Changing Patterns of Respiration in Premature Infants

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Abstract

The beneficial effects of the maternal voice in infant development have been demonstrated in numerous body systems. Due to underdeveloped respiratory systems, premature infants are at an increased risk for health problems. The purpose of this pilot study was to describe respiration patterns in premature infants in response to daily controlled exposure to a maternal voice recording. Twenty-three infants born at 27th to 28th weeks post menstrual age (PMA) were recruited from a Level III neonatal intensive care unit located at UF Health, a teaching hospital in the southeastern United States. Two experimental groups were exposed to maternal voice recordings; group 1 from 28-34 weeks PMA and group 2 from 32-34 weeks PMA. The control group was not exposed to a recording and was observed for respiratory pattern changes from 28-34 weeks PMA. Comparisons of the experimental groups to the control revealed that maternal voice recordings appear to reduce observed episodes of irregular deep-breathing in premature infants (group 1 = 60%, group 2 = 70%, control group = 90%). The percentage of deep respirations also differed between male (40%) and female (62%) infants. This pilot study suggests that exposure to maternal voice recordings may affect breathing patterns in premature infants.

I. Introduction

Premature birth, occurring before the completion of the 37th gestation week, is one of the most significant causes of infant morbidity and mortality. Often, these infants are considered very low birth weight (VLBW), weighing less than 1500 grams (UCSF Children's Hospital, 2004). Furthermore, underdevelopment of the lungs contributes to several health complications within this population. Lung development is still ongoing at term birth, with the maturation of the surfactant system and appearance of complete alveoli extending slightly past 40 weeks gestation. Premature infants, born before the 37th week of gestation, are still in the saccular period of lung development and do not have the capabilities of mature respiration (Glass et. al., 2015). Due to the immaturity of their lungs, respiratory complications continue to threaten premature infant survival and long-term clinical success.

In a review of her current research, Christine Moon addressed the role of auditory development on fetal and infant attachment and communication. For example, Moon (2011) found that sound can stimulate fetal movement as early as twenty-seven weeks gestation, indicating the development of the sensory system. Additionally, she demonstrated auditory discrimination as early as twenty-eight weeks gestational age, as the fetal cochlea was still developing. These findings suggest that the fetus can and does become accustomed to certain sounds while still in-utero. The mother's voice is likely the most familiar sound to the fetus, as it is the most accessible sound to them in the womb. Not only is the mother's voice most dominant in intensity, clarity, and total exposure to the fetus, but is transferred as the diaphragm produces movement against the fetus while the mother vocalizes. Given that mother's voice has this multi-modal effect, it likely acts as a strong agent in the fetus' auditory and attachment development.

Several studies have examined maternal voice recordings as therapeutic interventions that assist in the development of various body systems (i.e. cardiac system, Segall 1972; neuromuscular system, Chapman,1978; gastrointestinal system, Kruger et. al 2010), including the respiratory system (Standley and Moore, 2010). When exposed to the maternal voice, infants had lower heart rates (Segall, 1972), demonstrated laterality or the preference to one side of the body (Chapman 1978), and fewer episodes of feeding intolerance (Kruger et al. 2010). Finally, the mother's voice has been found to have a positive impact on premature infants' respiratory outcomes such as oxygen saturation (Standley & Moore, 2010). However, music exposure has led to better oxygen saturation outcomes compared to maternal voice recordings (Standley & Moore, 2010). Despite these findings, the effects of the maternal voice on respiratory patterns have not been described; this is the aim of the current pilot study. Describing which patterns are seen in these infants will inform future research on the health implications of the respiratory patterns that are seen here. Overall, these studies highlight the potential of maternal voice recordings as therapeutic options treating respiratory problems in premature infant.

