Research Article

The Effect of Experience on Recognition of Mother's Voice in Preterm Infants

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Abstract

Background: According to existing theories, supportive cares provided through specific kinds of stimuli affect the growth, development and neurobehavioral functioning of preterm infants. Some of the studies indicate that the fetal heart rate response to mother's voice begins in the week 32 of pregnancy. However, the fact that whether preterm infant is able to recognize mother's live voice from the voice of a stranger woman is unknown.

Objectives: The present study aimed to compare the effects of mother's voice and a stranger's voice on the heart rate of preterm infants hospitalized in a neonatal intensive care unit (NICU).

Methods: In a clinical trial study, 66 preterm infants hospitalized in the NICU were randomly assigned into three groups of 22 (i.e. mother's voice and stranger's voice groups and a silent group). The infants' heart rates were recorded by a monitoring system in all of the three groups each five minutes for 30 minutes overall (10 minutes before, during and after the intervention) in three consecutive days. Both one-way and repeated measures analysis of variance were used to analyze the data in terms of significant differences. Also, the chi-square test and analysis of variance were used to compare the demographic variables of the groups.

Results: The heart rate of the infants in the mother's voice group, stranger's voice group and the silent group were 133.99 ± 2.72, 134.26 ± 2.43 and 137.94 ± 2.92 per minutes, respectively ($P > 0.588$) and changed to 143.42 ± 2.85, 133.22 ± 2.15 and 138.28 ± 2.21, respectively ($P = 0.016$). Moreover, the infants' heart rates were respectively 136.87 ± 3.38, 132.68 ± 2.22 and 138.19 ± 2.65 per minutes, 10 minutes after the intervention ($P > 0.345$).

Conclusions: No significant difference was found between the mean heart rates of the three groups neither before, nor 10 minutes after the intervention. However, a significant difference was observed among the three groups during the intervention. Therefore, we can conclude that the preterm infants can recall and differentiate their mothers' voice from the voice of a stranger. Then, an opportunity can be provided during the developmental care for the infants to hear their mothers' voice.

Keywords: Mother's Voice, Intensive Care Unit, Premature Infant

1. Background

Despite the improvements in prenatal and midwifery care and advances in technology, the rate of preterm birth has increased during the past two decades (1, 2). Survival of preterm infants (3) requires hospitalization in the neonatal intensive care unit (NICU) (4). However, there are concerns about growth and development of infants hospitalized in NICUs.

Hearing is one of the initial senses that a fetus develops, insofar as until week 26 to 28 of pregnancy the auditory responses are stabilized in the auditory cortex and the brainstem (5) and enables the fetus to recognize and recall mother's voice after the week 24 to 33 (6, 7). It is believed that mother's voice is enough for the development of infant's auditory system. However, preterm infant hospitalized in the NICU is not only deprived of mother's voice (8), but also might be at risk of speech, hearing and cognitive impairments due to receiving excessive voices from the technologic environment of the NICU (9, 10). Moreover, the mother-child attachment might also be impaired (11). A study by Bozzette indicate that mother's voice is an important positive stimulus in preterm infants in NICU and the potential power of mother's voice removes the excessive stimuli existing in the NICU (12). Therefore, in addition to focus on therapeutic measures to survive preterm infants, it is important to take developmental care into consideration. One of interventions presented in developmental care is auditory stimulation like hearing mother's voice

(13). Mother's inclination to establish verbal communication (14) increases her tendency to deliver developmental care for her child and might decrease the long-term aftermaths of NICU including those that affect infants' speech, hearing and cognitive abilities (15).

Some of the studies suggest that infant's recognition of mother's voice (16), difference in infant's brain response to familiar and unfamiliar languages (17) and learning vernacular language and distinguishing it from other languages (18) are all affected by fetal experience. Some of the studies indicate that the fetal heart rate response to mother's voice begins in the week 32 of pregnancy (19) and the preterm infants' heart rate increases as they hear the mother's live voice (20). Moreover, the positive effects of mother's voice on improvement of oral feeding in preterm infants (21), decreased heart rate of preterm infants in the first month of life (22), improved skin color and decreased the heart rate of preterm infants at the 40th gestational week (4) have been shown. However, the fact that whether a preterm infant hospitalized in the NICU is able to recognize mother's live voice from the voice of a stranger woman is unknown. Therefore, this question comes to mind that "how differ the effects of mother's voice and a stranger's voice on heart rate of preterm infants?"

