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Fetal responses to induced maternal relaxation during pregnancy

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Abstract

Fetal responses to induced maternal relaxation during the 32nd week of pregnancy were recorded in 100 maternal–fetal pairs using a digitized data collection system. The 18-min guided imagery relaxation manipulation generated significant changes in maternal heart rate, skin conductance, respiration period, and respiratory sinus arrhythmia. Significant alterations in fetal neurobehavior were observed, including decreased fetal heart rate (FHR), increased FHR variability, suppression of fetal motor activity (FM), and increased FM–FHR coupling. Attribution of the two fetal cardiac responses to the guided imagery procedure itself, as opposed to simple rest or recumbency, is tempered by the observed pattern of response. Evaluation of correspondence between changes within individual maternal–fetal pairs revealed significant associations between maternal autonomic measures and fetal cardiac patterns, lower umbilical and uterine artery resistance and increased FHR variability, and declining salivary cortisol and FM activity. Potential mechanisms that may mediate the observed results are discussed.

Keywords: Pregnancy; Prenatal; Fetal development; Fetal heart rate; Fetal movement; Relaxation; Maternal stress; Autonomic nervous system; Respiratory sinus arrhythmia; HPA axis

> ‘‘When a pregnant woman falls, the baby in the womb answers’’ (West African proverb).

Literary and historical works are replete with descriptions of the impact of maternal perceptions, sensations and emotions on the fetus. There are no direct neural connections between mother and fetus, but maternal experiences generate a cascade of physiological and neurochemical consequences that may alter the intrauterine milieu either directly or indirectly and thereby generate a fetal response. Provocative reports of linkage between maternal stress and fetal heart rate and behavior have appeared in the academic literature since the 1930s (Sontag and Wallace, 1934). Anecdotal evidence reported since that time suggests temporary dysregulation of either fetal heart rate or behavior following a maternal fall (Hepper and Shahidullah, 1990), an earthquake (Ianniruberto and Tajani, 1981), and sounding of an air raid alarm during the Gulf War (Yoles et al., 1993).

Only a handful of studies measure fetal responses to experimental manipulation of maternal psychological state. Fetal tachycardia was observed in response to a variety of situations imposed on pregnant women, ranging from the mild (i.e., presentation of loud sounds) to more alarming (i.e., deceiving women that their fetuses were inadequately oxygenated) (Copher and Huber, 1967). The use of a less threatening stimulus to induce maternal arousal, a tape recording of a crying infant, has been associated with a decelerative fetal heart rate response in anxious, but not in non-anxious or depressed women (Benson et al., 1987). Three studies report fetal responses to maternal arousal induced by a common cognitive challenge that incurs a sympathetic response, the Stroop Color Word Test. These include increased variability in heart rate concomitant with suppression of motor activity (DiPietro et al., 2003) and increased fetal heart rate in fetuses of women with high trait anxiety or depression (Monk et al., 2000, 2004).

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To date, experimental research on the transmission of maternal state to the fetus has focused on stressful manipulations. This orientation is consistent with long-standing interest in more chronic effects of maternal psychological distress on untoward pregnancy outcomes (Paarlberg et al., 1995). As a result, pregnant women are often urged to relax more frequently. Research has begun to ascertain the efficacy of this admonition by examining whether prolonged stress reduction interventions, including yoga (Narendran et al., 2005), progressive relaxation (Janke, 1999), and massage (Field et al., 2004) help maximize pregnancy outcomes. Such therapeutic interventions reliably generate beneficial alterations to mood, anxiety, and depressive symptoms and there is modest support for a positive impact on gestational duration and/or birth weight (Janke, 1999; Narendran et al., 2005), as well as prenatal and perinatal complications (Field et al., 2004). A number of potential mechanisms for these findings have been proposed (Tiran and Chummun, 2004), and there is some empirical support for long-term mediation through alterations in neuroendocrine systems, including cortisol (Urizar et al., 2004) and catecholamines (Field et al., 2004).