II. Project narrative

The current project is a pilot study conducted as part of a larger study, "Maternal Voice as a Regulator of Neurobehavioral Development," conducted by Dr. Charlene Krueger, PhD, RN (Appendix A). The study was performed in a Level III neonatal intensive care unit (NICU) at UF Health Shands Hospital. Participants in the project included Dr. Charlene Krueger, PhD, RN of the University of Florida College of Nursing along with her research team of graduate and undergraduate students. Shands Hospital NICU staff nurses were informed about the testing procedures and actively assisted with the planning of test sessions. Stakeholders in the study are identified as Shands Hospital, NICU physicians and nurses, and the premature infants themselves, as well as their families and the research team. Positive outcomes of the study would potentially inform future NICU practices imperative to nurse and physician planning. The positive impact on the growth and success of infants would not only benefit the infants, but also their caregivers and the hospital in terms of overall increases in positive patient outcomes and cost of care.

Before members of the research team were allowed access to the study, IRB approval was achieved. Mothers of premature infants were approached by Dr. Krueger and a trained graduate student 24 hours post-delivery to describe the study and obtain both consent and a voice recording of the mother reciting a nursery rhyme. A twenty-four hour waiting period between birth and enrollment was implemented to allow mothers to feel more comfortable, relaxed, and open to participation. Infants had to meet the following inclusion criteria: (1) birth at twenty-seven or twenty-eight weeks post menstrual age (PMA), (2) English as the native household language, and (3) no major infant health complications. In total, 23 infants, ten males and thirteen females, were enrolled in this pilot study.

Subjects were randomly divided into two experimental groups and a control group. Experimental groups were exposed to maternal voice during two developmental periods. Group 1, comprised of six patients, listened to a playback recording of their mothers reciting a nursery rhyme twice daily for 45 seconds from weeks 28 - 34 PMA. Group 2 was comprised of seven patients who were exposed to the maternal voice recording also twice daily for 45 seconds, but only from weeks 32 – 34 PMA. This delay in time before exposing the infants to the recording was used to evaluate whether developmental differences affect the response to the voice recordings. Lastly, the control group of ten infants were not exposed to any particular sound stimuli, and were observed once per week in their resting state from 28-34 weeks PMA. Beginning at week 28 PMA, infants were observed in weekly test sessions. Breathing patterns, eye movement, and body movement were noted during test sessions to assess that the patient was in a quiet resting state, i.e. without large limb movement, with minimal eye movement, and respirations within normal limits (see Appendix C). For the control group, test sessions included two defined 45 second periods of observation without any maternal voice recording playback. For group 1, each test session consisted of recorded observation both prior to and during a 45-second long playback of the maternal voice recording. For group 2, test sessions from week 28-31 were identical to those of the control group, and from week 32-34, they were identical to those of group 1. Interrater reliability was maintained by using two research team members to observe respirations with greater than 95% agreement. To blind parents and health care team members from the treatments, blank playback devices were placed in the NICU incubators of the control group. Research team members were not blinded to the treatment groups.

Test sessions were planned to occur between infant feedings, visits from their mothers, and procedures. Additionally, test sessions were performed when the infant was in a stable, quiet resting condition. Test sessions followed a strict procedure using test session logs that included a pre-procedure checklist with the materials needed for testing and the bedside nurse's phone number, to confirm the infant was stable and recently fed before test sessions began (Appendix B). The checklist also included a detailed step-by-step procedure for setting up the equipment at the infant's bedside and preparing the infant for testing. To control for variations in maternal behavior, mothers were provided a "maternal log" to record the amount of time that they spent at the infant's bedside (Appendix D). The maternal log rated time spent on a scale 0-5, with 0 being no time spent that day and 5 being close to all of the mother's time. The log also asked the mothers to specify if they talked to or touched the infant.

Potential barriers to the study included first and foremost the unpredictable nature of patient enrollment and high-risk infant care as a whole. NICU premature infants are considered high-risk, and enrollment in the study was contingent on general health of the infant. Test session and participant unpredictability both factored into our pilot study. Some infants dropped out due to health issues and compromised health statuses. Additionally, a number of test sessions were cancelled due to emergency, unplanned procedures or infant irritability (i.e. excessive crying, fussiness) that carried potential to influence results from the session. The acceptable time frame for rescheduling test sessions was identified as 30 minutes at bedside; if the test session could not be performed within this time frame, the session was cancelled and recorded as having "no data."

Descriptive statistics were used to examine the data obtained. Specifically, comparisons were made between the total number of deep breaths observed in male versus female infants across time, the proportion of infants experiencing deep breathing by test session, and the total proportion of infants experiencing deep breathing episodes by experimental and control groups.

