Archives of Psychiatric Nursing 33 (2019) 46–50

Contents lists available at ScienceDirect

Archives of Psychiatric Nursing

journal homepage: www.elsevier.com/locate/apnu

Identifying psychophysiological stress targets for the promotion of mental health in pregnant women

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While many pregnancies are a joyous time, pregnancy may also be an emotionally taxing phase of life that is riddled with competing demands such as physical adaptations, role change, and financial strain (Baffour, Gourdine, Domingo, & Boone, 2009; DiPietro, Ghera, Costigan, & Hawkins, 2004; DiPietro, Goldshore, Kivlighan, Pater, & Costigan, 2015). Consequently, these stressors coupled with hormonal changes and even preexisting mental health conditions (e.g. anxiety) may develop into a chronic mental health issue (e.g. depression) that may afflict the pregnant woman for the rest of her life (Field et al., 2010; Williams et al., 2015). In fact, comorbid stress and depression affects 10–25% of pregnant women (Accortt, Cheadle, & Schetter, 2015) and is predictive of postnatal health and social behavior (e.g. postpartum depression) (Liu & Tronick, 2013; Qobadi, Collier, & Zhang, 2016; Salm Ward, Kanu, & Robb, 2017).

In addition, stress experienced in pregnancy is known to influence placental structure and blood flow which impacts fetal development (Mueller & Bale, 2008; Phelan, DiBenedetto, Paul, Zhu, & Kjerulff, 2015; Welberg, Seckl, & Holmes, 2001). Constriction of blood flow is mediated by alterations in heart rate or heart rate variability (HRV) (Nagel et al., 2012; Sherman et al., 2002). Alternatively, HRV is a stress biomarker that has been validated in several populations (Evans et al., 2013;Liew, Seera, Loo, Lim, & Kubota, 2016; Zauszniewski, Musil, & Variath, 2015) and evidence as a stress biomarker for pregnant women is developing (Braeken et al., 2015; Klinkenberg et al., 2009; Muthukrishnan, Jain, Kohli, & Batra, 2016' Satyapriya, Nagendra, Nagarathna, & Padmalatha, 2009).

In order to understand the unique stresses of pregnancy, one must also understand the coping styles and strategies that may be beneficial in mitigating the stress of pregnant women. Therefore, in this study, resourcefulness is employed as a coping repertoire of personal (self-help) and social (help-seeking) skills that are complementary to one another (Zauszniewski, 2006). A body of literature on resourcefulness indicates that a highly resourceful person exhibits overall better mental health (Zauszniewski, 2016; Zauszniewski, Au, & Musil, 2012; Zauszniewski, Bekhet, Lai, McDonald, & Musil, 2007) and highly resourceful people are able to use their toolkit of life lessons and skills to navigate difficult situations (Zauszniewski, 2006). Additionally, resourcefulness skills can be formally taught through the established intervention Resourcefulness Training (RT) (Zauszniewski, Eggenschwiler, Preechawong, Roberts, & Morris, 2006).

Emerging evidence implicates psychological stress and physiological stress (i.e. HRV) as contributing factors to adverse birth outcomes however, evidence is still lacking in the role of psychophysiological stress on the mental health of pregnant women. Therefore, the aims of this study are (1) to examine the relationship between psychophysiological stressors (perceived stress, pregnancy-specific stress, HRV) and maternal mental health (depressive symptoms, resourcefulness); (2) to determine the combined effects of psychophysiological stress on maternal mental health.

Methods

Design and Sample

A cross-sectional design with a convenience sample of 82 pregnant women was used to examine associations among psychophysiological stressors and maternal mental health. The study was approved by the University Hospitals Case Medical Center Institutional Review Board. Participants were recruited using a variety of methods. Participants were recruited from traditional antenatal care courses and flyers were distributed to several community locations in which pregnant women may frequent such as grocery stores, libraries, community stores, daycares, etc. The flyer was also posted electronically on Facebook. The flyer was shared by several birthing organizations on Facebook. The Principal Investigator also attended several community birthing events in Cleveland, OH that were aimed at providing expectant mothers with available community resources. Data were collected at one time point during the participant's second or third trimester in a private venue.

