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The effect of auditory stimulation on pain response of preterm infants

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Abstract

This study aimed to evaluate the effect of auditory stimulation on preterm infants' pain responses. A quasi-experimental design was utilized in this study. Thirty preterm infants were recruited for the study. They were one group used for three days as day one (routine care), day two (music intervention) and day three (recorded mother voice intervention) before, during and after blood sample procedure (heel prick) from Cairo University hospitals (El Monira and Kasar Aini). A tool containing two parts was used for data collection: 1) socio-demographic data for the preterm infants and the mothers, 2) Premature Infant Pain Profile (PIPP) tool for physiological responses (heart rate, oxygen saturation) behavioral state, brow bulge, eye squeeze, nasolabial furrow and respiratory rate was determined. Results of the study showed that during heel prick the majority of preterm infants (96.7%) who were exposed to recorded mother voice had highly statistical significant no or minimal pain followed by music groups (66.7%). On the other hand, nearly half of the cases (46.7%) had moderate pain and (30%) had severe pain among control group. There were significant differences between the three groups in the behavioral state, brow bulge, eye squeeze and nasolabial furrow ($P \leq 0.001$) and improved oxygen saturation ($P \leq 0.05$). After heel prick, the preterm infants (100%) who were exposed to recorded mother voice had highly statistically significant no or minimal pain in the items of behavioral state, eye squeeze and nasolabial furrow ($P \leq 0.001$), brow bulge was significantly lower ($P \leq 0.05$) when comparing by control or music group. In Conclusion, exposure to recorded mother voice during heel prick of preterm infants is better than exposure to music or no intervention and this was manifested by lower pain level, decrease heart rate, improved oxygen saturation and respiration.

Key words: Auditory stimulation; recorded mother voice; music; pain response; physiological responses; behavioral state

1. Introduction

The neonatal intensive care unit (NICU) can result not only in physical stress from invasive procedure that results in pain but also emotional stress as well from unfamiliar environment, inadequately managed pain from repeated painful procedures during a critical period of newborn brain development that can expose the infant to physiological changes as increased heart rate, respiratory rate and decreased oxygen saturation. Many types of pain can be managed by use of non-invasive, non-pharmacological techniques that don't pierce the skin and can lower the risk of infection and complications (Hockenberry &Wilson, 2015).

Research has shown that failure to reduce pain in preterm infants may lead to permanent changes in brain processing and maladaptive behavior later (Anand & Scalzo, 2008). Pain may have certain detrimental effect on the subsequent ability of the preterm infant to learn and remember new information. Also, prolonged stress due to pain may result in the irreversible depletion of hippocampal dendrites and repetitive pain and stress affect this apoptosis action more profoundly (Buskila, Neumann & Zmora, 2008).

Non-pharmacological pain intervention is a prophylactic and complementary approach to reduce pain. Also, at birth, the developing neonate is suddenly placed in an environment that is hugely different from that inside the womb, which was capable of taking responsibility for respiratory, cardiac, and digestive systems and body temperature. Thus, another technique for non-pharmacological intervention is environmental as multi-sensorial stimulation (Brenda, Elliot, Jeannie, Chris & Anand, 2007). Sound therapy has been described as a non-invasive and alternative health approach to wellness (Meyer, Neff & Garfield, 2009). Music alone or combined with the human voice seems to be a valuable resource to provide development stimulations in preterm newborn to reduce stress, promote bonding with parents and enhance development goals in NICU (Standley, 2002 in Medwell, 2012).

Music therapy deals with the controlled use of music and its influence on the human being in physiological, psychological and emotional integration of the individual during treatment of an illness or disability (Hartling et al., 2009). In the normal uterine environment, maternal speech provides a predominant, unique source of sensory stimulation (auditory, vibratory, and vestibular) for the developing fetus. Disruption of this normal exposure to the maternal voice has been hypothesized to negatively impact normal language development in humans and recognition of the maternal call in non humans so after birth, preterm infants seem to prefer their mother's voice over an unknown female voice (Kisilevsky, 2009).

