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Preterm infants exhibited less pain during a heel stick when they were played the same music their mothers listened to during pregnancy

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Short title: Using familiar music to reduce heel stick pain

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ABSTRACT

Aim: Playing music during painful procedures has shown inconsistent benefits for preterm infants. This study observed preterm infants during a heel stick procedure to assess whether listening to the music their mothers listened to during pregnancy had any impact on their pain, physiological and behavioural parameters.

Methods: We randomly exposed 42 preterm infants, with a mean gestational age of 31.8 ±2.79 weeks, to the music their mothers listened to during pregnancy, recorded lullabies and no music, before, during and after a heel stick. Pain responses were measured using the Neonatal Pain, Agitation and Sedation Scale (N-PASS) and physiological and behavioural responses were recorded by a nurse blinded to the intervention.

Results: N-PASS pain scores were lowest during mothers' music, with a mean of 1.40 (±1.28), compared to 2.33 (±1.64) for no music and 1.62 (±2.27) for the lullabies ($F\ (3/121) = 4.86$ p $=0.009$). Physiological parameters were not significantly different between the conditions. During the mothers' music, infants spent more time in a quiet alert state, with a significant decrease in their respiratory rates.

Conclusions: The music mothers listened to during pregnancy was more beneficial for preterm infants, as it decreased pain and improved behavioural states during a heel stick.

Key words: Music, Neonatal Pain, Agitation and Sedation Scale, Prenatal music exposure, Preterm infants

Key notes

- Playing music during painful procedures has shown inconsistent benefits for preterm infants.
- We randomly exposed 42 preterm infants to either the music their mothers listened to during pregnancy, recorded lullabies and no music, before, during and after a heel stick.
- The music mothers listened to during pregnancy was more beneficial for preterm infants, as it decreased pain and improved behavioural states during a heel stick.

INTRODUCTION

The incidence of preterm birth in both developed and developing countries is a worldwide health concern, as the rates have not significantly declined over the years (1). Preterm infants often require extensive care, are hospitalised for long periods of time in the neonatal intensive care unit (NICU) and are exposed to a multitude of stressful and painful events that have been linked to negative developmental outcomes (2,3). Thus, while the survival and medical prognosis of premature and low birth weight (LBW) infants have significantly improved during the last decade, concomitant improvements in neuro-developmental outcomes have not occurred. This may be due to the increasing ability of technology to enable very LBW infants to survive at the cost of spending prolonged time in the NICU with exposure to stress and pain (2-3). Exposure to neonatal pain and stress has been associated with an altered brain microstructure, as well as poorer cognitive, motor and behavioural neurodevelopment (2). A range of interventions have been researched to reduce stress in the NICU and allow for optimal neurobehavioral function, including music stimulation (4,5). Music is a non-invasive form of sensory stimulation that is presumed to be an effective and harmless method of pain relief by provoking feelings of familiarity and security (6). Physiologically softy rhythmic music acts by redirecting a person's attention away from pain inducers and it allows for the release of natural endorphins in the brain, reduces Adrenocorticotropic hormone (ACTH) levels and increases phenylethylamine secretion (7). It also triggers the autonomic nervous system to allow relaxation in muscle tone and release body tension (8). Several studies have noted that music recorded live and singing are effective in capturing premature infants' attention by distracting them from stress or pain, and by enhancing their physiological and behavioural responses (5-16). Music stimulation in preterm infants leads to higher oxygen saturation levels, decreased heart rate, decreased respiratory rate, fewer episodes of apnoeas and bradycardias, decreased stress levels and decreased energy expenditure (5,9-16). Enhanced behavioural responses include increased quiet, alert and sleep behavioural states and decreased crying and fussy states (5,9,10). In contrast to the above, a few studies do not report any significant benefits of music on vital signs or behavioural states (17,18,19). Nevertheless, two meta-analyses concluded that there was some evidence to the benefits of music on the physiologic and behavioural outcomes of preterm infants. However, the heterogeneity of the participants, the small effect sizes and the various interventions and outcomes warrant further research (20,21). Regarding the effect of music on pain responses, which was the main objective of this study, several studies have been published to date with disparate results (11-16,18,19). These inconsistent findings may be due to the different methods used in presenting the music.

