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Physiological blunting during pregnancy extends to induced relaxation

Janet A. DiPietro[a,*], Tamar Mendelson[b], Erica L. Williams[a], Kathleen A. Costigan[c]

[a] Department of Population, Family & Reproductive Health, 615 N. Wolfe St, W1033, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD 21205, United States
[b] Department of Mental Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD 21205, United States
[c] Division of Maternal-Fetal Medicine, Department of Gynecology and Obstetrics, Johns Hopkins University School of Medicine, Baltimore, MD 21205, United States

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ABSTRACT

There is accumulating evidence that pregnancy is accompanied by hyporesponsivity to physical, cognitive, and psychological challenges. This study evaluates whether observed autonomic blunting extends to conditions designed to decrease arousal. Physiological and psychological responsivity to an 18-min guided imagery relaxation protocol in healthy pregnant women during the 32nd week of gestation ($n = 54$) and non-pregnant women ($n = 28$) was measured. Data collection included heart period (HP), respiratory sinus arrhythmia (RSA), tonic and phasic measures of skin conductance (SCL and NS-SCR), respiratory period (RP), and self-reported psychological relaxation. As expected, responses to the manipulation included increased HP, RSA, and RP and decreased SCL and NS-SCR, followed by post-manipulation recovery. However, responsivity was attenuated for all physiological measures except RP in pregnant women, despite no difference in self-reported psychological relaxation. Findings support non-specific blunting of physiological responsivity during pregnancy.

1. Introduction

Pregnancy is associated with dramatic physiological changes in virtually every major organ system. Cardiovascular adjustments alone include increased blood volume, heart rate, and cardiac output, decreased systemic vascular resistance, and decreased arterial pressure (Fu and Levine, 2009; Monga, 1999). Indicators of autonomic balance derived from measures of heart rate variability in both frequency and time domains change over the course of pregnancy. For example, a lower sympathetic to parasympathetic ratio, which reflects greater vagal input, has been reported in early pregnancy followed by reduced vagal activity coupled with enhanced sympathetic activation later in pregnancy (DiPietro et al., 2005; Ekholm and Erkkola, 1996; Kuo et al., 2000; Voss et al., 2000). Pregnancy is also accompanied by fundamental changes to other physiological systems, including the hypothalamic–pituitary–adrenal axis (HPA). In pregnancy, the well-known negative feedback loop between glucocorticoids and hypothalamic control of corticotrophin-releasing hormone (CRH) is modified by the positive feedback loop between glucocorticoids and placental CRH (Robinson et al., 1988). This unique alteration to normal physiology is accompanied by a substantial increase in cortisol as gestation advances (Mastorakos and Ilias, 2003).

A number of studies have reported that, in addition to the dynamic changes in the physiological milieu, pregnancy is associated with blunting of responsiveness to physical and psychological challenges. A fairly extensive body of research has relied on well known cardiovascular reflex maneuvers, such as attempted forced exhalation against a closed airway (i.e., Valsalva maneuver), changes in posture, and isometric exercise (e.g., hand grip). This literature has documented diminished heart rate, heart rate variability, and catecholamine responses to these challenges during pregnancy (Barron et al., 1986; Ekholm et al., 1993; Matthews and Rodin, 1992). Pregnancy is further associated with a blunted renin response to thermal stress (Vaha-Eskeli et al., 1992) coupled with attenuated pain perception (Saisto et al., 2001) and failure to mount a cortisol response (Kammerer et al., 2002) to cold pressor tests.

In contrast to the extensive literature on physical challenges, few studies evaluate the effects of pregnancy on modulating responses to cognitive or psychological challenges using direct comparisons to non-pregnant samples. In one such study, pregnant women displayed reduced diastolic responsivity to mental arithmetic and mirror image tracing tasks, but not differential heart rate responsiveness, at 21–23 weeks gestation (Matthews and Rodin, 1992). In contrast, pregnant women showed significantly blunted heart rate and electrodermal (i.e., sympathetic) reactivity and recovery responses to administration of the Stroop Color Word test at both 24 and 36 weeks gestation (DiPietro et al., 2005). A more recent study did not find significant differences in

* Corresponding author at: Tel.: +1 410 955 8536; fax: +1 410 614 7871.
E-mail address: jdipietr@jhsph.edu (J.A. DiPietro).