Health care personnel should consider that painful procedures are part of the everyday care of neonates; pain reduction should be included as an important part of nursing education, an important condition for effective pain management lies in staff manner and values in addition to their skills in promoting pain management. Also, pain assessment in premature infants should be based on suitable tools (Al Hebabi, 2010).

2. Subjects and Methods

A quasi-experimental design (a design that lacks random assignments) was used and samples from 30 preterm infants were included in this study. They were examined for three days as day one (routine care), day two (music intervention) and day

three (recorded mother voice intervention) before, during and after blood sample procedure (heel prick). The study protocol was approved by the local institutional review board at Cairo University hospitals (CUH) (El Monira and Kasar Aini). An informed consent was obtained from the mothers prior to participation in the study and ethical consideration was, also, approved by the scientific research ethics committee, Cairo University, Faculty of Nursing. Inclusion criteria included babies having gestational age between 30 – <37 weeks, age 1-7 days, has positive startle reflex, APGAR scoring ≥7 and both sexes.

The study was examined for three days. In the first day (without any intervention), physiological responses (Heart rate, respiratory rate and oxygen saturation), behavioral state, brow bulge, eye squeeze and nasolabial furrow were measured four times: first time at 0 minute, second time after 5 minutes before painful procedure, third time during painful procedure at 10 minutes of starting painful procedure and fourth time at 5 minutes after finishing the painful procedure. In the second day, the infants were exposed to 15 minutes music of blue sky entertainment by Mozart (intervention 1). In the third day, they were exposed to 15 minutes of recorded mother's voice via headphone (intervention 2). The volume of music or recorded mother voice ranged from 50-60 decibel after consultation of a specialist using TM-102 sound level meter. Physiological responses were measured four times: first time before any intervention at 0 minute, second time after 5 minutes of starting intervention either music or recorded mother voice, third time during painful procedure at 10 minutes of starting interventions and fourth time at 5 minutes after finishing the procedure (total time of exposure to music or recorded mother voice was 15 minutes.

3. Statistical analysis:

Data were analyzed using the Statistical Package for Social Science (SPSS) version 20 (SPSS Inc. Chicago, IL). Numerical data were expressed as the mean and standard deviation (SD) while qualitative data were expressed as frequency and percentage. For quantitative data, comparison between three variables was done using ANOVA while Fisher's exact test was used for comparison of non parametric data. Probability (p-value) less than 0.05 was considered significant and less than 0.01 was considered highly significant.

4. Results

This study was conducted at the NICU of CUH in the period from August 2014 to February 2015.

Table 1: Socio-demographic data of preterm infants and their mothers (N=30).

Characteristics	Frequency	%
Male / Female	12/18	40/60
Gestational age (Mean ± SD)	33.4 ± 1.9	
Age at study (Mean ± SD)	2 ± 1.23	
APGAR score (Mean ± SD) at 1st minute	7.5 ± 0.50	
APGAR score (Mean ± SD) at 5th minute	8.6 ± 0.55	
Birth weight	2290.9 ± 2198	
Weight at 1st session Weight at 2nd session Weight at 3rd session	1884.5 ± 598 1817.9 ± 591 1787.6 ± 581	
Type of feeding		
- Breast feeding - Formula feeding - NPO & I.V fluids	2 12 16	6.7 40 53.3
Diagnosis		
- RDS - IDM - NJ - LBW - Poor feeding - IUGR	19 4 2 2 1 2	63.3 13.3 6.7 6.7 3.3 6.7
Mode of delivery		
- NVD/ C.S Type of mother anesthesia	19/4	63.3/13.3
- No or local	7	23.3
- General	6	20
- Spinal	17	56.7

