MBP is exerted pressure of the pregnant woman's blood on the inside walls of her blood vessels (ACOG, 2011; Carnethon et al., 2002; Snigh et al., 1999; Windham et al., 2012). The first or maximum number is the systolic pressure and the second or minimum number is the diastolic pressure, which occurs when the heart relaxes during the cardiac cycle's resting phase. Results of MBP examination procedures, as measured by a sphygmomanometer device, yield a MBP value of millimeters of mercury (*mmHg*) (i.e., MBP = 110/70 *mmHg*).

Pretest Values

Data values collected during the pretest phase of the study.

Statistical Analysis

The statistical analysis used quantitative data. Diagnos-Tech laboratory ran analysis procedures on the saliva cultures. Data analysis utilized Statistical Package for Social Sciences 27.0 for Windows.

Preliminary Analysis

Data Screening

Before proceeding with the statistical analysis, this study screened data to verify its quality. Descriptive statistics calculated the mean and the standard deviation for the dependent variables and covariates, which yield continuous data (Baguley, 2012). For each variable, use of descriptive statistics analyzed frequencies to evaluate for patterned and randomness of missing values.

Covariate Rationale

Blood pressure is an important component of hypertension and through the ANS is a component of cardiovascular function and can confound HRV (Windham et al., 2012). Although the ANS functions independent of blood pressure, as a measure of CBSR, MBP interferes with HRV outcome (Carnethon et al., 2002; Snigh et al., 1999; Windham et al., 2012).

In addition to MBP has the capacity to produce an effect on HRV rhythm and is a covariate of HRV rhythm (Snigh et al., 1999; Van der Meulen, 2009). Clinical covariates of HRV rhythm in this study are SMBP, DMBP, and pretest values (Carnethon et al., 2002; Snigh et al., 1999; Windham et al., 2012).

Demographic Questionnaire

This assessment measure calculated values from descriptive findings obtained via the demographic questionnaire listed in Appendix D. Quantitative descriptive statistics verified characteristic commonalities between the training group and the waitlist control group to increase internal validity (Altshuler et al., 2008; DiPietro et al., 2012). The

variables include sociodemographics (age, ethnicity, language, marital status, and education), geodemographics (region and area), obstetrics physical health (gestational stage and week in addition to current and past medical experiences) and mental health (current experience) parameters (Dayan et al., 2010). Mean and standard deviation were calculated on continuous demographic data (age, education, & gestational week) and frequencies were ran on categorical demographic data (ethnicity, language, marital status, region, area, gestational stage, current and previous medical experiences, and current mental health experience) (Baguley, 2012).

Cronbach's Alpha Coefficient

This study ran Cronbach's alpha on psychometric tests used in this study to evaluate the quality of internal consistency to verify each measure's reliability (Cortina, 1993; Tavakol & Dennick, 2011). Psychometric tests used in this study include the EPDS, PES, and WOC Questionnaire.

Assumption Testing for Analysis of Covariance

Review of nine necessary assumptions to run an analysis of covariance statistical analysis is as follows. Verification of the first three assumptions were planned to occur prior to analyses of the remaining six assumptions. The first three assumptions consist of continuous scale data; two categorical, independent groups; and independence of observation where each pregnant woman participated in only one of the two groups (Baguley, 2012). All dependent variables and covariates in this study yield continuous data, the research design consists of two independent groups, and participants were in

only one group, therefore, the first three analysis of covariance assumptions were in place prior to collection of data.

Investigation of the uncompleted six assumption testing procedures were planned to occur after data collection. The remaining six assumptions involve data outliers, normality of dependent variable data, homogeneity of variance, linearity of the covariates in relationship to the dependent variables, homoscedasticity, and homogeneity of regression slopes planned to address relationship between covariates and independent variable (Baguley, 2012). Use of box plot graphs were planned to analyze for extreme outliers. Shapiro-Wilk tests was planned to examine normality by generating within group and overall model fit assessments (Baguley, 2012). Levene's test for homogeneity of variances was planned to evaluate equality of data for both groups (Baguley, 2012). Assessment of deviation from linearity was planned to use analysis of covariance to assess the relationships between the covariates and dependent variables for both groups. Implementation of linear regression was planned to assess the quality of homoscedasticity on a scatter plot for each variable. Scatter plots for dependent variables and covariates were planned to test the parallelism of homogeneity of regression slopes (Baguley, 2012). Evaluation of assumption testing was planned to occur in the order presented. Implementation of statistical correction methods, if warranted, attempted to address assumption violations.

Main Analysis

The study implemented analysis of covariance on continuous dependent variables and covariate outcomes. First, analysis of the pre-measures' phase calculated the effect of

CBSR on the between waitlist and training groups. The significance level was planned to be set at .05 with the confidence interval planned for 95.0% as parameters to evaluate that data (Baguley, 2012). Due to high sensitivity of individual corticosteroids biosynthesis and immunoglobulin production, the post-measure between groups assessment was planned to use each participant's own match results to calculate between groups values.

Hypotheses

$H_0$1: While controlling for MBP and pretest values, there will be no significant effect in week 4 posttest HRV rhythm between the CBSR trained group and the waitlist group.

H_a1: While controlling for MBP and pretest values, there will be a significant effect in week 4 posttest HRV rhythm between the CBSR trained group and the waitlist group.

$H_0$2: While controlling for MBP and pretest values, there will be no significant effect in week 4 posttest stress response in cortisol levels between the CBSR trained group and the waitlist group.

H_a2: While controlling for MBP and pretest values, there will be a significant effect in week 4 posttest stress response in cortisol levels between the CBSR trained group and the waitlist group.

$H_0$3: While controlling for MBP and pretest values, there will be no significant effect in week 4 posttest DHEA/DHEAS stress adaptation levels between the CBSR trained group and the waitlist group.

H_a3: While controlling for MBP and pretest values, there will be a significant effect in week 4 posttest DHEA/DHEAS stress adaptation levels between the CBSR trained group and the waitlist group.

$H_0 4$: While controlling for MBP and pretest values, there will be no significant effect in week 4 posttest 17-OHP adrenal reserve indicators between the CBSR trained group and the waitlist group.

$H_a 4$: While controlling for MBP and pretest values, there will be a significant effect in week 4 posttest 17-OHP adrenal reserve indicators between the CBSR trained group and the waitlist group.

$H_0 5$: While controlling for MBP and pretest values, there will be no significant effect in week 4 posttest sIgA levels between the CBSR trained group and the waitlist group.

$H_a 5$: While controlling for MBP and pretest values, there will be a significant effect in week 4 posttest sIgA levels between the CBSR trained group and the waitlist group.

$H_0 6$: While controlling for MBP and pretest values, there will be no significant effect in week 4 posttest on intensity of symptoms of antenatal stress between the CBSR trained group and the waitlist group.

$H_a 6$: While controlling for MBP and pretest values, there will be a significant effect in week 4 posttest on intensity of symptoms of antenatal stress between the CBSR trained group and the waitlist group.

$H_0$7: While controlling for MBP and pretest values, there will be no significant effect in week 4 posttest on symptoms of antenatal depression between the CBSR trained group and the waitlist group.

H_a7: While controlling for MBP and pretest values, there will be a significant effect in week 4 posttest on symptoms of antenatal depression between the CBSR trained group and the waitlist group.

$H_0$8: While controlling for MBP and pretest values, there will be no significant effect in week 4 posttest on positive reappraisal coping responses between the CBSR trained group and the waitlist group.

H_a8: While controlling for MBP and pretest values, there will be a significant effect in week 4 posttest on positive reappraisal coping responses between the CBSR trained group and the waitlist group.

$H_0$9: While controlling for pretest values, there will be no significant effect in week 4 posttest on MBP between the CBSR trained group and the waitlist group.

H_a9: While controlling for pretest values, there will be a significant effect in week 4 posttest on MBP between the CBSR trained group and the waitlist group.

Threats to Validity

External Validity

Stress reduction seeking pregnant women may differ from participants who are not stress reduction seekers; therefore, recruitment efforts in the community increased exposure to a wider population including individuals who are not typically stress reduction seekers. Sample characteristic data collected on the demographic questionnaire

identified the extent of generalizability to the population (Kazdin, 2003). Stimulus and setting characteristics in an outpatient environment limit generalizability, for example, to pregnant women on inpatient obstetrics (Kazdin, 2003). Participant awareness of participation in stress resilience training affected variables of interest (Kazdin, 2003). Therefore, implementation of a waitlist group is an effort to control for reactivity to experimental arrangements.

Completion of pre-measures may expose the women to test sensitization problems affecting results that might not have occurred without pre-measures (Kazdin, 2003). A waitlist control group may allow for isolation of the training effect. Effects may result due to timing issues of measure administration. For example, all participants were in their second or third trimesters. However, the physiological variance in gestational age has the potential to produce differing results in relation to when administration of the measure occurs. Therefore, gestational age as a covariate may control for maturation; as well, scheduled collection of salivary measures addressed the nature of hormone fluctuation concerns (DiagnosTechs, 2011). Reactivity to novelty of the emWavePro stress resilience, software system may produce participant effects that interfere with generalizability (Kazdin, 2003). Pre and post emWave measures occurred in a single blind manner where participants are not exposed to the software program.

Internal Validity

When participants are pregnant, increased threat to internal validity may occur due to the effect of history (Kazdin, 2003). Mistaken effects of CBSR training may be the gestational maturation nature of pregnancy and maternal change occurs over a 4-week

period of time (Kazdin, 2003). Enrolling pregnant women in their second or third trimesters may address this threat. The effect of CBSR training could be resultant of changes that occur during the course of the pregnancy itself. Antenatal emergencies can occur at any time. With a pregnant population, attrition is highly possible given the nature of pregnancy possibly resulting in group-size differences. Calculations to assess for the randomness of attrition used analysis of analysis of covariance (Baguley, 2012). Threats occurring differently in the training group and wait-list group could result in a combination of selection and other threats. If participants realize there are two groups and they perceive the other group is receiving something they are not, the result may produce special treatment effect within the CBSR training group or non-study related reactions from the wait-list group (Kazdin, 2003). Every effort was made to maintain consistency in the presentation of all study procedures and conditions.

Pre-post measures design lends itself to a subsequent response effect on the post-measures because of familiarity (Kazdin, 2003). Although with a wait-list control group, the CBSR training group showed the impact of training over and above the effects of previous exposure to the measures (Kazdin, 2003). The standard nature of all the measures may not pose instrumentation problems, though the effect of a HeartMath provider's casual remark during the process of administering the measures might affect participant response (Kazdin, 2003). To control for provider effects, they adhered to HeartMath scripted interaction with participants. Regardless, if presentation of the measures is the same for both the pre and post phases, the pregnant women may derive a different understanding of the materials that could have an effect on their response

(Kazdin, 2003). Statistical regression to the mean could pose a problem to internal validity, though, with the wait-list group, change due to CBSR training was evident in the training group (Kazdin, 2003). Selection biases can result from differences in characteristics between the two groups (Kazdin, 2003). Recruitment materials disbursement within the community is an effort to provide each pregnant woman in her second trimester an equal opportunity to participate in this study.

Construct Validity

Differences in the amount of attention and type of attention that participants receive within the training group or across groups could adversely affect methodology and research questions that could invalidate the conclusions (Kazdin, 2003). Scripted communication may address attention and contact problems that may otherwise arise with random interaction. With numerous HeartMath providers potentially administering the CBSR training, problem with single operations and narrow stimulus sampling could bias the results posing a threat to external and construct validity (Kazdin, 2003). Provider communication with the participants were scripted in order to administer the training consistently to all participants. As well, an attempt was made for all HeartMath providers in the study to have an equal number of waitlist and training group participants in an effort to balance the differences across groups. Expectations of the investigator are a threat to construct validity (Kazdin, 2003). HeartMath providers were administered the training via a HeartMath specific script to remove experimenter expectancies.

Statistical Conclusion Validity

Presentation of statistical and conclusion validity issues are in the sample size and analysis of covariance assumptions sections. Calculating power to determine sample size reduces the potential for low statistical power increasing the likelihood for detection the effect of CBSR between groups in this study (Kazdin, 2003). To address potential for problems in variability of the procedures affecting capacity to detect the actual effect of CBSR between the waitlist and training groups, HeartMath providers adhere to the procedural script to maintain consistency (Kazdin, 2003). Levene's test for homogeneity of variances were planned to assess equality of data for both groups (Baguley, 2012). Analysis included Cronbach's alpha on psychometric tests used in this study to evaluate the quality of internal consistency to verify each measure's reliability (Cortina, 1993; Tavakol & Dennick, 2011).

Ethical Procedures

Sponsor Commitments

Access to participants for the purpose of this study followed sponsorship commitment of Rollin McCraty, PhD., Institute of HeartMath Executive Vice President and Director of Research. A letter of commitment for access to participant and data collection is in Appendix B. Access to ASI salivary measure results were sponsored by John White, M.D., Medical Director at Diagnos-Techs. Collection of data was overseen by Institute of HeartMath.

HeartMath one-on-one providers consult with Institute of HeartMath and followed their direction as the sponsor of the CBSR. They followed cautionary measures

recommended by HeartMath when administering emWavePro one-on-one provider training and pay particular attention to contraindications of self-regulation skills training. Participants followed the direction of John White, M.D., Medical Director at Diagnos-Techs involving collection of salivary measures.

Precautions

To ensure protection of human participants in accordance to American Psychological Association ethical guidelines for research, The research was conducted under the oversight of Institute of HeartMath within the scope of their standard operations. Institute of HeartMath agreed to share de-identified dataset for research purposed as described in Appendix B.

Participant recruitment occurred free of coercion on a voluntary basis and their right to decline participation was honored. Collection of contact information for potential participants did not occur in accordance of maintaining high standards of confidentiality (APA, 2002). Recruitment materials were adhered to HeartMath, Research Ethics Committee Guidelines. All recruitment materials received HeartMath Oversight approval prior to dissemination.

Participation in the study is voluntary without coercion. Therefore, prior of commencement of this project, participants informed that they may decline participation in at any time and request early withdrawal from the study without jeopardizing their stress resilience services with their HeartMath provider independent of the study. Data collection ceased, at any point that the participant requests or the completion of the study.

Utilization of an assigned participation code number, for maintenance of confidentiality throughout the study, coordinated all components of participant data.