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the responsiveness of non-pregnant and pregnant participants (at either 13–18 weeks or 26–31 weeks gestation) to the Trier Social Stress Test (TSST) in either heart rate or variability (Klinkenberg et al., 2009). Analysis of neuroendocrine responses of participants in the same study revealed attenuated salivary α-amylase responses, a primarily sympathetic derivative, to the TSST in pregnant women at both gestational periods. There was no difference in cortisol reactivity between pregnant and non-pregnant participants, although there was diminished (i.e., prolonged) cortisol recovery to the experimentally induced surge in pregnant women at the earlier gestational age (Nierop et al., 2006).

In summary, there is compelling evidence that pregnancy is associated with blunted responsivity to autonomic maneuvers that manipulate the cardiovascular system, and to a lesser extent, pain perception related to thermal challenges. Parallel data are generally supportive but less extensive regarding cognitive or psychological laboratory challenges. Evidence for attenuation of responsivity to laboratory challenges as pregnancy progresses in studies that include only pregnant women (e.g., DiPietro et al., 2005; Entringer et al., 2010; Glynn et al., 2004; Nierop et al., 2006) also provides support for this concept. Together, this research is typically interpreted as supporting the position that the physiological milieu of pregnancy confers stress-buffering effects on the developing fetus, and as such, is protective against potentially deleterious effects of maternal stress (deWeerth and Buitelaar, 2005; Glynn, 2010a). Similar hypotheses have been offered to reconcile observed reductions in fearful behavior in other species (e.g., Vierin and Bouissou, 2001).

However, it is equally possible that these observations reveal an overall dampening of maternal physiological lability to all experiences, both positive and negative, thereby promoting a condition of measured physiological homeostasis for the fetus. To the extent that pregnancy is characterized by a dampening of autonomic responsivity in general, one might expect attenuation of autonomic responses to laboratory-based cognitive or psychological challenges designed to increase physiological arousal (i.e., Stroop Color Word test or the TSST), and to manipulations designed to decrease arousal (i.e., progressive relaxation) since both result in changes to the intrauterine milieu. If, however, physiological blunting is observed in response to manipulations that heighten arousal due to their potential downstream effects on the fetus such as decreased blood flow, it is possible that pregnant women might show an enhanced response to conditions that facilitate the types of maternal physiological alterations that may be of benefit to the fetus. Relaxation techniques may fall into this category.

The relaxation response is generally regarded as the antithesis of the stress response (Jacobs, 2001). Relaxation techniques including guided imagery, meditation, and yoga have been found to reduce psychological distress while decreasing sympathetic and increasing parasympathetic activity in non-pregnant populations (Tang et al., 2009; Vempati and Telles, 2002). Several manipulations designed to induce relaxation in laboratory settings have been shown to be effective at garnering expected cardiovascular system changes in pregnant women including reductions in heart rate and/or blood pressure (Teixeira et al., 2005; Urech et al., 2010), alterations to both low and high frequency bands within heart rate variability (Satyapriya et al., 2009), and reducing resistance in the umbilical artery (DiPietro et al., 2008). Reductions in cortisol, ACTH, norepinerphine, and noradrenaline have also been observed, although it is more difficult to ascribe these to the relaxation manipulation itself as opposed to simple rest (DiPietro et al., 2008; Teixeira et al., 2005; Urech et al., 2010).