Since musical preferences vary according to culture, and because of the ability to understand and remember auditory stimuli heard while still in the womb, we hypothesised that listening to familiar music during pregnancy may have a positive effect on preterm infants during a painful procedure. The aim of this study was to assess the effect of the music listened to by mothers during pregnancy, referred to as mothers' music, on the pain responses, the physiological and the behavioural responses of preterm infants. The research questions were did the recorded music that the mothers listened to during pregnancy reduce the infants' pain and enhance their physiological and behavioural responses during a heel stick, compared to a recorded lullaby or no music, and what were the best predictors of pain responses during a heel stick?

METHOD

Study design

A double-blind randomised cross-over design was conducted with 42 infants who acted as their own controls and were randomly exposed to three conditions: a recorded lullaby, recorded music listened to by their mothers during pregnancy or the control, which was no music. This resulted in 126 conditions (Figure 1) that were separated by at least eight hours, which corresponded to one nursing shift.

Setting and participants

The study was carried out in a level three neonatal intensive care unit at the American University of Beirut Medical Center in Lebanon between March 2014 and April 2015. The study was approved by the American University of Beirut Institutional Review Board and informed consent was obtained from the parents of each infant (NCT02434432). Infants were included in the study if they met the following criteria: born between 28 and 36 weeks of gestation, based on the first trimester ultrasound or the last menstrual period, had Apgar scores above seven at five minutes, were at least one week old and had a maximum corrected age of 38 weeks, were not intubated and were breathing unassisted, did not have any major congenital anomalies or grade III or IV intraventricular bleeds, were not on any paralytic medications, were kept in an Isollette or open crib and were still requiring heel sticks for dextrose monitoring. A hearing screening test, based on auditory brain stem responses, was scheduled prior to the discharge of all infants. Mothers who indicated that they had listened to music routinely during the third trimester of pregnancy were approached for informed consent.

Outcome measures

The primary outcome was pain responses during a heel stick and the secondary outcomes were physiological and behavioural responses. All outcome measures were recorded by one of the four nurses, who were blinded to the intervention conditions as they were called from an adjacent room in the NICU to record the infant's pain responses, physiological measures and behavioural states before during and after the heel stick. All the nurses were trained by the principal investigator on the pain and behavioural states scales to a reliability of above $r = 0.80$ before the study began and inter-rater reliability was assessed at regular intervals during the study. All the data were recorded on a structured spreadsheet. For the primary outcome, the pain response was assessed by the Neonatal Pain, Agitation and Sedation Scale (N-PASS) (22). The N-PASS has been used in both term and preterm infants and comprises two measurements that are assessed through observation without intervention. One measurement is for sedation and one is for pain. Only the latter was used in this study as sedated infants were excluded. Five criteria were assessed: crying and irritability, behavioural state, facial expression, extremity tone and vital signs. Scores range from zero to 10, with zero to two points available for each criterion and a high pain and agitation score indicating more frequent or intense behaviour. The N-PASS has been validated for acute and prolonged pain and correlates highly with the other pain assessment tools and with nurses' subjective rating of pain (23). In our NICU, the N-PASS is used by nurses as part of their routine care and they are regularly trained on inter-rater reliability.

For the secondary outcomes, the physiological measurements included oxygen saturation levels (SpO_2), heart rate (HR) and respiratory rate (RR). These measures were recorded every minute, five minutes before, during and five minutes after the heel stick, by direct observation of the electrocardiogram monitor and using a Philips Intellivue MP40 pulse oximeter (Koninklijke Philips NV, The Netherlands). The researchers monitored time intervals using a stopwatch. Behavioural states were assessed using the Neonatal Behavioral Assessment Scale Behavioral state system, which has high reliability and validity (24). The Scale lists six states: deep sleep with regular breathing, light sleep with irregular breathing, drowsy, alert with bright look, awake and active and crying. Behavioural states were recorded every minute, five minutes before, during and five minutes after the heel stick by observing the infant using a stopwatch.

Based on previous research (9,10,12), the background data collected were the mothers' age and education, infants' gender, gestational age, age at study time, birth weight, APGAR scores, intubation status, primary diagnosis and the auditory brainstem response test.