The investigator received data collection results of all measures, directly from providers who collect the information, for the purpose of statistical analysis. HeartMath providers emailed participants' emWavePro data and Diagnos-Techs emailed the lab results of the ASI measures. Maintenance of data storage and protection adhered to secure Health Insurance Portability and Accountability Act guidelines for electronic records. Archival procedures of data occur for 10 years; at which time, maintenance of current archiving procedures according to American Psychological Association published practices for data storage are upheld (Clay, 2009).

Conflicts of Interest

There are no conflicts of interest regarding any component of this project.

Summary

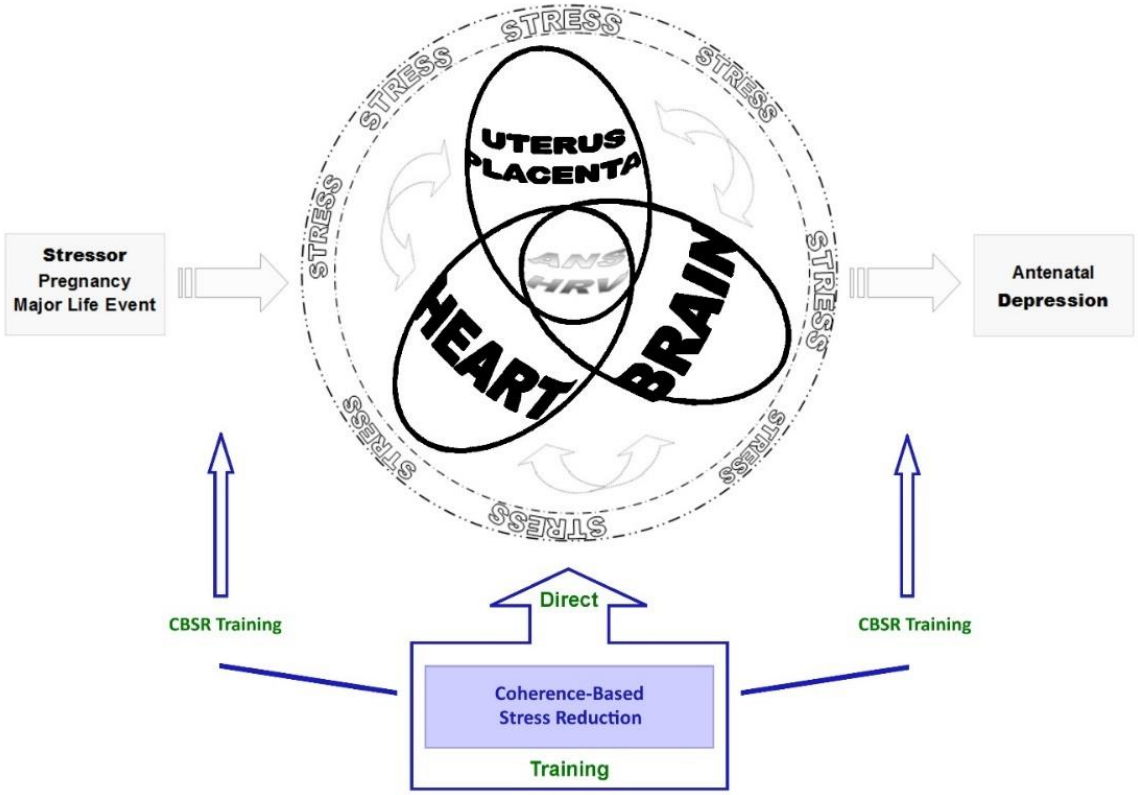
Chapter 3 described the quantitative research design, setting and sample, study procedures, the CBSR training technique, measures and materials, operational definitions of variables, statistical analyses, threats to validity, and ethical procedures. Chapter 3 described how the investigator worked with sponsors and providers involving participant recruitment, and data collection. Included in this chapter is an explanation of procedures for compliance with HeartMath oversight requirements regarding protection of participants. Chapters 4 and 5 explained the results and discuss the findings, limitations, and provide concluding remarks.

Chapter 4: Results

The purpose of this quantitative study was to identify the effect of CBSR intervention over 4-weeks on the NCUP system of second and third trimester pregnant women by measuring the effect of CBSR intervention on the NCUP relationship between antenatal stress and depression within the BPNSE framework as represented in Figure 5. While controlling for MBP and pretest values, there was a significant effect in Week 4 postintervention HRV, ASI (cortisol, DHEA/DHEAS, 17-OHP, and sIgA), PES, EPDS, WOC, and MBP between the CBSR intervention group (n = 8) and the waitlist group (n = 3).

Figure 5

Research Study's Model



Note. This study's overall hypotheses model was the path through which coherence-based stress resilience was expected to have an effect on stress and depression during pregnancy, thereby neuro-cardio-utero-placental homeostasis.

The data collection section describes the data collection process, recruitment procedures, response rates, and discrepancies from the planned approach. A report of baseline background and demographics outlines sample characteristics. Covariate inclusion evaluates effect size and pre-post correlation results. Quality of intervention fidelity describes challenges and adverse events to treatment implementation. The preliminary analysis involved data screening and cleaning. Cronbach's alpha assessed the quality of internal consistency and reliability of psychometric measures.

The primary statistical analysis examined continuous dependent variables and covariate outcomes via ANCOVA. Prephase and postphase measures defined experimental group measure effects. A purely exploratory review evaluated the experimental and control groups due to the small sample size. Postphase measure analysis used participant's own match results due to the high sensitivity of biomeasures.

Data Collection and Discrepancies

Data collection ran throughout July, 2016, to July, 2019, that initially included only second trimester participants. Extreme data collection challenges opened inclusion of the third trimester in December, 2017. The nurse providers and researcher shared a participant invitation with over 300,000 professionals and facilities nationwide. During the open recruitment phase, professional referrals emerged and proceeded throughout the study. Except for two small one-physician ob-gyn offices, all professionals and facilities expressed sharing the research opportunity with pregnant women they served. Providers

offered direct access, invitation, and outreach to 25,000+ moms-to-be, and approximately 10+ new potential participants inquired about the study each week. Sixty to 120 participants were awaiting screening and scheduling at any given time throughout the project.

Data Collection Plan Discrepancies

Data collection discrepancies resulted from significant California natural disasters and calamitous national disasters. These catastrophic events had adverse maternal-fetal, provider, and recruitment effects. Additional data collection discrepancies and catastrophic natural disaster details appear in Appendix E.

Original Analysis Plan Change

Small sample limitations have less power, chance of sampling error, and false-negative Type II error (Baguley, 2012; Weaver & Goldberg, 2012). To balance between Type I and Type II errors, alpha was set at 0.20 (Cohen, 1982). Sample size $N = 11$ led to violation of ANCOVA assumptions (Baguley, 2012). Regardless the statistical significance of findings, clinical providers need to know clinical significance. Accordingly, effect size being less affected by sample size was particularly important (Baguley; Weaver & Goldberg; Sullivan & Feinn, 2012). The *p*-value only indicates if there was an effect; it does not reveal the substantive significance of the effect size (Sullivan & Feinn; Weaver & Golberg). Therefore, this study evaluated statistical significance cautiously for purely exploratory purposes. The quantitative study's main discovery is effect size, particularly independent of sample size, the magnitude of differences, which is essential to substantive and clinical significance (Sullivan & Feinn).

Intervention Fidelity

Coherence-based stress resilience treatment fidelity was high, evidenced by the quality of adherence to the step-by-step CBSR intervention model per the nurse providers' verbal reports and subsequent confirmation of each experimental group participant. Likewise, the experimental group participants verbally confirmed they followed through and completed four consecutive CBSR intervention sessions. Two participants delivered their babies early. Because they were on the waitlist control group and birthed prematurely, neither of these circumstances interfered with the intervention process. While there were also several historically catastrophic adverse events in the immediate environments that may have adversely affected stress levels and pre-post results, there were no adverse events directly related to the intervention provided during this study. The researcher, nurse providers, and participants all experienced adverse effects of the historically catastrophic events outside of the immediate research meetings and sessions. Each professionally scheduled prephase and postphase data collection meetings and all consecutive CBSR experimental group professional intervention sessions adhered to the step-by-step model and proceeded uninterrupted as planned.

Data Screening and Cleaning

Data review found no duplicates, structural errors, inaccurate outliers, or missing values.

Psychometric Internal Consistency and Reliability

Preliminary analysis continued with the Cronbach's alpha coefficient calculation to evaluate the quality of internal consistency and reliability for each psychometric

measure. Internal psychometric consistency and reliability testing found scores for each scale to be acceptable or excellent. According to DiPietro et al. (2004), the 41-item PES had high internal consistency (α = .95 upset; α = .91 uplift). In the current study, the pretest and posttest Cronbach's alpha coefficient results suggested excellent internal consistency and reliability (pre α = .93 upset; pre α = .94 uplift; post α = .96 upset; post α = .97 uplift).

According to Cox et al. (1987), the 10-item EPDS had satisfactory sensitivity, specificity, high-quality internal consistency, and reliability (α = .87). In the current study, 9-items of the pretest EPDS internal consistency and reliability results were excellent (pre α = .92). Conversely, 9-items of the EPDS posttest internal consistency and reliability results were poor (post α = .31). Low alpha may have occurred due to the low number of items and low item variability resultant of responses to measure items on the EPDS (Brown, 2002; Tavoakol & Dennick, 2011). Alpha is best interpreted relative to the length of a specific measure. Pretest-posttest psychometric measures administered over time after learning experience and intervention may affect perception resulting in pretest-posttest response differences and thereby reduce alpha levels (Leppink & Perez-Fuster, 2017).

The poorest correlated items (2. anticipatory enjoyment; 7. difficulty sleeping) were discarded (Peters, 2014; Tavoakol & Dennick, 2011). The adjusted EPDS (7-items) posttest internal consistency and reliability results were acceptable (post α = .64). Administering psychometric repeated measures 4 weeks postintervention may likely be affected by gestational maturation and interval learning with high potential to affect alpha

levels (Leppink & Perez-Fuster, 2017). Essentially, mental efforts over two time points reflect differences in cognitive load and perception that may also present differences between participants in the same group; likewise, coherence intervention may result in participants' within-group emotional perceptive differences (Leppink & Perez-Fuster, 2017).

According to Folkman and Lazarus (1988), the 7-item WOC Questionnaire Positive Reappraisal subscale has high-quality internal consistency, with a Cronbach α = 0.79. Test results for this sample (pre α = .73) were within the acceptable range, which suggests quality internal consistency and reliability. Likewise, 7-items of the Positive Reappraisal subscale posttest internal consistency and reliability results were excellent (post α = .87).

Covariate Justification

Blood pressure through the ANS is an essential factor of cardiovascular function. Maternal blood pressure also interferes with HRV outcome; therefore, it is a covariate of HRV (Carnethon et al., 2002; Snigh et al., 1999; Windham et al., 2012). Baseline descriptive statistics present clear, direct information about the covariate parameters, thus increasing understanding of the covariate characteristics and enhance statistical conclusion validity (Baguley, 2012). Covariate data analyses entail effect size and pre-post correlation results presented in Table 5. The HRV covariate yielded a statistically significant correlation Pearson's $r(11) = .66$, $p = .026$. Likewise, the pre-post DHEA/DHEAS, PES, WOC, SMBP, and DMBP yielded statistically significant correlations. Conversely, cortisol, 17-OHP, sIgA, and EPDS had positively correlated,

non-significant results. Heart rate variability, DHEA, PES, WOC, SMBP, and DMBP pre-post variability association resulted in a large effect size. Effect size range is small *r* = .10, medium *r* = .30, large *r* = .50 (Shafer & Schwarz, 2019).

Table 5

Covariate Measures Pre-Post: Pearson's Correlations

Variable	Post		Pre-SMBP		Pre-DMBP	
	p	*R*	*p*	*r*	*p*	*R*
HRV	*.026	.66	.750	-.11	.520	-.22
Cortisol	.273	.36	*.074	.56	.616	.17
DHEA	*.084	.54	.884	.05	.328	.33
17-OHP	.602	.18	.698	-.13	.438	-.26
sIgA	.490	.23	.646	-.16	*.189	-.43
PES	*.070	.57	.247	.38	.581	.19
EPDS	.361	.31	.810	-.08	.787	.09
WOC	*.078	.55	*.175	.44	.916	.04
SMBP	*.045	.61				
DMBP	*.078	.55				

Note. SMBP = systolic maternal blood pressure; DMBP = diastolic maternal blood pressure; HRV = heart rate variability; DHEA/DHEAS = dehydroepiandrosterone /dehydroepiandrosterone sulfate; 17-OHP = 17-hydroxyprogesterone; sIgA = secretory immunoglobulin A; PES = Pregnancy Experience Scale; EPDS = Edinburgh Postnatal Depression Scale; WOC = Ways of Coping; *p<.20

Preliminary Results

Participant Descriptive Statistics

Baseline Descriptive and Demographic Characteristics

Baseline descriptive and demographic information directly address questions about the sample parameters (Altshuler et al., 2008; DiPietro et al., 2012). A demographic questionnaire collected baseline descriptive and demographic characteristics. Descriptive statistics describe the sample data, specifically regarding the data's central tendency, spread, and shape (Baguley, 2012; Weaver & Goldberg, 2012). Analysis of demographic data entails descriptive statistics and frequencies.

Sociodemographic Characteristics

Sociodemographic characteristics were expectant women between the ages of 20 and 39 (*M* = 32.18; *SD* = 5.49). The majority of women in this study had at least some college (*M* = 16.18; *SD* = 3.16). Women over age 25 in the general population reported attainment of education as 12 years (27.01%), 14 years (11.15%), 16 years (22.78%), 18 years (10.97%), 20 years (1.70%) (U.S. Census, 2019). Women in this study reported education levels similar to women in the general population. Nearly half (45.5%; *n* = 5) of the participants were White. In contrast, more than half of the participants endorsed the other ethnicities combined. The primary language of participants was English (81.8%; *n* = 9). Marital status was primarily married (72.7%; *n* = 8). More participants in this study reported being married than single (18.2%; *n* = 2) or divorced (9.1%; *n* = 1). Women age 25 and over in the general population reported marital status as single (21.08%), married (55.08%), widowed (9.93%), divorced (12.78%) (US Census, 2019).

Geodemographic Characteristics

Geodemographic characteristics involved the location of participants. While the study was open to participants across the nation, most (72.7%; *n* = 8) endorsed a Pacific location. Large city residence was also most identified (45.9%; *n* = 5).