To be included in this study, participants had to be in their second (13–27 weeks) or third (28–40 weeks) trimester. Some of the most drastic cardiovascular changes occur in the first trimester; therefore, this gestational range was chosen in an attempt to control for known HRV changes that occur during this time period (Khlybova, Tsirkin, Dvoryanskii, Makarova, & Trukhin, 2008; Sanghavi & Rutherford, 2014). Additionally, participants had to be at least 18 years old and able to speak and understand English to be eligible for the study. Individuals were excluded if they self-identified as a substance user (cigarettes, alcohol, illegal or recreational drugs) or if they disclosed any of the

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https://doi.org/10.1016/j.apnu.2018.10.003
Received 11 July 2018; Received in revised form 18 September 2018; Accepted 3 October 2018

following: previous or current treatment or diagnosis of depression, history of or current gestational diabetes, and current treatment for a respiratory condition (i.e. bronchodilator). Additionally, potential participants were screened for hypertension and would be excluded from the study if their systolic blood pressure was > 140 mmHG. All aforementioned exclusion criteria were chosen based on a review of the literature on the known factors that influence HRV.

The following variables were monitored and controlled for in this study: respiratory rate, caffeine and food consumption, and time of day. Respiratory rate was recorded and controlled for in this study because HRV fluctuates with respiration and heart rate (Voss et al., 2000). For example, upon inspiration, heart rate increases and HRV decreases (Appelhans & Luecken, 2006). Also, participants who ingest caffeine (i.e. coffee, energy drinks, soda) are more likely to exhibit attenuated HRV compared to individuals who did not ingest caffeine (Koenig et al., 2013). Therefore, the present study collected data on the type of caffeine ingested, how much caffeine ingested, and the time the caffeine was ingested in order to account for the potential effect of caffeine on HRV. Additionally, food consumption is a potential factor that influences individual's HRV (Sauder, Johnston, Skulas-Ray, Campbell, & West, 2012).In order to account for the potential effects of food on HRV, the research participants were asked to record the last time they ate and the content of the meal. Finally, HRV is a diurnal measure meaning that HRV has predictable changes that correspond with the time of day. Typically adult HRV slowly increases in the morning and peaks in the afternoon (Armstrong, Kenny, Green, & Seely, 2011). Therefore, the time of the day that the participant undergoes HRV measurement was recorded in the present study.

Variables and measures

Self-report measures were collected at one time point during the participant's second or third trimester. During these interviews, participants used a tablet computer with all study measures displayed in a survey format. Study data were collected and managed using REDCap electronic data capture tools (Harris et al., 2009).

Heart rate variability (HRV) was measured and recorded using the Biopac MP150. The Biopac MP150 is a noninvasive, portable electrocardiogram (ECG) that can be easily used in the outpatient setting. The Biopac MP150 can measure a variety of cardiac parameters, however this study employed the standard deviation of R-to-R intervals (SDNN). The SDNN is the gold standard measure of HRV because it is a time-dependent measure that is reproducible and has small variations according to the level of stress (Nunan, Sandercock, & Brodie, 2010). The Principal Investigator was trained in using the Biopac MP150 equipment and software before data collection. Participants were asked to rest for 5 min prior to HRV measurement. Participants were then asked to sit down in a chair with their legs uncrossed per the recommendation of previous literature (D'Silva, Davies, Emery, & Lewis, 2014). Participants were instructed to breathe normally and refrain from speaking during the five minute HRV measurement.

Perceived stress was measured using the Perceived Stress Scale developed by Cohen, Kamarck, and Mermelstein (1983). The Perceived Stress Scale contains 10 items that measure the degree to which situations in the participant's life are appraised as stressful (Cohen et al., 1983). Individuals rate each item on a 5-point scale. A 0 indicates that participant never appraises the situation as stressful and a 4 indicates that the participant very often appraises the situation as stressful. Scores range from 0 to 56, with higher scores indicating greater perceived stress. The Cronbach's α for the Perceived Stress Scale ranges from 0.84 to 0.87 (Cohen et al., 1983).

Pregnancy-specific stress was measured using the Revised Prenatal Distress Questionnaire (Lobel et al., 2008). The Revised Prenatal Distress Questionnaire contains 17 items that measure the degree to which an individual perceives stress that is due to being pregnant (Lobel et al., 2008). Individuals rate each item on a 3-point scale. A score of 0 indicates the individual rates the situation to not at all be stressful. A score of 3 indicates that the individual rates the situation as not at all stressful. Scores range from 0 to 34 with higher scores indicating a higher degree of pregnancy-specific stress. The Cronbach's α for the Revised Prenatal Distress Questionnaire ranges from 0.80 to 0.81 (Lobel et al., 2008).