Table (1) shows the socio-demographic characteristics of the preterm infants and the mothers included in the study. Females' preterm infants were more than males (60% Vs 40%, respectively). Approximately half of the preterm infants (53.3%) had a gestational age of 34-<37 weeks followed by (46.7%) of 30-33 weeks and the mean gestational age was 33.4 ± 1.9 weeks. The highest frequency of age of the study participants was 1 day (43.3%) and the mean age was 2 ± 1 days. The mean APGAR score in the 1st minute was 7.5 ± 0.5 while in the 5th minute, it was 8.6±0.5. The mean birth weight was 2291 ± 2198gm and decreases every session, prospectively. I.V feeding was the most frequent type of feeding between preterm infants (53.3%) followed by formula feeding (40%). On the other hand, the highest frequency of preterm infants had a diagnosis of respiratory distress syndrome (RDS) (63.3%) followed by infant of diabetic mothers (IDM) (13.3%) and the lowest frequency had poor feeding (3.3%). In addition, the highest frequency of cases was delivered by caesarian section (C.S) (76.7%) and most of cases received spinal anesthesia (56.7%).

Table (2): Comparison of total pain score between Control, Music and recorded mother's voice before, during and after heel prick (n=30)

Total pain score before heel prick	Control group	Music group	Recorded Mother's Voice group	Fisher Exact	P value
	NO (%)	NO (%)	NO (%)		
No or Minimal pain ≤ 6	29 (96.7)	30 (100)	30 (100)		
Moderate pain (7 – 12 score)	1 (3.3)	0 (0)	0 (0)	1.02	0.364
Severe pain ≥ 13 score	0 (0)	0 (0)	0 (0)		
Mean SD	1.9 ± 2.1	1.7 ± 1.3	1.4 ± 1.1		
During heel prick					
No or Minimal pain ≤ 6	7 (23.3)	20 (66.7)	29 (96.7)		
Moderate pain (7 – 12 score)	14 (46.7)	10 (33.3)	1 (3.3	41.75	0.000**
Severe pain ≥ 13 score	9 (30)	0 (0)	0 (0)		
Mean SD	9.8 ± 3.9	5.4 ± 3.4	2.8 ± 2.2		
After heel prick					
No or Minimal pain ≤ 6	23 (76.7)	28 (93.4)	30 (100)		
Moderate pain (7 – 12 score)	5 (16.7)	1 (3.3)	0 (0)	9.96	0.04*
Severe pain ≥ 13 score	2 (6.6)	1 (3.3	0 (0)		
Mean SD	4.3 ± 3.9	2.3 ± 2.6	1.4 ± .7		

Table (2) shows the comparison between the total pain score according PIPP score. There were no significant difference between the three groups (control, music and recorded mother's voice) before heel prick and the total percentages of cases among recorded mother's voice or music groups who had no or minimal pain while 3.3% of cases had moderate pain among the control group. During heel prick, the majority of preterm infants (96.7%) who were exposed to recorded mother's voice had highly significant no or minimal pain followed by music groups (66.7%) while approximately half of the control group cases (46.7%) had moderate pain and an additional 30% had severe pain. After heel prick, all the preterm infants (100%) who were exposed to recorded mother's voice had highly significant no or minimal pain followed by the music groups (93.4%) compared with the control group where 16.7% of cases had moderate pain and 6.6% had severe pain.

Table 3: Comparison between the mean score of Control, Music and Recorded Mother's voice groups according to PIPP during painful procedure (n=30)

Items	Control group	Music group	Recorded Mother's Voice group	F test	P value
Heart rate	136.3 ± 17.6	135 ± 18.1	135.5 ± 19.4	0.04	0.95
Oxygen saturation	94.4 ± 10.3	97.2 ± 2.8	98.3 ± 1.2	3.14	0.048*
Behavioral state	2.1 ± 0.81	1.3 ± 0.87	0.40 ± 0.67	35.68	0.000**
brow bulge	1.83 ± 1.11	0.76 ± 0.81	0.20 ± 0.48	28.79	0.00**
Eye squeeze	1.93 ± 0.94	0.76 ± 0.77	0.30 ± 0.53	35.84	0.000**
Nasolabial furrow	1.93 ± 0.98	1.03 ± 0.85	0.46 ± 0.57	24.49	0.000**
Respiratory rate	52.2 ± 19.6	48.9 ± 16.2	46.4 ± 11.8	0.97	0.380