Physical Health Characteristics

Physical health characteristics of gestational age (*N* = 11) were *M* = 27.6 with *SD* = 8.35. The experimental group comprises marginally higher mean gestational age. Most participants were in their third trimester (63.6%, *n* = 7), while fewer were in their second trimester (36.4%; *n* = 4). All participants denied any current or previous obstetrics

complications, treatment for current chronic medical conditions, and current medications. Almost half of the participants were new moms-to-be. Consistent with new motherhood, 81.8% (*n* = 9) denied a former live birth. Women ages 20-40 reported first-time motherhood between 20% to 78.6%. A higher percentage of new moms-to-be in the general population were age 20-24 (78.6%), whereas women age 25-29 (54.2%) reported less first-time pregnancies (U.S. Census, 2019).

Mental Health Characteristics

Mental health characteristics reveal responses to current mental health experience of psychiatric disorder, psychological services, or psychiatric medications. All participants in this study denied current psychiatric diagnosis, psychiatric medication, and psychological services. Mental health characteristics delineate substance use before and during pregnancy. During pregnancy, substance use revealed over half (63.6%; *n* = 7) drank coffee before pregnancy, although less than half (45.5%; *n* = 5) drank coffee during pregnancy. All participants denied the current antenatal use of tobacco, alcohol, and illicit drugs. Ninety-point nine percent (*n* = 10) of participants denied any history of tobacco and illicit drug use. The majority of pregnant participants in this study had no use of tobacco or illicit drugs. While one individual reported 20 years of use, they denied use during pregnancy.

Study Variables

Ensuring quality data for analysis and decision-making included data screening, cleaning, and preliminary data analysis. This data set was valid, accurate, complete, consistent, and uniform (Chamrad & Meyer, 2005; Menaspa, 2016; Rault-Bucklin, 2021).

Data screening further analyzed descriptive statistics for sample size, minimum and maximum values, mean, standard deviation, and skewness for HRV, cortisol, DHEA/DHEAS, 17-OHP, sIgA, PES, EPDS, and WOC variables. Heart rate variability measured real-time R-R interval in milliseconds (*ms*) by emWave pro software and further examined by Kubios advanced HRV analysis software (Tarvainen, 2014). Heart rate variability descriptive characteristics for pre-post measures was an antenatal sample ($N = 11$) and within 2*ms* - 6*ms*.

The ASI measured via a salivary process collected hormone levels on cortisol in nanometers (*nM*), DHEA/DHEAS in nanograms per milliliter (*gn/ml*), 17-OHP picograms per milliliter (*pg/ml*), and sIgA milligrams per deciliter (*mg/dl*) (Diagnos-Techs, 2013a, 2013b). Adrenal stress index descriptive characteristics for pre-post measures was an antenatal sample of pregnant women ($N = 11$). Cortisol data was within 0*nM* - 30*nM*. Dehydroepiandrosterone/dehydroepiandrosterone sulfate data was within 1*gn/ml* - 9*gn/ml*. 17-OHP data was within 0*pg/ml* and >130*pg/ml*. Secretory IgA data was within range of 5*mg/dl* - 60*mg/dl* (Diagnos-Techs, 2013a, 2013b).

The PES assessed intensity according to various co-occurring positive and negative pregnancy-specific stressor experiences (DiPietro, 2004). Pregnancy experience descriptive characteristics for moms-to-be ($N = 11$) pre scores ranged from 0.15 to 2.81 with a mean of 1.07 while post scores ranged from 0.02 to 1.82 with a mean of 0.65. The EPDS measured the type and number of antenatal depressive symptoms (Cox, 1987). Edinburgh Postnatal Depression Scale adjusted descriptive characteristics for pregnant women ($N = 11$) pre scores ranged from 2 to 17 with a mean of 9.36 and post scores

ranged from 1 to 8 with a mean of 5.09. The WOC evaluated thoughts and actions that comprise a positive reappraisal coping (Folkman & Lazarus, 1988). Ways of Coping descriptive characteristics for expectant moms (N = 11) pre scores ranged from 0.51 to 2.33 with a mean of 1.56 whereas post scores ranged from 0.55 to 2.16 with a mean of 1.46. These initial descriptive statistics do not calculate significance, as they are of exploratory interest.

Research Question Results

Specific hypotheses were tested to answer research questions that compared a CBSR treatment group (n = 8) with a waitlist group (n = 3) on post-intervention HRV, ASI (cortisol, DHEA/DHEAS, 17-OHP, & sIgA), PES, EPDS, WOC, and MBP. Independent variables were also measured pre-intervention and used as a covariate in their respective ANCOVAs.

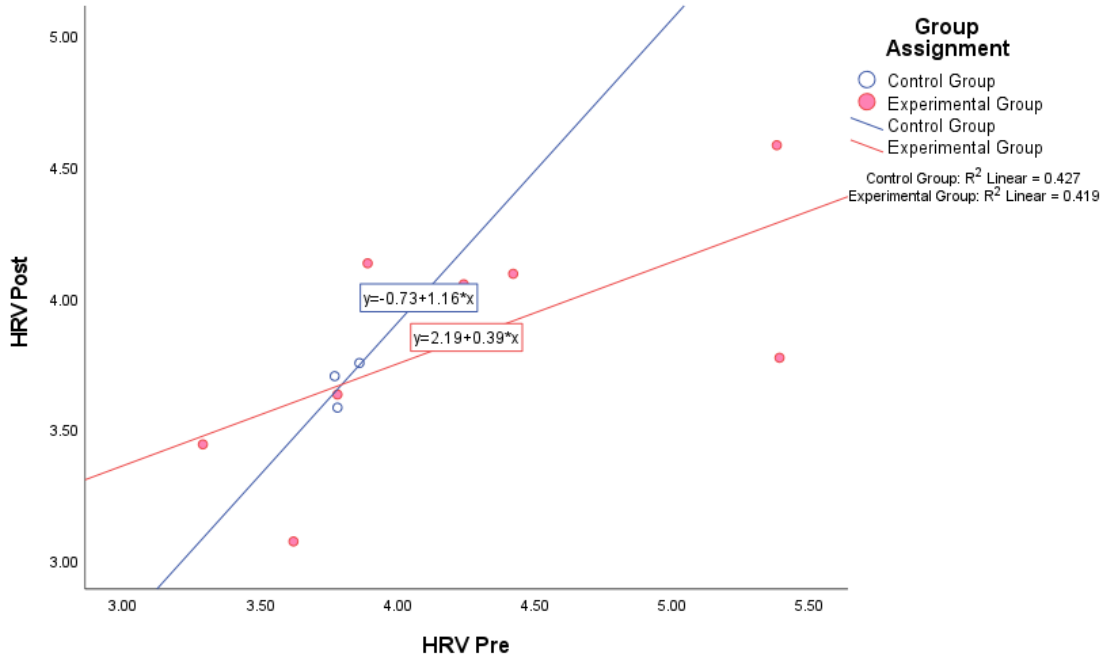
Homogeneity of Regression Slopes

The statistical analysis process implemented the homogeneity of regression slopes to assess the covariates linear relation to the dependent variables; ergo, the covariate and factors correlation significance level (Baguley, 2012). Regression line graphs for HRV, ASI, PES, EPDS, WOC, and MBP dependent variables and covariates show the interaction of the treatment effect with the independent variables illustrated in Figure 6, panels A-J (Baguley). Intercepting regression lines represent a significant interaction between the interaction and covariate.

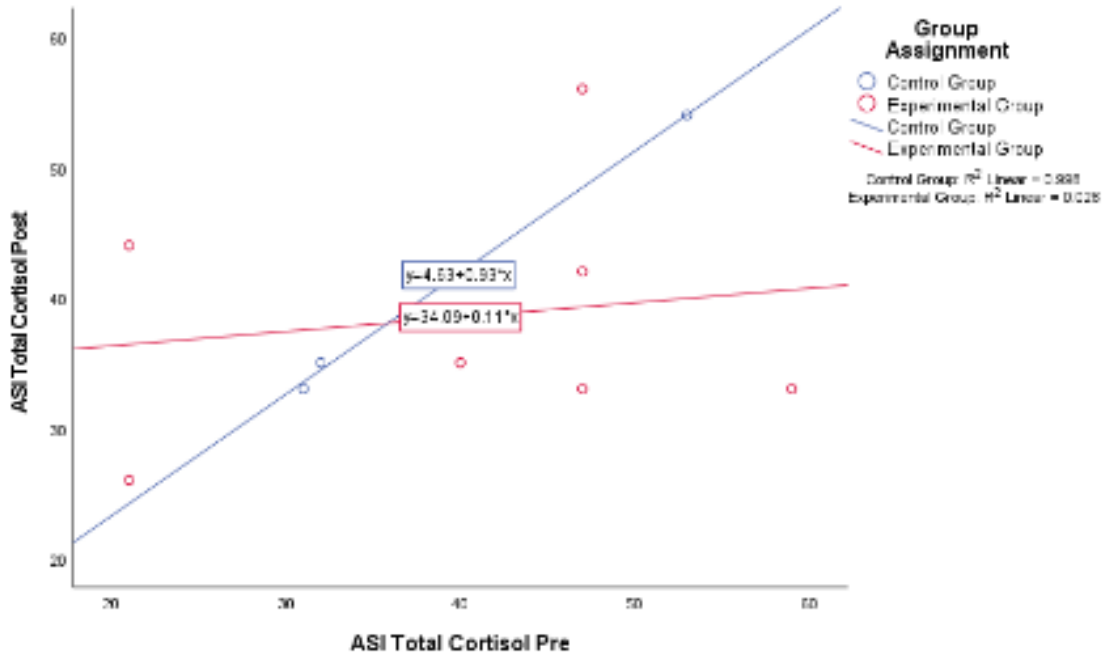
Figure 6

Regression Slopes for Two Group ANCOVA: Control and Experimental Groups Pre-Post Variables

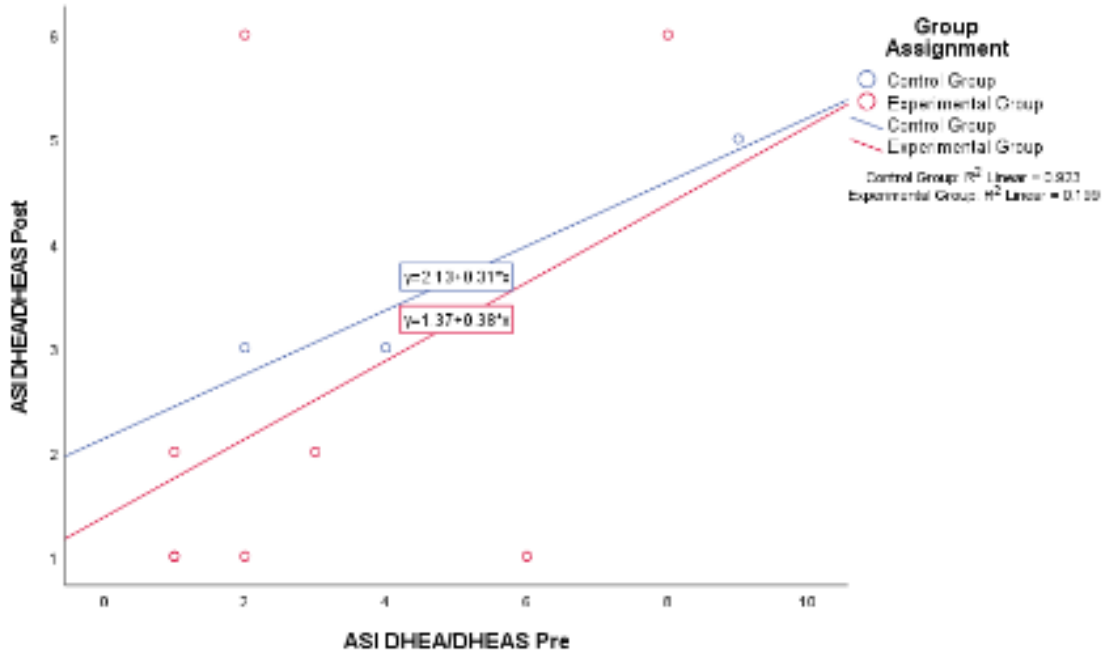
A



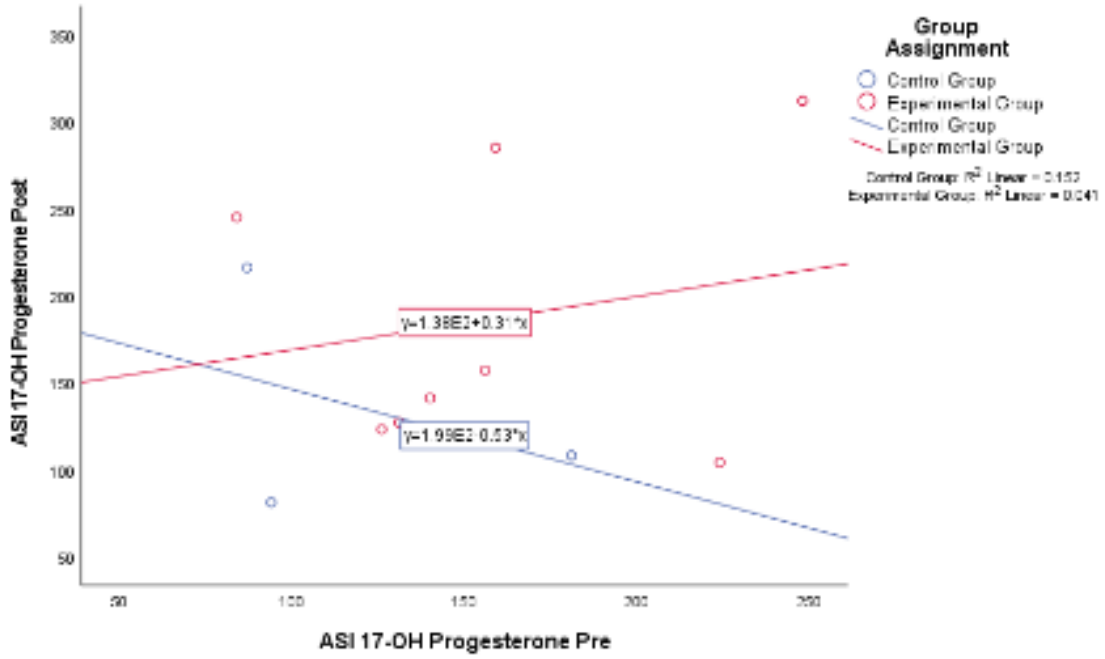
B


Group Assignment
Control Group
Experimental Group
Control Group
Experimental Group
ASI Total Cortisol Post
ASI Total Cortisol Pre
y=34.09+0.11*x