III. Results and Discussion

We found that infants who were not exposed to the maternal voice recordings experienced more deep breathing episodes compared to those who did, regardless of the developmental timing of exposure to the recording. Deep breathing was observed in 90% of the infants that were not exposed to maternal voice recordings, whereas only 60% of the infants in group 1 and 70% of infants in group 2 exhibited these deep respirations across all test sessions (Figure 1).

The sex ratio of each group varied from 33% male in group 1 to 50% male in the control group. Interestingly, the data collected showed a difference in the amount of deep respirations seen in male infants versus female infants regardless of group assignment. Four out of ten male infants (40%) experienced deep respirations at least once across all test sessions, compared to eight of the thirteen total female infants (62%). Additionally, in terms of total deep breathing "episodes," female infants demonstrated deep breathing in eighteen individual test sessions, while male infants showed only five total episodes. These differences were most notable in the first few test sessions; female infants were the only infants who demonstrated deep respirations in the first, second, and fifth test sessions, and were the predominant exhibitors of deep respirations until the final test session (TS7). By the final session, two male infants and five female infants exhibited deep respirations. While this difference could be attributable to low sample size, it may also indicate a difference between the sexes in respiratory development and stability.

The findings of this pilot study suggest that the maternal voice might play a role in stabilizing premature infant respirations, specifically in reducing the amount of deep respirations experienced by the infants. If the deep respirations are interpreted as a startle response, then the maternal voice may serve as a calming stimulus.

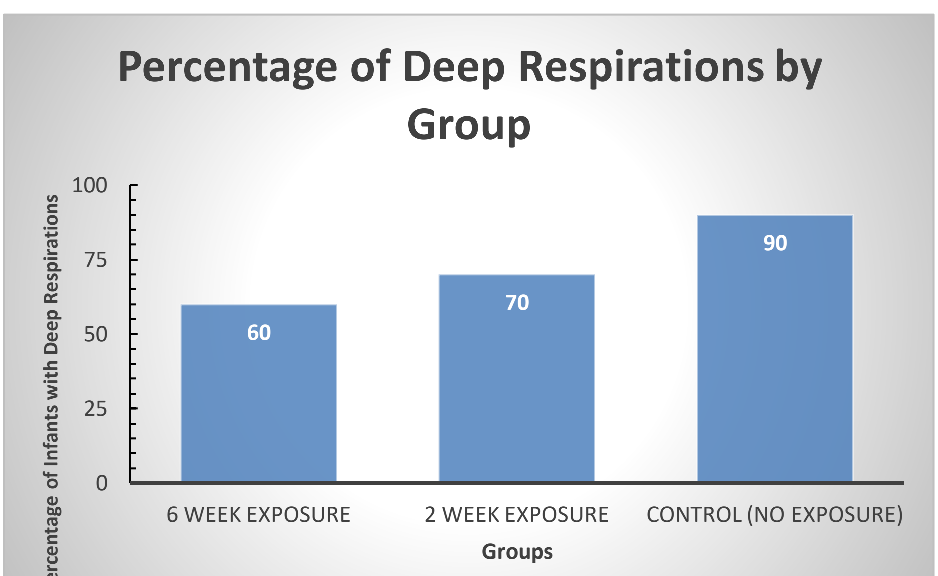

Figure 1: Percentage of infants exhibiting deep respirations by group. Group 1 represents the 6-week exposure experimental group, Group 2 represents the 2-week exposure group, and Group 3 represents the control.

