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Positive effects of low intensity recorded maternal voice on physiologic reactions in premature infants

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ABSTRACT

Objective: To evaluate the effect of low intensity recorded maternal voice on the physiologic reactions of healthy premature infants in the neonatal intensive care unit (NICU).
Methods: Physiologic responses of 20 healthy preterm infants in the NICU of Shariati Hospital, Tehran, were obtained during a 15 min intervention including three 5 min periods (no-sound control, audio recorded playback of mother's voice, no-sound post-voice). The intervention was presented three times a day for three consecutive days. During each intervention, oxygen saturation (%, OSPR), heart rate (HR), and respiratory rate (RR) were recorded at 1 min intervals over the 15 min and then averaged over each 5 min period, resulting in 3 averages for each variable for each intervention.
Results: Repeated Measures Analysis of Variance were employed to examine each variable separately. Over the three days, comparison of oxygen saturation over each of the three periods (before, during voice, after) revealed an increase in oxygen saturation during the voice period, compared to the pre-voice period, which persisted over the post-voice period; there were no differences between the voice and post-voice periods. Analyses of the HR and RR data showed a decrease in both variables during the voice period compared to the pre-voice period which persisted over the post-voice period. Again, there were no differences between the voice and post-voice periods.
Conclusion: Exposure to low intensity recorded maternal voice has positive effects on the preterm infants 'physiologic responses.

1. Introduction

In a normal, healthy pregnancy, the fetus develops within the uterus until delivery at term [38–42 weeks gestational age (GA)]. While in-utero, they begin to perceive sounds as early as 26–28 weeks of gestation (Chelli & Chanoufi, 2008) and by term, they can identify and differentiate their own mother's voice from a stranger's voice (Chelli & Chanoufi, 2008; Kisilevsky et al., 2003). The mother's voice is regarded as an important sensory stimulus in the intrauterine environment, playing a key role instructural and functional fetal development (Kisilevsky et al., 2009; Krueger, 2010; Verklan et al., 2014). However, when an infant is born prematurely (i.e., before term), they are not only deprived of the normal intrauterine environment

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Table 1
Demographic characteristics of infants and mother.

Maternal age (years), mean ± SD, range	29.9 ± 7.17(18–50)
Infant's gender, N (%)	
Male Female	10 (50%) 10 (50%)
Gestational age (weeks), mean ± SD, range	31.35 ± 1.79 (30–34)
Age after birth (days), mean ± SD, range	10.10 ± 6.55 (3–25)
Birth weight (grams), mean ± SD, range	1450 ± 413 (1000–2570)
Weight on the first day of intervention (grams), mean ± SD, range	1629 ± 453 (1100–2650)

and the stimulatory effect of their mother's voice, but also they are exposed to elevated levels of sensory stimuli such as lights and sounds during hospitalization in the neonatal intensive care unit (NICU) (Als, 1982; Kisilevsky et al., 2003). According to several studies, such elevated levels of auditory stimulation can negatively affect the infant's cardiovascular and respiratory systems, oxygen saturation, sleep pattern, feeding, and future cognitive, behavioral, and language development (Bhutta, Cleves, Casey, Cradock, & Anand, 2002; McMahon, Wintermark, & Lahav, 2012; Wachman & Lahav, 2011).

The positive effects of the mother's voice in newborns such as better weight gain, less feeding intolerance attacks, earlier achievement of full enteral feeding, reduced attacks of apnea and bradycardia, improved sleep quality, stable vital signs, earlier discharge from NICU and larger auditory cortices have been reported in several studies (Bozzette, 2008; Cevasco, 2008; Cimino, 2009; Doheny, Hurwitz, Insoft, Ringer, & Lahav, 2012 ; Filippa, Devouche, Arioni, Imberty, & Gratier, 2013; Krueger, 2010; Krueger, Parker, Chiu, & Theriaque, 2010; Zimmerman, Keunen, Norton, & Lahav, 2013).

Most studies reporting the positive effects of the mother's voice have used sound levels greater than those recommended by the American Academy of Pediatrics (AAP) Committee on Environmental Health (1997).The purpose of the present study was to examine the effects of sound levels within the AAP recommended levels (i.e., ≤50 dB).

