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Babywearing's Influence on Parent and Infant Heart Rates

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BABYWEARING'S INFLUENCE ON PARENT AND INFANT HEART RATES

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ABSTRACT

Babywearing is the practice of carrying an infant in a baby carrier close to the body. It provides an environment that allows the bodies of the parent and infant to be close together. The closeness of parent and infant improves the well-being and coregulation of the parent and infant, which could be estimated with heart rate (HR). Few studies have examined mother-infant dyads, but even fewer have examined father-infant dyads. This study examined mother-infant and father-infant dyads, especially for infants with neonatal abstinence syndrome (NAS). The significance of studying babywearing in this vulnerable population is that if babywearing is associated with a decrease in HR, it would indicate a possible decrease in distress among infants with NAS. Babywearing would benefit the infant and possibly the parent through autonomic coregulation, improving their well-being.

Autonomic coregulation occurs when the parent and infant coregulate through their behaviors (e.g., emotional communication), influencing the autonomic nervous system. Per the Calming Cycle Theory, autonomic coregulation and emotional connection are influenced by emotional communication between the parent and infant (e.g., eye contact, listening, vocalization, or facial expressiveness). Babywearing facilitates emotional communication by providing an environment where the parent's and infant's bodies are near each other. This nearness allows the infant and parent to respond readily to each other's emotional cues. Insight into autonomic coregulation can be seen through heart rate, as the autonomic nervous system controls the heartbeats from the sinoatrial node. Therefore, babywearing may improve autonomic coregulation and emotional connection simultaneously because it provides a condition that facilitates the behaviors found in emotional communication.

This study examined the influence of babywearing on the heart rate (HR) of infants with

NAS and their parents, using the Calming Cycle Theory as the framework, where autonomic coregulation was examined through HR. The research question explored was: Does babywearing influence parents' and infant's HRs (PHR and IHR)? The aims of this proposal examined the influence of babywearing on PHR and IHR, the correlation between PHR and IHR, and the association between parents' gender on PHR and IHR.

Secondary data analysis was completed using the Newborn Wellness and Attachment Study data (PI: Rankin). Statistical analysis was conducted using HLM 8 and SPSS. Mixed model analyses and Pearson correlation coefficient analyses were conducted to examine these hypotheses.

Although the results of the analyses did not support any of the hypotheses in the expected direction, there were two statistically significant findings. PHR increased during babywearing when examining parents with their infant who was not medicated, and mother's HR and IHR had the strongest correlation during babywearing. The significant finding in the mother-infant dyad during babywearing indicates that autonomic coregulation may be at work, supporting the Calming Cycle Theory.

A significant correlation was found between PHR and IHR during babywearing for the mother-infant dyad. Based on this study, babywearing may be a remarkable nonpharmacological intervention for infants with NAS and their parents to improve the autonomic coregulation between the dyads. However, further research is needed to examine the effects of babywearing on autonomic coregulation.

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DEDICATION

I dedicate this dissertation which has played a significant role in our lives for the past few years to my Hunnie and daughter. Without you guys, babywearing would have never captured my attention as a research topic. Hunnie, your unwavering encouragement has propelled me forward, even in the face of challenges. Ellie, witnessing the bond we shared through babywearing has profoundly shaped my interest in babywearing. I love you both and can’t wait to experience our next adventure.

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CHAPTER 1

INTRODUCTION

Babywearing is when an infant is carried close to the body with a supportive device such as a baby carrier (Merriam-Webster, n.d.). This research proposal examines babywearing's influence on the parent's heart rate (PHR) and the infant's heart rate (IHR), especially in vulnerable infants. This chapter includes the background, significance, purpose, and definitions.

Background

Although the term "babywearing" was first used in the late 1980s (Merriam-Webster, n.d.), babywearing has been a common practice since ancient times (Berecz et al., 2020). For example, the Aztecs carried their babies against their bodies in woven clothes called rebozos, which are still used today in Mexico (Berecz et al., 2020). It is theorized that baby carriers such as the rebozo were initially developed to allow the person carrying the infant hands-free to gather and move as needed (Berecz et al., 2020). As the environment became safer and humans learned to defend themselves better, babywearing evolved from a necessity to an option. In cultures that developed other ways to have the baby near but not on the body (as with babywearing), items such as the baby carriage were invented and used. The use of the baby carriage eventually became the norm in Western cultures, and the practice of babywearing was discontinued by many. Recently, babywearing has gained more traction in Western culture, especially with research showing the positive effects of close contact between parent and infant.

Babywearing provides an environment that allows the parents' and infants' bodies to be close to each other. The closeness of the infant's and parent's bodies during babywearing has been shown to improve the infant's and the mother's well-being (Blois, 2005; Buil et al., 2016; Little et al., 2019) and influences mother-infant coregulation (Mörelius et al., 2015). However, most babywearing studies have focused on mother-infant dyads and few on father-infant dyads. Furthermore, there are even fewer studies on babywearing and autonomic coregulation for the father-infant and mother-infant dyads.

Autonomic coregulation occurs when the parent and infant coregulate through their behaviors (e.g., emotional communication), which influence the autonomic nervous system (Welch, 2016). Per the Calming Cycle Theory, autonomic coregulation and emotional connection are influenced by emotional communication between the parent and infant (Welch & Myers, 2016). Examples of emotional communication include eye contact, listening, vocalization, facial expressiveness, and reciprocal responsiveness of these behaviors. Babywearing facilitates emotional communication by providing an environment where the parent's and infant's bodies are near each other. This nearness allows the infant and parent to respond readily to each other's emotional cues. Insight into autonomic coregulation can be seen through heart rate (HR), as the autonomic nervous system controls the heartbeats from the sinoatrial node (Waxenbaum et al., 2022). Therefore, babywearing may improve autonomic coregulation and emotional connection simultaneously because it provides a condition that facilitates the behaviors found in emotional communication (Little et al., 2019).

A positive effect on autonomic coregulation and emotional connection results in a calmer state for the dyad. Vulnerable infants, such as infants with neonatal abstinence syndrome (NAS) in the NICU and their parents, are distressed. NAS refers to a collection of neonatal withdrawal symptoms from intrauterine drug exposure (Doherty et al., 2021). Infants with NAS are often hyperirritable with high-pitched crying, jitteriness, tachycardia, tachypnea, and gastrointestinal disturbances (Anbalagan & Mendez, 2023). High-pitched crying is usually associated with pain in infants. Pain and anxiety in infants and adults can increase their HR (Bradt et al., 2013; Shah et al., 2012; Waxman et al., 2016). If babywearing positively influences autonomic coregulation and emotional connection, there should be a decrease in HR and high-pitched crying, indicating a calmer state for the dyad.

Babywearing may provide a non-expensive, nonpharmacological intervention for the parent-infant dyad to handle mental stressors, such as pain and anxiety, especially among vulnerable infants. Therefore, the primary purpose of this research is to examine the influence of babywearing on the HR of parents and their infants with NAS.

Significance

Currently, the literature examining the autonomic coregulation in the parent-infant dyad when babywearing is nonexistent. This study will assess the impact of babywearing on the parent-infant dyad by analyzing PHR and IHR via autonomic coregulation. An extensive longitudinal study is needed to demonstrate improved HR with babywearing and further explore concepts in the Calming Cycle Theory, such as measures of the calming emotional state and other measures of the autonomic nervous system (e.g., heart rate variability). If babywearing is associated with a decrease in HR (indicating a possible decrease in distress), nurses can recommend babywearing to promote a nonpharmacological intervention for infants with NAS to improve the well-being of the parent-infant dyad.

Purpose

This study examines the influence of babywearing on infants diagnosed with NAS on PHR and IHR. A secondary analysis of the data collected from the Newborn Wellness and Attachment Study (PI: Rankin) will also be conducted. Parent-infant dyads were recruited from a NICU in the Southwest United States. HR was measured in the infants and parents for 5 minutes each across the three waves (i.e., pre-babywearing, babywearing, and post-babywearing) for 30 minutes.

Definitions

Autonomic coregulation: the influence of a parent on an infant and an infant on a parent, and how their behaviors towards each other influence their autonomic system, i.e., HR.

Babywearing: when a parent carries their infant in a baby carrier.

PHR: parent heart rate; the number of times the parent's heart beats per minute (bpm), measured every 15 seconds in 5-minute intervals.

IHR: infant heart rate; the number of times the infant's heart bpm, measured every 15 seconds in 5-minute intervals.

Chapter Summary

Although babywearing can enhance mother-infant relationships through attachment, babywearing has not been examined for its association with PHR and IHR. The research proposed aims to examine the relationship between babywearing, PHR, and IHR. Babywearing can be recommended to promote a nonpharmacological intervention for infants with NAS if it positively influences PHR and IHR. Findings from the proposed study would provide evidence and a rationale to examine babywearing as part of an extensive, longitudinal study to improve the infant's and the parent's physical and mental well-being.

CHAPTER 2

REVIEW OF THE LITERATURE

This chapter examines the current state of the science on the overarching topic of babywearing, with a specific focus on babywearing's influence on PHR and IHR, especially in vulnerable infants. Babywearing, neonatal abstinence syndrome (NAS), and HR are topics of interest within this focus. Infants with NAS and their parents in high-stress situations would benefit from an intervention that would assist in calming them, such as babywearing. In addition, the changes in their HR would indicate if babywearing has a calming effect.

Based on the topics of interest, key terms used for the literature search were babywearing, baby wearing, baby carrier, baby carrying, neonatal abstinence syndrome, and HR. Databases in EBSCOhost (e.g., Child Development & Adolescent Studies, Cumulative Index to Nursing and Allied Health Literature [CINAHL], Education Resource Information Center [ERIC], Family & Society Studies Worldwide, APA PsycArticles, and APA PsycInfo), as well as other databases, including Cochrane Library, Embase, Global Health, ProQuest Dissertations & Theses Global, PubMed, Scopus, Web of Science, and Google Scholar, were utilized.

Babywearing Effects on Parent, Infant, and the Dyad

Babywearing is carrying an infant in a baby carrier close to an adult's body using various supportive devices (Blois, 2005; Little et al., 2019). The type of baby carrier used depends on the infant's age, the baby carrier's comfort, ease of use, and the parents' budget to purchase a baby carrier.

Babywearing appears to be beneficial to the mother and infant. It may be beneficial to the father as well, but there were very few studies found that examined the fathers' outcomes with babywearing separately from the mother's outcome, although there were studies that looked at both parents' outcomes to babywearing (Mireault et al., 2018; Williams et al., 2020).