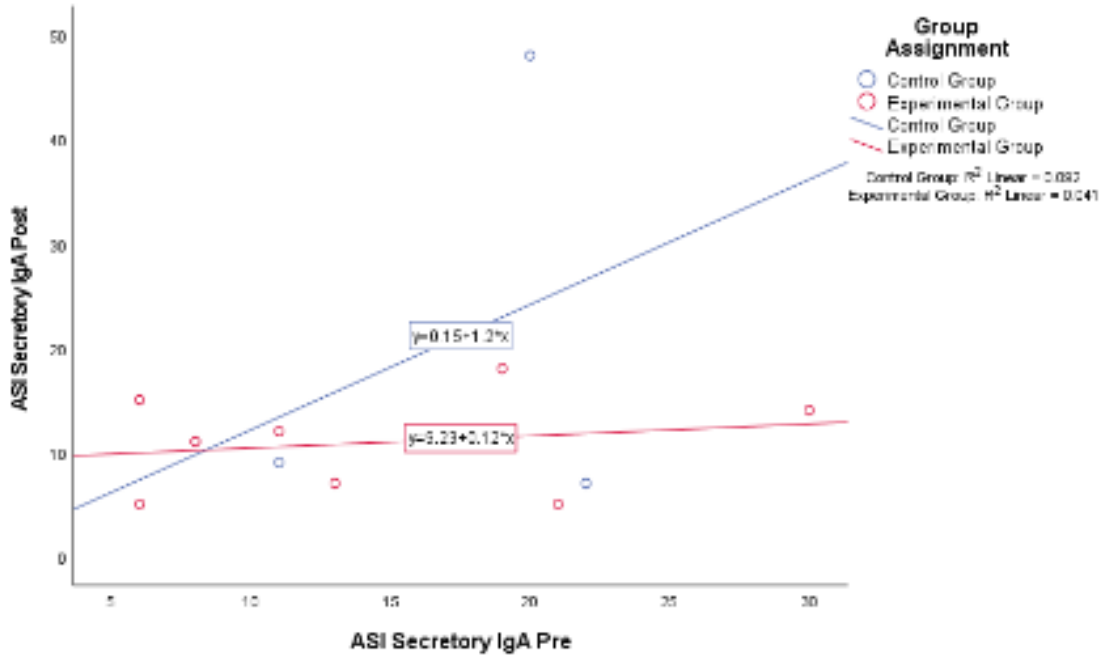
C


Group Assignment
Control Group
Experimental Group
Control Group
Experimental Group
ASI DHEA/DHEAS Post
ASI DHEA/DHEAS Pre
y=1.37+0.38*x

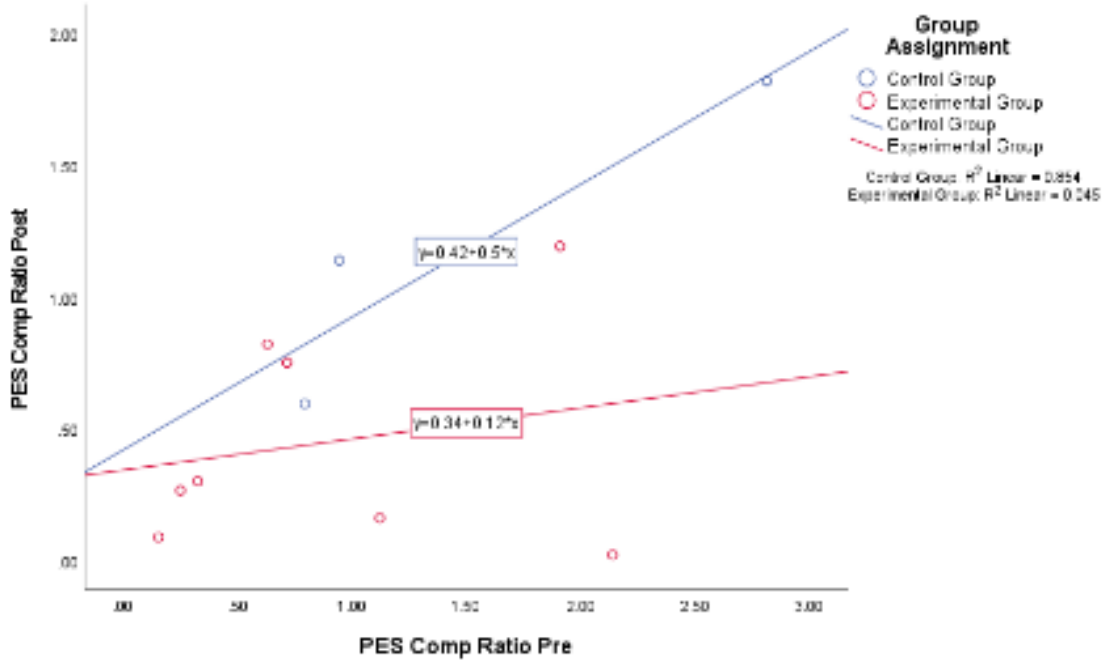
D


Group Assignment
Control Group
Experimental Group
Control Group
Experimental Group
ASI 17-OH Progesterone Post
ASI 17-OH Progesterone Pre

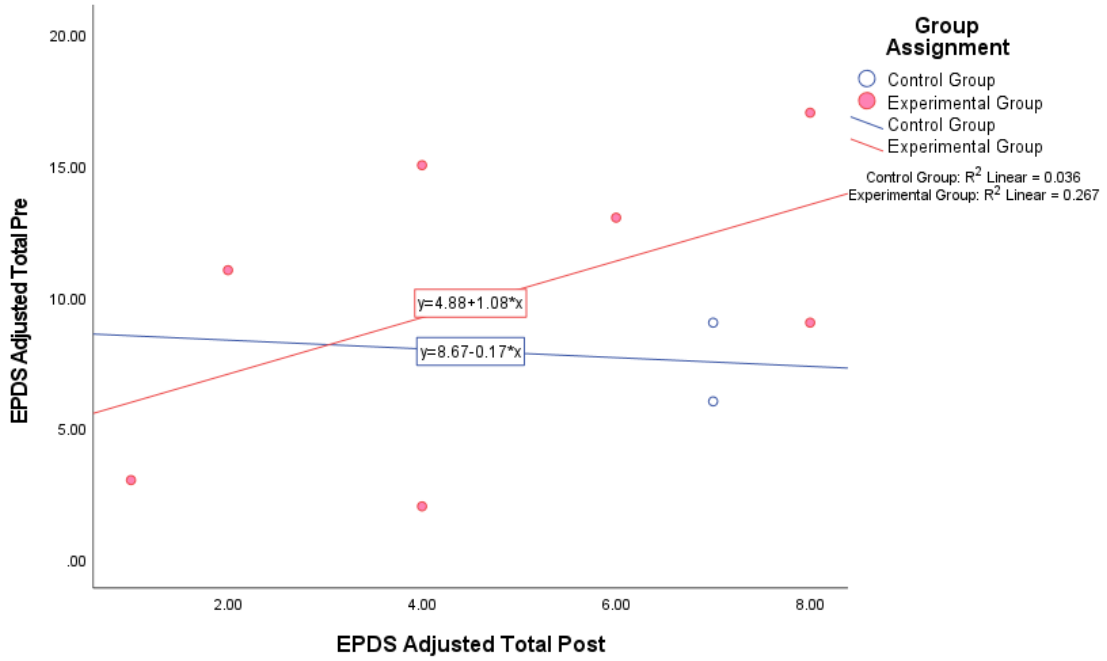
E


Group Assignment
Control Group
Experimental Group
Control Group
Experimental Group
ASI Secretory IgA Post
ASI Secretory IgA Pre

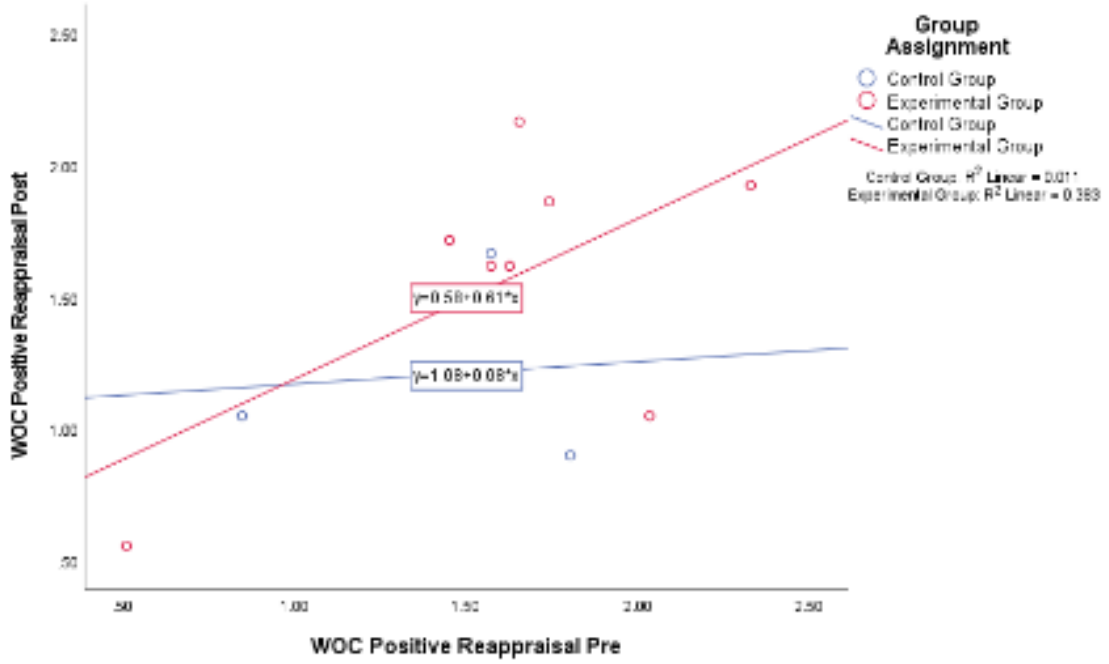
F


Group Assignment
Control Group
Experimental Group
Control Group
Experimental Group
Control Group: R² Linear = 0.854
Experimental Group: R² Linear = 0.045
y=0.42+0.5*x
y=0.34+0.12*x
PES Comp Ratio Post
PES Comp Ratio Pre
2.00
1.50
1.00
.50
.00
.00
.50
1.00
1.50
2.00
2.50
3.00

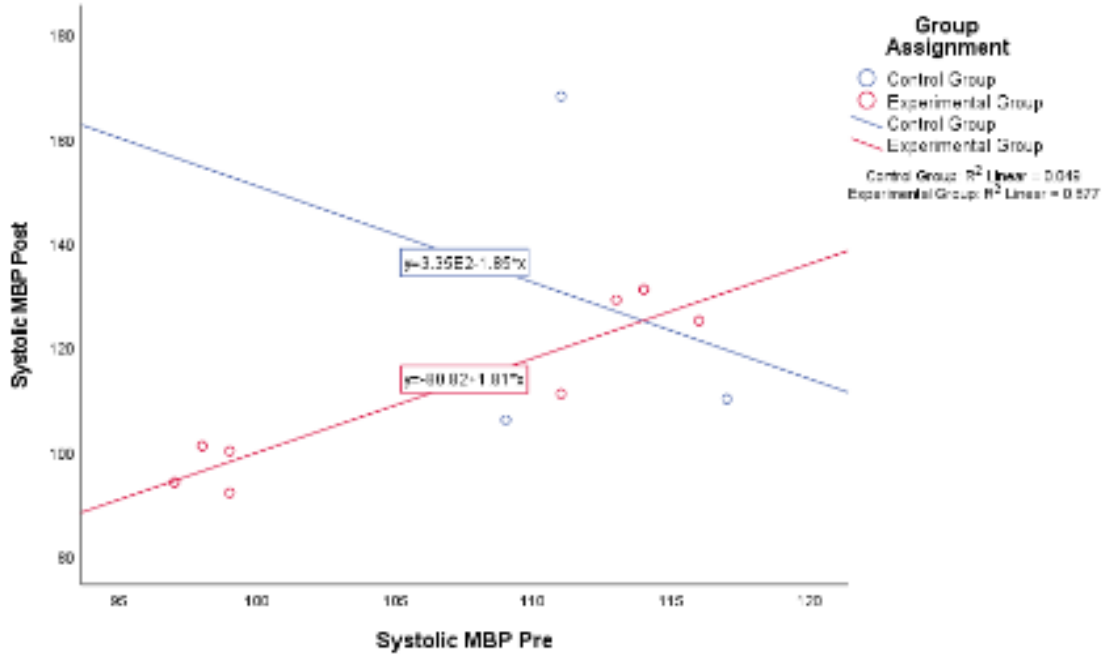
G


Group Assignment
Control Group
Experimental Group
Control Group
Experimental Group
Control Group: R² Linear = 0.036
Experimental Group: R² Linear = 0.267
y=4.88+1.08*x
y=8.67-0.17*x
EPDS Adjusted Total Pre
EPDS Adjusted Total Post
20.00
15.00
10.00
5.00
.00
2.00
4.00
6.00
8.00