We conducted this study to investigate the effect of low intensity recorded maternal voice on physiologic responses including HR, RR, and OSPR of premature infants during their NICU stay.

2. Material and methods

2.1. Participants

Thirty five premature infants were hospitalized in the NICU of Shariati Hospital, affiliated to Tehran University of Medical Sciences, Tehran, Iran, from January2015to March2015.Infants with a history of maternal diseases (such as diabetes, preeclampsia, hypertension . . .), drug abuse or alcoholism were excluded from the study. Other exclusion criteria were neonates who had congenital anomalies; congenital hearing loss; viral, fungal or bacterial infections; metabolic disorders or diseases, intraventricular hemorrhage or other cranial pathologies; acute diseases such as asphyxia and necrotizing enterocolitis; a history of receiving mechanical ventilation, respiratory support, and oxygen intake using medicines such as cardiogenic medications and muscle relaxants. Infants whose parents were not willing to participate in the study were not included. Totally, 20 premature infants who were stable, appropriate for gestational age (AGA) with no acute disease, born between 30 and 34 weeks of gestational age and weighed more than 1000 g at birth with a minimum age of 48 h after birth were enrolled in this study. All participants passed otoacoustic emissions (OAE) and auditory brainstem response (ABR) tests according to the study protocol. All of them had intact hearing. Demographic maternal and infant characteristics are shown in Table 1.

2.2. Procedures

2.2.1. Training

A specialized NICU nurse was trained for carrying out the study protocol, monitoring the pulse oximetry, heart and respiratory devices, and recording data. Sitting in a quiet, comfortable room, the mothers were 'asked' to speak out loud to their infants in the same manner they had spoken to the fetus during pregnancy. Then, they were asked to talk into a recorder. So, every neonate just heard its maternal voice with her special words, feelings and speech. Their voices were recorded for five minutes.

2.2.2. Intervention

Before each intervention, the alarm of the devices was turned off. To ensure the authenticity of the function of the devices during the intervention, the infant's nurse was present at the bedside. In order to omit additional sounds around the participants, the intervention was performed in one of the isolated rooms of NICU where the noise and traffic were the least. The maternal voice was broadcast three times a day (at 8a.m., 1p.m. and 6p.m.) for the infants while they were alert and awake and had received nursing care before intervention.

To ensure the infants' auditory safety, the intensity of maternal voice was monitored individually for each infant to be ≤50 dB by a sound level meter device (Bruel & Kjear 2250, Germany) near the speaker, based on the recommendations of AAP (1997). The sound level ranged from 55.4 to 58.2 dB in the room and from 53.2 to 55.5 dB near the infants' heads, respectively.

Each 15 min intervention included three, 5 min periods (no- sound before the playing of the mother's recorded voice, no-sound following the voice) and was delivered three times a day for three consecutive days.

During the first period of each cycle, the infant's baseline HR, RR, and OSPR were recorded for five minutes. Next, the infant was exposed to audio recordings of its mother's voice over the second five minutes, during which the variables were recorded too. Finally, the infant's HR, RR, and OSPR were recorded for five minutes after cessation of the maternal voice broadcast. The recorded voice was broadcast via speakers placed approximately 20 cm from the infant's head.

2.3. Equipment

The brand of the incubators was David Medical YP 90A, made in China. OSPR was measured with a pulse oximeter (Novametrix, USA). To make sure of the accuracy of OSPR, the sensor of the pulse oximeter was fastened to the limbs in such a way not impairing the blood flow to that area. HR and RR were monitored using Oxypleth monitoring devices (Respironics, California, USA).Auditory tests including OAE and ABR were done for all infants using Accuscreen (Madsen, Denmark).Maternal voices were recorded using a computer program (Cool Edit 2000) for five minutes.

2.4. Statistical analysis

The results were analyzed by SPSS software, version 21. Quantitative and qualitative variables were described in terms of mean ± SD and percentages, respectively. Each variable was recorded by the trained nurse under supervision of the researcher every one minute at the same time. We computed the mean for each five-minute period (before, during, and after intervention).