Fatigue and insomnia are common occurrences experienced by new mothers, leading to poor mental health (Webb et al., 2008). Increasing the frequency of babywearing weekly is associated with decreased insomnia and fatigue among parents in the early years of a child's life (Havens et al., 2022), possibly due to decreased crying in infants, which may lead to parents waking up less. Decreased insomnia and fatigue correlate to decreased stress and anxiety and increased calmness in babywearing mothers (Miller et al., 2020). Mothers likewise have reduced repetitive negative thinking (a factor that affects mother-infant interactions) and higher positive mental health scores while babywearing (Schoppmann et al., 2021). In addition, babywearing may help prevent postpartum depression, which affects almost 20% of mothers with newborns (Werner et al., 2016). New mothers benefit from the practice of babywearing through the positive mental health outcomes babywearing provides.

There is evidence that babywearing is beneficial to the infant. Longitudinal studies suggest that increasing babywearing decreases crying (Hunziker & Barr, 1986) and increases breastfeeding (Pisacane et al., 2012). Decreased crying indicates less agitation and pain in infants when assessed with behaviors such as facial grimaces (Bellieni, 2012). In addition, breastfeeding has been shown to reduce infections such as gastroenteritis and ear infections in infants. The risks of chronic conditions, such as eczema and diabetes, are also reduced in breastfed babies (Groom, 2020). Infants who are a babyworn are less likely to cry and are encouraged to breastfeed more, and thereby tend to be calmer and less prone to infections and other chronic conditions.

Finally, babywearing has been shown to promote mother-infant interactions in several studies. Compared to non-babywearing mothers, babywearing mothers responded more often to their infants' vocal cues (Anisfeld et al., 1990; Little et al., 2019; Mireault et al., 2018). Babywearing is also associated with increased secure attachment (Anisfeld et al., 1990). Secure attachment is a measure of the mother-infant relationship and indicates a positive mother-infant relationship. Anisfeld et al. (1990) found that mothers who practiced babywearing had a significantly greater number of securely attached infants than non-babywearing mothers by the time the infant was 13 months old. Similarly, adolescent mothers with infants showed increased secure attachment with increased babywearing (Williams & Turner, 2020). In two qualitative studies, mothers described increased bonding with their infants while babywearing (Miller et al., 2020; Moran, 2017). These studies included infants older than 12 months, showing that babywearing also benefits older babies. In addition to these positive effects on bonding and attachment, babywearing increases an infant's vocal cue responsivity, decreases crying, and increases breastfeeding (Hunziker & Barr, 1986; Mireault et al., 2018; Pisacane et al., 2012). These effects can influence HR through autonomic coregulation.

Parents' and their Infant's Heart Rates

Heart rate refers to the number of times the heart beats over one minute. Heart rate variability (HRV) is the change in the time between each heartbeat (Cattaneo et al., 2021). Although HRV indicates emotional and mental health (Cattaneo et al., 2021), HR can also reflect strong emotions such as stress or anxiety (American Heart Association, 2015). HR and its changes can give insight into the autonomic nervous system as the autonomic nervous system controls the heartbeats from the sinoatrial node (Waxenbaum et al., 2022). Strong emotions can influence autonomic coregulation by influencing the heart rate. For example, stress can increase a mother's heart rate, which can then increase the heart rate in the infant (Mueller, 2021). Therefore, HR will be used to give insight into the dyad's autonomic coregulation in this study.

Factors that Affect Heart Rates

Mental and biological factors can affect HR. Mental factors such as stress and anxiety in infants and adults can increase HR (Bradt et al., 2013; Shah et al., 2012; Waxman et al., 2016). Biological factors, such as gender, are also associated with HR. In younger adults (M = 23.3 years, SD = 0.5), a significant difference between gender was seen in HR changes under stress, where females had a higher increase in HR for an extended time compared to males when placed in a socially stressful situation (Kudielka et al., 2004). Females with high levels of chronic stress (measured with the Perceived Stress Scale) had increased HR when placed in acute stressful settings compared to males with high levels of chronic stress (Jones et al., 2016).

Parent Heart Rate

Emotions like enjoyment can affect PHR (American Heart Association, 2015). Although HR was not measured, Siqveland et al. (2022) found that mothers reported more positive engagement and enjoyment scores than fathers with their infants, which may influence different HRs between mother and father. Considering the autonomic coregulation between the parent-infant dyad, IHR can also be influenced differently, depending on which parent interacts with them and their parent's mood.

Maternal HR is also affected by infant behaviors. Postpartum mothers who showed greater sympathy for infant cries had higher HRs than postpartum mothers with less sympathy (Stallings, 2001). In addition, mothers who breastfeed have lower HRs than mothers who do not breastfeed their infants (Groer et al., 2013).

Literature on paternal HR is scarce; few groups have studied the association between father and infant HRs. Only one study indicated a higher paternal HR when the fathers were more verbal with their infants (Jones & Thomas, 1989). It is unclear whether paternal HR is linked to their bond with their infant.

Infant Heart Rate

Increased maternal stress is linked to increased IHR (Monk et al., 2000). Infants of mothers who tested positive for substance abuse were more likely to have higher HRs than infants of mothers who tested negative (Jansson et al., 2010). IHR also seems to decrease with physical and pharmaceutical calming agents. For example, IHR decreased more when the mother held their infant while walking than when stationary (Esposito et al., 2013). Infants with skin-to-skin contact with their fathers 45 minutes after Caesarean delivery had a more stable HR than infants not carried during the first 2 hours of life (Ayala et al., 2021). Reiki therapy (a touch therapy) reduced IHR in infants with NAS (Radziewicz et al., 2018). Premature infants' HRs also decreased when given pharmaceutical agents, such as morphine, for discomfort (Hartley et al., 2018).

Another consideration on IHR related to babywearing is who is wearing the baby. Autonomic coregulation may occur differently in the infant depending on which caregiver is babywearing. For example, when a parent was babywearing their infant with NAS, IHR decreased by more than double compared with when a non-parent caregiver was babywearing the infant (Williams et al., 2020), where a decrease in HR indicates less stress. In infants with NAS, this would mean the less likely use of narcotics to decrease the infant's stress. Various methods can be used to reduce IHR, most involving close physical contact between parent and infant.

Neonatal Abstinence Syndrome and Interventions

Neonatal abstinence syndrome (NAS) is commonly a collection of neonatal withdrawal symptoms from intrauterine drug exposure (Doherty et al., 2021). Infants with NAS are often hyperirritable. The triad of initial withdrawal symptoms is increased muscle tone, tremors, and a change in Moro reflex. Other common withdrawal symptoms are hyperirritability, high-pitched crying, jitteriness, tachycardia, tachypnea, and gastrointestinal disturbances (Anbalagan & Mendez, 2023). Infants with NAS often suffer detrimental long-term outcomes such as reduced visual acuity, motor problems, and behavioral and cognitive problems (Maguire et al., 2016). Because these infants are hyperirritable, parents need a method to calm them. Babywearing may be beneficial to calm infants with NAS. By keeping these infants calm, NAS symptoms would be reduced, decreasing the discomfort of infants with NAS.

From 2010 to 2017, there was a significant increase in NAS across most of the United States (Hirai et al., 2021). Almost 80 newborns are diagnosed with NAS daily (Centers for Disease Control and Prevention, 2021). As the number of infants with NAS increases, the cost of treatment increases. Treatment of infants with NAS totaled $572.7 million in 2016, trending upward compared to previous years, with Medicaid covering a little over 80% of the cost (Strahan et al., 2020). Pharmacological treatment of infants with NAS increases the costs; a nonpharmacological intervention would significantly reduce the cost of treating NAS.

Nonpharmacological interventions are less costly than pharmacological interventions for NAS and are the initial line of management for NAS (Kocherlakota, 2014). Nonpharmacological interventions include soothing techniques, skin-to-skin contact, a low-stimulation environment, clustering care, breastfeeding, and parental presence (Byerley et al., 2021). Babywearing may be an alternative nonpharmacological interventional option that may provide a low-stimulation environment and more opportunities for parental presence, soothing techniques, breastfeeding, and skin-to-skin contact.

Covariates

A covariate is a variable that may influence the independent variable (Fan, 2010, p.285), obscuring the relationship between the independent and dependent variables. In this study, the independent variable is the wave, and the dependent variable is PHR and IHR. Potential covariates associated with babywearing and autonomic coregulation of the parent-infant dyad are gender and medication.

Gender

Gender may affect HR in both parents and infants. There is a difference in how adult females and males respond to stress (Jones et al., 2016), emotional stimuli (Bianchin & Angrilli, 2012), and pain (Tousignant-Laflamme et al., 2005). Mothers may also have a stronger relationship with their infants than fathers. Compared to female infants, male infants with more severe NAS symptoms have higher HR, longer pharmacologic treatment, and extended hospitalization (Jansson et al., 2010). These factors indicate that gender may influence autonomic regulation, affecting HR.

Medication

Medication has differing effects on HR in adults and infants. For infants with NAS, morphine is the most used initial line of pharmacological management, and clonidine can be used as adjunct therapy (Kocherlakota, 2014). Morphine can decrease HR (Murphy, Bechmann, & Barrett, 2022). In infants with NAS, HR decreased when treated with clonidine (Meddock & Bloomer, 2018). Treatment for mothers with substance use disorder is usually methadone (Committee on Obstetric Practice American Society of Addiction Medicine, 2017) which also can decrease HR (Durrani & Bansai, 2022). These factors indicate that medication may influence HR.

Potential Covariates

The following potential covariates may influence the parent-infant interactions but were not included in this study. This exclusion was because data on these covariates were not collected in the secondary data set this study will use.

Babywearing Experience

Prior babywearing experience (i.e., number of babywearing hours) has been found to promote positive interactions in the mother-infant dyad (Williams & Turner, 2020). In addition, mothers who practiced babywearing as a primary transport mode for their infants touched their infants more than mothers who did not (Little et al., 2019). Therefore, babywearing mothers are more likely to interact positively with their infants because of increased interaction opportunities. This may be reflected in the mother's HR and IHR.

Carrying Position

The gaze between mother and infant may affect their autonomic coregulation. For example, how an infant is carried may encourage or discourage gaze. A front inward-facing carrying position (Norholt, 2011), in which the infant faces the mother, would encourage gaze in the dyad, while a front-outward facing carrying position (Norholt, 2011), with the infant facing away from the mother, would discourage gaze in the dyad.

Type of Feeding

The type of feeding for the infant may also influence the autonomic coregulation of the mother-infant dyad. Babywearing may increase breastfeeding duration in the first month of life (Pisacane et al., 2012). Weaver et al. (2018) determined that increased breastfeeding increases maternal sensitivity. Since maternal sensitivity can influence the emotions of the infant and mother, the type of feeding needs to be considered.

Oxytocin

Oxytocin is a hormone secreted during breastfeeding (Moberg & Prime, 2013) and influences maternal sensitivity and attachment (Tharner et al., 2012). Oxytocin influences maternal behaviors (Feldman et al., 2007; Sammut et al., 2017), which can influence the emotional states of the mother and infant and their autonomic coregulation. For example, increased oxytocin levels promote maternal behaviors, such as affectionate touch, vocalization, gazing at the infant, and positive facial responses (Feldman et al., 2007).