2. Objectives

The present study aimed to compare the effects of mother's voice and a stranger's voice on a heart rate of preterm infants hospitalized in the NICU.

3. Methods

3.1. Study Design and Participants

This clinical trial study was conducted on 66 preterm infants hospitalized in the NICU of Bou-Ali-Sina medical training center in Sari city (Northern Iran) from May to November 2015.

The inclusion criteria for the preterm infants included the gestational age of 28 to less than 37 weeks, birth weight of between 1000 and 2500 g, at least three days passed from the birth, being kept in incubators, having no congenital anomalies, physiological stability, using no respiratory devices such as nasal cannula or positive-pressure ventilation delivered through nasal/face mask and mechanical ventilator, receiving no muscle relaxants, undergoing no surgical operation, using no pacifier or feeding only with breast milk, healthy auditory system, no incidence of problems including intracranial hemorrhage, periventricular leukomalacia, cerebral palsy, necrotizing enterocolitis, patent ductus arteriosus, sepsis, chronic lung dis-

ease, anemia (Hb < 10g/dL), no addiction to alcohol, narcotic drugs and psychotropic substances in mother. The infants' inclusion in the study was confirmed after the attending physician visited them. The exclusion criteria included the occurrence of seizure during the intervention, mother's decision to withdraw from the study, use of sedatives by mother in the intervention day, incidence of any problem in recording the physiological responses and the infant's need to any medical or nursing intervention or any contact during the study.

Sample size was calculated using a pilot study on two groups of 5 infants. One group was the silent group and the other group received the mother's voice stimulation similar to the main study. The post-intervention mean of the neonatal heart rate was 148 $\pm$ 7.50 in the group that received mother's voice and 143 $\pm$ 5.75 in the silent group. Then by using an online software (i.e. https://www.statstodo.com/SSizAOV_Pgm.php), and considering the β = 0.20, and α = 0.05, the number of groups in the analysis = 3, largest difference between the two means = 5 and the expected background standard deviation = 6, the sample size for each of the three groups was estimated to be 22 infants.

A total of 256 preterm infants were investigated in the aforementioned center, of which, 190 infants were omitted because either they did not meet the inclusion criteria (183 infants) or their parents withdrew from the study (seven infants). Finally, a total number of 66 infants were recruited. The samples were randomly allocated into the three groups of 22 (silent, mother's voice and stranger's voice) by computer randomization. However, the data of six infants were omitted from analysis as they were outliers (the data showed excessive increase or decrease in heart rates insofar as it seemed that the pulse oximeter probes placed on infant's legs were dislocated) (Figure 1).