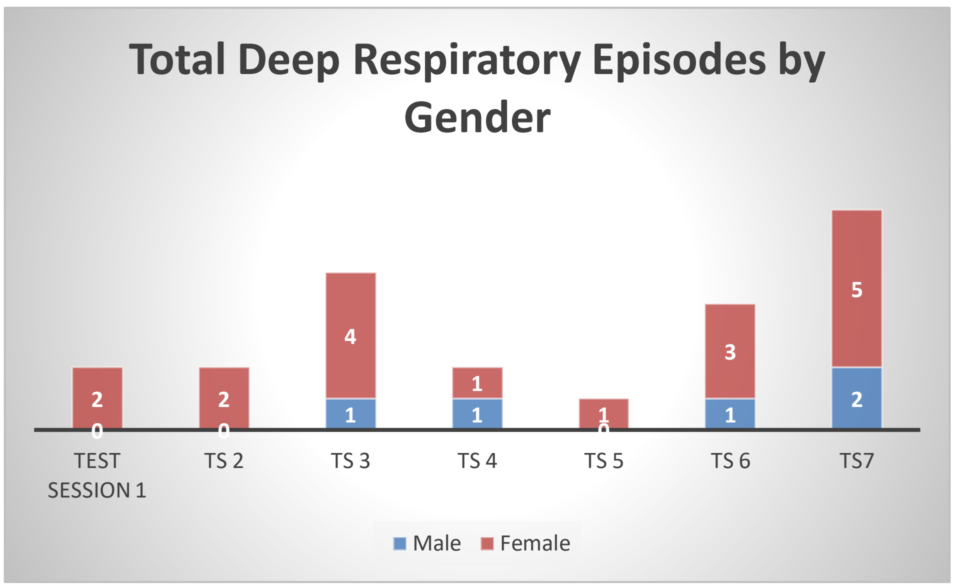

Figure 2: Total number of infants showing deep respiration episodes across gender and time.

IV. Summary and Conclusions

The goal of this project was to evaluate the effects of the maternal voice on premature infant respiratory patterns. The results of our study suggest that the maternal voice may be a beneficial stimulus for these premature infants. If the maternal voice serves as a calming stimulus in premature infants, it should be considered as an intervention for stabilizing respiration patterns and improving respiratory maturation for NICU-admitted premature infants. The maternal voice is not only a simple tool, but a very accessible one as well.

Despite the evidence favoring its use, maternal voice recordings have not implemented as a true method for improvement of NICU infant development. Here, we argue that maternal voice recordings may improve patient outcomes in premature infants. With further research, it may be recommended that NICUs attempt to provide recordings for premature infants when feasible. For patients and their families, these recordings may lead to more positive health outcomes and shorter hospitalization time due to enhanced respiratory stability and potential respiratory system maturation. Lastly, maternal voice recordings promote the advancement of nursing by providing a simple yet effective way for nurses to improve the health of their patients. Additionally, these recordings can involve the mother in the care of their infants during a time when they feel they may be unable to, which could promote maternal satisfaction and overall bonding between mother and child.

Our pilot study was limited by a small sample size, participant attrition, and multiple missing data points. Future studies should increase the sample size, stratify the groups by gender, and increase retention rates across the study, and examine the long-term consequences of maternal voice recordings. These future studies should connect the relevance of deep breathing respirations with long term health outcomes. Furthermore, these studies should involve quantitative methods to identify significant differences between the groups. For example, identifying a quantifiable method to measure the respiratory deep breaths of these premature infants, possibly with the use of Fast Fourier graphs (Appendix E), to evaluate the interactions between heart rate and respiration patterns could strengthen the decision whether or not to use maternal voice recordings in premature infant care.

In terms of my own learning and professional development, this project has taught me the importance of nursing research in multiple dimensions. Research in nursing puts the majority of its focus and purpose into finding the most effective improvements in patient care; in the research we conducted, the patients' experience was first and foremost, with the focus on those improvements that are safe, easy, and effective without unnecessary procedures or medications. With research like this, the benefits of the maternal voice have been strengthened and expanded. I have been able to see how nursing research can develop new practices that can be put into place to change patient care. Additionally, working on my project has taught me the practical developmental and analytic components of research. After working on this project I now understand the time, energy, and effort that is necessary to develop a successful research project. It is incredibly motivating to see the results of the study and the effects it can have on patient care, and inspires me to continue with clinical research in the future.

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Appendix A

Maternal Voice as a Regulator of Neurobehavioral Development in Premature Infants

Charlene Krueger, PhD, RN

The primary objective of the proposed study is to systematically replicate the PI's previous findings in the fetus and premature infant in order to establish the reproducibility of our previous empirical progress in regulatory implications for maternal voice recordings on neurobehavioral development in very low birth weight (VLBW) preterm infants.