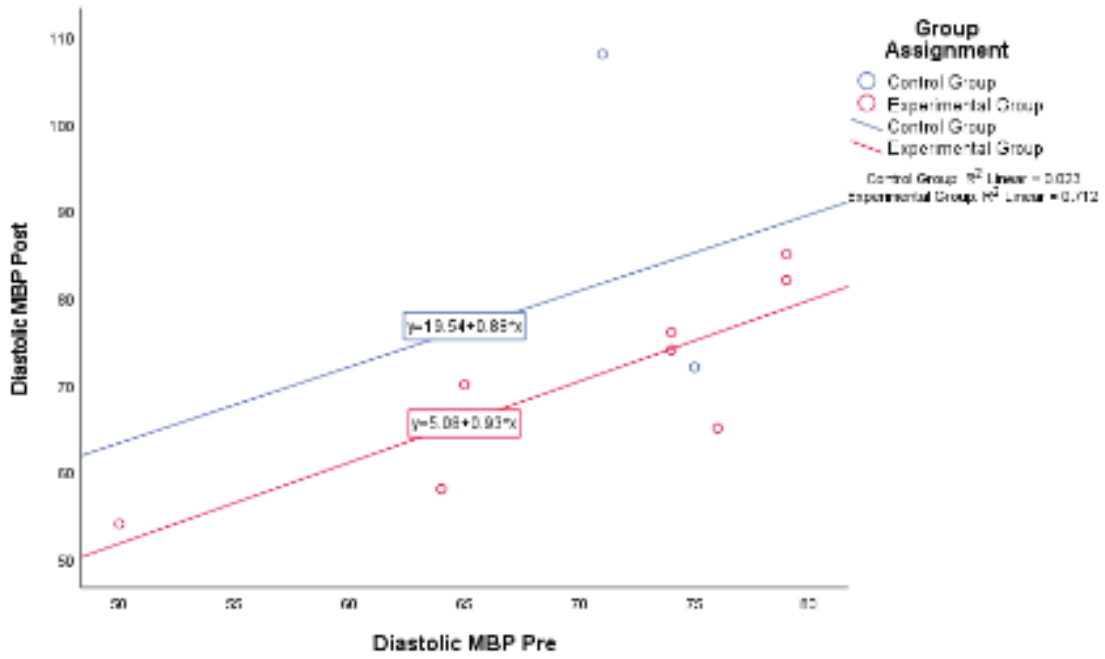
H


Group Assignment
Control Group
Experimental Group
Control Group
Experimental Group
WOC Positive Reappraisal Post
WOC Positive Reappraisal Pre

I


Group Assignment
Control Group
Experimental Group
Control Group
Experimental Group
Systolic MBP Post
Systolic MBP Pre

J



Note. Regression slope results for the pre-post measures represent the control and experimental groups. Panels A-J are homogeneity of regression slope scatterplots for pre-post: Panel A: HRV, Panel B: ASI Total Cortisol, Panel C: ASI DHEA/DHEAS, Panel D: ASI 17-OH Progesterone, Panel E: ASI Secretory IgA, Panel F: PES Comp Ratio, Panel G: EPDS Total, Panel H: WOC Positive Reappraisal, Panel I: Systolic MBP, and Panel J: Diastolic MBP. HRV = heart rate variability, ASI = Adrenal Stress Index, DHEA/DHEAS = dehydroepiandrosterone/dehydroepiandrosterone sulfate, 17-OHP = 17-hydroxyprogesterone, sIgA = secretory immunoglobulin A, PES = Pregnancy Experience Scale, EPDS = Edinburgh Postnatal Depression Scale, WOC = Ways of Coping, MBP = maternal blood pressure.

These interactions indicate the relationships between the dependent variables and covariates were different between groups. A difference in slopes is interpreted as differences in the amount of change in rates among groups (Baguley, 2012). Statistical and substantive significance were shown in Table 6. Significance for the homogeneity of regression slopes was set at $p < .20$. All variables lacked significance therefore met assumption with the exception of cortisol at $p = 0.193$. Accordingly, the ANCOVA main analysis was void of the cortisol variable.

Table 6

Homogeneity of Regression Slopes: Results Summary

	Group interaction	
Dependent variable	*P*	η^2
HRV	.886	.00
Cortisol	*.193	.23
DHEA/DHEAS	.893	.00
17-OHP	.547	.05
sIgA	.528	.06
PES	.299	.15
EPDS	.555	.03
WOC	.497	.07
SMBP	.309	.15
DMBP	.982	.00

Note. HRV = heart rate variability; DHEA/DHEAS = dehydroepiandrosterone /dehydroepiandrosterone sulfate; 17-OHP = 17-hydroxyprogesterone; sIgA = secretory immunoglobulin A; PES = Pregnancy Experience Scale; EPDS = Edinburgh Postnatal Depression Scale; WOC = Ways of Coping; SMBP = systolic maternal blood pressure; DMBP = diastolic maternal blood pressure; * $p < .20$

Analysis of Covariance

Repeated measures pre-post design, between groups ANCOVA compared means based on repeated observations. Outcome variable measurements precede the implementation of the intervention phase of the study (Baguley, 2012). The post-phase transpired 4-weeks after the baseline measure. This study included control and experimental groups as independent variables and nine covariate pre-phase measures and MBP. This study had eight dependent variables observed twice, once during the pre-phase and once during the post-phase.

The ANCOVA assessed the effectiveness of CBSR intervention on HRV, ASI (DHEA/DHEAS, 17-OHP, sIgA), PES, EPDS, WOC, SMBP, and DMBP between a

control group and an experimental group (Baguley, 2012). Coherence-based stress resilience intervention as the independent variable. Dependent variable scores were HRV, ASI (DHEA/DHEAS, 17-OHP, sIgA), PES, EPDS, WOC, SMBP, and DMBP administered after completing the first collection phase. Scores collected during the initial stage before the intervention phase were used as covariates to control individual differences (Baguley, 2012).

Analysis of Covariance: Estimated Marginal Means

The Estimated Marginal Means adjusted for the covariates in the ANCOVA (Baguley, 2012). The estimated marginal means and pre-post means depicted in Table 7 are for the control and experimental groups. Estimated marginal means for the interaction effect are equal for the control and experimental group HRV results. All remaining experimental group estimated marginal mean results were lower than the control group except for the 17-OHP and WOC variables, which yielded higher results. Observed posttest means for all variables were lower for the experimental group results except for the 17-OHP, SMBP, and DMBP experimental group variables, which yielded higher posttest means.

Table 7

Means and Estimated Marginal Means: Main Results Summary

	Pretest		Posttest			
	SE_M		SE_M		SE_{EMM}	
Variable	Wait	Tx	Wait	Tx	Wait	Tx
HRV	3.80	4.25	3.68	3.85	3.80	3.80
	0.03	0.28	0.05	0.17	0.20	0.12
DHEA/DHEAS	5.00	3.00	3.67	2.50	3.16	2.70
	2.08	0.93	0.67	0.78	1.12	0.67
17-OHP	120.67	158.50	135.00	186.75	138.47	186.45
	30.23	18.90	41.24	28.72	50.41	30.07
sIgA	17.67	14.25	21.33	10.88	20.72	11.10
	3.38	3.00	13.35	1.71	7.18	4.35
PES	1.52	0.91	1.18	0.45	1.07	0.49
	0.65	0.27	0.35	0.15	0.26	0.16
EPDS adj	7.67	10.00	6.00	4.75	6.82	10.32
	1.53	5.32	1.73	2.55	2.63	1.59
WOC	1.41	1.61	1.20	1.56	1.28	1.53
	0.29	0.19	0.23	0.18	0.26	0.16
SMBP	112.33	105.88	128.00	110.38	120.67	113.12
	2.40	2.93	20.03	5.65	11.76	6.94
DMBP	71.00	70.13	81.67	70.50	81.08	70.72
	2.31	3.51	13.32	3.88	7.32	4.48

Note. HRV = heart rate variability; DHEA/DHEAS = dehydroepiandrosterone/dehydroepiandrosterone sulfate; 17-OHP = 17-hydroxyprogesterone; sIgA = secretory immunoglobulin A; PES = Pregnancy Experience Scale; EPDS = Edinburgh Postnatal Depression Scale; adj = adjusted; WOC = Ways of Coping; SMBP = systolic maternal blood pressure; DMBP = diastolic maternal blood pressure.

Analysis of Covariance: Main Results

The statistical analysis process completed a repeated measures ANCOVA to assess the effectiveness of CBSR intervention and HRV, ASI, PES, EPDS, WOC, and MBP. The independent variables were CBSR intervention. The dependent variables were the posttest values measured after completion of the CBSR intervention. The pretest values measured before completing the CBSR intervention were used as a covariate to control for individual differences.

The ANCOVA revealed a significant main effect for the covariates of HRV, DHEA/DHEAS, PES, EPDS, WOC, SMBP, and DMBP with a large effect size for all except two variables, 17-OHP and sIgA. The main effect for group was statistically significant for only the PES variable at $F(1, 4) = 3.33$, $p = 0.29$, with a large effect size $\eta^2 = .11$; Effect size range is small $\eta^2 = .01$, medium $\eta^2 = .06$, large = .14 (Shafer & Schwarz, 2019). These results may represent effect sizes not directly affected by sample size (Lantz, 2012). Effect size may not guarantee statistical significance with small sample sizes. Heart rate variability yielded statistical significance as portrayed in Table 8 with a large effect.

Table 8

Analysis of Covariance: Main Results Summary

	Group			Covariate		
Variable	*F* ratio	*P*	η^2	*F* ratio	*p*	η^2
HRV	0.00	,981	.00	5.72	*.044	.42
DHEA/DHEAS	0.12	.736	.02	2.65	*.142	.25
17-OHP	0.61	.456	.07	0.06	.816	.01
sIgA	1.29	.289	.14	0.23	.644	.03
PES	3.33	*.105	.29	2.46	*.155	.24
EPDS adj	1.27	.293	.14	2.27	*.171	.22
WOC	0.68	.433	.08	3.10	*.117	.28
SMBP	0.29	.606	.04	3.41	*.102	.30
DMBP	1.46	.262	.15	3.90	*.084	.33

Note. HRV = heart rate variability; DHEA/DHEAS = dehydroepiandrosterone/dehydroepiandrosterone sulfate; 17-OHP = 17-hydroxyprogesterone; sIgA = secretory immunoglobulin A; PES = Pregnancy Experience Scale; EPDS = Edinburgh Postnatal Depression Scale; adj = adjusted; WOC = Ways of Coping; SMBP = systolic maternal blood pressure; DMBP = diastolic maternal blood pressure; * $p < .20$

Post-Hoc Analysis

Advanced Heart Rate Variability Metrics and Physiological Phenomena

The ANCOVA was used to assess the CBSR intervention's effectiveness on advanced aspects of HRV metrics and physiological phenomena between the control and experimental groups (Baguley, 2012). Advanced HRV metrics include the stress/recovery index, low frequency (LF), high frequency (HF), and low frequency/high frequency (LF/HF) ratio. Physiological phenomena of the ANS comprise the parasympathetic nervous system (PNS) and sympathetic nervous system (SNS).

The ANCOVA revealed a significant main effect for the stress index, PNS, SNS, and LF with a large effect size. Effect size range is small η^2 = .01, medium η^2 = .06, large = .14 (Shafer & Schwarz, 2019). The HF variables had a medium effect size, as illustrated in Table 9. The main effect for group was statistically significant for only the LF and HF variables. Low Frequency, and HF resulted in a large effect size, while the LF/HF ratio yielded a medium effect. These results may represent effect sizes not directly affected by sample size (Lantz, 2012). Effect size may not guarantee statistical significance with small sample sizes.

Table 9

Analysis of Covariance: Post-Hoc Results Summary

	Group			Covariate		
Variable	*F* ratio	*P*	η^2	*F* ratio	*p*	η^2
Stress index	0.03	.875	.00	4.45	*.068	.36
PNS	0.01	.916	.00	2.55	*.149	.24
SNS	0.05	.832	.01	9.43	*.015	.54
LF	8.82	*.018	.52	2.11	*.185	.21
HF	2.72	*.138	.25	0.85	.384	.10
LF/HF	1.05	.336	.12	0.02	.892	.00

Note. PNS = parasympathetic nervous system; SNS = sympathetic nervous system; VLF = very low frequency; LF = low frequency; HF = high frequency; LF/HF = low frequency/high frequency ratio; *p<.20.

Summary

This quantitative study cautiously conducted an exploratory statistical evaluation on a complete, valid data set of HRV, ASI, PES, EPDS, WOC, and MBP variables for an antenatal sample (N = 11) to identify the effect of CBSR intervention on the NCUP system. Cronbach's Alpha psychometric internal consistency and reliability for the PES and EPDS yielded excellent scores, whereas the WOC results were at an acceptable range. The statistical analysis process assessed the linearity of covariate and dependent variables via homogeneity of regression slopes (Baguley, 2012). Homogeneity of regression slopes yielded an interaction between the dependent variables and covariates. The relationships for all variables were linear.

Repeated measures pre-post design ANCOVA compared means for the control and experimental groups. Statistical analysis revealed a significant main effect for HRV, DHEA/DHEAS, PES, WOC, SMBP, and DMBP. All variables except 17-OHP and sIgA yielded a large effect size. Evaluation of the stress recovery system and the frequency

domain yielded a significant main effect for the stress index, PNS, SNS, and LF variables with a large effect size. Chapter 5 discussed the findings, limitations and provide concluding remarks.

Chapter 5: Discussion

This discussion first provided a summary of the study's main analyses. Secondly, this chapter provides an interpretation of the effect of CBSR intervention on the NCUP expectant women who received training and practiced CBSR in comparison to the control group. Specifically, interpretation of findings regarding stress, depression, and cardiovascular disorders such as gestational hypertension and preeclampsia within the NCUP integrative framework were discussed. This is followed by a discussion of the limitations of the present research and recommendations for future research. The chapter concludes with discussion of individual, family, and community social change matters, in addition to applied recommendations for practice.

The purpose of this quantitative study was to identify the effect of CBSR intervention on the NCUP system of second and third trimester pregnant women. Noninvasive CBSR synchronizes the ANS of nonpregnant individuals, which showed promise for stress resilience and improvement of depression through ANS homeostasis within the uteroplacental-heart-brain connection during pregnancy (Ho, 2008; McCraty et al., 2009; McCraty & Childre, 2010; Sutarto et al., 2010; Thomas, 2010). Considering the necessity for uteroplacental-heart-brain coherence and pregnancy viability, evaluation of the effect of CBSR within the NCUP system was overdue (Ho, 2008; Lehrer et al., 2010; McCraty et al., 2009; Plastow, 2009; Thomas, 2010). Moreover, the nature of this study examined the effect of CBSR that occurred over a 4-week period within the NCUP system of second and third trimester pregnant women who received training and

practiced CBSR and a group that received no training or practice. This study aimed to explain the effect of CBSR within the NCUP system.

Rationale for the study was that there was no research to date that evaluated noninvasive CBSR intervention that synchronizes ANS communication within the uteroplacental-heart-brain connection to reduce stress and improve mood (Ho, 2008; McCraty et al., 2009; McCraty & Childre, 2010; Sutarto et al., 2010; Thomas, 2010). Neuro-cardio-utero-placental homeostasis, when exposed to stress and depression, decreases HRV as shown by gestational milieu incoherence, dysregulated uteroplacental haemodynamics, gestational hypertension, and preeclampsia (Childre et al., 2000; Ho, 2008; McCraty et al., 2003; Stein et al., 2008; Vrekousis et al., 2010). The current study further contributes to better understanding of stress, depression, and cardiovascular disorders such as gestational hypertension and preeclampsia within the NCUP integrative framework. Antenatal stress and depression-induced gestational hypertensive disorders during pregnancy are treatable even as they remain the leading cause of maternal morbidity and mortality (Diego et al., 2006; Faber et al., 2004; McCraty & Childre, 2010; Pavithran et al., 2008; Sugiura-Ogasawara et al., 2002).