Theoretical/Conceptual Framework

Calming Cycle Theory

The Calming Cycle Theory provides a novel perspective and a theoretical foundation to examine the parent-infant dyad while babywearing. Although the Calming Cycle Theory is specific to the mother-infant dyad, this proposal applies this theory to the father-infant dyad. Another theory used to describe the relationship between mother and infant while babywearing is the Attachment Theory (Anisfeld et al., 1990; Williams & Turner, 2020). Unlike the Calming Cycle Theory, the Attachment Theory does not consider autonomic coregulation in the dyad. Instead, the Calming Cycle Theory indicates that both the mother and infant are influenced by each other and consider the dyad as a whole (Welch & Ludwig, 2017a). In contrast, the Attachment Theory views the relationship from the individual perspectives of the mother and infant (Welch, 2016).

The Calming Cycle Theory posits that consistent emotional communication leads to autonomic coregulation and emotional connection in the dyad, producing a calming emotional state in both mother and infant (Welch, 2016). The calming emotional state describes physical and emotional calm in the dyad (Welch, 2016). According to the Calming Cycle Theory, this state can be achieved through emotional communication. Examples of emotional communication are eye contact, listening, vocalization, facial expressiveness, and reciprocal responsiveness in the dyad (Hane et al., 2019). Mothers' emotions and intentions can also influence emotional communication (Welch & Ludwig, 2017b), such as when a mother is calm, an infant is calmer. Babywearing provides an environment where emotional communication can be practiced consistently, promoting a calming emotional state.

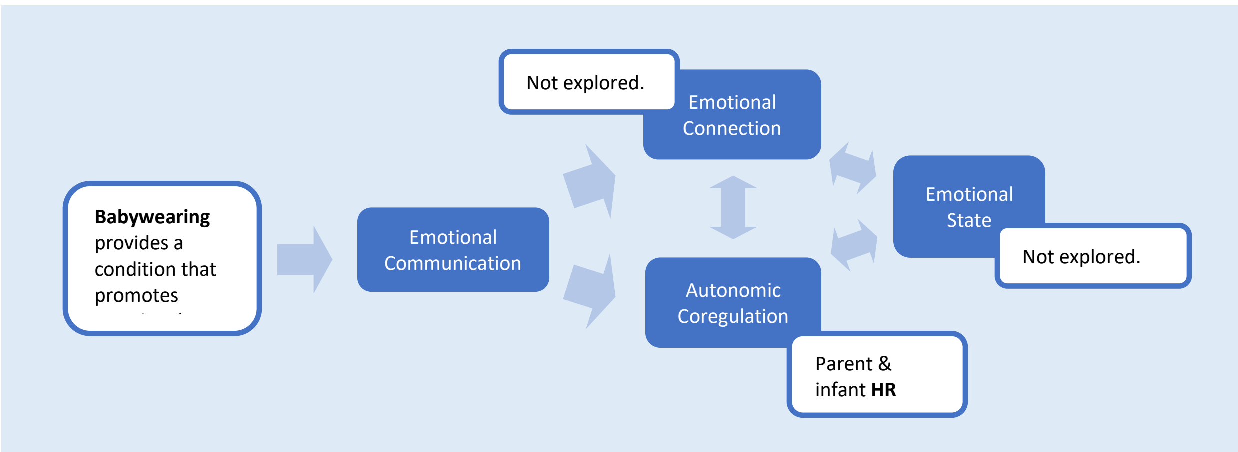
Autonomic coregulation and emotional connection are bi-directional and begin in the womb (Welch & Ludwig, 2017a). When the infant is born, skin-to-skin touch-in the healthy dyad results in the up-regulation of oxytocin and other hormones (Welch & Ludwig, 2017a). The process triggered by skin-to-skin touch positively influences the autonomic systems of the dyad (autonomic coregulation), resulting in behaviors that would consider the dyad emotionally connected. For example, the breast crawl from the infant and cooing from the mother results in an emotional bond between mother and infant (Welch & Ludwig, 2017a). Emotional connection and autonomic coregulation are reinforced through repeated emotional communication.

Based on the Calming Cycle Theory, it can be argued that babywearing may promote emotional communication between mother and infant. This is because the Calming Cycle Theory postulates that emotional communication (i.e., maternal-infant interactions, such as babywearing) affects autonomic coregulation (i.e., HR) and emotional connection (i.e., mother-infant relationship). From the literature review of babywearing and using the Calming Cycle Theory as a conceptual framework, it is hypothesized that babywearing will provide a condition that increases emotional communication, thereby positively influencing autonomic coregulation and emotional connection. Therefore, measuring HR while babywearing will provide insight into the role of autonomic coregulation in mother-infant relationships.

Although the Calming Cycle Theory does not apply to the father, a novel application will be applied to fathers. In this study, autonomic coregulation, inferred from PHR and IHR, will be explored in association with babywearing. Figure 1 visually describes the application of the Calming Cycle Theory as a conceptual framework in this study.

Figure 1

Application of the Calming Cycle Theory as a Conceptual Framework



Note. Adapted from "Calming Cycle Theory: The Role of Visceral/ Autonomic Learning in Early Mother and Infant/ Child Behaviour and Development," by M. G. Welch, 2016, *Acta Paediatrica, International Journal of Paediatrics*, *105*, 1266–1274 (https://doi.org/10.1111/apa.13547).

Research Question, Hypotheses, and Specific Aims

The research question explored is: Does babywearing influence PHR and IHR? A secondary data analysis of the Newborn Attachment and Wellness Study (PI: Rankin) on babywearing that measures PHR and IHR with NAS were conducted to answer this question.

PHR and IHR were measured across the three waves. A reading is considered a set of the three different waves (see Appendix A for a diagram of how the dyads, waves, readings, and HRs are related) and describes the number of times an infant was babyworn by a parent. The specific aims and hypotheses of the study are:

1. To examine the influence of babywearing on PHR.

   H1.1. The PHR during babywearing will be lower than pre-babywearing.

   H1.2. The PHR during post-babywearing will be lower than babywearing.

2. To examine the influence of babywearing on IHR.

   H2.1. The IHR during babywearing will be lower than pre-babywearing.

   H2.2. The IHR during post-babywearing will be lower than babywearing.

3. To examine the correlation between the PHR and IHR during each wave.

   H3.1 PHR and IHR will have the strongest correlation during babywearing.

   H3.2. The correlation between PHR and IHR will be stronger in the mother-infant dyads than in the father-infant dyads.

4. To examine the influence of the parent's gender on PHR and IHR during babywearing.

   H4.1. The mother's HR will be lower than the father's HR during babywearing.

   H4.2. IHR will be lower with the mother than the father during babywearing.

Chapter Summary

The current literature indicates increased positive maternal-infant interactions, including emotional communication when babywearing (Little et al., 2019). The positive interactions affect autonomic coregulation and emotional connection (Welch, 2016). This study explored the relationship between babywearing, PHR, and IHR, where HR was used to infer the degree of autonomic coregulation.

CHAPTER 3

METHODOLOGY

This chapter provides an overview of the methodology proposed for this study. In addition, the research design, sample, measurements, and statistical analyses are explored in this chapter.

Research Design

Secondary data analyses were completed using data from the Newborn Wellness and Attachment Study (PI: Rankin). A within-person repeated-measures design was used to examine the effects of babywearing on IHR with neonatal abstinence syndrome and their caregivers' HR. The variables examined were condition, infant gender, medication, babywearing, and HR. The condition examined was the Family Centered NAS Program (FC-NAS) compared to traditional treatment. The infant's gender was identified as male or female. Medication was identified as given or not given, where if given morphine or clonidine was administered to the infant up to 4 hours before the reading. Babywearing occurred when the caregiver carried the infant in a baby carrier. Infants were worn in an Ergobaby Adapt Baby Carrier (The Ergobaby Carrier, Inc., 2023) or Baby K'Tan Original Infant Carrier (Baby K'Tan, LLC., 2023). The parent chose their preferred baby carrier (see Appendix B for babywearing pictures). HR was measured in infants and parents before, during, and after babywearing for 5 minutes each in 15-second intervals.

Sample

Data for the current study were retrieved from the Newborn Wellness and Attachment Study (PI: Rankin) dataset. The parent study used convenience sampling to recruit the participants from a NICU in the Southwest United States. Thirty-seven infants were recruited. Recruitment occurred after the infant was diagnosed with NAS and admitted to the NICU.

Parents were at least 18 years old. The inclusion criteria for infants were a) born in the hospital, b) admitted to the NICU by day 4, and c) diagnosed with NAS by day 3. Infants were excluded if an infant's Apgar score was lower than 8. In addition, parents were excluded if they were non-English speakers. Informed consent was collected from the biological parent(s) or the legal caregiver. The infants were either enrolled in the FC-NAS or traditional treatment group. The Eat, Sleep, Console approach was used for infants in the FC-NAS program, where infants were given morphine and clonidine only if they could not eat, sleep, or be consoled in a reasonable timeframe (within 20 minutes). Parents in the FC-NAS program roomed with their infant, had been compliant with prenatal care, and had to comply with their medication-assisted treatment. The traditional treatment group followed hospital-specific protocol for medication administration to infants. Morphine and clonidine were given if the infants' modified Finnegan Neonatal Abstinence Score Sheet was 8 or higher consecutively thrice or 12 or higher consecutively twice.

This study used data from 20 out of the 37 infants from the parent study. Infants were excluded if their parents did not participate in the study. All mothers who participated had drug exposure during their pregnancy and were voluntarily receiving methadone treatment.

Measurements

The variables that were measured were PHR and IHR. PHR was measured using a pulse oximeter (ReliOn) on either forefinger, and IHR was measured with a cardiorespiratory monitoring device.

Before the HR was measured, researchers waited for infants to be assessed, fed, and not fussy. The parents and infants were in a calm state for about 20 minutes. Parents were on the phone, chatting, reading, or sitting. Infants were being fed, sleeping, or calmly lying in their bassinet. Next, three waves were measured: pre-babywearing, babywearing, and post-babywearing. Each wave was measured at 15-second intervals for 5 minutes across 30 minutes, resulting in 21 HR for each wave (i.e., timepoints). Pre-babywearing was measured before the infant was placed in the baby carrier while the infant was in a bassinet and the parent was in a chair. Afterward, the parent would babywear for 20 minutes. The parents usually walked the halls of the NICU while babywearing. Next, babywearing was measured before the infant was taken out of the carrier. Finally, post-babywearing was measured when the infant was placed back in the bassinet and the parent was sitting in a chair, similar to pre-babywearing (see Appendix B for timeline). Babywearing was allowed at any point, but those instances were not recorded.