3.2. Instrument

The instruments used in this research included of two parts. The first part was a questionnaire consisting 10 questions about the infant and mother's characteristics such as the type of delivery, date of birth, gender, gestational age, chronological age (i.e. the number of days passed from the infant's birth), weight, five-minute Apgar score, the infant's auditory capability, and the mother's age and education level. The second part was a checklist for recording the infant's heart rate, and also the mother's sound level. The infants' heart rate was measured by a monitoring system (Siemens SC 6002 XL®) in an automatic mode, the infants weight was measured using a Seca® Digital Baby Scale with $\pm$ 10g accuracy and the mothers voice level was measured in decibels using a Cirrus CR: 274® Sound Level Meter.
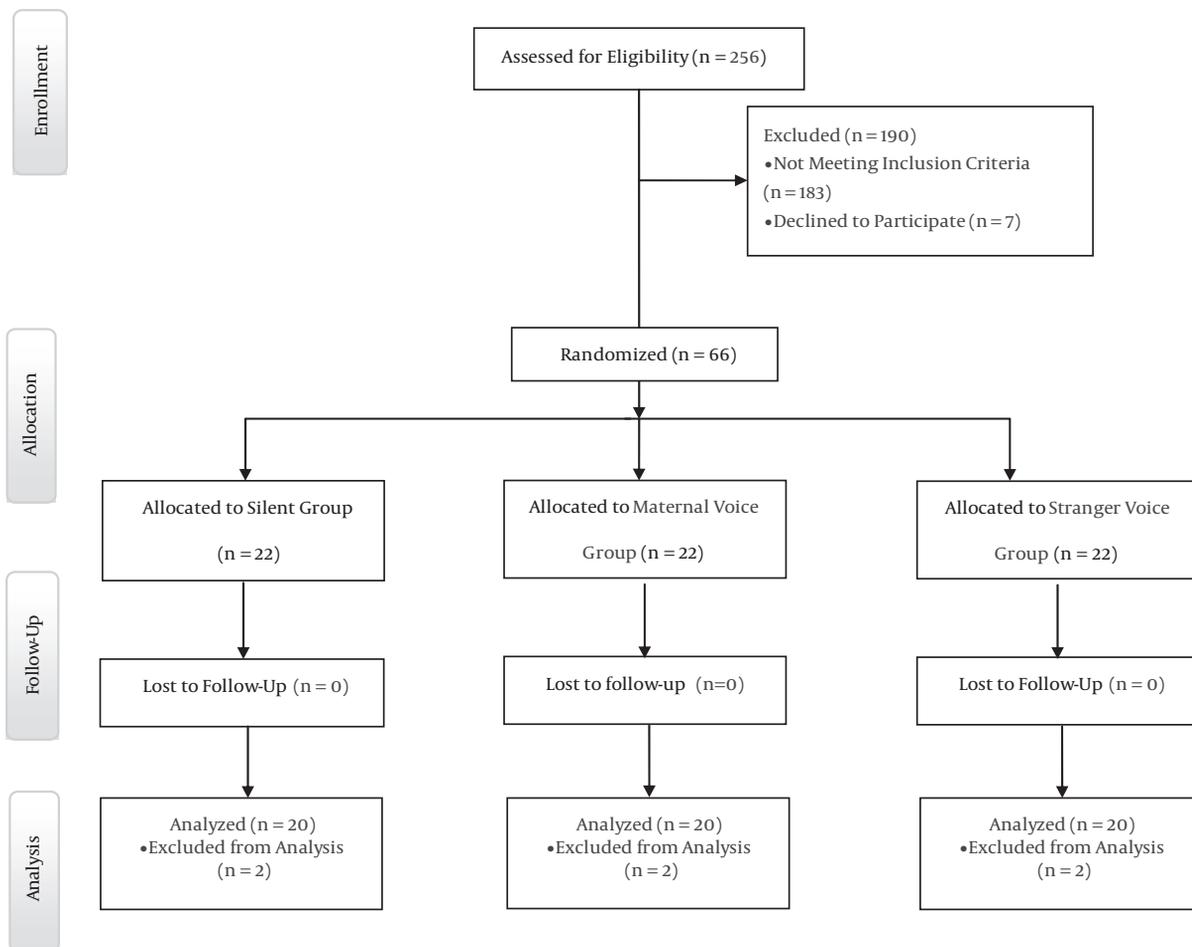
Figure 1. Consort Flow Diagram

An inter-rater reliability method was used to evaluate the reliability of the instruments (the digital scale and the patient monitoring system).To evaluate the reliability of the digital scale, two colleagues were trained and then were asked to weigh 10 infants and record the results in two distinct charts. Then the correlation coefficient was calculated and the result was approximately equal to one (r = 0.97) for the digital scale. Moreover, the patient monitoring system was put in an automatic mode. The monitoring system and the digital scale used to measure the variables for all of the infants were the same.

3.3. Intervention

All infants in the three groups were kept in incubators and received the routine ward care such as changing the diaper, feeding, finding a vein (for intravenous injections), drawing blood, etc. before the intervention was started.