The intervention and procedure

The intervention for this study was either the kind of music mothers listened to in the last trimester of pregnancy or the lullabies used in previous studies (13,14,25). There was no limit to what the mothers' music was as the hypothesis was to discern if the infant got used to that kind of music *in utero* and not to a specific melody or tune. The majority of mothers (61%) selected the Quran as the music they had listened to while pregnant. The Quran has a rhythmic prose or melody that comes from the combination of words and letters based on sacred meanings and is chanted by a male singer (26). The remaining listened to either Fayrouz (20%) or other types of music (19%). Fayrouz is a famous Lebanese singer with a velvet-like smooth voice who sings common traditional Arab music, which uses various maqams or melodic modes. The music of Fayrouz has been accepted by many Lebanese and other Arab countries as a nationalistic, cultural and political symbol. The songs used in this study were downloaded from YouTube and included Shayef el Bahr shou Kbir, Ya tayr and Aatini elnaya. The control condition was no music, but the headphones were applied in order to minimise the bias of the nurses recording the outcome variables and eliminate ambient noise.

Figure 1 summarises the study protocol. After securing parental consent, mothers were asked to provide the music they listened to while pregnant. An infant could leave the study if they were discharged, transferred or their parents did not wish them to continue. Infants were exposed to all three conditions, separated by a wash out period of at least eight hours, and each condition was randomly selected by picking an opaque envelope from a box. Each envelope had one of three numbers, one for control or no music, two for intervention group two and three for intervention group three. After an envelope was picked it was discarded, so that each condition could only be picked once. After verifying the infant had been fed within the past two hours, the headphones (Figure 2) were applied, the intervention was applied for five minutes before and five minutes after the procedure. The infant remained untouched during the procedure. The music listened to by mothers prenatally was recorded on a portable MP3 player and attached to the noise isolating headphones, which were set at a maximum of 45 decibels (dB). The infants were observed for any signs of agitation from the headphones for one minute and then the music was started if they were in group two or three. If the infant was to show any sign of distress or agitation when the headphones were applied, they would be comforted and the procedure would be terminated. Sucrose is not available in our setting. The headphones were applied in all three conditions in order to blind the nurses obtaining the outcome data to the condition. The heel stick, which takes one to five seconds, was performed as ordered by the physicians using the quick heel lancet for premature infants in line with the unit's routine procedure, which is every eight to 24 hours depending on the infant's condition. Before each condition was initiated, a sound level meter recorded the environment's noise levels and continued recording during the procedure. The Extech 407764 sound level meter (Extech Instruments, New Hampshire, USA) was used and was calibrated to measure noise between 30 to 130dB, according to the manufacturer's instructions. The infants' physiological and behavioural states were assessed and recorded five minutes before, during and five minutes after the heel stick. The pain assessment was carried out during the heel stick by a nurse blinded to the condition (Figure 1).

Statistical analysis

The sample size calculation was based on a previous study (27) that reported a significant difference between two groups with a mean N-PASS score (primary outcome) of 5.2 and 5.8, with an estimated standard deviations of 0.7, using the following formula: $n = (Z\alpha + Z\beta)^2 \times 2 \sigma^2/\text{mean difference}^2$.

A minimum sample size of 21 infants in each group was required to achieve a power of 80% and a significance level (alpha) of 0.05 using a two-sided t- test ($n = 2\ (1.96 + 0.84)^2 \times 0.7/0.6^2 = 21$).

Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 22.0. (IBM Corp, Armonk, New York, USA). Socio-demographic and clinical characteristics were described using frequency distributions for categorical variables and means and standard deviations for continuous variables. For the physiological measures the mean number of each measure was calculated for the five minutes before and five minutes after the heel stick. Comparisons were made between the conditions before, and after heel stick using analysis of variance (ANOVA) with post-hoc analysis using Bonferroni adjustment. Analysis of covariance (ANCOVA) was used to assess any effect of gestational age on the outcome measures and t-tests were used to assess changes within conditions. For the behavioural states, the average percentage time for each state, five minutes before and five minutes after the heel stick, were calculated and differences between the interventions before and after heel stick were computed using chi-square. The N-PASS pain scores during heel stick were compared among conditions using ANOVA. Multiple regression analysis was conducted to assess factors associated with pain responses and to facilitate the interpretation of the multiple regression results the following categorisations were made: gestational age was divided into 28 to 31 weeks and 31.1 to 36 weeks, the corrected gestational age at the time of study was divided into 30 to 34 weeks and 34.1 to 37 weeks, birth weight was categorized as ≤1500 grams and > 1500 grams and the five-minute Apgar scores were divided into less than eight and at least eight.