Statistical Analysis

Secondary data analyses were conducted using IBM's SPSS software (Version 28) and HLM 8 (Raudenbush et al., 2019). Mixed model analyses were conducted to analyze the hypotheses for aims 1, 2, and 4, and Pearson correlation analyses were conducted for aim 3. The covariates tested were the infant gender, parent gender, and medication. For aim 1, the independent variable (IV) was the wave (pre-babywearing, babywearing, and post-babywearing), and the dependent variable (DV) was PHR. For aim 2, the IV was the wave, and the DV was IHR. For aim 3, the variables were PHR and IHR. Finally, for aim 4, the IV was the parent's gender, and the DV was PHR for H4.1 and IHR for H4.2.

Effect coding was used for the covariates, while dummy coding was used for the IV. Specifically, infant and parent gender were coded as -1 for male (i.e., infant boy and father) and 1 for female (i.e., infant girl and mother). Medication variable was coded as -1 for not receiving and 1 for receiving medication. Wave was dummy coded with babywearing as the referent point. The wave was also coded to detect nonlinear relationships that may exist.

A 3-level mixed model was deemed appropriate due to non-independence among the nested data. At level 1, HR (21 HR in each wave) was nested within the waves (pre-babywearing, babywearing, and post-babywearing). Level 2, waves, were nested within readings. Level 3, readings, were nested with the dyads. The mixed model allowed infants and parents to serve as their own control while examining the effects of the waves (i.e., pre-babywearing, babywearing, and post-babywearing), controlling for variations across the readings (i.e., medication and parent gender), and controlling for differences in infants (i.e., infant gender). There were 2493 PHR (882 HR in pre-babywearing; 848 HR in babywearing; and 763 HR in post-babywearing) and 2491 IHR (881 HR in pre-babywearing; 849 HR in babywearing; and 761 HR in post-babywearing) analyzed at level 1. The metric for HR was beats per minute (bpm).

Pearson correlations between the mean of PHR and IHR across all timepoints per reading within each wave were deemed appropriate for aim 3. The intraclass correlation coefficient (ICC) was calculated to assess the stability of PHR and IHR across all the timepoints per reading within each wave. A high ICC, above 0.9, indicates excellent reliability (Koo & Yi, 2016). Given the high ICC ranging from 0.90 to 1.00 for PHR and IHR, the Pearson correlation between the mean of PHR and IHR across all timepoints per reading within each wave was calculated. The Pearson correlation was analyzed only for the first reading (i.e., the first-time mother or father wore an infant) for two reasons. The first reason was to eliminate the potential confounding effects of previous readings on the parents. If the parent-infant dyad had a negative or positive interaction in their previous babywearing session, this might influence the next babywearing session, increasing or decreasing PHR related to their previous experience. Second, the sample size for the first reading is the largest for both parents.

Data Screening

Data screening was completed for all study variables in the model. In instances where DV, PHR, or IHR had missing data, those cases were excluded from the analysis. Specifically, three cases were deleted for PHR and five for IHR due to missing data. Furthermore, data that exhibited extreme outliers for HR (i.e., HR = 7 bpm) were also excluded, resulting in one case deletion for PHR and none for IHR. The percentage of missing values for PHR and IHR was less than 1%.

Chapter Summary

This study examined the relationship between babywearing, PHR, and IHR. Secondary data analysis was completed using data from Newborn Wellness and Attachment Study (PI: Rankin). The statistical analysis was conducted using mixed model analyses and Pearson's correlation analyses, and the covariates tested were infant gender, parent gender, and medication.

CHAPTER 4

RESULTS

This chapter presents the statistical results of this study. First, sample characteristics were conducted using SPSS. Then, hypotheses were tested using HLM 8 and SPSS.

Demographic Characteristics of the Sample

Data were retrieved from 25 parent-infant dyads. The race/ethnicity for infants and mothers were mainly Non-Hispanic White (50% and 40%, respectively), with more female participants. Father's race/ethnicity and age information/data were unavailable. There was almost twice the number of infant girls (65%) compared to infant boys (35%). A quarter of the infants received medication, with one infant not receiving medication near the end of its stay in the hospital. An infant was considered to have received medication if they received medication (dosage and frequency excluded) up to 4 hours before measurements were taken. There was more than twice the number of mothers compared to fathers. More than half the parents participated in babywearing their infant once, and less than 15% participated in babywearing their infant at least three times. Both parents participated in babywearing for only five infants (20%). Table 1 describes the sample's demographic characteristics, and Table 2 describes the descriptive characteristics of the parent-infant dyads.

Table 1

Demographic Characteristics

	% (*n*)	*M* (SD)
Infants (*n* = 20)		
Gender		
Boy	35 (*7*)	
Girl	65 (*13*)	
Race/Ethnicity		
Non-Hispanic White	50 (*10*)	
Latino/Hispanic	30 (*6*)	
African American	10 (*2*)	
Other	10 (*2*)	
Birth weight, kg [a]		*3.13* (0.47)
Gestation, weeks [b]		*39.20* (1.56)
Age at first babywearing reading, days		*5.10* (4.03)
Parents (*N* = 25)		
Gender		
Father	32 (*8*)	
Mother	68 (*17*)	
Mother's race/ethnicity [c]		
Non-Hispanic White	40 (*8*)	
Latino/Hispanic	25 (*5*)	
African American	5 (*1*)	
Native American	10 (*2*)	
Other	5 (*1*)	
Birth mother's age, years		*28.05* (5.01)

Note. [a] *n* = 18. [b] *n* = 17. [c] *n* = 17.

Table 2

Descriptive Statistics of Parent-Infant Dyads (Level 2)

	% (*n*)
Infants [a] who received medications	25 *(5)*
When mother was babywearing	80 *(4)*
When father was babywearing	40 *(2)*
Mother babywearing (*n* = 17)	
At least thrice	12 (*2*)
Twice	35 (*6*)
Once	53 (*9*)
Father babywearing (*n* = 8)	
At least thrice	12 (*1*)
Twice	25 (*2*)
Once	63 (*5*)

Note. [a] *n* = 20.

Hypothesis Testing

Hypothesis 1, regarding PHR across the three waves (pre-babywearing, babywearing, and post-babywearing), was tested with a mixed model analysis. The overall PHR mean was 85.24 (*SD* = 1.90), with a significant overall PHR change from babywearing to post-babywearing (β = 1.18, *p* = .01). For the covariate, infant gender, there was a significant overall difference in the PHR by infant gender. PHR was significantly higher by 4.66 bpm when with infant girl compared to infant boy (β = 4.66, *p* = .006). However, the covariates parent gender and medication did not influence PHR (β = -1.34, *p* = .31, β = 2.86, *p* = .08, respectively; see Table 3).

Analysis of H1.1, regarding the PHR change from pre-babywearing to babywearing, was not significant (β = 0.31, *p* = .51), but parent gender, infant gender, and medication had a significant effect on PHR change from pre-babywearing to babywearing. Pre-babywearing PHR was significantly lower than babywearing PHR, by 3.27 bpm for mothers compared to fathers (β = 3.27, $p < .001$). Pre-babywearing PHR was significantly higher than babywearing PHR when with infant girls by 5.35 bpm than with infant boys (β = -5.35, $p < .001$). Pre-babywearing PHR was significantly lower compared to babywearing when with infants who received medication by 3.04 bpm compared to infants who did not receive medication (β = 3.04, $p < .001$).

Analysis of H1.2, regarding the PHR change from babywearing to post-babywearing, was significant (β = 1.18, $p = .01$) with an increase of 1.18 bpm. Infant gender and medication had a significant effect on PHR change from babywearing to post-babywearing, but parent gender did not (β = -0.54, $p = .15$). Babywearing PHR was significantly lower than post-babywearing PHR with infant girls by 1.77 bpm than with infant boys (β = -1.77, $p < .001$). Also, babywearing PHR was significantly higher than post-babywearing PHR if parents' infants received medication (β = 1.87, $p < .001$).

There was a significant effect on medication on PHR change from pre-babywearing to babywearing and babywearing to post-babywearing. When comparing parents with infants who did not receive medications ($n = 20$) to parents with infants who did receive medications ($n = 6$), the direction of the PHR change across the waves was inverted. Figure 2 shows the PHR changes over the three waves. Further analysis of PHR is based only on parents with infants who did not receive medications to eliminate the effect of medications.

Analysis of H1.1 for parents with non-medicated infants only, regarding the PHR across pre-babywearing to babywearing, showed a significant (β = -2.30, $p < .001$) increase of 2.30 bpm. However, analysis of H1.2, regarding PHR across babywearing to post-babywearing, was not significant (β = -0.36, $p = .42$). Figure 3 shows the difference in PHR across the three waves between the mother and father, while Figure 4 shows the difference in PHR between infant girls and boys. There was a significant overall difference in the PHR for infant gender (β = 5.03, p = .002), where the group mean difference was 5.03 bpm across the waves. Pre-babywearing PHR with non-medicated infants were significantly higher (β = -6.04, $p < .001$) than babywearing PHR if their infant was a girl. Post-babywearing PHR with non-medicated infants were significantly lower than babywearing PHR if they had an infant girl (β = -2.29, $p < .001$), with a group mean difference of 2.29 bpm.