Repeated Measures Analysis was used to show changes of variables over time in studied group (within group variances)and the of mean ± SD of OSPR, HR, and RR changes before, during and after periods of intervention over three cycles per day. When Mauchly's test was not significant – assumption had not been met – we reported the univariate results with an epsilon correction(Greenhouse-Geisser).But if Mauchly's test was significant -assumption of compound sphericity was met-we reported "sphericity assumed" results. Both Linear and quadratic contrasts in all analysis were significant.

The final analysis was performed by GLM (general linear method) that clarified the changes of mean ± SD of all three indices (OSPR, RR and HR)before, after and during periods of intervention over three days.

The significance level and power of the study were determined as 5% and 80%, respectively.

2.5. Ethics

The present quasi-experimental, repeated measures study was registered as a research project (code91-04-19451) at Breastfeeding Research Center. It was approved by the Research Ethics Committee of Tehran University of Medical Sciences and was also registered at the Iranian Registry of Clinical Trials (ID: 201111268199N1). Both parents provided informed, written consent for their infants to participate in the study.

3. Results

A total of 35 premature newborns were investigated. Five infants with a history of maternal diabetes, preeclampsia, hypertension and drug abuse were excluded from the study. Eight neonates were also excluded because they had congenital heart diseases, sepsis, intraventricular hemorrhage, asphyxia, necrotizing enterocolitis, a history of receiving mechanical ventilation or other respiratory supports. Two infants whose parents were not willing to participate in the study were not included. According to the inclusion and exclusion criteria of the study,only 20 premature infants (50% boys, mean gestational age: 31.35 ± 1.79 weeks) were enrolled.The mean ± SD of OSPR, HR and RR changes before, during and after periods of intervention over three cycles per day, F (df) and P-values are shown in Table 2.

The mean changes of physiologic variables (including OSPR, HR, and RR) during each cycle of intervention (before, during and after periods of the intervention) are shown in Figs. 1–3 .There were three cycles on each day and a total of 9 cycles on three consecutive days that have been shown in each figure.

3.1. Oxygen saturation percentage rate variations

OSPR increased significantly during each intervention on three consecutive days ($p < 0.005$). Fig. 1 shows a slow declining pattern of OSPR after interrupting the intervention, an increasing pattern again after the intervention and repeated similar cycles in each 15 min.

According to the final analysis which was performed by GLM, changes of the mean ± SD of OSPR over three days were similar. But comparison of the mean ± SD of three time points (before, after and during periods of intervention) over three

Table 2
Comparison of mean ± SD of OSPR, HR, and RR changes before, during and after periods of interventions over three cycles per day by Repeated Measures Analysis.

Physiologic Variable	Day	Voice playing	Mean ± SD of each index over three cycles per day	F(df)	P.value
Oxygen Saturation Rate	1	before	94.95 ± 2.21	27.63(1.6)	0.0001
		during	96.62 ± 2.28		
		after	96.62 ± 2.61		
	2	before	95.60 ± 2.03	40.67(2)	0.0001
		during	97.45 ± 1.66		
		after	96.97 ± 1.60		
	3	before	95.55 ± 1.67	91.63(1.6)	0.0001
		during	97.00 ± 1.41		
		after	96.82 ± 1.61		
Heart Rate	1	before	158.45 ± 16.62	74.61(1.8)	0.001
		during	149.42 ± 14.0		
		after	147.45 ± 11.09		
	2	before	154.95 ± 14.58	66.62(1.8)	0.0001
		during	150.77 ± 12.31		
		after	148.72 ± 11.88		
	3	Before	160.12 ± 11.69	155.60(1.9)	0.001
		during	154.22 ± 10.04		
		after	154.72 ± 9.1		
Respiratory Rate	1	before	56.60 ± 5.36	2.19(1.8)	0.0001
		during	53.60 ± 4.96		
		after	53.62 ± 5.79		
	2	before	56.75 ± 3.84	11.50(2)	0.0001
		during	52.62 ± 3.34		
		after	52.67 ± 3.86		
	3	before	55.70 ± 3.72	4.67(2)	0.015
		during	52.67 ± 4.26		
		after	52.90 ± 3.5		