RESULTS

Participants' characteristics

Of the 64 parents approached, 49 agreed to take part - a 77% acceptance rate - one infant passed away, two had missing data and four were discharged before the three conditions were met. This resulted in a sample size of 42 infants and 126 observations. The reasons for refusal were mostly that parents felt that their infant could not handle the additional stress. The participants' characteristics are shown in Table 1. None of the infants showed any signs of stress when the headphones were applied and music or no music was played. The average noise level recorded during data collection was 63.23±8.73 dB with a range of 40 to 100. The noise levels were not different between infants placed in an open crib or those in an Isollette with opened port holes and all infants passed the hearing screen based on the auditory brain stem response.

Between conditions results

Pain scores on the N-PASS were lowest for the mothers' music with a mean of 1.40 (± 1.28), compared to a mean of 2.33 (±1.64) for the control condition and a mean of 1.62 (± 2.27) for the recorded lullaby condition, $F (3/121) = 4.86$, $p = 0.009$. The Bonferroni post-hoc analysis revealed that the mothers' music was significantly different than the control condition (p = 0.009), but no differences were noted between the recorded lullaby and the control condition (p = 0.11) or the recorded lullaby and mothers' music ($p = 0.82$). There were no differences between the three conditions, in SpO_2, respiratory rates and heart rates, five minutes before and five minutes after the intervention. In terms of the infants' behavioural states, one of the six behavioural states showed a significant difference. Infants listening to the recorded music listened to by their mothers during pregnancy spent significantly more time in the active alert state: chi-square (3/122) = 7.45, ($p = 0.02$) (Figure 3). The kind of music - Quran, Fayrouz or other – that the mother chose did not affect the infants' pain, physiological or behavioural pain responses. The results of the ANCOVA by gestational age did not show any significant effect of gestational age on pain scores, physiological or behavioural responses.

Within conditions results

There was a significant decrease in RR for the mothers' music before and after heel stick, t (2/82) = 1.96 ($p = 0.03$), and a significant increase in HR for infants in the control condition, t (2/82) = 1.84, ($p = 0.04$) (Table 2). In terms of pre and post heel stick behavioural states, infants who listened to the mothers' music spent significantly more time in the quiet alert state after the heel stick: chi-square (2/78) = 8.06, ($p = 0.009$) (Figure 4).

Predictors of pain responses during heel stick

The factors entered in the multiple regression analysis which may have affected the infants' pain responses were: gender, gestational age, birth weight, corrected gestational age at time of study, Apgar scores at five minutes, whether the infant had been previously intubated or not and whether they heard the mothers' music, recorded lullaby or no music and the kind of music selected, namely Quran, Fayrouz or other. The mothers' music ($\beta = -0.219$, $p = 0.041$) and the infant's, gestational age ($\beta = 0.712$, $p = 0.003$) and birth weight ($\beta = -0.518$, $p = 0.038$) were significant determinants of pain responses (Table 3). The equation explained 20% of the variance F (8/33) = 2.57, ($p = 0.023$).

DISCUSSION

This study demonstrated that 10 minutes of music provided via headphones to premature infants before, during and after a painful procedure, had a significant effect on the infants' pain scores, but did not cause significant differences in their physiological measures. It also showed that the type of music listened to by mothers during the last trimester of their pregnancy was most effective in lowering the pain scores. The pain scores were lowest for mothers' music, although the significance was only between the mothers' music and the control and not between the recorded lullaby and the mothers' music. However, there was also no significance between the recorded lullaby and the control. This finding has not been reported in previous studies and warrants further investigations with a larger number of participants. The fact that music may help reduce pain during a heel stick is supported by most previous studies (11-15) and not supported in a few others (18, 19). For example, a triple-blind trial that divided 80 preterm infants into three groups - 24 in an experimental music group one, 33 in an experimental music plus 25% glucose group and 23 in a control group with 25% glucose - found no significant association between pain scores and intervention groups (18). The incongruous findings in these studies may be due to the differences in the duration and the loudness of the musical stimuli, the kind of music provided and the method of pain assessment. In addition, the designs used are not comparable. Whereas most studies used a cross-over design, others did not have a true control, which limits estimating the effect size. Assessment of pain in preterm infants is also problematic. Clinically, it is difficult to interpret the infant's behaviour, or determine the aetiology of the behaviour, since the presence of conditions such as fatigue, hunger, withdrawal, response to medications and consolability may affect pain scores (28). Thus, any conclusions related to pain responses in infants remain questionable and further research is warranted with larger sample sizes and rigorous control of variables in order to confirm the benefits of music for preterm infants.