Table 3

Influencing Factors on Parent Heart Rates

	Parents with All Infants (N = 25) [a]			Parents with Non-Medicated Infants (n = 20) [b]		
	β	*SE*	*p*	β	*SE*	*p*
Dyad level						
Intercept, π_0						
Intercept	**85.24**	**1.90**	**< .001**	**81.76**	**1.38**	**< .001**
Infant Gender (-1, boy; 1, girl)	**4.66**	**1.50**	**.006**	**5.03**	**1.31**	**.002**
Reading level						
Medication (-1, no medication; 1, medication)	2.86	1.54	.08	—	—	—
Parent Gender (-1, father; 1, mother)	-1.34	1.29	.31	-0.87	1.27	.50
Wave level						
Pre, $\pi_{1(slope)}$						
Intercept	0.31	0.47	.51	**-2.30**	**0.41**	**< .001**
Infant Gender	**-5.35**	**0.36**	**< .001**	**-6.04**	**0.38**	**< .001**
Parent Gender	**3.27**	**0.34**	**< .001**	**2.91**	**0.37**	**< .001**
Medication	**3.04**	**0.38**	**< .001**	—	—	—
Post, $\pi_{2(slope)}$						
Intercept	**1.18**	**0.48**	**.01**	-0.36	0.45	.42
Infant Gender	**-1.77**	**0.38**	**< .001**	**-2.29**	**0.39**	**< .001**
Parent Gender	-0.54	0.38	.15	-0.78	0.42	.07
Medication	**1.87**	**0.38**	**< .001**	—	—	—

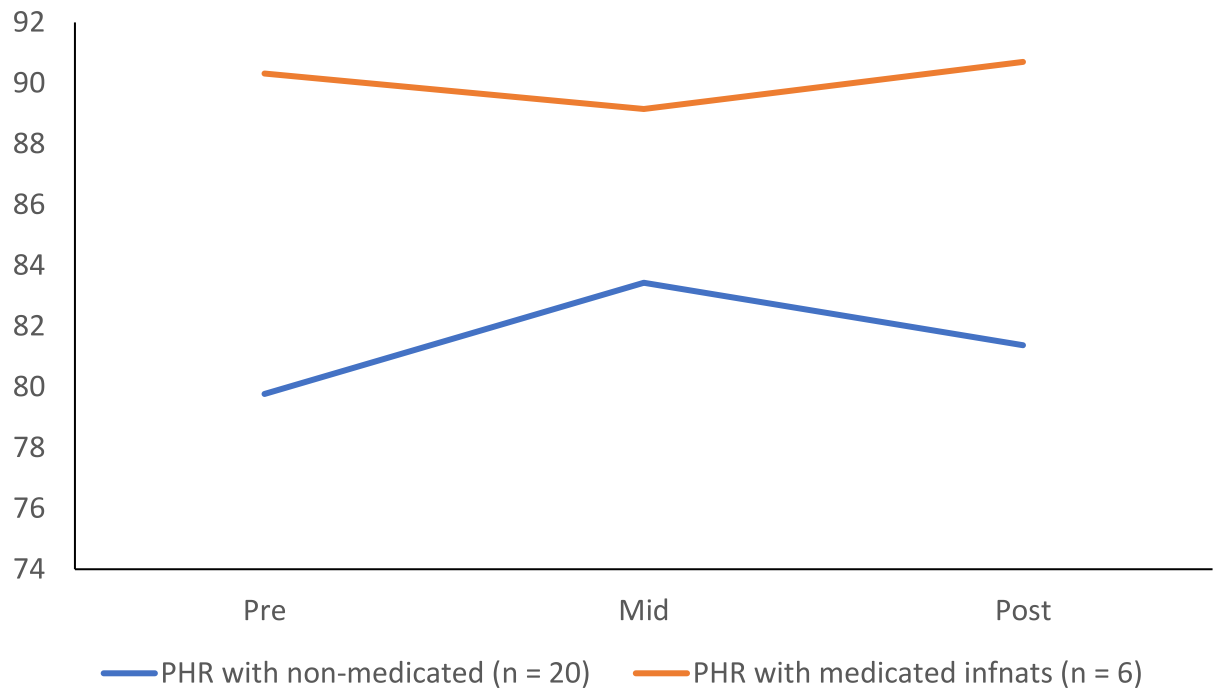
Note. Pre: pre-babywearing; Post: post-babywearing. Babywearing was used as the reference point.

[a] Hierarchical linear modeling equation: $PHR_{ijk} = \gamma_{000} + \gamma_{001}$*INFANT_GENDER$_k$ + γ_{010}*MEDICATION$_{jk}$ + γ_{020}*PARENT_GENDER$_{jk}$ + γ_{100}*PRE_{ijk} + γ_{101}*PRE_{ijk}*INFANT_GENDER$_k$ + γ_{110}*PRE_{ijk}*MEDICATION$_{jk}$ + γ_{120}*PRE_{ijk}*PARENT_GENDER$_{jk}$ + γ_{200}*$POST_{ijk}$ + γ_{201}*$POST_{ijk}$*INFANT_GENDER$_k$ + γ_{210}*$POST_{ijk}$*MEDICATION$_{jk}$ + γ_{220}*$POST_{ijk}$*PARENT_GENDER$_{jk}$ + r_{0jk} + u_{00k} + e_{ijk}.

[b] Hierarchical linear modeling equation: $PHR_{ijk} = \gamma_{000} + \gamma_{001}$*INFANT_GENDER$_k$ + γ_{020}*PARENT_GENDER$_{jk}$ + γ_{100}*PRE_{ijk} + γ_{101}*PRE_{ijk}*INFANT_GENDER$_k$ + γ_{110}*PRE_{ijk}*PARENT_GENDER$_{jk}$ + γ_{200}*$POST_{ijk}$ + γ_{201}*$POST_{ijk}$*INFANT_GENDER$_k$ + γ_{210}*$POST_{ijk}$*PARENT_GENDER$_{jk}$ + r_{0jk} + u_{00k} + e_{ijk}

Figure 2

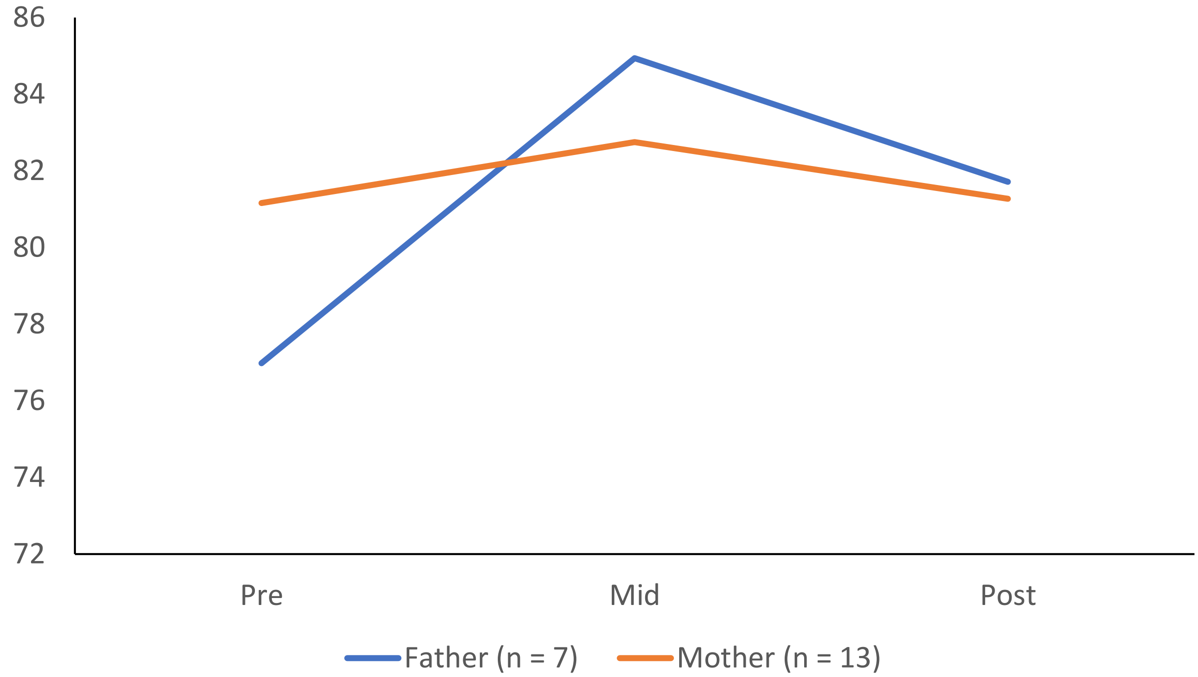
Medication Effects on Parent Heart Rates at Each Wave



Note. Pre = pre-babywearing; Mid = babywearing; Post = post-babywearing.

Figure 3

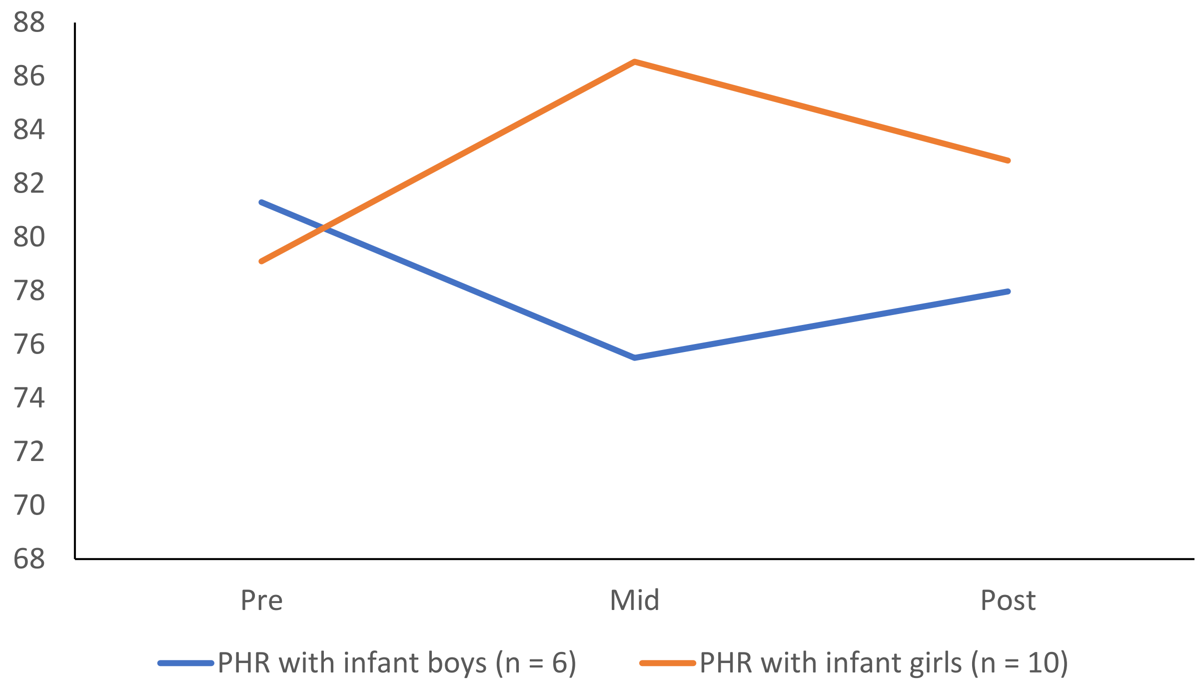
Parent Gender Effects on Parent Heart Rates with Non-Medicated Infants at Each Wave



Note. Pre = pre-babywearing; Mid = babywearing; Post = post-babywearing.

Figure 4

Infant Gender Effects on Parent Heart Rates with Non-Medicated Infants at Each Wave



Note. Pre = pre-babywearing; Mid = babywearing; Post = post-babywearing.

Hypothesis 2, regarding IHR across the three waves, was tested with a mixed model analysis. The overall IHR mean was 151.49 (SD = 4.84). There was no overall difference in the IHR between infants who received or did not receive medication, infant gender, and parent gender (see Table 4). Analysis of H2.1, regarding IHR, across pre-babywearing to babywearing (β = -0.99, p = .32), and H2.2, regarding IHR, across babywearing to post-babywearing (β = .55, p = .59), were not significant. However, medication had a significant effect on IHR change from babywearing to post-babywearing. Post-babywearing IHR was significantly higher than babywearing IHR by 2.61 bpm if the infant received medication compared to not receiving medication ($\beta = 2.61$, $p = .002$; see Figure 5). For hypothesis 2, medicated and non-medicated infants were not separated as it was for hypothesis 1 because the effect of medication was not significant across all the waves.