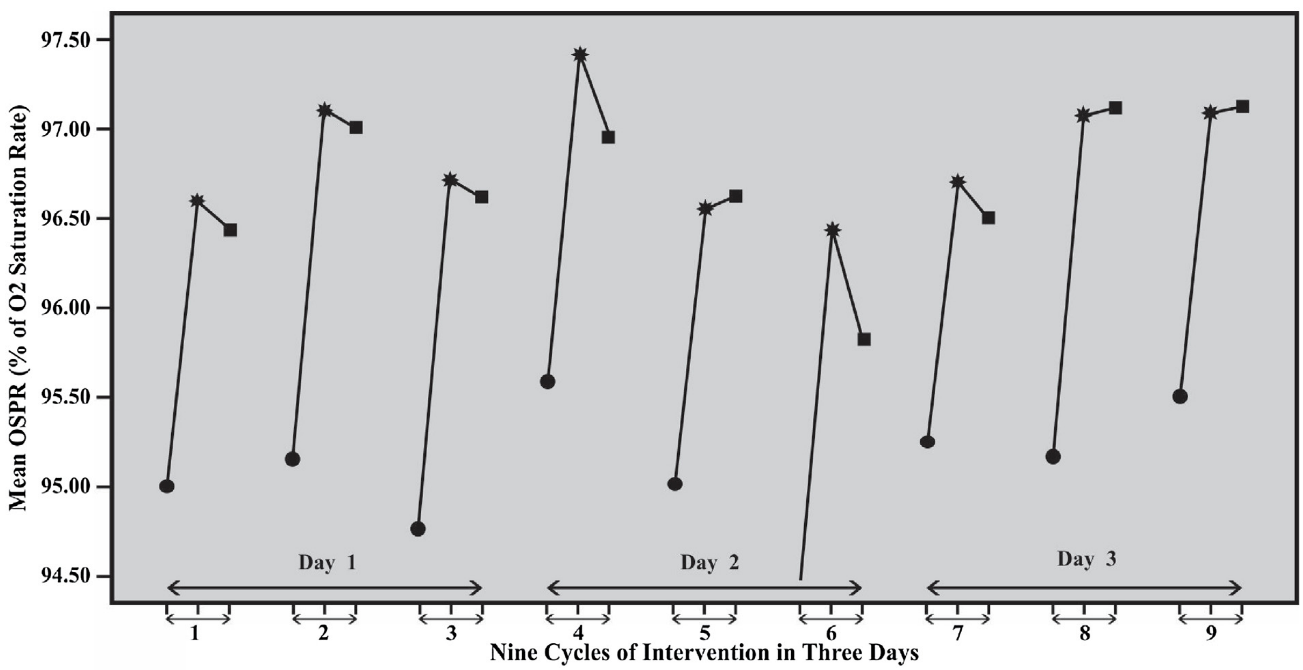

Fig. 1. The symbol (●) points the mean OSPR in 5 min before intervention, (*) the mean of OSPR in 5 min during intervention & (■) the mean of OSPR in 5 min after intervention.

days showed significant increase during and after periods of each intervention relative to before voice broadcast. There was no significant difference between mean ± SD of OSPR during and after periods of interventions over three days (Table 3).