Depressive symptoms were measured using the Centers for Epidemiological Studies Depression Scale-Revised (CESD-R) (Radloff, 1977). The CESD-R consists of 20-items. Participants rate each item on a 5-point scale. A rating of 5 indicates the participant identifies with the stem provided “nearly every day for two weeks” and a 0 indicates that the participant identifies with the stem provided “not at all or less than one day last week”. Scores range from 0 to 60 with higher scores indicating a higher frequency of depressive symptoms (Radloff, 1977). The Cronbach's α for the CESD-R ranges from 0.88–0.91 (Radloff, 1977).

Resourcefulness was measured using the Resourcefulness Scale (Zauszniewski, Lai, & Tithiphontumrong, 2006). The Resourcefulness Scale consists of two subscales; personal and social resourcefulness. There are 16 personal (self-help) resourcefulness items and 12 social (help-seeking) resourcefulness items. The Resourcefulness Scale consists of 28 items that describe behaviors that are considered resourceful and not resourceful. Participants rate each item according to the degree to which each particular items describes their behavior on a 6-point scale ranging from 0 to 5. A rating of 0 indicates the participant does not feel the stem is describing them. A rating of 5 indicates the participant feels the stem is extremely descriptive of them. Total scores range from 0 to 140 with higher scores indicating a higher level of resourcefulness (Zauszniewski, Eggenschwiler, et al., 2006). The Cronbach's α for the Resourcefulness Scale is 0.83 (Zauszniewski, Eggenschwiler, et al., 2006).

Data analysis

Two types of statistical tests were used to gain better understanding of how psychophysiological stress contributes to mental health in pregnant women. Pearson correlations were used to examine the relationships between psychophysiological stressors (perceived stress, pregnancy-specific stress, HRV) and maternal mental health (depressive symptoms and resourcefulness) and two multiple linear regressions were run to determine how psychophysiological stressors impact maternal mental health. Furthermore, the following variables were measured and controlled for statistically in this study: respiratory rate, caffeine and food consumption, time of day, and body mass index.

Results

Sample characteristics

The ages of the participants ranged from 18 to 41 years old with the average age of 30 years (M = 30.15, SD = 4.73); participants ranged in gestational age from 13 to 39 weeks with an average gestational age of 26 weeks (M = 25.5, SD = 6.81). The sample was comprised of 80.5% Caucasian (n = 66) and 19.5% other races (i.e. African American, Asian, Hispanic) (n = 16). The sample was well educated as 8.5% (n = 7) completed high school or less, 17.1% (n = 14) completed some college or trade school, 6.1% (n = 5) completed an Associate's degree, 29.3% (n = 24) completed a Bachelor's degree, 28% (n = 23) completed a Master's degree, and 11% (n = 9) completed a Doctorate degree. Most of the sample (68.3%, n = 56) were middle to upper class ranging in total household income from $60,001 to over $100,000 and the majority of the sample were employed (79.3%, n = 65), married (81.7%, n = 67),and had other children (64.6% n = 53). Table 1 displays the sample characteristics.

Table 1
Sample characteristics ($N = 82$).

Characteristics	N	%
Age		
18–21	4	4.9
22–26	14	17.1
27–31	31	37.8
32–36	26	31.7
37–41	7	8.5
Gestational age		
13–17	12	14.6
18–23	23	28.0
24–29	20	24.4
30–35	17	20.7
36–40	10	12.3
Race		
Caucasian	66	80.5
African American	13	15.9
Hispanic	2	2.4
Middle Eastern	1	1.2
Education		
High school or Less	7	8.5
Some college/Trade	14	17.1
Associate's degree	5	6.1
Bachelor's degree	24	29.3
Master's degree	23	28
Doctoral degree	9	11
Total household income		
Less than $20,000	9	11
$20–40,000	9	11
$40,001–60,000	8	9.8
$60,001–80,000	8	9.8
$80,001–100,000	13	15.9
$100,001 or more	35	42.7
Employed		
Yes	65	79.3
No	17	20.7
Marital status		
Single (never married)	14	17.1
Married	67	81.7
Separated	1	1.2
Other children		
Yes	53	64.6
No	29	35.4

Associations between psychophysiological stressors and maternal mental health

Pearson correlations (r) were examined to determine the strength, magnitude and direction of the relationships between psychophysiological stress and maternal mental health. Perceived stress was inversely correlated with resourcefulness ($r = -0.567, p < .001$), and positively correlated with depressive symptoms ($r = 0.780$. $p < .001$). Pregnancy-specific stress was inversely correlated with resourcefulness ($r = -0.304$, $p < .001$) and positively correlated with depressive symptoms ($r = 0.530$, $p < .001$). No significant correlations were detected between HRV (i.e. SDNN) and resourcefulness ($r = -0.040$, $p = .721$) nor depressive symptoms ($r = 0.133$, $p = .234$). Table 2 depicts the correlations between psychophysiological stress and maternal mental health.