Table 4

Influencing Factors on Infant Heart Rates

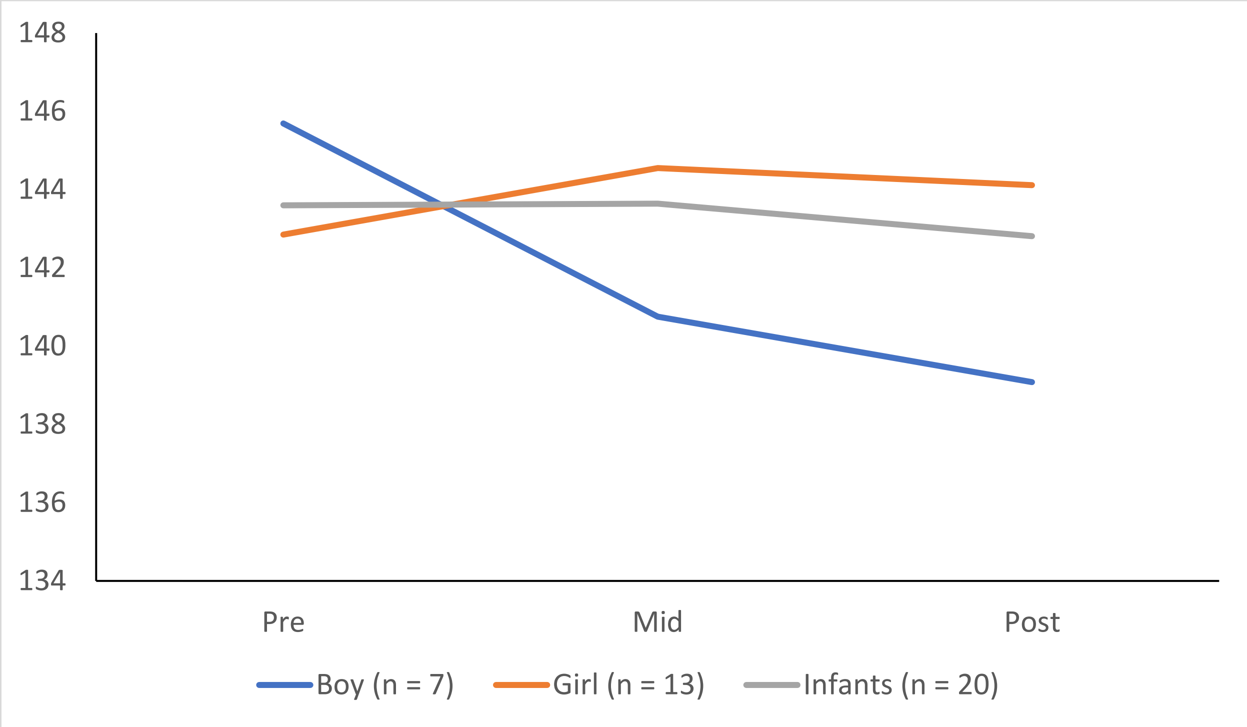
	β	*SE*	*p*
Dyad level			
Intercept, π_0			
Intercept	**151.49**	**4.84**	**< .001**
Infant Gender (-1, boy; 1, girl)	1.10	4.05	.79
Reading level			
Medication (-1, no medication; 1, medication)	5.08	3.54	.17
Parent Gender (-1, father; 1, mother)	-3.80	2.72	.18
Wave level			
Pre, $\pi_{1(slope)}$			
Intercept	-0.99	1.00	.32
Infant Gender	-1.41	0.78	.07
Parent Gender	1.19	0.73	.10
Medication	-0.11	0.82	.90
Post, $\pi_{2(slope)}$			
Intercept	0.55	1.03	.59
Infant Gender	0.65	0.81	.42
Parent Gender	-0.75	0.82	.36
Medication	**2.61**	**.83**	**.002**

Note. *n* = 20 infants. Pre: pre-babywearing; Post: post-babywearing. Babywearing was used as the reference point.

Hierarchical linear modeling equation: $IHR_{ijk} = \gamma_{000} + \gamma_{001}$*INFANT_GENDER$_k$ + γ_{010}*MEDICATION$_{jk}$ + γ_{020}*PARENT_GENDER$_{jk}$ + γ_{100}*PRE_{ijk} + γ_{101}*PRE_{ijk}*INFANT_GENDER$_k$ + γ_{110}*PRE_{ijk}*MEDICATION$_{jk}$ + γ_{120}*PRE_{ijk}*PARENT_GENDER$_{jk}$ + γ_{200}*$POST_{ijk}$ + γ_{201}*$POST_{ijk}$*INFANT_GENDER$_k$ + γ_{210}*$POST_{ijk}$*MEDICATION$_{jk}$ + γ_{220}*$POST_{ijk}$*PARENT_GENDER$_{jk}$ + r_{0jk} + u_{00k} + e_{ijk}.

Figure 5

Infant Heart Rates at Each Wave



Note. Pre = pre-babywearing; Mid = babywearing; Post = post-babywearing

Hypothesis 3, regarding the correlation between PHR and IHR within each wave, was tested with Pearson's correlation. One father-infant dyad did not participate in babywearing and post-babywearing, and the other did not participate in post-babywearing. Analysis of H3.1 showed that PHR and IHR had the strongest correlation during babywearing in both the mother-infant dyad ($\bar{r}$ = .52, *p* = .03) and father-infant dyads ($\bar{r}$ = .58, *p* = .17), compared to pre-babywearing or post-babywearing, but it was not significant in the father-infant dyad (see Table 5). Analysis of H3.2 showed that the correlation between PHR and IHR was not significantly higher (z = .22, p = .82) in the mother-infant dyad ($\bar{r}$ = .42, $p < .1$) than in the father-infant dyad ($\bar{r}$ = .32, p = .44).

Table 5

Pearson Correlation Coefficients Between the Mean of Parent Heart Rates and Infant Heart Rates Across All Timepoints for the 1st Reading

	Father-Infant Dyads			Mother-Infant Dyads		
	n	$\bar{r}$	*p*	*n*	$\bar{r}$	*p*
Pre-babywearing	8	-.05	.90	17	.39	.12
Babywearing	7	.58	.17	**17**	**.52**	**.03**
Post-babywearing	6	.04	.93	17	.06	.84

Hypothesis 4, regarding the influence of parents' gender on PHR and IHR during babywearing, was tested with a mixed model analysis (see Table 6). Analysis of H4.1 showed no significant effect of parent gender (β = -1.14, p = .47) on PHR during babywearing. Likewise, analysis of H4.2 showed no significant effect of parent's gender (β = -2.33, p = .46) on IHR during babywearing.

Table 6

Heart Rates During Babywearing

	Parent Heart Rates [a]			Infant Heart Rates [b]		
	β	*SE*	*p*	β	*SE*	*p*
Dyad level						
Intercept, π_0						
Intercept	**84.89**	**2.27**	**< .001**	**148.55**	**4.94**	**< .001**
Infant Gender (-1, boy; 1, girl)	**4.76**	**1.77**	**.02**	1.70	3.97	.67
Reading level						
Medication (-1, no medication; 1, medication)	2.94	1.80	.12	3.44	3.72	.37
Parent Gender (-1, father; 1, mother)	-1.14	1.56	.47	-2.33	3.08	.46

Note. N = 25 parent-infant dyads.

[a] Hierarchical linear modeling equation: $PHR_{ijk} = \gamma_{000} + \gamma_{001}$*INFANT_GENDER$_k$ + γ_{010}*MEDICATION$_{jk}$ + γ_{020}*PARENT_GENDER$_{jk}$ + r_{0jk} + u_{00k} + e_{ijk}.

[b] Hierarchical linear modeling equation: $IHR_{ijk} = \gamma_{000} + \gamma_{001}$*INFANT_GENDER$_k$ + γ_{010}*MEDICATION$_{jk}$ + γ_{020}*PARENT_GENDER$_{jk}$ + r_{0jk} + u_{00k} + e_{ijk}.

Chapter Summary

This chapter presented the statistical results of the study. Demographic characteristics included gender, medication, and babywearing frequency. Statistical analyses for each hypothesis were presented, and the following findings were reported: H1.1 analysis showed the contrary result to H1.1 with a significant increase in PHR from pre-babywearing to babywearing, while H1.2 was not supported with any statistical significance. H2.1 and H2.2 were not supported. H3.1 was not supported, as the strongest correlation between PHR and IHR during babywearing, compared to pre-babywearing or post-babywearing, was only significant for the mother-infant dyads and not for father-infant dyads. H3.2 was not supported. Finally, H4.1 and

H4.2 were not supported where parent gender did not significantly affect PHR or IHR during babywearing. Appendix C provides a summary of the hypotheses.

CHAPTER 5

DISCUSSION

This chapter discusses the study findings, limitations, and future research possibilities.

Discussion

Aim 1, which examined the influence of babywearing on PHR, was analyzed by comparing the PHR across the waves. This analysis found that babywearing significantly affected PHR and the interaction between medication and wave. The interaction between medication and wave indicates that a variable affected the PHR differently in parents who had infants who received medications than those who did not. It is plausible that the medications wore off when measures were taken. Also, it could be possible that the infants who received medications had more severe withdrawal symptoms than those who did not. With this possibility, parents may have become more anxious as their infants' withdrawal symptoms reappeared. For these reasons, the analysis of H1.1 and H1.2 was based only on parents with infants who did not receive medication.

It was hypothesized that PHR would decrease across the waves. The findings found PHR to decrease from pre-babywearing to babywearing but not to be significant, and to be significant but increasing from babywearing to post-babywearing, supporting neither H1.2 nor H1.1. In a previous study, a decrease in caregiver HR was found throughout all three waves (Williams et al., 2020), although, in the study, the caregivers included parents, volunteers, and staff. Only parents were included in this study, which may influence HR. PHR may have also increased from pre-babywearing to babywearing because parents were actively walking while babywearing; this activity could increase HR. It is plausible that in this study, because the mothers had substance abuse disorder and were being treated postpartum, their autonomic regulation differed from non-parent caregivers. In addition, women seem to be highly sensitive to drug effects, such as cocaine and amphetamine which activate their sympathetic nervous system, which then increases the HR (Wemm & Sinha, 2019).

A significant interaction was also found between infant gender and wave on PHR, indicating that a variable affected the PHR differently for parents with infant girls than parents with infant boys. There is a possibility that infant boys' autonomic nervous system may have more difficulties than infant girls in regulating the heart rate as Jansson et al. (2010) found a significant difference in infant boys compared to infant girls, where infant boys had more severe NAS symptoms during the first 4 days of life and required longer treatments and hospital stays and infants with NAS have neurobehavioral dysregulation (Anbalagan & Mendez, 2023).