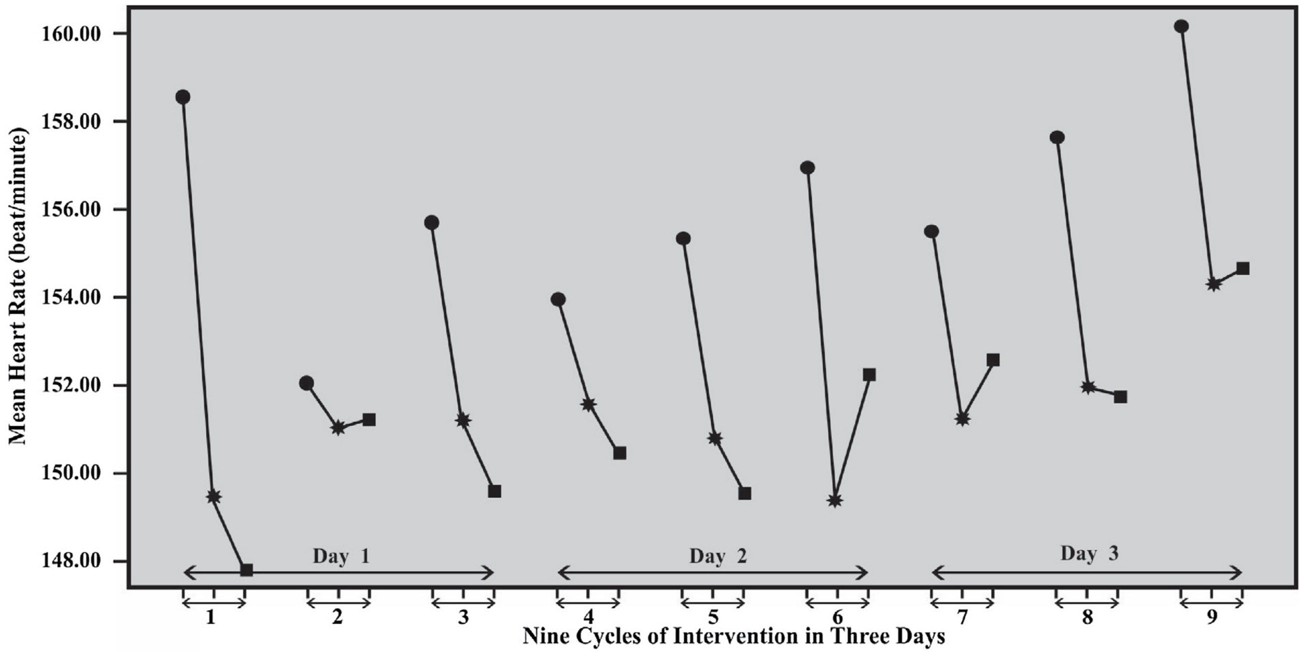

Fig. 2. The symbol (●) points the mean HR in 5 min before intervention, (*) the mean of HR in 5 min during intervention & (■) the mean of HR in 5 min after intervention.