Findings

Participant Demographics

Baseline descriptive and demographic information directly address questions about the sample parameters (Altshuler et al., 2008; DiPietro et al., 2012). A demographic questionnaire collected baseline descriptive and demographic characteristics. Sociodemographic characteristics were expectant women between the

ages of 20 and 39 with at least some college. Nearly half of the participants were White, while more than half endorsed the other ethnicities combined. Their primary language was English. More participants in this study reported being married than single or divorced. The study was open to participants across the nation although most came from a Pacific large city location.

Mean gestational age was 27.6 weeks. The experimental group featured a marginally higher mean gestational age. Seven participants were in their third trimester and four were in their second trimester. All participants denied any current or previous obstetrics complications, treatment for current chronic medical conditions, and current medications. Nine participants were new moms-to-be. All participants in this study denied current psychiatric diagnosis, psychiatric medication, and psychological services. Seven participants reported coffee use before pregnancy and five expressed drinking coffee during their pregnancy. All participants denied the current antenatal use of tobacco, alcohol, and illicit drugs while only one participant disclosed a 20-year use of tobacco and illicit drugs prior to pregnancy.

Main Analysis

An analysis of covariance prepost design compared means based on repeated observations of HRV, DHEA/DHEAS, 17-OHP, sIgA, PES, EPDS, WOC Positive Reappraisal, SMBP, and DMBP. Heart rate variability (p = 0.044), DHEA/DHEAS (p = 0.142), PES (p = 0.155), EPDS (p = 0.171), WOC (p = 0.117), SMBP (p = 0.102), and DMBP (p = 0.084) yielded statistically significant findings for the pre-post variables and generated large substantive effect size significance for each of these variables.

Conversely, 17-OHP and sIgA were not significant and yielded a small effect size. The ANCOVA group comparison yielded only one significant result for the PES (p = .105); nonetheless, the sIgA, PES, EPDS, and DMBP resulted in large substantive significance. Two group variables, 17-OHP and WOC Positive Reappraisal, yielded medium effect size significance, and two additional group variables, DHEA/DHEAS and SMBP, resulted in a small effect size.

Advanced Heart Rate Variability Metrics and Physiological Phenomena

Analysis of covariance pre-post design compared means of advanced HRV metrics and physiological phenomena including the stress index, PNS, SNS, LF, HF), LF/HF ratio. Stress index (p = 0.068), PNS (p = 0.149), SNS (p = 0.015) and LF (p = 0.185) yielded statistically significant findings for pre-post variables and generated large substantive effect size significance for each of these variables. Conversely, HF and LF/HF ratio were not significant; HF yielded a medium substantive significance and LF/HF ratio yielded a small effect size. The advanced HRV metrics and physiological phenomena group comparison yielded two significant results for LF (p = 0.018) and HF (p = 0.138) along with large substantive significance for both variables. One group LF/HF ratio variable yielded medium effect size significance and one additional group SNS variable had a small effect size.

Interpretation

Biological Systems

Heart Rate Variability

Variation within maternal beat-to-beat intervals between each heartbeat constitute antenatal HRV. Fluctuation in maternal HRV occurs relative to the level of stress and depression (Heiskanen et al., 2008; McCraty & Childre, 2010). The alternative hypothesis for HRV specified there may be a significant effect in Week 4 posttest HRV rhythms. Heart rate variability results for this study were statistically significant with large substantive significance and lower results on posttest. The HRV alternative hypothesis was cautiously accepted given the small sample size. Higher HRV rhythms were purported by prior researchers to maintain healthier quality cardiovascular communication within the NCUP network and between systems in the body (Ho, 2008). Conversely, the condition of pregnancy independently was found to increase risk of low HRV and cardiovascular imbalance (Solanki et al., 2020). The outcomes for this antenatal sample likewise show decreased HRV and may indicate decreased mood after 4-week resilience intervention with autonomic vascular disequilibrium that disrupts NCUP coherence.

Adrenal Stress Index

The ASI salivary hormone test assessed endocrine function of DHEA/DHEAS, 17-OHP, and sIgA hormone levels in a noninvasive manner (Diagnos-Techs, 2013a, 2013b). Prior research found that DHEA/DHEAS has a role in mood fluctuation with higher levels of DHEA/DHEAS consistent with improved mood and stress reduction

(Buckwalter et al., 1999; Gold & Chrousos, 2002). The alternative hypothesis for DHEA/DHEAS stated there would be a significant effect in week-4 posttest DHEA/DHEAS stress adaption levels. An endogenous steroid hormone DHEA/DHEAS results in this project decreased significantly after 4-weeks with large effect size and a lower score on posttest that may be consistent with low mood. The DHEA/DHEAS alternative hypothesis was prudently accepted considering a small sample size. Lower levels of DHEA/DHEAS found in previous studies indicate decreased mood and increased stress (Gold & Chrousos, 2002). The DHEA/DHEAS results for this sample of pregnant women may show potential for antenatal depression.

DHEA/DHEAS has been found to prevent damaged inflammatory process of cortisol's harmful effects in subsequent studies (Guilliams & Edwards, 2010). Notwithstanding, DHEA/DHEAS is a more stable biomarker than cortisol resultant of higher daily fluctuation (Markopoulou et al., 2009), which also occurred in this study. Salivary 17-OHP is a natural hormone building block of cortisol and may have also contributed to its high fluctuation (Diagnos-Techs, 2013a, 2013b). Secretory IgA is an antibody that plays a key role in understanding effects of stress (Negril et al., 1995; Diagnos-Techs, 2013a, 2013b). Both sIgA and 17-OHP results in this study lacked significance; therefore, their null hypotheses were accepted. Progesterone was more stable during the second trimester with higher fluctuation during the third trimester, while sIgA had very low change.

Maternal Blood Pressure

Exerted pressure of an expectant mom's blood on the blood vessel's interior wall (ACOG, 2013; Carnethon et al., 2002; Windham et al., 2012). The maximum number is the systolic pressure and the minimum number is the diastolic pressure. The alternative hypothesis for MBP stated there would be a significant effect in week-4 posttest on MBP. Systolic MBP findings for this research were statistically significant with large substantive significance and increased values. Diastolic results were also statistically significant with a large effect and higher scores. Accordingly, the MBP alternative hypothesis was cautiously accepted given the small sample size. Previous research findings suggest that mons-to-be with higher MBP have higher incidence of depression during pregnancy, further posing risk for preeclampsia (Chen et al., 2004; Diego et al., 2006; Kurki et al., 2000). Results for MBP values of this study may represent increased stress and decreased mood with potential for increased risk of gestational hypertension.

Psychometric Indices

Pregnancy Experience Scale

Integrated homeostasis dysregulation of antenatal stress together with antenatal stress symptoms pose a threat to NCUP coherence (McCraty et al., 2009; Vrekousis et al., 2010). Persistent stress at the onset of pregnancy together with subsequent reproductive neuroendocrine change may potentially result in depression (Gold & Chrousos, 2002; Hippman et al., 2009; Paz-Filho et al., 2010; Schwerdtfeger & Friedrich-Mai, 2009). The alternative hypothesis for antenatal stress stated there would be a significant effect in week-4 posttest on intensity of symptoms of antenatal stress. Symptoms of natural-

environmental antenatal stress measured by the PES during this study was statistically significant for more uplifts than upsets with large substantive significance. Therefore, the PES alternative hypothesis was judiciously accepted. Negative and positive stressors may occur simultaneously, affecting separate biological systems (DiPietro et al., 2004). Likewise, stressful life events may not result in illness, instead may produces positive outcomes (Brunton, 2010). Findings for this study may indicate improved situational stress therefore potential for enhanced psychophysiologic homeostasis.

Edinburgh Postnatal Depression Scale

Antenatal depression occurs during pregnancy within the NCUP system (Simone & Pun, 2007; Vrekousis et al., 2010). Antenatal depression's course and severity triggered by stress was found by prior researchers to disrupt ANS equilibrium and dysregulates NCUP homeostasis (Bunevicius et al., 2009a; Paz-Filho et al., 2010; Stewart, 2011; Thomas, 2010). The alternative hypothesis for antenatal depression stated there would be a significant effect in week-4 posttest on symptoms of antenatal depression. Symptoms of antenatal depression measured by the EPDS in the research was statistically significant with large substantive significance. An adjusted EPDS yielded a slight increase in scores that may have represented possible mild to moderate depression. The alternative EPDS hypothesis was cautiously accepted due to small sample size. Psychological repercussions of untreated depression during pregnancy found in prior research are commonly sleep related disorders, cognitive decline, suicide, and mortality (Brunton et al., 2010; Bunevicius et al., 2009b). Two scale items that were removed showed the most improvement in difficulty sleeping and anticipatory enjoyment.

Including both of those items the scale scores showed improved mood, which are inconsistent with decreased HRV and DHEA/DHEAS found in this study.

It is essential to assess for suicidality during pregnancy given the risk factors of antenatal depression (Bunevicius et al., 2009b; Gausia et al., 2009). All pregnant women in this study endorsed zero suicidal ideation and need to be considered cautiously given indicators of decreased mood endorsed by this antenatal population. Due to the full zero status of the suicidal item on the EPDS, the statistical procedure removed this item from the analysis process. Pregnancy was also found to have potential protective factors against suicide by previous researchers (Gausia et al., 2009; Manber et al., 2008).

Ways of Coping Positive Reappraisal

Process-oriented, cognitive focused coping approach that reframes negative thought (Gold & Chrousos, 2002; Folkman & Lazarus, 1988). Physiologic and metabolic reactivity associated with unrelated stress responses precipitated by inaccurate perception thus skewed emotional reaction leads to maladjusted coping (Duncan & Bardacke, 2010; Gold & Chrousos, 2002; Obel et al., 2005; Urizar et al., 2004). The alternative hypothesis for positive reappraisal stated there would be a significant effect in week-4 posttest on positive reappraisal coping responses. Ways of Coping Positive Reappraisal results for this project were statistically significant in week-4 posttest with large effect significance and lower scores on posttest. Consequently, the positive reappraisal alternative hypothesis was forethoughtfully accepted given the small sample size. Possible skewed perception and emotional response may have contributed to slight decrease in positive reappraisal coping.

Heart Rate Variability Stress-Recovery

Stress Index

Cardiovascular system stress shown by a geometric measure of HRV (Tarvainen, 2014). High SNS activation and lower variability are indicated by high stress index values (Tarvainen, 2014). Stress index findings for this project were statistically significant with large substantive significance and increased stress index scores. Reduced HRV stress index effects on antenatal stress and depression were found by prior research to be predictors of gestational hypertension (Bushnell & Chireau, 2011; Christian, 2012). The outcomes for this study may indicate increased stress, decreased mood, and potential for gestational hypertension.

Parasympathetic Nervous System

One of two branches of the ANS, the PNS system functions unconsciously to control restful conditions to conserve energy (Tindle & Tadi, 2021). Prior research found that parasympathetic dysfunction within the ANS led to an exacerbated risk of depression (Schwerdtfeger & Friedrich-Mai, 2009). Parasympathetic nervous system findings for this study were statistically significant with large substantive significance and decreased values. A dysregulated relationship between the sympathetic and parasympathetic branches of the ANS are consistent with lower HRV (McCraty & Childre, 2010). The outcomes of this expectant sample may represent decreased PNS activity therefore indicate increased stress and physiological incoherence.

Sympathetic Nervous System

One of two branches of the ANS, the SNS instinctually prepares for stress-related citations (Tindle & Tadi, 2021). Prior research found a higher risk of depression was connected to dysfunction of the sympathetic and parasympathetic branches of the ANS (Schwerdtfeger & Friedrich-Mai, 2009). Sympathetic nervous system findings for this study were statistically significant with large substantive significance and increased values. Prior research found evidence of a relationship between increased sympathetic nervous system activity antenatal hypertension, and preeclampsia (Spradley, 2020). The increased SNS findings of this antenatal sample may suggest the potential for hypertensive disorders during pregnancy.

Heart Rate Variability Frequency-Domain

Low Frequency

A spectrum of HRV that mirrors accurate sympathetic activity, seemingly vagus nerve mediated (Houle & Billman, 1999). Sympathetic and parasympathetic nervous systems contribute to the LF domain (Yang et al., 2000). Antenatal stress in prior research found lower levels of HF and LF values than women who were non pregnant (Klinkenberg et al., 2009). Low-frequency results for this expectant sample were statistically significant with large substantive significance and increased values. Prior research likewise found higher LF domain values than the other frequency domain indices (Yang et al., 2000). The LF domain for this sample was the dominant component within the entire frequency spectrum that may indicate increased potential for stress, depression, and hypertensive disorders during pregnancy.

High Frequency

A spectrum of HRV that synchronizes respiration (Houle & Billman, 1999). Parasympathetic responsivity and decreased HF flexibility comprise quality of emotional health (Shinba et al., 2008). High-frequency domain results for this antenatal sample lacked significance with medium substantive significance and decreased values. Prior research likewise found elevated HF parameters associated in response to stress (Egizio et al., 2008). The HF domain for this pregnancy sample may show potential for gestational hypertensive disorders and depression.

Low Frequency/High Frequency Ratio

Spectra used as a parasympathetic-sympathetic balance guide (Houle & Billman, 1999). Higher scores endorsed on the EPDS representative of increased depression were associated with increased values on the LF/HF ratio (Shea et al., 2008). Low-frequency/high-frequency ratio results for this expectant sample of pregnant women lacked significance with no effect and increased values. Likewise, prior research findings showed increase LF/HF ratio was associated with higher depression scores (Shea et al., 2008). The LF/HF ratio for this antenatal sample may indicate depression as represented by their increased LF/HF ratio response.