Aim 2, to examine the influence of babywearing on IHR, was analyzed by comparing the IHR across the waves. Analysis of H2.1 and H2.2 was not supported as IHR was not significant across all three waves, but IHR was found to decrease across the three waves for infant boys and decrease from babywearing to post-babywearing for infant girls. In another study (Williams et al., 2020), medicated infants with NAS had lower HR and decreased HR throughout the waves but with parents and non-parent caregivers. Other factors not examined in conjunction with babywearing may significantly impact IHR, such as touching (Manzotti et al., 2019) while babywearing.

Aim 3, to examine the correlation between the mean PHR and IHR during each wave, was analyzed by comparing Pearson's correlations across the waves. H3.1 was supported for the mother-infant dyad, as the correlation was strongest during babywearing and significant, but not for the father-infant dyad, where the correlation was strongest during babywearing but not significant. This may be due to the father-infant autonomic coregulation occurring differently from the mother-infant autonomic coregulation. It also may be because the mother had spent more time with the infant while the infant was in utero and at the hospital, which would give the mother-infant dyad more opportunities to be autonomically coregulated. The number of fathers who participated in the study was less than half the size of the mothers, which would affect the significance of the analysis. Although the mother-infant dyad had a stronger correlation than the father-infant dyad, H3.2 was unsupported because the correlation was not statistically significant. Mother-infant dyads were expected to have a stronger correlation based on the Calming Cycle Theory. The correlation increased from pre-babywearing to babywearing and then decreased from babywearing to post-babywearing for both the father-infant and mother-infant dyads, which is expected per the Calming Cycle Theory since autonomic coregulation would be strongest when babywearing. Statistical significance may not have been achieved due to the small sample size, especially for the father-infant dyads, or the effect of babywearing was not strong enough. The effect of babywearing may increase as the number of times babywearing occurs between the parent-infant dyad increases. Further exploration is needed to examine the correlation between PHR and IHR.

Aim 4, to examine the influence of the parent's gender on PHR and IHR during babywearing, was analyzed by comparing parents' genders on PHR and IHR during mid-babywearing. Although parent gender had no significant effect on PHR and IHR, mothers had a lower HR than fathers, and infants with their mothers had a lower HR than infants with their fathers. Mothers having a lower HR than fathers is an interesting finding as postpartum mothers have, on average, a higher HR than the average woman (Green et al., 2021), and the average HR of a female is higher than that of a male (Prabhavathi et al., 2014). The mothers in this study may have had lower heart rates because they were receiving treatment for their drug abuse disorder.

Although neither H4.1 nor H4.2 was supported, further exploration of the lower HR in the mother-infant dyad compared to the father-infant dyad may give more insight into the autonomic coregulation of the parent-infant dyad.

Limitations

This study had limitations that need to be considered. There were some limitations to the Newborn Wellness and Attachment Study (PI: Rankin). Convenience sampling was used, which makes it difficult to control bias and increased variability of results. Another limitation was that babywearing history and babywearing frequency in the NICU were not controlled in a standardized manner. These factors could affect the parents' and infants' behaviors, influencing the dyad's autonomic coregulation.

There were other limitations in this research study as well. First, because secondary data was being used, it was impossible to ask additional questions of interest, such as previous babywearing experience, if babywearing occurred at other times, or if they had other children. The use of secondary data also means the use of proxy variables. HR was used instead of HRV in this case, as that was the data available. Another limitation of the study was the low number of fathers who participated. Although a mixed model analysis allows multiple data points of the same participant to be examined (which is advantageous with a small sample size), the small sample size of fathers is a limitation.

Other limitations of this study are that the focus is specific to parents and their infants with NAS and babywearing. Infants with NAS and their parents' autonomic nervous system may work differently from the general population due to drug abuse disorder and NAS. Consistent babywearing may also not be feasible for the general population; if the parent works, the opportunities for babywearing are limited. Although this study found that even with more than

50% of babywearing only occurring once, there was a significant correlation between PHR and IHR, indicating that even babywearing once may positively influence the dyad.

Future Research

Babywearing significantly affects the physiological response of parents (PHR). However, babywearing did not have a significant effect on IHR. Further investigation is required to determine whether this lack of significance was due to the limited duration of babywearing, the underdeveloped autonomic nervous system of infants with NAS, the severity of their mother's drug abuse disorder, and other factors. The Calming Cycle Theory supports the strong correlation between PHR and IHR during babywearing for the mother-infant dyad, which suggests that babywearing has a calming effect on infants and mothers. Father-infant dyads may be influenced similarly, but further research is needed.

Further research on the variables influencing correlation on the parent-infant dyad would strengthen this theory and provide further insight into autonomic coregulation and emotional connection. Parent gender did not significantly impact babywearing, but the HR followed the theorized trend of mothers' HR being lower than fathers and infants having a lower HR with their mothers than their fathers. Although this trend may not necessarily be a gender difference, it could result from how much time mothers spend with their infants compared to fathers. The small sample size may have influenced these results, and a larger sample size may show a trend toward significance.

Chapter Summary

The results of the analyses did not support any of the hypotheses. PHR was significantly influenced by babywearing when examining parents with infants who were not medicated but not in the hypothesized direction. IHR was not affected across the three waves (pre-babywearing,

babywearing, and post-babywearing), nor was parents' gender found to influence PHR and IHR. Both parent-infant dyads had the strongest correlation during babywearing, but it was only significant for the mother-infant dyad. While not statistically significant, the mother-infant dyad had a stronger correlation than the father-infant dyad between PHR and IHR, indicating that autonomic coregulation may be at work and supported by the Calming Cycle Theory, the framework used for this study.

While not statistically significant, the findings show clinical relevance in that babywearing lowers the IHR of the infants across the waves, which is beneficial physiologically and mentally for infants and, through autonomic coregulation, beneficial to parents. This study suggests that babywearing is an effective nonpharmacological intervention for parents and their infants with NAS to improve the PHR and IHR. However, further research is needed to examine the effects of babywearing on autonomic coregulation and emotional connection.

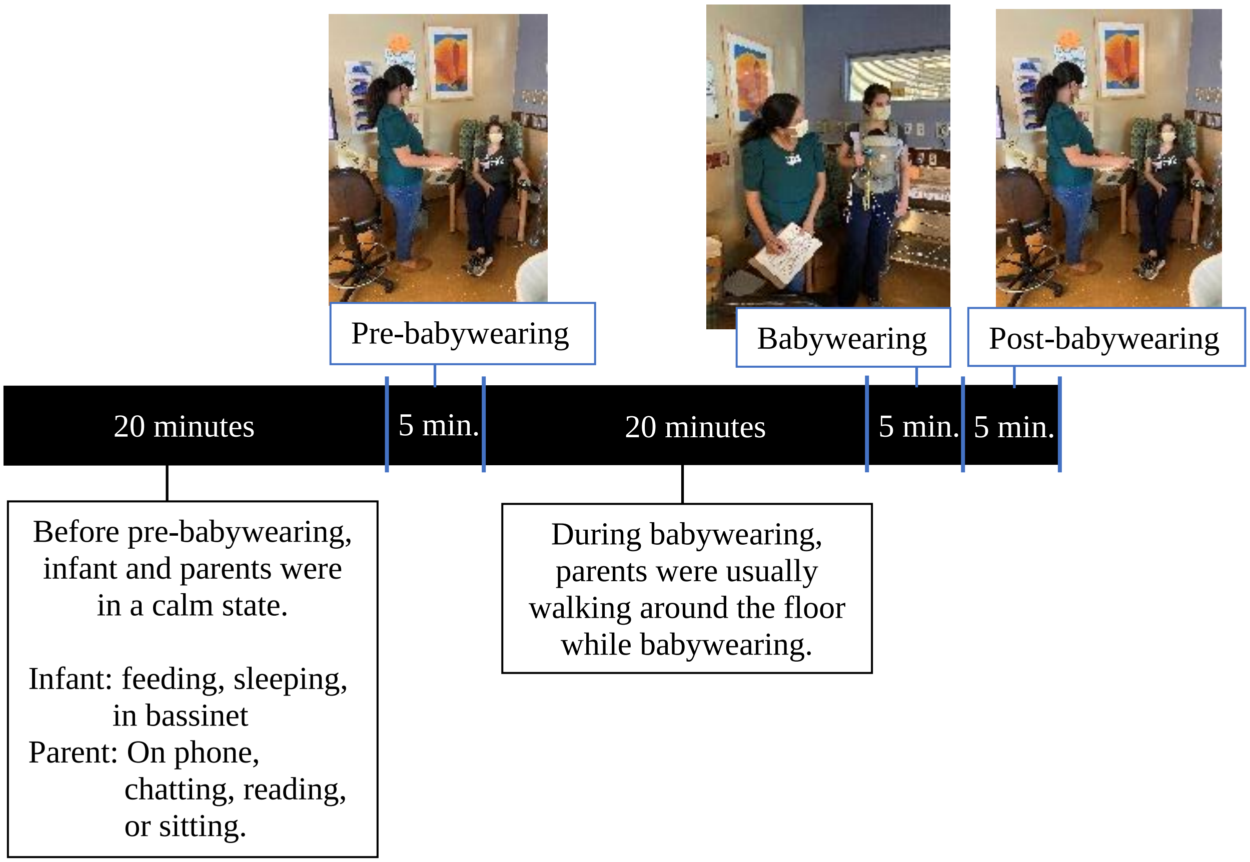
APPENDIX A

BABYWEARING DIAGRAM


20 Infants (ID)
25 Dyads (IF = infant father; IM = infant mother; Level 4)
42 Readings (Level 3)
125 Waves (Level 2)
2496 Heart Rates (Level 1)
31
IM
2
3 waves: pre, mid, post-babywearing
21 HR per wave
IF
2
5 waves: pre (2), mid (2), post-babywearing (1)
21 HR per wave
33
IM
1
3 waves: pre, mid, post-babywearing
21 HR per wave
IF
1
3 waves: pre, mid, & post-babywearing
21 HR per wave
34
IM
2
3 waves: pre, mid, post-babywearing
21 HR for 5 waves;18 for 1 wave
35
IM
5
3 waves: pre, mid, post-babywearing
21 HR per wave
36
IM
1
3 waves: pre, mid, post-babywearing
21 HR per wave
53
IM
1
3 waves: pre, mid, post-babywearing
21 HR per wave
60
IF
2
3 waves: pre- mid, post-babywearing
21 HR per wave
61
IM
2
3 waves: pre, mid, post-babywearing
21 HR per wave
67
IM
2
3 waves: pre, mid, post-babywearing
21 HR per wave
68
IM
1
3 waves: pre, mid, post-babywearing
21 HR per wave
70
IF
1
3 waves: pre, mid, post-babywearing
21 HR for 2 waves; 13 HR for 1 wave

APPENDIX B

TIMELINE



APPENDIX C

HYPOTHESES SUMMARY TABLE

Aim	Hypotheses	H	S
1. To examine the influence of babywearing on PHR.	H1.1. The PHR during babywearing will be lower than pre-babywearing.	N	Y
	H1.2. The PHR during post-babywearing will be lower than babywearing.	Y	N
2. To examine the influence of babywearing on IHR.	H2.1. The IHR during babywearing will be lower than pre-babywearing.	Y	N
	H2.2. The IHR during post-babywearing will be lower than during babywearing.	Y	N
3. To examine the correlation between the PHR and IHR during each wave.	H3.1 PHR and IHR will have the strongest correlation during babywearing.	Y	N [a]
	H3.2 The correlation between PHR and IHR will be stronger in the mother-infant dyads than in the father-infant dyads.	Y	N
4. To examine the influence of the parent's gender on PHR and IHR during babywearing.	H4.1. The mother's HR will be lower than the father's during babywearing.	Y	N
	H4.2. IHR will be lower with the mother than the father during babywearing.	Y	N

Note. H = Did the results trend in the direction of the hypothesis? S = Was there statistical significance?