With hospitalization of each infant, the third researcher reviewed its hospital record for eligibility. In case the infant met the inclusion criteria, its demographic information including type of delivery, date of birth, gender, gestational age, chronological age (the number of days passed from the infant's birth), inclusion weight, five-minute Apgar score, mother's age and mother's level of education were registered in data collection forms. In this study, the variable outcome was the heart rate recorded during the study. Then the infant's auditory capability was evaluated by observing the startle reflex and the response to auditory stimulus and its weight was measured by the digital scale. Before the monitoring system was attached to the infant, the researcher was ensured that the infant was fed; its diaper was changed and did not need any nursing intervention and care within the next 30 minutes. Afterward, the hands were washed, the infant was laid on its back in

the incubator and in order to assess the heart rate the Oxypleth Pulse Oximeter (model A520, USA) was on the one side attached to the infant's toe and on the other side was attached to the monitoring system through a cable. The pulse oximeter probe was covered with carbon paper to increase the accuracy and avoid the effect of light. Moreover, the sound level meter was placed at a distance of 15 centimeters at one side of an infant's head in the incubator in a way that it could be seen by an observer. To make the research condition equal for all cases, the same sound level meter was used for all of the infants. The mothers and a female nurse, who was willing to sing the lullaby for the stranger's group, were taught to sing the Good Night Kid (produced by the national radio of Iran) gently, rhythmically and steadily.

Every infant was investigated in three 10-minute phases (30 minutes overall), once a day in three consecutive days. The patient monitoring system was set to record the heart rate automatically every five minutes for 30 minutes. In the first phase, the heart rate was recorded 10 minutes before the intervention in all of the three groups. In the second phase, in mother's voice group the heart rate was recorded every five minutes during the 10-minute intervention while the mother sat on a chair beside the incubator, placed her head next to the incubator porthole on the opposite side of the sound level meter in a way that her face was 15 centimeters away from the infant's ear and sang the lullaby. The mother then left the infant in the 20th minute but the heart rate was recorded every five minutes for another 10 minutes as the third phase.

The condition for the silent group and the stranger's voice group was quite the same as explained above but with a slight difference. In the silent group, the mother sat in the same position as in the mother's voice group; however, she was silent, without singing or saying anything. In the stranger's voice group a trained female nurse sang the same lullaby for the infants for 10 minutes. The research condition was completely the same in the first and the last 10-minute phases for all of the three groups and only their intervention phases (the second 10 minutes) were different.

The mothers and the stranger person (the female nurse) were taught to keep their voices at 60 - 70 decibels and it was suggested that the ambient noise level during the intervention should be less than 45 decibels. Neither the mothers nor the stranger female nurse were allowed to touch the infant during the intervention. Moreover, the research was conducted between 15 and 17 o'clock that was not a busy period in terms of workload.

3.4. Ethical Considerations

This study was approved by the research ethics committee of Babol University of Medical Sciences (code: MUBABOL.REC.1394.360). The parents who participated in the study were given all the required information about the research, its purposes and its significance. They were assured that their participation was voluntary, the information would be kept confidential and their refusal to take part in the study would not affect the delivery of care and services for their children. They were also given an informed consent to read and sign in case they were inclined to participate in the study. The parents were encouraged to ask the researcher if they had any question. This study is registered in Iranian registry of clinical trials with registration number: IRCT2015081623636N1.

3.5. Data Analysis

Data were analyzed by SPSS software version 13 (SPPS Inc., Chicago, Illinois, USA). The Kolmogorov-Smirnov test was used to evaluate the normality of quantitative variables. Descriptive statistics (i.e. frequency distribution, percentage, mean and standard deviation) were calculated for demographic variables. Chi-square test and analysis of variance were used to compare demographic variables among the groups. Tukey's post-hoc test was also used for pairwise comparison of the groups. Repeated measures analysis of variance was used to compare the mean heart rates in the consecutive measurements (at 0, 5, 10, 15, 20, 25 and 30 minutes). A P-value less than 0.05 ($P < 0.05$) was considered statistically significant.