Limitations

First, there was limited access to participants due to the severity and number of natural disasters that occurred during the data collection phase which led to in a reduced sample size. Unexpected stress experiences that participants endured during this study were the natural disasters that annihilated social communities, entire cities, and

geographical environments, adversely affecting millions with widespread fatalities. They lost their homes, family, generations of history, and way of life with threats to their own lives and that of their unborn. These pregnant women experienced globally historic devastation. This during gestation, instinctual nesting, and tend-and-befriend supports of new life. These women, however, were evacuated from their homes and separated from supports with disruption to vital resources. Additional data collection discrepancies and catastrophic natural disaster details written-up in Appendix E. As a result of the small sample size, any significant findings as noted above, are considered tentatively.

Second, while a longitudinal study may have been preferable in determining causality (Duckworth et al., 2010; Toh & Herman, 2008) limited time and resources of this study required the use of a quasi-experimental design with a waitlist control condition in the interest of methodological rigor. Last, as a result of the limited sample size, any findings as noted above are considered tentative which in turn limits the ability to generalize these findings (Kukull & Ganguli, 2012; Tipton et al., 2016). As a result, this study should be replicated using a larger sample.

Regardless the stated limitations, this study provides a foundation for further empirical investigation. Exploring biological systems, psychometric indices, HRV stress recovery, frequency domain factors and adequate effective treatment for antenatal stress, depression, and gestational hypertension provides useful groundwork for potentially saving reproductive maternal/fetal lives.

Recommendations

Considering the severe consequences of untreated stress during pregnancy, it is important to further explore interconnected aspects of antenatal stress and depression. These results suggest the need to replicate this study with a larger sample size so as to increase data and power (Serdar et al., 2021). Additional exploration may be warranted on noninvasive treatment interventions to address antenatal stress, depression, and gestational hypertension. Another option is to run an expanded study to analyze the second and third trimesters as separate groups given the uniqueness of each gestational phase (Wang et al., 2017). Further research could also include evaluation of provider variables which have the potential to influence the participant status. This may provide added insight to the interconnectedness that providers may have with their patient as well.

Implications

Hypertension and depression relationship during pregnancy affects 5-10% of women during pregnancy (Faber et al., 2004; Jahic et al., 2008; Leeners et al., 2007). Gestational hypertensive disorders are the leading cause of death during pregnancy (Faber et al., 2004; Jahic et al., 2008; Leeners et al., 2007). The implication for this and future studies is the potential for literally saving maternal/fetal lives. Preeclampsia is a severe gestational hypertensive disorder occurring during pregnancy and is one of the most preventable causes of maternal death (Bacidore et al., 2009; Beddoe & Lee, 2008; Jahic et al., 2008). Despite advanced medical care birth outcomes have not improved.

Psychological care of antenatal depression translates to cost savings for families, healthcare systems, and the whole society due to the financial consequences of untreated

mental health (O'Brien et al., 2009). Adverse effects of medication are a deterrent for antenatal depression in seeking necessary emotional support (Ventura et al., 2011). As a result, an implication regarding this deterrent to essential antenatal emotional support is increasing visibility of noninvasive treatment interventions that naturally connect neurocardio synoptically that presents in a tend and befriending way organic to pregnancy.

Social Change

Individual

Coherence is an individual's defining quality via synchronization of psychophysiological fluctuation that occur within an organism (Ho, 2008; McCraty & Childre, 2010; McCraty et al., 2012). Increased awareness in quality of individual antenatal mood and the consequence of stress, depression, and antenatal hypertension may assist individuals with implementing informed social change. Uteroplacental-heart-brain coherence is NCUP homeostasis, which is akin to individual neurocardiac equilibrium (McCraty et al., 2009). Development of increased awareness is a skill that may help moms-to-be experience decreased negative outcomes associated with disequilibrium thereby maximize the capacity for increased familial and social change.

Family

Maintenance of psychological family equilibrium is a necessary component of healthy family interrelations that promote optimal antenatal outcomes (Hippman et al., 2009; Rubertsson et al., 2003). Quality dynamics of familial support effects antenatal depression; in turn the entire household may experience serious consequences (Bennett et

al., 2004a; Hippman et al., 2009; Rubertsson et al., 2003). Befriending behaviors within the family system are indicative of improved mood have important psychophysiologic benefits that counter the ill effects of stress; optimizing pregnancy outcomes; and are essential to promoting positive social environmental change (Adewuya et al., 2007; Hippman et al., 2009).

Social

Social coherence occurs wherein partner, family, and community interactions transpire from a stable foundation (McCraty & Childre, 2010; McCraty et al., 2012; Schwerdtfeger & Friedrich-Mai, 2009). Hidden costs of antenatal depression involve outpatient office, inpatient hospitalization, and pharmaceuticals that affect the stability of individuals, families, and the social community (Barrio & Burt, 2000; Bennett et al., 2004b). The annual U.S. economic burden effects of untreated depression during pregnancy are approximately $30 to $44 billion dollars with a worldwide cumulative cost of $47 trillion further shaking antenatal social stability (Barrio & Burt, 2000; Bennett et al., 2004a; Bloom et al., 2011; Chand, 2012 Karavidas et al., 2007; Pariante, 2003). These consequences affecting society as a whole have potential devastating effects on the unborn in utero and throughout the baby's entire life cycle for compound consequences on future generations (O'Brien et al., 2009).

Depression was declared the 21st century's leading cause of morbidity of women during the reproductive years greatly increasing risk of physical and social disability and commonly result in death of the maternal/fetal dyad (Bennett et al., 2004a; Mathers et al., 2004; Novikova et al., 2009). Most common cause of fetal death is antenatal hypertension

related neonatal mortality resultant of depression during pregnancy (Ursem et al., 1999). Sympathetic dominance-based imbalance between sympathetic and parasympathetic subsystems during maternal depression adversely affect fetal wellbeing (Shea et al., 2008). Sympathetic modulation manages the quality of hemodynamic function within the placenta and maternal/fetal dyad (Heiskanen et al., 2008; Struijk et al., 2001).

Maternal/fetal morbidity and mortality, are directly affected by the consequence of parasympathetic deactivation resultant of gestational hypertensive disorders (Heiskanen et al., 2008; Jahic et al., 2008; Siddiqui et al., 2010). Getting healthy babies saves money and lives as psychological care of antenatal depression translates to cost savings for families, healthcare systems, and the whole society due to the financial consequences of untreated mental health (O'Brien et al., 2009). Emotional self-regulated stress management may effectively reduce symptoms of antenatal stress, depression, and hypertension, and improve the quality of life during pregnancy with reduced healthcare costs (DiPietro et al., 2004; Evans, 2007; McCraty et al., 2003).

Social coherence affects psychophysiologic components of HRV (Ho, 2008; McCraty & Childre, 2010; Vrekousis et al., 2010). Antenatal psychophysiologic health, is directly related to heart-based reappraisal of stress that maintains ANS equilibrium, decreases doctor visits, improves pregnancy outcomes, and increases mortality (McCraty et al., 2009; Moreno & Lau, 2007; Oz et al., 2009; Ritz et al., 2013). The experience of social stress results in significantly decreased HF components of HRV and was significant for increased LF/HF ratio (Klinkenberg et al., 2009). Stress during pregnancy generally shows lower levels of HF and LF values than in non-pregnant women. The

NCUP coherence strengthens a coherence feedback loop between the pregnant woman, her offspring, the social community and global generations to come (Ho, 2008; McCraty & Childre, 2010; McCraty et al., 2012; Sutarto et al., 2010; Thomas, 2010; Vrekousis et al., 2010). The positive social change benefits, therefore, have potential to reach beyond the immediate antenatal, familial, and social effects to global future generations.

Pregnant women avoid treatment for depression even when referred by their physician; consequently, a barrier forms between referral and psychiatric appointment (Felice et al., 2007; Harvey & Pun, 2007). In an effort to circumvent non-compliant treatment follow-through with referrals, intervention programs within the physician office would potentially increase compliance. To treat antenatal depression effectively, multidisciplinary collaborative care within an integrative framework is necessary to ease barriers that prevent recovery from depression during pregnancy as only about 50% of physicians refer for antenatal mental healthcare (Bacidore et al., 2009; Coleman et al., 2008; Trixler et al., 2005). Conventional psychiatry compartmentalizes mind and body, separating the biological, psychological, and social aspects of the individual (Plastow, 2009). Given the multisystemic nature of antenatal depression, integrative obstetrics mental healthcare as a cohesive multidisciplinary approach may improve the quality of treatment for depression during pregnancy. These multidisciplinary programs can be offered within the physician office or at least within the same healthcare building or complex. Follow-up mental healthcare for moms-to-be can also be offered via telehealth or video conferencing as well. Telehealth convenience may also appeal to the busy

moms-to-be. The tend-and-befriend nature of pregnancy may also lend itself to potential in person or video conference group intervention.

Applied

Risk for depression-based disease results from untreated antenatal depression. Gestational hypertension complicated pregnancy has a direct relationship with antenatal depression (Jahic et al., 2008; Leeners et al., 2007). Factors adversely affected by untreated antenatal depression are HRV, gestational hypertension, and preeclampsia (Dayan et al., 2006; Diego et al., 2006; O'Mahony et al., 2006). Pregnancy specific disease symptoms can be invisible or mild to critically severe, is potentially lethal, and when left untreated has potential adverse effects (Chen et al., 2004; Gayasen et al., 2003; Kurki et al., 2000). An integrated NCUP approach focused on uteroplacental-heart-brain coherence, therefore, is necessary to respond to the connection between antenatal stress, depression, and neurocardio pregnancy related disease such as gestational hypertension (Ho, 2008; Hui, 2012; Thomas, 2010; Vrekousis et al., 2010).

Increased HRV that result from treatment for depression has emotion-focused HRV feedback benefits (Karavidas et al., 2007; McCraty et al., 2003). Intervention increases cardiovagal activity, has immediate significant increased HRV, positive long-term effects and is useful non-invasive care for antenatal depression (Karavidas et al., 2007; McCraty et al., 2003). Antenatal hypertensive diseases have major clinical importance. Timely delivery is currently the only effective treatment (Leeners et al., 2007). Providing treatment beneficial in reduction of antenatal stress and depression, both early signs of gestational hypertension, remain essential.

Conclusions

The current study supports prior findings that higher sympathetic and lower parasympathetic control may be associated with increased MBP that occurs in gestational hypertensive disorders such as preeclampsia. Moreover, the current study suggests that providing noninvasive treatment may be beneficial to reduce antenatal stress and depression, and early signs of gestational hypertension. The current results add to the current research by showing potential cooccurring biological systems, psychometric indices, HRV stress recovery, and HRV frequency domain findings. While the results of this study need to be considered cautiously due to insufficient sample size, the consistencies between the systems, indices, and domain finding are consistent with prior research.

First, the decreased HRV and DHEA/DHEAS are consistent with prior findings of increased antenatal MBP showing potential for hypertension during pregnancy. Second, given the increased uplifts, increased depressive symptoms, and decreased positive reappraisal coping, both positive and negative processes have the potential of cooccurring during pregnancy. Third, increased stress, decreased PNS relaxation activity, and increased SNS activation are consistent with an accurately functioning stress recovery system in that when relaxation is down, stress activation is up. Fourth, dominant LF within the frequency spectrum may be a potential marker for antenatal stress, depression, and hypertensive disorders during pregnancy.

Finally, the extreme level of natural disaster crisis exposure during this study suggests an even greater need may exist to study the impact of environmental stressors on

such reproductive variables and functioning. In addition, the increased number of such natural disaster events (Nour, 2011; Pourhosseini et al., 2015) also suggest there may be increased need for specialized noninvasive interventions to reduce symptoms of antenatal stress, depression, and gestational hypertension. Continuing to study and develop adequate, effective noninvasive treatment to address treatable conditions such as gestational hypertension and antenatal stress and depression is therefore feasible and imperative.

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Appendix A: Glossary of Acronyms Terms

Acronyms	Terms
17-OHP	17-Hydroxyprogesterone
ANS	Autonomic Nervous System
ASI	Adrenal Stress Index
BPNSE	Biological, Psychological, Natural- and Social-Environmental
CBSR	Coherence-Based Stress Resilience
DHEA/DHEAS	Dehydroepiandrosterone/Dehydroepiandrosterone Sulfate
DMBP	Diastolic Maternal Blood Pressure
EPDS	Edinburgh Postnatal Depression Scale
HPA	Hypothalamic-Pituitary-Adrenal
HRV	Heart Rate Variability
MBP	Maternal Blood Pressure
NCUP	Neuro-Cardio-Utero-Placental
PES	Pregnancy Experience Scale
sIgA	Secretory Immunoglobulin A
SMBP	Systolic Maternal Blood Pressure
WOC	Ways of Coping

Appendix B: Program Oversight and Data Use Agreement

March 05, 2016

Rollin McCraty, PhD
HeartMath Institute

Our volunteer researcher, Patrice Fortune, MA, MS, is involved in the coherence initiative which will be conducted under our organization's supervision within the scope of our standard operations. We understand that Patrice Fortune seeks to write about this initiative as part of a doctoral study for Walden University. To this end, we agree to share a de-identified dataset with the student for research purposes, as described below.

The Walden University Institutional Review Board (IRB) will be responsible for ensuring that the student's published study meets the university's ethical standards regarding data confidentiality (outlined below). All other aspects of the implementation and evaluation of the initiative are the responsibility of the student, within her role as our research volunteer.

The doctoral student will be given access to a Limited Data Set ("LDS") for use in the doctoral project according via the ethical standards outlined below.

This Data Use Agreement ("Agreement"), effective as of 03/12/16 ("Effective Date"), is entered into by and between Patrice Fortune, MA, MS ("Data Recipient") and HeartMath Institute ("Data Provider"). The purpose of this Agreement is to provide Data Recipient with access to a Limited Data Set ("LDS") for use in research **in accord with laws and regulations of the governing bodies associated with the Data Provider, Data Recipient, and Data Recipient's educational program.** In the case of a discrepancy among laws, the agreement shall follow whichever law is stricter.