Preterm infants experience major disruptions in maternal nurturing due to limits imposed during their hospitalization within the Neonatal Intensive Care Unit (NICU). In nonhumans exposed to similar disruptions (e.g., loud sounds, limited maternal touch and voice), short and long-term alterations in the brain, behavior patterns and hormone levels have been demonstrated. Our central hypothesis is that providing a low-decibel recording of the mother's voice at regular times during the day will beneficially regulate early neurobehavioral and that these benefits will vary depending upon the developmental timing at which exposure was begun. Our hypothesis has been formulated on our own previous work in which controlled exposure to maternal voice recordings potentially improved weight gain, significantly reduced the number of days to achieve enteral feeds and, more recently, resulted in earlier learning and maturation of the parasympathetic nervous system.

Forty-five stable premature infants born between 27 and 28 weeks postmenstrual age (PMA) and their forty-five mothers will be randomized to listen to a recording of their mothers reciting a passage during two different developmental time periods (28-34 weeks PMA or 31-34 weeks PMA) or to no recording (sham control group). Maternal recordings will be played twice daily for 45 seconds, 7 days/week for each developmental time period. Neurobehavioral development will be measured by following the infant's progression to oral feeding (weight gain, days to enteral feeding and days to oral feeding) and weekly assessments for determining when infants learn to recognize their mother's voice and normative changes in heart rate variability as a measure of autonomic nervous system development (using a spectral analysis). Results are expected to contribute to the development of interventions to improve a variety of health outcomes for preterm infants who are at high risk for complications related to neurobehavioral development.

Appendix B

Procedure for Preterm Testing Session

Date ____________Beginning time__________ Ending Time____________
****Maximum Time at Bedside is 30 Minutes****

PMA ________Week of Participation ________

Research Team Present: ____

<u>Prior to Test Session</u>

CHECK CART FOR:

- o ECG/Respiratory Monitor with ECG/Resp Module
- lap-top
- sound level meter
- speaker, speaker plug, and speaker cord
- tape measure/straw
- screwdriver
- Validate maternal recording is on laptop (shortcut to voice recordings on desktop).
- Subject binder
- Toy for preterm infant (t-shirt if 34 weeks PMA)

ECG Machine and Laptop Setup:

- Take out lap-top, place on top of cart, and plug in the power cord. Turn the lap-top on now.
- Use the grey cord to connect the monitor to the computer through the RX232 port (slot 14).
- Power on the Laptop, type in the password at the login and wait for the computer to load up.

Check with Bedside Nurse:

- Call 265-0033 and ask if the infant is stable for testing

<u>Once in the Neonatal Intensive Care Unit</u>

Room Set-up:

- Wash hands thoroughly prior to test session and prior to touching infant!
- Check for consent in preterm chart under consent section (burgundy tab "Procedure/Consent"). If the consent is not present, place copy in chart under this tab.
- Obtain permission from nurse in front of mom to proceed with test session. Validate with nurse that infant's vitals have been stable.
- Ask permission to transfer their ECG/Resp cable from their monitor to our monitor during the test session.
- Check time since last feeding (at least 15 minutes but no less).

Preparing Infant for Test Session:

- Begin hospital log (date, time, time since last meal).
- Unplug speaker from alarm clock and plug into laptop
- Double check speaker is positioned near the infant's <u>right ear</u>.
- Place sound level meter at ear closest to speaker.
- After nurse's approval, take cable from the NICU monitor and insert into our roving monitor.
- Plug in the monitor and the equipment cart.
- Unplug ECG/Resp cable from the NICU monitor and plug the cable into our roving monitor.
- Turn the monitor on by pressing the Power button
- To silent the monitor:
  - Turn the Monitor on.
  - Once it is warmed up, suspend the alarm by pressing the suspend button on the ECG monitor.
  - Press Alarms: Limits Review: Parameters On/Off: Select Off for all parameters one at a time
  - Press the ECG button located on the module
- Select the tab that says 'Change leads'.
  - Choose lead II. (Generally lead II is better, however you may try I or III if there is a lot of noise.)
  - Be careful not to choose the lead where the ECG signal is inverted.
  - To return the main screen, press the ECG button on the module once again.