However, these interventions have been implemented in advance of basic understanding of the immediate maternal and fetal effects that such activities generate. Only one report examines contemporaneous effects of an active relaxation protocol (i.e., guided imagery directed by a therapist) on physiological functioning in pregnant women; findings include reduced maternal heart rate and cortisol in response to the intervention (Teixeira et al., 2005). We have been unable to identify any study that has systematically examined how or whether maternal relaxation affects fetal functioning. The goal of the current research was to extend inquiry regarding the effects of maternal relaxation during pregnancy into the fetal domain. A number of maternal physiological indicators were included to confirm the efficacy of the experimental relaxation manipulation and provide information regarding source mechanisms. These include heart and respiratory rates, measures commonly used in studies to evaluate systemic relaxation responses. Both are influenced by non-neural and neural processes, as well as parasympathetic and sympathetic control. To better isolate sympathetic effects, electrodermal activity was also measured. Skin conductance reflects changes in conductivity of the skin mediated by eccrine glands which are singly innervated by the sympathetic branch of the nervous system (Venables, 1991). Activity in the hypothalamic–pituitary–adrenal (HPA) axis was assessed via salivary cortisol. In addition, blood flow in the uterine and umbilical vessels was inferred by measuring resistance in these arteries using Doppler technology. Decreased blood flow to the uterus can generate increased placental resistance to umbilical arterial flow and a stress on fetal cardiac function (Trudinger, 1994). Uterine artery resistance has been linked to factors that affect maternal peripheral blood flow, including anxiety (Sjostrom et al., 1997; Teixeira et al., 1999).

Ascertainment of fetal responsiveness to maternal relaxation was based on fetal heart rate, motor activity, and their interrelation. These measures of fetal functioning are typically referred to as neurobehaviors, develop in predictable ways over the course of gestation, and are widely regarded as indicators of the developing fetal nervous system (Hepper, 1995; James et al., 1995; Maeda et al., 2006; Nijhuis and ten Hof, 1999; Yoshizato et al., 1994). In particular, fetal heart rate variability is a well-known indicator of fetal well being (Parer, 1999), and the degree of coupling between brief acceleratory changes in fetal heart rate in response to motor activity provides an indicator of integration between neural circuits (Baser et al., 1992; DiPietro et al., 2006).

Induced maternal relaxation was expected to invoke maternal autonomic responses consistent with sympathetic withdrawal and/or parasympathetic activation, indicated by reduced maternal heart rate, slowed respiration, decreased skin conductance, and increased respiratory sinus arrhythmia, as well as transient HPA suppression ascertained through cortisol output, and decreased vascular resistance. Given the lack of available evidence relevant to fetal effects, our hypotheses were based on the converse of observations generated under acute or persistent conditions of maternal stress or arousal. As such, we expected that induced maternal relaxation would generate decreased fetal heart rate, increased fetal heart rate variability and fetal movement–fetal heart rate coupling, and increased fetal motor activity. In addition, we expected that variation in the magnitude of the maternal physiological responses would correspond to the magnitude of the fetal response within maternal–fetal pairs.

1. Methods

1.1. Participants

Eligibility was restricted to normotensive, non-smoking women with uncomplicated pregnancies at the time of enrollment carrying singleton fetuses. Accurate dating of the pregnancy was required and based on early first trimester pregnancy testing or examination and confirmed by ultrasound. A total of 100 self-referred pregnant women were enrolled. Participants continued to have generally healthy pregnancies; significant subsequent pregnancy complications were uncommon but included a range of conditions such as gestational diabetes ($n = 2$) and anemia ($n = 3$). Most participants (96%) delivered at term. Socio-demographic characteristics reflect a sample of mature, college-educated (M age = 31.1, S.D. = 4.8, range 21–43; M years education = 16.7 years, S.D. = 2.3, range 12–20), and married (91%) women. Mean maternal weight and height, collected by self-report, were 67.1 kg and 1.638 m, respectively. Most (81%) women were non-Hispanic white; the remainder was African-American (12%), Hispanic or Asian (7%). Forty-eight percent of the fetuses were female and this was the first child for 56% of the sample.

1.2. Design and procedure

The relaxation protocol took place during the 32nd week of gestation. Testing commenced at 13:30 and women were instructed to eat 1.5 h prior to the visit but not thereafter. Upon arrival, a brief ultrasound scan was administered to determine fetal position, collect Doppler blood flow data (see below), and provide photographs for parents. Maternal–fetal monitoring began once women were comfortably positioned in a semi-recumbent, left-lateral posture. Eighteen minutes of baseline, undisturbed data were collected, followed by an 18-min long guided imagery, progressive relaxation audio recording (‘‘Beach Summer Day’’, Suki Productions, Cincinnati, OH) delivered through headphones with lights dimmed. Progressive relaxation can involve either systematic tensing followed by relaxation of muscle groups or conscious release of tension without initial contraction. The latter approach was selected because it has been shown