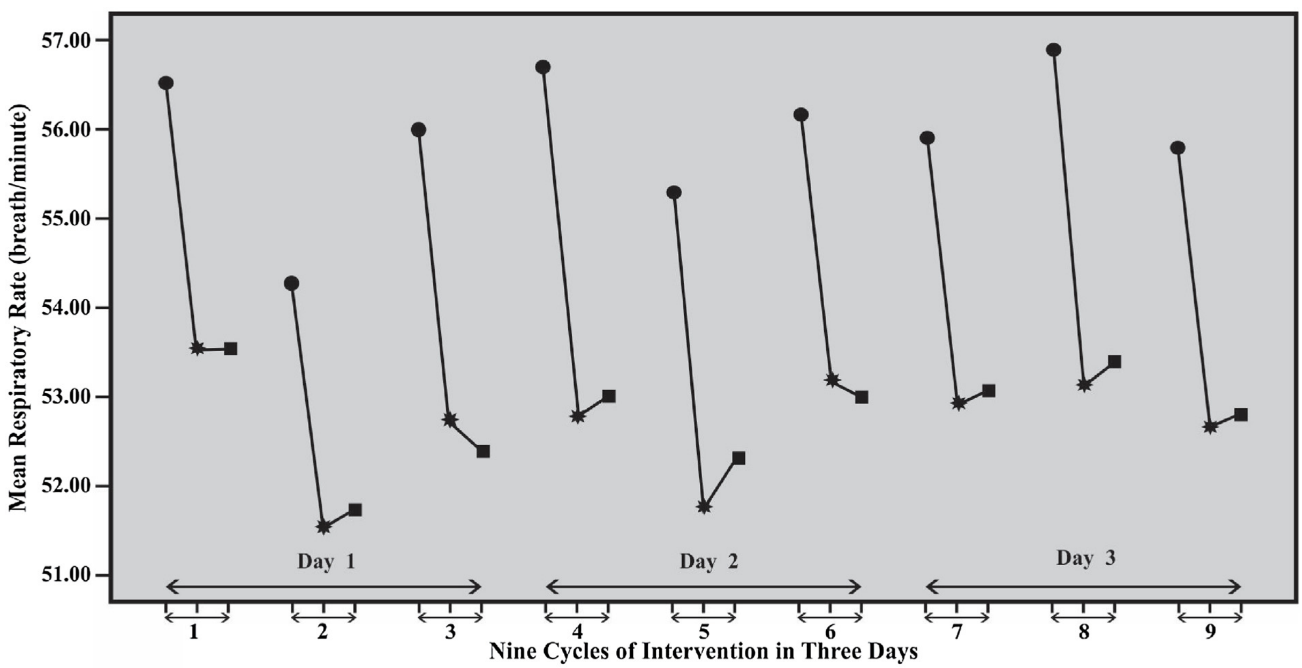

Fig. 3. The symbol (●) points the mean RR in 5 min before intervention; (*) the mean of RR in 5 min during intervention & (■) the mean of RR in 5 min after intervention.

3.2. Heart rate variations

The reduction of HR was significant during each intervention($p < 0.05$). Fig 2 shows decline of HR during intervention, a slow increasing pattern after the intervention, and repeated similar cycles in each 15 min. The mean ± SD of HR changes before, during and after periods of interventions over three cycles per day, F (df) and P-values are shown in Table 2.

According to the final analysis which was performed by GLM, changes of the mean ± SD of HR over three days were similar. But comparison of the mean ± SD of three time points (before, after and during periods of intervention) over three

Table 3
Comparison of mean ± SD of OSPR, HR and RR before, during, and after periods of each intervention over three days by General linear Method Analysis.

Physiologic Variable	Voice playing	Mean ± SD of each index over three days	P-value
Oxygen Saturation Rate	before	95.11 ± 0.27	0.0001
	during	96.59 ± 0.23	
	before	95.11 ± 0.27	0.0001
	after	96.66 ± 0.23	
	during	96.59 ± 0.23	0.480
	after	96.66 ± 0.23	
Heart Rate	before	156.04 ± 7.54	0.0001
	during	151.11 ± 7.04	
	before	156.04 ± 7.54	0.0001
	after	151.05 ± 7.11	
	during	151.11 ± 7.04	0.949
	after	151.05 ± 7.11	
Respiratory Rate	before	2.3 ± 55.93	0.0001
	during	52.70 ± 2.13	
	before	55.93 ± 2.33	0.0001
	after	52.86 ± 2.67	
	during	52.70 ± 2.13	0.480
	after	52.86 ± 2.67	

days shows significant decrease during and after each intervention relative to before voice broadcast. There was no significant difference between mean ± SD of HR during and after periods of interventions over three days (Table 3).

3.3. *Respiratory rate variations*

The reduction of RR was significant during each intervention ($p < 0.05$).As shown in Fig. 3, the RR decreased every time the maternal voice was broadcast and increased again slowly after the intervention. This cycle was repeated again in each session. The mean ± SD of RR changes before, during and after intervention periods of over three cycles per day, F (df)and P-values are shown in Table 2.

According to the final analysis which was performed by GLM, changes of the mean ± SD of RR over three days were similar. But comparison of the mean ± SD of three time points (before, after and during periods of interventions) over three days shows significant decrease during and after periods of each intervention relative to before voice broadcast. There was no significant difference between mean ± SD of RR during and after periods of interventions over three days (Table 3).

4. Discussion

The purpose of the present study was to evaluate the positive effects of low intensity maternal voice on preterm infants' physiologic responses. Meanwhile the high intensity noise potentially results in adverse effects on the cardiovascular and respiratory systems of preterm infants (Wachman & Lahav, 2011), the permissible noise criteria has positive effects on vital signs, sleep pattern and improvement in speech intelligibility (Philbin, Robertson, & Hall, 2008).In contrast to previous reports, in this study, the maternal sound level was monitored in level of ≤50 dB, which is within the sound level recommended by AAP (1997).