Table 2
Correlation matrix among psychophysiological stress and maternal mental health ($N = 82$).

Variables	HRV	Pregnancy-specific stress	Perceived stress
Resourcefulness	−0.040	−0.304***	−0.567***
Depressive Symptoms	0.133	0.530***	0.780***

*$p \leq .05$.
**$p \leq .01$.
***$p \leq .001$.

Table 3
Predictors of Resourcefulness ($N = 82$).

Variables	β coefficient unstandardized	SE	β coefficient standardized
Perceived stress	−1.229	0.240	−0.575***
Pregnancy-specific stress	0.046	0.342	0.015
HRV	−0.002	0.023	−0.006

*$p \leq .05$.
**$p \leq .01$.
***$p \leq .001$.

Effects of psychophysiological stressors on maternal mental health

The second research question aimed to determine the effects of psychophysiological stressors on maternal mental health. Multiple linear regression was used to determine if psychophysiological stress predicts resourcefulness and depressive symptoms in pregnant women. In the first model, perceived stress, pregnancy-specific stress, and HRV predicted 32.2% of the variance in resourcefulness, $R^2 = 0.322$, F (3, 78) = 12.33, $p < .001$ (adjusted $R^2 = 0.296$). The only significant predictor of resourcefulness was perceived stress (Std. Beta = −0.575, $p < .001$). Table 3 summarizes the findings.

The second linear regression aimed to determine if HRV, perceived stress, and pregnancy-specific stress predicted depressive symptoms. This model accounted for 68.3% of the variance in depressive symptoms, $R^2 = 0.683$, F (3, 78) = 56.0, $p < .001$ (adjusted $R^2 = 0.671$). Significant predictors of depressive symptoms were perceived stress (Std. Beta = 0.726, $p < .001$) and pregnancy-specific stress (Std. Beta = 0.169, $p < .05$). Table 4 summarizes the findings.

Discussion

This descriptive correlational study is foundational research that provides insight into the relationships and effects among psychophysiological stress and maternal mental health in a sample of pregnant women. The findings from this study indicate that that perceived stress and pregnancy-specific stress are inversely correlated with resourcefulness. This supports the literature which convenes that individuals who exhibit greater resourcefulness are less stressed and are more able to cope with stress in a more effective manner (Huang & Guo, 2009; Zauszniewski, Lekhak, Yolpant, & Morris, 2015; Zauszniewski & Musil, 2014). There is a very small body of literature on resourcefulness in pregnant women with the majority of studies conducted only in Asia. For example, Chinese researchers found that learned resourcefulness and stress appear to correlate significantly across the perinatal period, meaning that the relationship between learned resourcefulness and stress is sustained over time (Ngai & Chan, 2012). In addition, increased stress during pregnancy negatively correlates with maternal role competence (Ngai, Chan, & Ip, 2009), and pregnant women with greater learned resourcefulness also experience greater maternal role satisfaction, (Ngai et al., 2009).

Table 4
Predictors of depressive symptoms ($N = 82$).

Variables	β coefficient unstandardized	SE	β coefficient standardized
Perceived stress	0.029	0.003	0.726***
Pregnancy-specific stress	0.338	0.147	0.16***
HRV	0.005	0.010	0.030

*$p \leq .05$.
**$p \leq .01$.
***$p \leq .001$.

In this study, psychophysiological stressors are predictors of resourcefulness. While this was a significant model ($p < .001$), only 32.2% of the variance was explained, meaning there are potentially several other predictors of pregnant women's resourcefulness. Other variables from the literature such as negative emotions (Zauszniewski, Tsay-Yi, & Musil, 2013), positive cognitions, or daily hassles (Zauszniewski, Fulton Picot, Roberts, Debanne, & Wykle, 2005) are significant predictors of resourcefulness in caregivers (Zauszniewski et al., 2013) and African American women (Zauszniewski et al., 2005), respectively. Because negative emotions, positive cognitions, and daily hassles are significant predictors in other female populations, researchers in the future may elect to include these variables as predictors of resourcefulness in pregnant women to account for additional variance.

Furthermore, the only significant predictor of resourcefulness in this sample of pregnant women was perceived stress (std. beta = −0.575, $p < .001$). This is not surprising as perceived stress was a highly significant predictor of resourcefulness in Taiwanese adolescents (Huang & Guo, 2009), school-aged children (Grace Suk Man & Xuesong, 2010), women dementia caregiver (Zauszniewski, Lekhak, et al., 2015), and grandmothers raising grandchildren (Zauszniewski et al., 2012). While HRV and pregnancy-specific stress were not significant predictors of resourcefulness in this sample of pregnant women, this was the first study to examine such a relationship and future research is warranted.