4. Results

From a total of 60 infants studied, 56.6% were girls and 85% were delivered through cesarean section. Most of the infants were born after 32 weeks gestation, the mean of the infants' weight was 1806.949 ± 402.797 g, the mean of the infants' hemoglobin was 14.11 ± 2.18 g/dL, the five-minute Apgar score was between 7 and 10, and the infants were 4 to 25 days old. The mothers were 20 to 42 years old and 60% of them were university graduates. No significant differences were found between the three groups in terms of baseline demographics and clinical characteristics (Table 1).

No significant difference was found between the mean heart rates of the three groups neither before ($P > 0.588$), nor 10 minutes after the intervention ($P > 0.345$). However, a significant difference was observed among the three groups during the intervention ($P = 0.016$). The maximum heart rate was occurred in the mother's voice group and the minimum one was in the stranger's voice group. The Tukey's post-hoc test showed that the observed statistical

Table 1. Demographic Characteristics of the Three Groups[a]

Variables	Groups			P Value
	Silent	**Mother's Voice**	**Stranger's Voice**	
Gender				0.622[b]
Female	11 (55)	10 (50)	13 (65)	
Male	9 (45)	10 (50)	7 (35)	
Mother's education level				0.197[b]
Primary and secondary education	1 (5)	2 (10)	6 (30)	
Associate's degree	6 (30)	6 (30)	3 (15)	
University graduates	13 (65)	12 (60)	11 (55)	
Type of delivery				0.308[b]
Cesarean	16 (80)	16 (80)	19 (95)	
Normal	4 (20)	4 (20)	1 (5)	
Five-minute Apgar	9.64 ± 0.78	9.91 ± 0.28	9.73 ± 0.59	0.515[c]
Gestational age (weeks)	32.7 ± 2.17	32.60 ± 1.98	33.0 ± 2.15	0.823[c]
Chronical age (days)	8.85 ± 5.62	7.45 ± 4.12	6.95 ± 4.09	0.416[c]
Birth weight (g)	1847 ± 659.53	1800 ± 302.56	1771 ± 352.97	0.842[c]
Infant's hemoglobin level	13.88 ± 2.30	14.15 ± 2.25	14.31 ± 2.09	0.822[c]
Mother's age	28.95 ± 5.03	31.20 ± 5,64	30.55 ± 5.31	0.396[c]

[a]The data are presented as No. (%) or Mean ± SD.
[b]Chi-Square test.
[c]ANOVA test.

Table 2. Comparison of the Mean Infants' Heart Rates in the Three Groups[a]

Time Periods	Groups			
	Silent	**Mother's Voice**	**Stranger's Voice**	**P Value[b]**
Before intervention	137.94 ± 2.92	133.99 ± 2.72	134.26 ± 2.43	0.588
During intervention	138.28 ± 2.21	143.42 ± 2.85	133.22 ± 2.15	0.016
After intervention	138.19 ± 2.65	136.87 ± 3.38	132.68 ± 2.22	0.354
P value[c]	0.711	< 0.001	0.399	

[a]All of the data are presented as Mean ± SD.
[b]ANOVA test
[c]Repeated measures analysis of variance.

difference was between the mother's voice group and the stranger's voice group (P = 0.012). In the repeated measures analysis of variance, the results of Mauchly's sphericity test showed that the assumption of sphericity was violated (P < 0.001). As multivariate statistics do not need to establish sphericity assumption, Greenhouse-Geisser correction was used for performing tests on the variable heart rate in three consecutive times within the three groups. Only in the mother's voice group, a statistically significant difference was observed in the three measurement times (P < 0.001); insofar as, the infants' heart rates increased sig-