The lack of differences between conditions in physiological measures is supported by a few previous studies (17,19). For example, a double blind randomised controlled trial in Iran (17) noted no differences in the physiological responses of 90 premature infants randomly selected to three groups: recorded lullaby music produced in Iran, silence with headphones or control. On the other hand, Arnon et al (9) compared the effects of live and recorded lullaby music, played at 55 to 70 dB for 30 minutes, and noted significantly lower heart rate and more favourable behavioural scores 30 minutes after live music compared to recorded music and the control group. However, the respiratory rate and SpO_2 in the three groups were not significantly different. Likewise, Calabro et al (19) evaluated the effects of recorded instrumental lullabies in 22 preterm infants with a respiratory disorder who were randomly assigned to a control or an experimental group. They found no significant differences in the physiological or behavioural outcomes between the groups, who were observed for a total of 45 minutes a day for four days. In contrast, a large multi-centre randomizsd control trial of 272 premature infants who were randomly assigned to three interventions ever day for weeks - a lullaby sung live to infants, an ocean disk simulating the sounds of the womb and a rhythm simulating the heart beat sound in the womb - and a control group, found that the lullaby selected and sung live had the most favourable behavioural and physiological responses (10). The results of these studies may indicate that recorded music may not have as significant an effect on physiological responses as live music may. Nevertheless, the inconsistencies in results warrant further research to reach conclusive evidence on the efficacy of music on preterm infants.

Although there were no significant physiological differences between the groups, there was a significant decrease in the respiratory rates of infants who listened to their mothers' music before and after the heel stick, which is supported by some earlier studies (9-11) and not others

(17,18). The inconsistent results in our case may be due to the duration of the stimulus provided and further studies that evaluate the impact of specific elements of music are suggested. The kind of music that the mothers chose for their infants, and which they had exposed their infants to during pregnancy, did not have any effect on infants' physiologic responses. Considering that the majority of mothers (61%) chose the Quran as their choice of music, we expected to confirm an earlier study from Iran where the recitation of the Quran played at 50-60 dB for 20 minutes via headphones significantly decreased mean respiratory and heart rates and increased SpO_2 compared to a basic measurement (26). However, we were not able not to replicate similar results.

The significant difference in behavioural states both between and within conditions has been supported by most previous studies (9, 11,12). For example, Loewy et al (10) noted that the parents' choice of a lullaby song, sung live to the preterm infant, had a significant effect on time spent in quiet alert. In our study, we found that infants spent more time in the active alert state and more time in the quiet alert state after a heel stick when they listened to the music listened to by their mothers during pregnancy than the other two conditions. This suggests that music that is familiar and is played at safe sound levels can help the premature infant self-regulate and may have beneficial long-term effects. The effect of gestational age on the infants' responses to music was not significant in this study, unlike a few studies that assessed this variable (16, 29), and may be explained by the fact that most infants in this study were above 31 weeks of gestation at the time of intervention.

The results of the multiple regression analysis confirmed that the music listened to by mothers during pregnancy, a gestational age of above 31.1 weeks and a birth weight of more than 1,501 grams were significant predictors of pain responses. While the recorded music listened to by mothers prenatally has not been studied previously, studies have had equivocal results in terms of the factors affecting pain responses in preterm infants. For example, Dureau (30) noted that gender was not significantly related to pain responses, while Sellam et al (28), showed that male infants had higher pain scores on the Bernese Pain Scale for Neonates during a heel stick. Apgar scores were not related to pain scores and neither was intubation, contrary to the studies by Cardoso et al (18) and Sellam et al (28), who found that pain scores were affected by Apgar scores. Researchers have argued that the relationships between contextual variables and pain responses are mostly inconsistent and the results are inconclusive (25, 29). Thus, inconsistent findings may reflect the various methods used to measure pain as well as the various gestational ages assessed.