Table (3) shows the comparison of the mean score of the three groups (control, music and recorded mother's voice during painful procedure. It shows that preterm infants who were exposed to recorded mother's voice during painful procedure had highly significant no or minimal pain in the items of behavioral state, brow bulge, eye squeeze and nasolabial furrow (P≤0.001) and improved oxygen saturation (P=0.04) when compared with the control or music group.

Table 4: Comparison between the Mean score of Control, Music and Recorded Mother Voice groups according to PIPP after painful procedure (n=30)

Items	Control group	Music group	Recorded Mother Voice group	F test	P value
Heart rate	136.4 ± 17.5	134.3 ± 16.9	132.4 ± 19.6	0.36	0.69
Oxygen saturation	96.8 ± 3.5	97.3 ± 2.6	98.4 ± 1.6	2.69	0.073
Behavioral state	0.63 ± 0.92	0.30 ± 0.65	0.00 ± 0.00	7.03	0.001**
Brow bulge	0.40 ± 0.77	0.23 ± 0.56	0.00 ± 0.00	3.96	0.02**
eye squeeze	0.56 ± 0.89	0.13 ± 0.43	0.00 ± 0.00	7.94	0.000**
Nasolabial furrow	0.60 ± 0.96	0.16 ± 0.46	0.00 ± 0.00	7.50	0.001**
Respiratory rate	57 ± 18.8	52.1 ± 14.7	47.6 ± 11.4	2.79	0.066

Table (4) shows the comparison between the mean score of the three groups (control, music and recorded mother's voice) after painful procedure. As shown, the preterm infants who were exposed to recorded mother's voice after painful procedures had highly significant difference of no or minimal pain in the items of behavioral state, eye squeeze and nasolabial furrow (P≤0.001) while in the item of brow bulge there was significant pain decrease (P=0.02) when compared with the control or music group.

5. Discussion

In this study, we examined the effect of auditory stimulation (Recorded mother's voice and music) on pain response of preterm infants during heel prick and compared it to routine care in a quasi-experimental design at CUH. We found that the majority of preterm infants (96.7%) who were exposed to recorded mother's voice during heel prick had highly significant no or minimal pain followed by music groups (66.7%) while nearly half of the neonates in the control group (46.7%) had moderate pain and an additional 30% had severe pain. According to a meta-analysis (Alipour et al., 2013), music has important clinical benefits for premature infants. These benefits include increased oxygen saturation, reduced stress, enhanced bonding with family members, reinforced non-nutritive suckling, increased suckling ability, and sustained homeostasis during multimodal stimulation

In some studies, the impact of music on oxygen saturation and heart rate were ineffective. For example, Johnston, Filion & Nuyt (2007), reported a decrease in infant's oxygen saturation. Also, Calabro, Wolfe & Shoemark (2003), reported no change in infants' heart rate following music therapy (Wood, 2008).

Two more recent studies reported advantages of exposure to maternal voice, but none were significant. Standley and Moore (2012), compared the effects of exposure to maternal voice and music on preterm infants aging 14–16 days. Infants were exposed to 20-min recordings of either maternal voice or music (decibel level = 65–70) for three consecutive days. While researchers found that both maternal voice and music positively affected the mean percentage of oxygen saturation rates, only the music group displayed significantly higher oxygen saturation rates on days 2 and 3 ($p < 0.05$). Findings suggested that exposure to maternal voice does not stabilize infants' oxygen regulation as well as music.