The effects of live or recorded maternal voice, whether talking or singing, on preterm infants have frequently been investigated. However, the effect of low density recorded maternal voice on OSPR, HR and RR, has been rarely evaluated in previous reports.

It has long been shown that sudden transition from intra-uterine environment and exposure to sensory stimuli during NICU stay negatively affect preterm infants (Als, 1982; Kisilevsky et al., 2003).

As a result, non-pharmacologic interventions such as maternal voice broadcast, administering oral sucrose (Stevens, Yamada, Lee, & Ohlsson, 2013), melody or music therapy (Loewy, Stewart, Dassler, Telsey, & Homel, 2013) and kangaroo care (Jefferies and Canadian Pediatric Society, Fetus and Newborn Committee, 2012) have been suggested as a part of NICU developmental care protocols. These approaches stabilize vital signs and physiologic reactions, improve neuro-behavioral reactions and sleep pattern, reduce pain in performing painful procedures in premature infants and shortening the length of NICU stay.

The underlying mechanisms of the effects of maternal voice are not fully understood; Rand and Lahav (2014) have suggested that maternal sounds may improve autonomic stability and provide a more relaxing environment for preterm neonates. Wirth et al. (2016) hypothesized that auditory stimulation of preterm infants with their mothers' recorded voices can stabilize their physiologic reactions, probably by reducing stress reactions. This hypothesis should be investigated in future prospective studies.

Our study showed that broadcasting the maternal voice had a positive effect in the mean ± SD of OSPR, HR and RR changes before, during and after periods of intervention over three cycles per day. During and after periods of each intervention, OSPR was increased while HR and RR decreased significantly.

Rand and Lahav (2014) specifically addressed the effect of mother's voice on preterm infants' HR, reporting a significant lower HR during exposure to maternal sounds regardless of underlying factors such as gestational age or birth weight.

Picciolini et al. (2014) investigated the effects of exposure to maternal voice on infants' neurobehavioral and autonomic parameters, using HR and OSPR as outcome variables. They reported lower HR but similar OSPR in infants exposed to maternal voice.

On the other hand, Bozzette (2008) evaluated the effects of the maternal voice on the physiologic signs (HR, RR and OSPR) and behavioral responses of fourteen clinically stable premature infants, aged 31–34 gestational weeks, and reported different results. The maternal voice was broadcast over a period of 3 days, 4 times per day, for each infant. No significant difference was observed in HR and OSPR, but the infants' RR showed a significant reduction which was attributed to the identification of the maternal voice by the infant (Bozzette, 2008). Although the study by Bozzette (2008) is similar to ours regarding variables and methodology, some of their reported results are different from ours. The difference can be attributed to the number of infants (14 vs. 20), infants' mean age (2–5 days vs. 10.1 days), and decibel levels of the broadcast maternal voice (55–75 dB vs. <50 dB). Future studies with more participants and controlled confounders such as neonates 'age after birth are recommended.

Our study showed that broadcasting of low intensity maternal voice had a positive effect in establishing the clinical conditions of the infants and was harmless to the premature infants hospitalized in the NICU.

Zimmerman et al. (2012) also showed the successful incorporation of maternal voice into routine daily care in preterm infants as early as 6th day of life until NICU discharge. So, it can be recommended to add broadcasting of the maternal voice to routine care of premature infants in the NICU.

5. Conclusion

This study was limited to a healthy preterm population; only 3 physiological variables were measured; the study was limited to 3 days; no long term follow-up of the infants was reported. While it may be that playing the maternal voice at low intensity for short durations over a few days has positive effects on the 3 variables observed, it could be that longer durations over longer periods over stimulate the preterm depending on frequency and duration of mother's visit and speech to infant. While playing the mother's voice to the infant showed potential benefits in this study, more research on longer durations of intervention and longer term outcome are needed before firm conclusions can be reached.

We also suggest similar studies on infants with more participants. Future studies regarding the effect of the maternal sound level ≤50 dB on other behavioral responses such as the sleep pattern and reducing pain in painful procedures in premature infants are also suggested.

Conflict of interest

The authors report no conflict of interest.

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