To our knowledge, no study has compared the relaxation response in pregnant and non-pregnant women. Doing so has practical implications for both the design of relaxation interventions for pregnant women as well as an explicit evaluation of the stress buffering hypothesis. This study assessed responsivity to a guided imagery relaxation protocol in healthy nulliparous women and non-pregnant women of similar age. The measures selected for study include heart rate, the most commonly used cardiovascular indicator in prior studies. As heart rate is governed by multiple autonomic influences and non-neural factors, it is fairly non-specific; for this reason, we also included respiratory sinus arrhythmia (RSA), a well-known indicator of parasympathetic activation that corresponds primarily to vagal input to the heart (Berntson et al., 1993). In addition, electrodermal activity data were collected, measured as changes in skin conductance (SC) mediated by eccrine glands which are uniquely innervated by sympathetic processes (Venables, 1991). Intervals between breaths were quantified to provide both peak to trough fluctuations for RSA quantification and to ascertain maternal compliance to the relaxation task demands. We anticipated that both pregnant and non-pregnant women would display a relaxation response consistent with enhanced parasympathetic (i.e., RSA) and reduced sympathetic activity (i.e., SC) but that the relaxation response of pregnant women would be attenuated.

2. Method

2.1. Participants

Pregnant participants ($n = 54$) were comprised of the nulliparous women for whom adequate autonomic data had been collected out of a larger sample of 100 self-referred pregnant women described elsewhere (DiPietro et al., 2008). Eligibility was restricted to normotensive, non-smoking women with uncomplicated pregnancies at the time of enrollment carrying singleton fetuses. The comparison group consisted of 28 non-pregnant, healthy women volunteers with no previous pregnancies and who were non-smokers. Pregnant and non-pregnant participants did not differ from one another in terms of age (M age = 29.8 versus 28.6; $t(80) = 1.29$, ns) or education (M years education = 16.8 versus 17.5; $t(80) = -1.49$, ns). Most women in the pregnant and non-pregnant groups were non-Hispanic white (81.5% and 64.3% respectively); the remaining participants were African-American (11.1% and 7.2%) and of Asian or Indian descent (7.4% and 28.5%). The study was approved by the University's Institutional Review Board and all women provided written informed consent prior to participating.

Note that the pregnant group in this study comprises a subsample (nulliparous only) of a larger study and a prior report focused on the effects of maternal relaxation on the neurobehavioral functioning of the fetus (DiPietro et al., 2008). That report presented maternal relaxation data for the entire group (nulliparous and multiparous) but was focused principally on affirming that the manipulation was effective in generating a maternal physiological response in order to evaluate whether there was a resultant fetal response.

2.2. Design and procedure

Data were collected at a standardized time in early afternoon (13:30). Pregnant participants were recorded during the 32nd week of gestation, as determined by first trimester ultrasound and clinical confirmation. Non-pregnant women were tested in the follicular stage of their menstrual cycle, consistent with procedures by others (e.g., Nierop et al., 2006), to partially control for stability in estrogen and progesterone levels. Women were instrumented and 18 min of baseline, undisturbed data were collected, followed by an 18-min guided imagery, progressive relaxation audio recording ("Beach Summer Day," Suki Productions, Cincinnati, OH) delivered through headphones with lights dimmed. Instructions guided women through imagery designed to release tension and foster a relaxed state. Women were monitored in reclined position on a hospital bed with head elevation; pregnant women were shifted slightly to their sides to avoid compression of the vena cava. After the relaxation interval, the lights were switched on, and women evaluated the experience. An additional 18-min post-relaxation recovery period followed during which time women rested silently.

Physiological measures: Continuous physiological signals were amplified using a multi-channel, electrically isolated, bioamplifier (Model JAD-04; James Long Company, Caroga Lake, NY). Data were digitized on a personal computer at 1000 Hz via an external analog to digital board using Snapstream data acquisition system (HEM Data Corporation, Southfield, MI). Electrocardiogram was recorded from three carbon fiber disposable electrodes in triangulated placement (right mid sub-clavicle, left mid-axillary thorax, and upper left thigh for ground lead). Electrodermal activity was monitored from two silver-silver chloride electrodes with a gelled skin contact area placed on the distal phalanxes of the index and second fingers of the non-dominant hand. Electrodes were affixed with adhesive collars to limit gel contact to a 1 cm diameter circle and secured with Velcro. Respiration was measured from a bellows apparatus stretched across the ribcage below the breasts.