Appendix C

Test Session Log Sample

Confidential

Krueger - Maternal Voice
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28th Week TS1 Log

Date ____________________

Time now ____________________

Time passed since last meal ____________________
(Expressed in minutes)

Calibrated dB Level (1) ____________________

Ambient dB Level in NI ____________________

Eyes
- ○ closed
- ○ open

Resp.
- ○ irregular
- ○ regular

Movement
- ○ None
- ○ Fine motor
- ○ Gross movement

During Recording dB Level (2) ____________________

Eyes
- ○ remained closed
- ○ opened

Resp.
- ○ remained irregular
- ○ increased in depth

Movement
- ○ None
- ○ Fine motor
- ○ Gross movement

Mean Weight at week 28 ____________________
(Grams)

Comments (Week 28)

____

06/01/2016 12:00pm

www.projectredcap.org REDCap

Appendix D

Maternal Log Sample

Maternal Log

Please record below approximately how much time spent talking or touching your infant.

The scale below represents the amount of time spent speaking or touching your infant:

0 **No time spent**
1 **Very little. Brief time spent speaking or touching**
2 **Less than half but, not half the time**
3 **Half of the time**
4 **More than half but, not the whole time**
5 **Very close, if not, all your time**

NUMBER OF HOURS =	0	1	2	3	4	5
Speaking to your infant						
Touching your infant						
NUMBER OF HOURS=	0	1	2	3	4	5
Speaking to your infant						
Touching your infant						
NUMBER OF HOURS=	0	1	2	3	4	5
Speaking to your infant						
Touching your infant						
NUMBER OF HOURS=	0	1	2	3	4	5
Speaking to your infant						
Touching your infant						
NUMBER OF HOURS=	0	1	2	3	4	5
Speaking to your infant						
Touching your infant						
NUMBER OF HOURS=	0	1	2	3	4	5
Speaking to your infant						
Touching your infant						
NUMBER OF HOURS=	0	1	2	3	4	5
Speaking to your infant						
Touching your infant						

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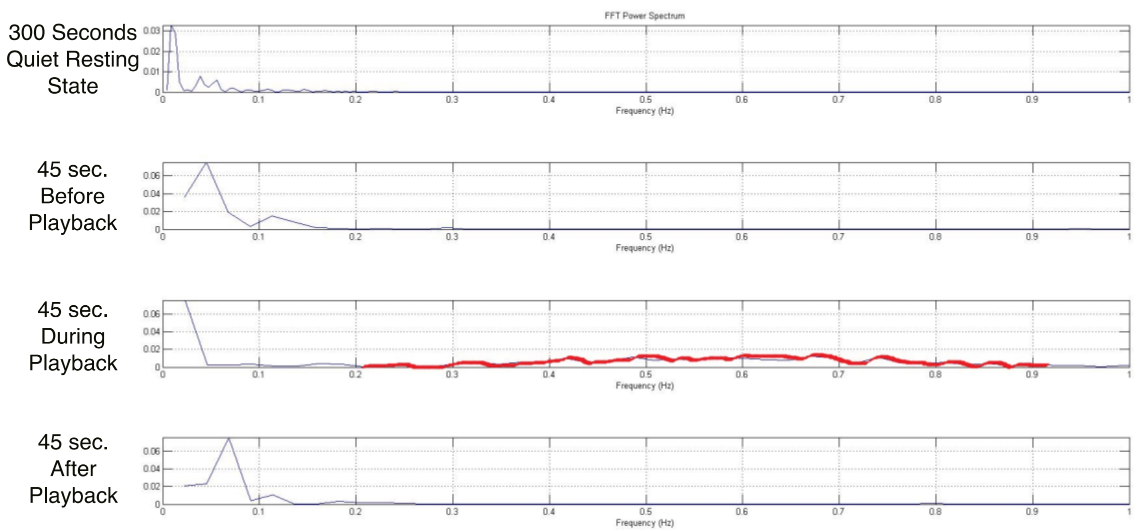
Appendix E

Fast Fourier Graph sample from data.



Fast Fourier Graph Example
from Data