Our study indicated that the mean score of the three groups during painful procedures shows that preterm infants who were exposed to recorded mother's voice during the painful procedures had highly significant no or minimal pain in the items of behavioral state, brow bulge, eye squeeze and nasolabial furrow (P≤0.001) and improved oxygen saturation (p=0.04) when compared with the control or music group. Segall (2012); in a similar historical study; described the cardiac response following exposure to maternal voice in preterm infants born between 28–32 weeks' post-menstrual age (PMA), using an experimental design, infants received 30-minutes exposure to a daily recording of their mother's voice for 4–8 weeks. All

recordings were presented at 85 decibels and once the infants reached 36 weeks, PMA they were all tested. Finally, the experimental group responded with a significantly ($p<0.01$) greater decrease in heart rate to a recording of the mothers' voice and a recording of an unfamiliar female (−24.5 beats per minute & −19.50 beats per minute, respectively) than the control group (−7.95 beats per minute & −8.33 beats per minute, respectively).

The majority of studies reinforce that music therapy has positive effects on the premature infants' behavioral parameters. For instance, the infants can calm down and relax, as a result of this pacification. A study by Farhat et al. (2010), showed an increase in oxygen saturation levels as well as regularity in heart rate. The premature infants also became more self-balanced and had more energy left to grow. It is incongruent with another study by Standley and Moore (2011), compared the effects of exposure to maternal voice and music on preterm infants. They were referred to as preterm and 14–16 days post-birth, using an experimental, repeated measures design. They exposed the infants to 20 minute recordings of either maternal voice or music (overall decibel level=65–70) for 3 consecutive days and they found that both maternal voice and music positively affected the mean percentage of oxygen saturation rates compared to the baseline rates. The music group displayed significantly higher oxygen saturation rates on days 2 and 3 (Day 2: $t=3.40$. $df=8$, $p<.05$; Day 3: $t=2.81$, $df=8$, $p<.05$). This finding suggests that exposure to music stabilizes infants' oxygen regulation better than exposure to maternal voice. Moreover, Johnston et al. (2011), denoted that exposure to familiar sounds has been positively associated with improved physiological stability (decreased heart and respiratory rates and an increase in oxygen saturation), less agitation and more time in stable sleep or quiet alert state, may the larger decrease in heart rate as a more adaptive response to their mother's voice.

In the current study, the mean score of the three groups (control, music and recorded mother's voice) after painful procedures, shows that preterm infants who were exposed to recorded mother's voice after painful procedures had highly significant difference of no or minimal pain in the items of behavioral state, eye squeeze and nasolabial furrow ($P\leq0.001$). On the other hand, brow bulge showed significantly decreased pain ($P=0.02$) when compared with the control or music group. It is congruent with Hartling et al. (2009), who stated that a recent review included nine randomized trials that examined the efficacy of music for procedural pain management (circumcision and heel lance) in both full term and preterm infants. Outcomes reported were primarily physiological (heart rate, SaO2, respiratory rate) and behavioral and validated pain score and the authors concluded that music therapy may improve physiological stability and diminish pain response during procedural pain. However, more rigorous trails were needed to confirm these findings.

A similar study by Johnston et al. (2007), examined infants delivered between 32 to 36 weeks of gestational age during a routine painful procedure in the NICU (heel stick) using a within-subject experimental design, infants were tested 10 days after birth following a 48-hour exposure to hearing their mothers' voices 3 times a day and recordings were presented for 10 minutes at 70 decibels and filtered, in order to mimic how the mother's voice sounds from the amniotic fluid of the uterus. While outcomes denoted that no significant findings were reported related to the components of the pain tool (oxygen saturation, facial expressions, and sleep-wake state); a significantly greater decrease in oxygen saturation rates ($p<0.01$) was noted following exposure to maternal voice (94.1) compared to no exposure prior to the heel stick (96.2).

6. Conclusion

In conclusion, this study showed that using of recorded mother's voice during heel prick is superior to using music or usual routine care as manifested by improved oxygen saturation and minimizing behavioral state, brow bulge, eye squeeze and nasolabial furrow.