There were also significant relationships between depressive symptoms and perceived stress and pregnancy-specific stress. According to the literature, stress and depressive symptoms in pregnancy are closely intertwined. The most common stressors that lead to depressive symptoms in pregnancy include: a young age, intimate partner violence, illicit drug, and alcohol use during pregnancy, reproductive history, social support, and food insecurity (Molina & Kiely, 2011; Sidebottom, Hellderstedt, Harrison, & Hennrikus, 2014). Conversely, excitement about the pregnancy, social support, and the ability to regulate mood was associated with decreased depressive symptoms (Molina & Kiely, 2011). The second linear regression in this study tested psychophysiological stress as predictors of depressive symptoms. Like the model for resourcefulness, this model predicting depressive symptoms was also significant ($p < .001$) and accounted for 68.3% of the variance. In this model, perceived stress and pregnancy-specific stress were significant predictors and perceived stress (std. beta = 0.726) was a better predictor than pregnancy-specific stress (std. beta = 0.169).

Results of this study indicate that there were no significant relationships detected between the measure of HRV, SDNN, and resourcefulness nor depressive symptoms. This finding contradicts the wide and varied body of literature that depicts an inverse relationship between HRV and depressive symptoms. However, research regarding relationships between HRV and depressive symptoms in pregnant women is minimal. For example, Shea et al. (2008) provided substantiation that HRV is related to depressive symptoms because women with depressive symptoms had lower 24-hour ambulatory HRV than women without depressive symptoms. It remains possible that measurement error accounts for the lack of significance in this model. For example, several measurements in the literature have operationalized depressive symptoms differently (e.g. Personal Health Questionnaire or the Beck Depression Inventory). Furthermore, it remains possible that the HRV parameter used in this study (SDNN) is not the most sensitive or best physiological predictor of depressive symptoms in pregnant women. Researchers in the future may elect to test a battery of other HRV parameters such as RMSSD or any of the frequency domain indices (e.g. HF, LF, HF: LF).

Again, the findings described here are foundational descriptive data on the relationships between psychophysiological stress and maternal mental health. A major strength of the study was the incorporation of the stress biomarker, HRV. Adding HRV as a stress measure in this study was novel because HRV is a visual representation of an individual's real-time stress level and HRV as a stress biomarker in pregnancy is relatively unexplored. There are several HRV parameters to choose from depending on what the investigator desires to measure (e.g. sympathetic or parasympathetic nervous system). The Principal Investigator opted to only use the SDNN HRV parameter, a time-dependent measure that has been well validated as a stress biomarker in other populations. While HRV was largely insignificant in this study as both a correlate and predictor of maternal mental health, future exploration is warranted to determine if this finding is valid with the use of other HRV parameters. Researchers in the future may benefit from asking participants prior to HRV measurement if they experienced any stressors that day such as running late for an appointment, disagreement with partner, etc. because these acute stressors may impact the HRV measurement as well.

The present study only elected to examine mental health in the context of stress perception, depressive symptoms, and resourcefulness. In the future, researchers may elect to examine other mental health phenomena such as anxiety or PTSD in relation to HRV. An additional limitation of the study was the cross-sectional design, which did not allow the researcher to examine change in variables over time. Furthermore, the study sample was primarily comprised of Caucasian, wealthy, well-educated women. Therefore, the results of this study may not be generalizable to other pregnant women.

Despite the study's limitations, the findings provide strong evidence for relationships and effects of psychological stress (perceived stress, pregnancy-specific stress) on maternal mental health (resourcefulness, depressive symptoms) in pregnant women that support intervention development and implementation. While HRV was not a significant correlate nor predictor of maternal mental health, we strongly suggest that researchers in the future opt to use a battery of HRV parameters to better elucidate the true relationship and impact of physiological stress on the mental health of pregnant women.

Conflict of interest

Kayla Herbell, PhD, RN declares that he/she has no conflict of interest.

Acknowledgment

I would like to thank my dissertation committee for their support on this project: Dr. Jaclene A. Zauszniewski, Dr. Susan Ludington, Dr. Chris Burant, Dr. Mary Quinn Griffin, and Dr. Arin Connell.

Funding

This study was funded by the International Society of Psychiatric Mental Health Nurses and the Foundation for Education and Research in Biofeedback and Related Sciences.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study.

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