[a] Statistically significant for the mother-infant dyad but not for the father-infant dyad.

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Welch, M. G., & Myers, M. M. (2016). Advances in family-based interventions in the neonatal ICU. *Current Opinion in Pediatrics*. https://doi.org/10.1097/MOP.0000000000000322

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Williams, L. R., & Turner, P. R. (2020). Infant carrying as a tool to promote secure attachments in young mothers: Comparing intervention and control infants during the still-face paradigm. *Infant Behavior and Development, 58*. https://doi.org/10.1016/j.infbeh.2019.101413

CURRICULUM VITAE

JOO-HEE HAN
hanj0205@gmail.com

EDUCATION

University of Las Vegas, Nevada, Las Vegas, NV **Summer 2023**
- Doctoral of Philosophy in Nursing
- Sigma Theta Tau Honor's Society

Northeastern State University, Muskogee, OK **August 2012**
- Master of Science in Nursing, Education

University of Pennsylvania, Philadelphia, PA **August 2009**
- Master of Science in Nursing, Pediatric Nurse Practitioner Program

La Salle University, Philadelphia, PA **December 2006**
- Bachelor of Science in Nursing
- Sigma Theta Tau Honor's Society

University of California at San Diego, San Diego, CA **June 2003**
- Bachelor of Science in Molecular Biology

NURSING GRADUATE/RESEARCH ASSISTANT EXPERIENCE

Fall 2022
- Run statistical analyses through SPSS and HLM

Spring 2022
- Assist with statistical analysis using R Studio
- Assist with literature review on "high school students' and high school counselors' perceptions of nursing as a career"
- Participate in R Studio, SPSS, literature review, and academic webinars

Fall 2021
- Assist with statistical analysis using R Studio
- Assist with literature review on "minority high school students' perceptions of nursing as a career"
- Participate in R Studio and literature review webinars

Spring 2021
- Assist with nursing course syllabi review to be accessible to all students in undergraduate and graduate courses
- Assist with alignment mapping of graduate nursing courses
- Assist with literature review on "secondary male students' perceptions of nursing as a career"

Spring 2020
- Assist with statistical analysis using R Studio
- Assist with initial and secondary screening for a scoping review

Fall 2017
- Assist with initial search and screening for a literature review
- Assist with R Studio directions for a graduate statistics course
- Assist with formatting of a professional resume for grant submission

Teaching Experience

uExams, Phoenix, AZ **10/2019 – 08/2020**
Exam Proctor
- Proctor LSAT exams
- Read professional certification exams for examinee
- Record answers for professional certification exams for examinee

Bacone College, Muskogee, OK **08/2019 – 12/2020**
Adjunct Instructor
- Provide online instruction for Health Science Courses

Tulsa Community College, Tulsa, OK **08/2017 – 08/2018**
Adjunct Instructor
- Provides theory and clinical instruction for the ADN track

Tulsa Community College, Tulsa, OK **08/2013 – 06/2017**
Assistant Professor
- Provides theory and clinical instruction for the ADN track

Bacone College, Muskogee, OK **08/2013 – 08/2018**
Adjunct Instructor
- Provide online instruction for Medical Diagnostic Imaging track
- Provide online instruction for RN-BSN track

Bacone College, Muskogee, OK **05/2011 – 08/2013**
Clinical Coordinator
- Coordinates the clinical assignments for the ADN program
- Monitors clinical experiences of faculty and students
- Liaison for the school and clinical facilities

Bacone College, Muskogee, OK **05/2011 – 08/2013**
Assistant Professor
- Provides theory and clinical instruction for the ADN track
- Provides theory instruction for the BSN track

Bacone College, Muskogee, OK **01/2011 – 05/2011**
Adjunct Clinical Instructor
- Provide clinical instruction for the ADN track

Kaplan Test Preparation, Tulsa, OK **04/2010-02/2015**
NCLEX Instructor
- Prepares students for the NCLEX in a classroom setting

Clinical Experience

Jack C. Montgomery Medical Center, Muskogee, OK **12/2013 – 02/2015**
Clinical Nurse II, Intermittent Registered Nurse
- Provides direct patient care to veterans in the emergency room, medical-surgical, and rehabilitation floors

Mollen Immunization Clinic, Broken Arrow, OK **08/2010 – 08/2013**
Registered Nurse
- Vaccinates clients 4 years and older with the flu vaccine and/or pneumonia vaccine

Holland Clinic, Philadelphia, PA (suburban setting) **2009**
Spectrum Clinic, Philadelphia, PA (urban setting) **2009**

- Pediatric primary care practice from birth to age 18
- Performed well-child visits as well as treating acute and stable chronic illnesses
- Provided preventive health counseling to patients and families
- Performed developmental testing

Covenant House Clinic, Philadelphia, PA **2009**

- Urban primary care practice within adolescent (age 18-21) crisis center
- Performed complete histories and physical examinations
- Counseled on psychosocial and behavioral issues

Helen O'Dickens Women's Clinic, Philadelphia, PA **August 2009**

- Urban obstetrics/ gynecology clinic seeing patients 18 years old and up
- Performed bimanual vaginal exams, PAP smears, and wet mount preps
- Counseled on birth control methods, pregnancy, and sexually transmitted diseases

Hospital of University of Pennsylvania, Philadelphia, PA **4/2007– 6/2010**

Clinical Nurse II, Registered Nurse

- Provides direct patient care to adults in a neurology/neurosurgery unit
- Observes patients in an EEG monitoring unit
- Performs duties as charge nurse
- Precepts new to practice nurses and nursing students

ACCREDITATIONS & LICENSES

- OK Registered Nurse #RN0099171 through January 2024
- AZ Registered Nurse #RN214459 through April 2026
- Certified Pediatric Nurse Practitioner – Primary Care #20100071 through January 2024
- BLS Certified through June 2024

PRESENTATIONS

Spring 2023

- Han, J., Lee, H., Feng, D., Benfield, R., Gray, P., & Rankin, L. (2023, April 19-22). *Babywearing's Influence on Parent and Infant Heart Rates* [Poster Presentation]. WIN 2023 "Leveraging Technology to Advance Nursing and Equity in Research, Practice, and Education." Tucson, AZ. https://assets-002.noviams.com/novi-file-uploads/win/pdfs-and-documents/2023_Conference_Program.pdf

Spring 2022

- Han, J., & Lee, H. (2022, April 6-9). *Babywearing: A Scoping Review* [Poster Presentation]. WIN 2022 "Justice, Equity, Diversity, and Inclusion (JEDI): Creating a Nursing Force for Change." Portland, OR. https://www.winursing.org/conference/2022-win-conference/

Spring 2021

- Han, J., Lee, H., Feng, D., Benfield, R., & Gray, P. (2021, April 14-16). *Association of babywearing to mother-infant emotional connection and maternal heart rate variability* [Poster Presentation]. WIN 2021 "Better Together: Integration of Nursing Research, Practice, and Education." Virtual. https://www.winursing.org/conference/2021-win-conference/

Spring 2019

- Han, J. (2019, April 10-13). *Maternal psychological benefits of babywearing: Calming cycle theory* [Poster Presentation]. WIN 2019 "Career, Connection, Community." San Diego, CA.

Spring 2013

- Presenter for Bacone College, Faculty Development Series: Moodle Quiz Feature in a Traditional Classroom

Spring 2011

- Presenter for a self-defense seminar at a regional Oklahoma Nurses Association meeting

PROFESSIONAL ACTIVITIES

Spring 2017

- Co-Chair of Simulation Council at Tulsa Community College

Fall 2016

- Co-Chair of Simulation Council at Tulsa Community College

Spring 2016

- Co-Chair of Simulation Council at Tulsa Community College
- Region 3 Representative for Oklahoma Nurse Association

Fall 2015

- Co-Chair of Simulation Council at Tulsa Community College
- Region 3 Representative at Oklahoma Nurse Association Convention

Spring 2015

- Chair of Simulation Council at Tulsa Community College
- Secretary at the regional Oklahoma Nurses Association meetings
- Guest expert for Cultural Awareness discussion about Asian cultures for Northeastern State University

Fall 2014

- Secretary regional Oklahoma Nurses Association meetings
- Guest expert for Cultural Awareness discussion about Asian cultures for Northeastern State University

Spring 2014

- Chair of Simulation Council at Tulsa Community College
- Secretary at the regional Oklahoma Nurses Association meetings
- Guest expert for Cultural Awareness discussion about Asian cultures for Northeastern State University

Fall 2013

- Chair of Simulation Council at Tulsa Community College
- Secretary at the regional Oklahoma Nurses Association meetings
- Guest expert for Cultural Awareness discussion about Asian cultures for Northeastern State University

Spring 2013

- Attendance at the regional Oklahoma Nurses Association meetings
- Guest expert for Cultural Awareness discussion about Asian cultures for Northeastern State University

Spring 2012

- Developed an "Introduction to Nursing" course
- Guest expert for Cultural Awareness discussion about Asian cultures for Northeastern State University

VOLUNTEER ACTIVITIES

Fall 2021 - present

- Basis Booster School Volunteer

Spring 2015

- Reading Partner Volunteer

PROFESSIONAL MEMBERSHIPS

- Alpha Chi
- American Nurses Association
- National Association of Pediatric Nurse Practitioners
- Phi Kappa Phi
- Sigma Theta Tau
- Western Institute of Nursing

AWARDS AND ACTIVITIES

- Western Institute of Nursing WIN/CANS Dissertation Grant recipient
- Grad Rebel Writing Boot Camp participant