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7. Competing interests and disclosures

All authors do not have any commercial or other association that might pose a conflict of interest.

References

Al Hebabi, J. (2010). Do neonates need pain management? UCQ Nursing Journal of Academic Writing, winter, 45-50, http://www.qatar.ucalgary.ca/acwr/w 2010.

Anand K and Scalzo F. (2008). Can adverse neonatal experiences alter brain development and subsequent behavior? Biology of the Neonate; 77:69–82.

Brenda Golianu, Elliot Krane, Jeannie Seybold, Chris Almgren, and Anand K. (2007). Non-pharmacological techniques for pain management in neonates. Semin Perinatol; 31:318-22.

Buskila D, Neumann L, Zmora E. (2003). Pain sensitivity in prematurely born adolescents. Arch Pediatr Adolesc Med; 157:1079 in www.nnfpublication.org (2008).

Farhat, A., Amirib, R., Karbandic, S., Esmailyd, H., & Mohammadzadeha, A. (2010). The effect of listening to lullaby music on physiologic response and weight gain of premature infants. Journal of Neonatal-Perinatal Medicine, 3, 103–107.

Hartling L, Shaik MS, Tjosvold L, Leicht R, Liang Y, Kumar M. (2009). Music for medical indications in the neonatal period: a systematic review of randomized controlled trials. Arch Dis Child Fetal Neonatal Ed; 94: F349–54.

Hartling L, Shaik MS, Tjosvold L, Leicht R, Liang Y, Kumar M. Music for medical indications in the neonatal period: a systematic review of randomized controlled trials. Arch Dis Child Fetal Neonatal Ed 2009;94:F349–54.

Hockenberry M. J &Wilson D. (2015). Wong's nursing care of infants and children, CHAP 9 The High-Risk Newborn and Family 10th edition., Mosby, an imprint of Elsevier Inc, 364.

Johnston c., Fernandes A. & a Campbell-Yeo M. (2011). Pain in neonates is different, 0304-3959/$36.00 _ 2010 International

Association for the Study of Pain. Published by Elsevier B.V, PAIN_ 152 (2011) S65–S73.
Johnston CC, Filion F, Nuyt AM. (2007).Recorded maternal voice for preterm neonates undergoing heel lance.Adv Neonatal Care;7(5):258-266.
Kisilevsky B.S. (2009). Fetal sensitivity to properties of maternal speech and language, Infant Behav, Dev. 32: 59–71.
Meyer W, Neff G & Garfield-O'Brien. (2009). A summary of sound therapy and vibretional healing concepts. http://www.healingsound.com.
Segall M. (2012). Cardiac responsivity to auditory stimulation in premature infants. Nurs Res;21(2):15–19. [PubMed: 4480928]
Standley J. (2002). A meta-analysis of efficacy of music therapy for premature infants. J. Pediatr.Nurs.m 17: 107-113, in Research Journal of medical science. (2012), © Medwell Journal,6(3):148-153.
Standley JM, Moore RS. (2011).Therapeutic effects of music and mother's voice on preterm infants. Pediatr Nurs;21(6):509–512. 574. [PubMed: 8700604]
Standley JM, Moore RS. (2012). Therapeutic effects of music and mother's voice on premature infants. Pediatr Nurs.;21:509–512
Standley JM. (2002)A meta-analysis of the efficacy of music therapy for premature infants. J PediatrNurs;17:107-113; in Eskandari N, Alipour Z, Tehran H A, Hossaini S & Sangi S. (2013). Effect of vocal stimulation on responses of premature infants: A randomized controlled trial, Health, Spiritual Med Ethics - Vol.1, No.1.
Wood AH. (2008). Effect of music therapy on premature infant in the neonatal intensive care unit.PhD Dissertation.Alabama University, p.61-98
Calabro, J., Wolfe, R., & Shoemark, H. (2003). The effects of recorded sedative music on the physiology and behaviour of premature infants with a respiratory disorder. Australian Journal of Music Therapy, 14, 3–19.