nificantly during the intervention compared to their heart rates before and after the intervention. However, no significant differences were found in the within-subjects comparisons neither in the silent group (P > 0.711), nor in the stranger voice group (P > 0.399). Moreover, an interaction was found between the groups and the time in the silent and the mother's voice groups (P < 0.001) (Figure 2).
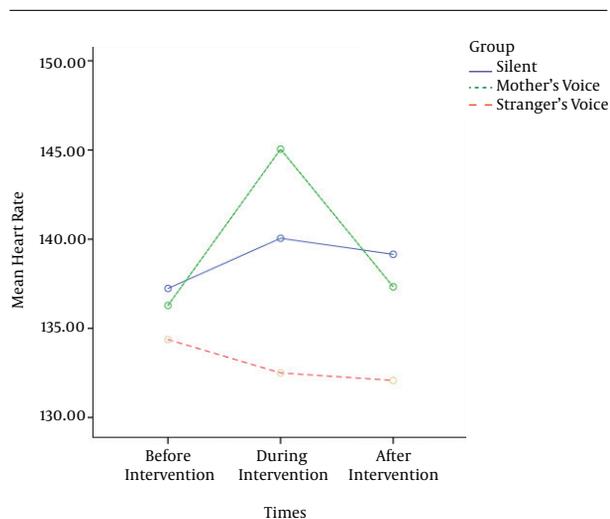
Figure 2. Comparison of the Mean Values of Infants' Heart Rates in Different Time Periods for Each of the Three Study Groups

5. Discussion

The findings of this study show that preterm infants are able to recognize their mothers' voice and the voice of a stranger in a way that it affects their heart rates. The infants' heart rates increased as they heard their mothers' voice and decreased as they heard the voice of a stranger. An earlier study conducted by Kisilevsky et al. (16) has also reported that the heart rate of the near-term fetus increased by hearing mother's voice and decreased by hearing stranger's voice. As the gestational ages of the three groups were the same (i.e. above 32 weeks), the different responses in the three groups cannot be attributed to the development of the auditory system. Therefore, we can conclude that the preterm infants can recall and differentiate their mothers' voice from the voice of a stranger. A previous study has also reported that the infant's heart rate begins to respond to mother's voice at 32 weeks gestation simultaneously with the onset of auditory performance (19). In an electrophysiological study of voice processing in term newborn infants, Beauchemin et al. (23) found that not only is mother's voice processed faster than stranger's voice, but also its processing is different. Werker and Tees (24) best explained the infant's recognition and differentiation of the voice by the epigenetic process through which the experience of a certain voice leads to emergence of genes associated with neural development. This neural development occurs as a result of formation of an exclusive neural network and new synapses that form as a reaction to previous memories. Therefore, the difference in infant's heart rate response to voices can be attributed to its exclusive memory of mother's voice to which it was

frequently exposed during the pregnancy. Filippa et al. (20) and Joseph (25) have also reported that at the beginning of its life, the infant is able to recognize between its mother's voice and a stranger's voice, recall the stories and the melodies he/she heard during the last three months of pregnancy and also prefer the mother's voice to the stranger's. Moon et al. have also reported that infants' perception of vowels after birth is affected by the language experienced during the fetal life (18).

There is no known reason for supporting the increased heart rate in response to mother's voice; nonetheless, the infants' heart rate increases in reaction to positive and negative stimuli, which is partly because of the activities of catecholamines. According to developmental changes, an increased heart rate in response to mother's voice can be resulted from the rise in release of cortisol dependent on or independent of the increased perception of mother's voice (19).

The limitations of the present study were due to the unwanted ambient noise and also because the monitoring system had no printing option and some of the mothers could not be present at the infants' bedside at the appointed time in three consecutive days. The findings of the present study show that regarding the experience of life inside the uterus, the preterm infant recognizes its own mother's voice. As a result, it is suggested that they should be provided with an opportunity to hear their mothers' live voices at their bedsides during developmental care so that the undesirable complications in preterm infants including hearing impairments, learning, cognitive, speech and behavioral disorders that are regarded as greatest social and economic problems could be avoided. Further studies are required to investigate the effect of mother's live voice on newly born preterm infant to determine the specific age groups that receive the most effect.

Footnotes

Authors' Contribution: Mojgan Ahmadi Vastani: study design, statistical analysis, acquisition of data, and drafting of the manuscript; Seyedeh Roghayeh Jafarian Amiri: study design, supervision, statistical analysis, and revision of the manuscript for important intellectual content;

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