1. *Definitions. Unless otherwise specified in this Agreement, all capitalized terms used in this Agreement not otherwise defined have the meaning established for purposes of the "HIPAA Regulations" codified at Title 45 parts 160 through 164 of the United States Code of Federal Regulations, as amended from time to time.*

2. *Preparation of the LDS. Data Provider shall prepare and furnish to Data Recipient a LDS in accord with any applicable HIPAA or FERPA Regulations*

3. *Data Fields in the LDS. No direct identifiers such as names may be included in the Limited Data Set (LDS). In preparing the LDS, Data Provider or shall include the data fields specified as follows, which are the minimum necessary to accomplish the research:*

   Pre training results

- ❖ Demographic Questionnaire: background and demographics information results.
  - ♦ sociodemographics, geodemographics, obstetrics physical health, and mental health parameters related to ANS and HRV, pregnancy experience, and associated lifestyle elements that cannot be separated

Pre- and posttraining results

- ❖ Edinburgh Postnatal Depression Scale: antenatal depression measure
- ❖ Pregnancy Experience Scale: antenatal stress experience measure
- ❖ Ways of Coping Questionnaire: positive cognitive reappraisal measure
- ❖ emWavePro: heart rate variability rhythm coherence ratio measure
- ❖ Systolic/Diastolic Maternal Blood Pressure: sphygmomanometer cuff measure
- ❖ Adrenal Stress Index Panel hormone values
  - ♦ Cortisol
  - ♦ DHEA/DHEA-S
  - ♦ 17-OHP
  - ♦ sIgA

4. *Responsibilities of Data Recipient. Data Recipient agrees to:*

   a. *Use or disclose the LDS only as permitted by this Agreement or as required by law;*

   b. *Use appropriate safeguards to prevent use or disclosure of the LDS other than as permitted by this Agreement or required by law;*

   c. *Report to Data Provider any use or disclosure of the LDS of which it becomes aware that is not permitted by this Agreement or required by law;*

   d. *Require any of its subcontractors or agents that receive or have access to the LDS to agree to the same restrictions and conditions on the use and/or disclosure of the LDS that apply to Data Recipient under this Agreement; and*

   e. *Not use the information in the LDS to identify or contact the individuals who are data subjects.*

5. *Permitted Uses and Disclosures of the LDS. Data Recipient may use and/or disclose the LDS for its research activities only.*

6. Term and Termination.

a. Term. The term of this Agreement shall commence as of the Effective Date and shall continue for so long as Data Recipient retains the LDS, unless sooner terminated as set forth in this Agreement.

b. Termination by Data Recipient. Data Recipient may terminate this agreement at any time by notifying the Data Provider and returning or destroying the LDS.

c. Termination by Data Provider. Data Provider may terminate this agreement at any time by providing thirty (30) days prior written notice to Data Recipient.

d. For Breach. Data Provider shall provide written notice to Data Recipient within ten (10) days of any determination that Data Recipient has breached a material term of this Agreement. Data Provider shall afford Data Recipient an opportunity to cure said alleged material breach upon mutually agreeable terms. Failure to agree on mutually agreeable terms for cure within thirty (30) days shall be grounds for the immediate termination of this Agreement by Data Provider.

e. Effect of Termination. Sections 1, 4, 5, 6(e) and 7 of this Agreement shall survive any termination of this Agreement under subsections c or d.

7. Miscellaneous.

a. Change in Law. The parties agree to negotiate in good faith to amend this Agreement to comport with changes in federal law that materially alter either or both parties' obligations under this Agreement. Provided however, that if the parties are unable to agree to mutually acceptable amendment(s) by the compliance date of the change in applicable law or regulations, either Party may terminate this Agreement as provided in section 6.

b. Construction of Terms. The terms of this Agreement shall be construed to give effect to applicable federal interpretative guidance regarding the HIPAA Regulations.

c. No Third Party Beneficiaries. Nothing in this Agreement shall confer upon any person other than the parties and their respective successors or assigns, any rights, remedies, obligations, or liabilities whatsoever.

d. Counterparts. This Agreement may be executed in one or more counterparts, each of which shall be deemed an original, but all of which together shall constitute one and the same instrument.

e. Headings. The headings and other captions in this Agreement are for convenience and reference only and shall not be used in interpreting, construing or enforcing any of the provisions of this Agreement.

IN WITNESS WHEREOF, each of the undersigned has caused this Agreement to be duly executed in its name and on its behalf.

DATA PROVIDER

Signed: 

Print Name: Rollin McCraty, PhD

Print Title: Vice President and Director of Research

DATA RECIPIENT

Print Name: Patrice Fortune, MA, MS

Print Title: Clinical Psychology Doctoral Candidate,
Walden University School of Psychology

Appendix C: Program Oversight and Data Use Agreement: Addendum

Inclusion Criteria Change

November 06, 2017

Rollin McCraty, PhD
HeartMath Institute

There has been an extreme level of natural disasters and tragic adverse effects on the HeartMath Nurse Providers and participant recruitment process. Following is recommendation and authorization for an inclusion criteria change to increase the data collection gestational phase from the current second trimester (13-weeks – 22-weeks) to also include the second and third trimesters (13-weeks – 36-weeks).

As a result of extensive recruitment efforts, there has been increased participant interest from pregnant women in their third trimester. Given the level of interest from women in their third trimester, combined with the level of loss throughout the study, expanded enrollment to include pregnant women in their second and third trimesters (13-weeks - 36-weeks) has been authorized.

IN WITNESS WHEREOF, each of the undersigned has caused this Agreement to be duly executed in its name and on its behalf.

DATA PROVIDER

Signed:

Print Name: Rollin McCraty, PhD

Print Title: Vice President and Director of Research

DATA RECIPIENT

Print Name: Patrice Fortune, MA, MS

Print Title: Clinical Psychology Doctoral Candidate,
Walden University School of Psychology

Appendix D: Demographic Questionnaire

This is a confidential, voluntary questionnaire and no identifiable information should be written on this form. Also, if there are any questions you do not want to answer, please skip to the next question.

Section 1: SOCIODEMOGRAPHICS

a) Age in years (*at 20 weeks gestation*): _____

b) Ethnicity (*please check one*):
☐ White ☐ Black ☐ American Indian
☐ Asian ☐ Pacific Islander ☐ Hispanic
☐ Other: _____

c) Language (*please check one*):
☐ English ☐ English, 2nd Language ☐ Other

d) Marital status (*please check one*):
☐ Single ☐ Married ☐ Widowed
☐ Divorced ☐ Separated

e) Education (*last grade completed*): _____

Section 2: GEODEMOGRAPHICS

a) Region of residence (*please check one*):
☐ North East ☐ South Central ☐ North West
☐ South Atlantic ☐ Mountain ☐ Pacific
☐ Midwest

b) Area of residence (*please check one*):
☐ Large City ☐ Rural Area ☐ Inner City
☐ Middle Sized City ☐ Uptown ☐ Suburb
☐ Small City ☐ Downtown

Section 3: PHYSICAL HEALTH

Current Pregnancy Experiences:

a) Gestational age (*please check one*):
☐ First Trimester ☐ Second Trimester ☐ Third Trimester
b) Gestational week: _____

Current Pregnancy Experiences (*cont.*):

c) *Current* obstetrics complications (*please check all that apply*)? ☐ Yes ☐ No
☐ Gestational Hypertension ☐ High Blood Pressure ☐ Severe Hypertension
☐ Heavy Proteinuria ☐ Preeclampsia ☐ Eclampsia
☐ Amniotic Fluid Anomaly ☐ Heart Disease

d) Current treatment for chronic medical condition? ☐ Yes ☐ No

e) Current medication (*other than prenatal vitamins*)? ☐ Yes ☐ No

Previous Pregnancy Experiences:

a) *Previous* obstetrics complications (*please check all that apply*)? ☐ Yes ☐ No
☐ Gestational Hypertension ☐ High Blood Pressure ☐ Severe Hypertension
☐ Heavy Proteinuria ☐ Preeclampsia ☐ Eclampsia
☐ Amniotic Fluid Anomaly ☐ Heart Disease

b) How many of the following events have you experienced during *prior* pregnancies?

please write the number that corresponds with each event					
	Number of Pregnancies		Twins		Multiples ≥ 3
	Full-Term ≥ 36 Weeks		Pre-Term < 36 Weeks		Live Births
	Induced Abortions		Spontaneous Abortions		Entopic

Section 5: MENTAL HEALTH

Current Mental Health Experiences:

a) Diagnosed with a psychiatric disorder? ☐ Yes ☐ No
b) Receiving psychological services? ☐ Yes ☐ No
c) Taking psychiatric medication? ☐ Yes ☐ No

Do you use any of the following (*Any Use*):

Substance	**Before Preg**	**During Preg**	**# of Years**
Coffee	☐ Yes ☐ No	☐ Yes ☐ No	
Tobacco	☐ Yes ☐ No	☐ Yes ☐ No	
Alcohol	☐ Yes ☐ No	☐ Yes ☐ No	
Illicit Drugs: (*Cocaine, Heroin, Hallucinogens, Marijuana, Phencyclidine-Hydrochloride (PCP), Other*)	☐ Yes ☐ No	☐ Yes ☐ No	

Appendix E: Data Collection Discrepancies Catastrophic Natural Disasters

Data collection discrepancies resulted from significant California natural disasters and calamitous national disasters. These catastrophic events had adverse maternal-fetal, provider, and recruitment effects.

Natural Disaster: California

Natural disasters forced 85,000 mandatory evacuations in 2016, threatened 270 structures, and burnt 669,534 acres. Fatal fire tornadoes killed six civilians, two firefighters and injured three (California Department of Forestry & Fire Protection, 2016). Oroville Dam broke in 2017, required 188,000 evacuations, and deployed 23,000 National Guardsman (France, Alvi, Dickson, Falvey, Rigbey, & Trojanowski, 2018). Firestorms in 2017 lead to 100,000 evacuations across eight counties. Firefighters (11,000) from 17 states and Australia fought raining embers and 60mph winds, costing 22 fatalities, 7,500 buildings, 1.2 million power outages, and burnt 36,810 acres. Another 90,000 evacuations with 10,000 international firefighters and 102mph winds cost 44 lives ranging from age 14 to 100-years-old, 192 injuries, 8,900 buildings, and burnt 245,000 acres.

Followed by 100,000 evacuations in 2018 when 5,596 firefighters from all Western Unites States fought the deadliest fires in California recorded history that killed 97 civilians, six firefighters, destroyed 19,336 buildings, and burnt 1,893,913 acres, including entire towns (Cal Fire, 2018). In 2019, unprecedented fires led to 200,000 evacuations, 5,000 firefighters deployed, 90,000 structures threatened, 374 destroyed buildings, and 77,758 acres burnt. Thousands were displaced and homeless six months to

a year after each fire. Emergency health warnings with 400-500+ air quality index disrupted broad regions and five international airport flight schedules with continuous power outages affecting millions (Cal Fire, 2018).

Catastrophic Disaster: National

Hurricanes of historic proportions ravaged traumatized communities across multiple states, causing school and work closures, widespread power outages, disruption of telecommunications, flooding, road closures, and displaced hundreds of thousands. Three back-to-back hurricanes in 2016 lead to a state of emergency that evacuated hundreds of thousands with 2,694 structures damaged and left 325,000 without power. Another 165mph hurricane with 2.5 million evacuated and 608 fatalities, nearly 1.5 million were without power (Beven, 2016).

Three hurricanes in 2017 caused additional deaths. The second-most intense tropical cyclone worldwide with 180mph winds forced the evacuation of 7 million people, 134 fatalities, 6.7 million without power, and 111,000 jobless. Another hurricane with 130mph winds, 107 deaths, 40,000 evacuations, 32,000 displaced, left one million homeless with 33,000 unemployed. Two years later, people remained adversely affected, trailed by another 2017 hurricane with 175mph winds and 4,600 fatalities. Three and a half million people were adversely affected by the hurricane caused blackouts from September 2017 through 2018; 62,000 remained without power (Cangialosi, 2017).

Two 2018 hurricanes with 150mph winds, 2,200 road closures, 54 fatalities, 890,000 power outages, and 1 million evacuated victims with 20,000 homeless. Torrential rains lead to 5,215 rescues, with 74,563 structures damaged and more than

100,374 adversely affected after two years. Another hurricane with 160mph winds, 1,300 road closures, 74 fatalities with 1 million evacuations, 10 million people affected, 1.2 million power outages, 27 trillion-gallon downpour, 8,15 rescues, 30,000 homes destroyed that took over 1.5 years to recover (Cangialosi, 2018).

Catastrophic Disaster Provider Affect

Fifty nurse providers agreed to enroll at least two clients each. Thirty-five of the 50 nurse providers planned to enroll 6 to 10 clients. The nurse providers alone estimated enrollment of at least 330 participants. Unexpectedly, beyond severe natural disasters, most of the nurse providers experienced extreme personal circumstances. When the provider experienced tragedy, displacement, and health system closures, their clients awaiting screening for the study could not proceed with participation (PwC Health Research Institute, 2018). Potential participants further experienced house fires, car accidents, unusual illnesses, sudden unexpected in-home deaths, and unexplained, unusual occurrences preventing participation.

The hurricane and wildfire natural disasters that battered the southern, midwest, and eastern states, and ravages the western states directly presented devastating consequences to health systems and essential operations (PwC, 2018). These physically damaging natural disasters destroy operations and displace healthcare providers and patients (research participants). Once the natural disaster event is over, the health systems experience downgrades and significantly reduced operations leading to lab test problems, labor and product shortages for the unforeseeable future, often with adverse consequences lasting years (PwC).

Catastrophic Disaster Maternal-Fetal Affect

Back-to-back fires, hurricanes, floods, earthquakes, and resulting trauma over three-year data collection prevented the majority of referrals from enrolling. After catastrophic disasters of such epic proportions, a common occurrence is to see a spike in births of antenatal women (Nour, 2011). Third trimester attrition in the study was minimal compared to enrollment-related disaster loss (Lau, 2018; Hughes & Trantham, 2011).

Catastrophic Disaster Recruitment Affect

Severe tragic events interfered with recruitment, resulting in a smaller than planned sample. Tragedy, natural disasters, and long-term displacement affect pregnant moms most (Nour, 2011). Expectant women are more vulnerable to reproduction problems during times of natural disasters (Nour, 2011). These catastrophic consequences contributed to a reduced sample size from an estimated $N = 330$ and desired $N = 68$ per power analysis. The experimental sample size was $n = 8$, control $n = 3$. Early birth controls pre-phase only $n = 2$, complete pre-phase and post-phase participation $N = 11$, thus 22 points of observation resultant of 410 points of data each participant for a total of 9,020 points of data. During a catastrophic disaster, pregnant women experienced increased early birth (17%) (Pourhosseini, Ardalan, & Mehrolhassani, 2015). Consequently, an antenatal population vulnerable to premature birth circumstances requires obstetrics healthcare by a medical physician (Hughes & Trantham, 2011; PWC Health Research, 2018). A cautious exploratory approach was used, given the small sample size.