To our knowledge this was the first study that assessed the effect of music listened to by mothers prenatally on pain, physiological and behavioural responses of preterm infants during a heel stick. The strengths of our study were the robust double-blind randomised controlled trial design, a sufficient sample size with adequate power to detect a difference if there was one, the fact that each infant served as his own control and the control of music delivery at less than 45dB using headphones, which eliminates the effect of environmental noise to some extent. However, there were a few limitations worth noting. Our N-PASS scores were lower than those found in the literature, which may be due to the fact that infants in our NICU receive more heel sticks than infants in the United States. This may have resulted in habituation, a finding reported in an earlier study (3). It is also possible that nurses in our unit underreported pain responses even though they were well trained based on the instructions of the N-PASS author. The infants in this study were at least one week old when assessed and this may have had an effect on their responses to music, especially because the environmental noise in the NICU was much higher than the recommended by the American Academy of Pediatrics guidelines, which are less than 45 dB. Thus, they may have become habituated to the high noise levels and not responsive to the music played at 45dB. In addition, although the conditions were randomly selected, the time of day when the heel stick occurred may have had an effect on the infants' behavioural states. The N-PASS score was only assessed during the heel stick, not before and after, which may have provided a better understanding of the effect of music in lowering pain scores. Although, we calculated the power for sample size between conditions, we did not calculate the power for the predictor model. Finally, we did not document the actual time, for example days or weeks, that the mothers spent listening to their preferred music, which may also have influenced the study results.

CONCLUSION

We have shown when infants were exposed to the recorded music listened to by mothers during their pregnancy when they underwent a heel stick, this resulted in significantly lower pain scores than the silent control condition, but the scores were not lower than the recorded lullaby. Since the effect of recorded music on the physiological and behavioural response were minimal in this study compared to previous reports, especially when live music was played, it may be that live music is more beneficial to preterm infants. However, no studies to date have assessed the potential long-term benefits that would be an advantage to this area of research, especially interventions that would be implemented routinely in the NICU to decrease pain and stress. In addition, we did not find that the kind of recorded music selected by mothers was of any significance, which warrants further studies to evaluate the specific elements of music that are most effective for preterm infants.

Abbreviations:

ACTH, Adrenocorticotropic hormone; ANOVA, analysis of variance; ANCOVA, analysis of covariance; dB, decibel; Low birth weight, NICU, neonatal intensive care unit; N-PASS, Neonatal Pain, Agitation and Sedation Scale; O_2 SAT: oxygen saturation
RCT: randomised controlled trial,

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Conflict Of Interest

None

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Table 1: Demographic and Clinical Characteristics of Participants (n=42)

Infants Characteristics	**N (%)**	**Mean ± SD**	**Range**
Gender: Female	26 (61.9)		
Gestational age (weeks)		31.78 ± 2.8	25.4-37.2
Gestational age at study (weeks)		34.83 ± 1.3	31-37
Weight (g)		1577 ± 499.2	587-2700
Apgar 5 minutes		9.03 ± 1.5	7-10
Intubated on respirator (Yes)	17 (40.5)		
Primary diagnosis of infant			
RDS	10 (23.8)		
Sepsis	18 (42.9)		
Cardiac	04 (9.5)		
Other	10 (23.8)		
Noise level during intervention (dB)		63.23±8.7	40-100
Mother's age (years)		32.15±5.1	22-45

Table 2: Physiological measures before and after heel stick per condition

	No Music		Lullaby		Mothers' Music	
	Pre	Post	Pre	Post	Pre	Post
O_2 Saturation	98.06 (2.66)	97.36 (1.98)	97.94 (2.49)	98.95 (2.36)	98.00 (2.45)	97.57 (3.47)
Heart rate	153.02 (11.08)	158.03 (13.97)*	153.45 (14.14)	155.27 (12.05)	152.39 (12.43)	151.24 (23.22)
Respiratory rate	42.05 (12.24)	45.36 (13.77)	45.74 (13.82)	46.62 (22.53)	46.64 (11.28)	41.86 (6.15)*

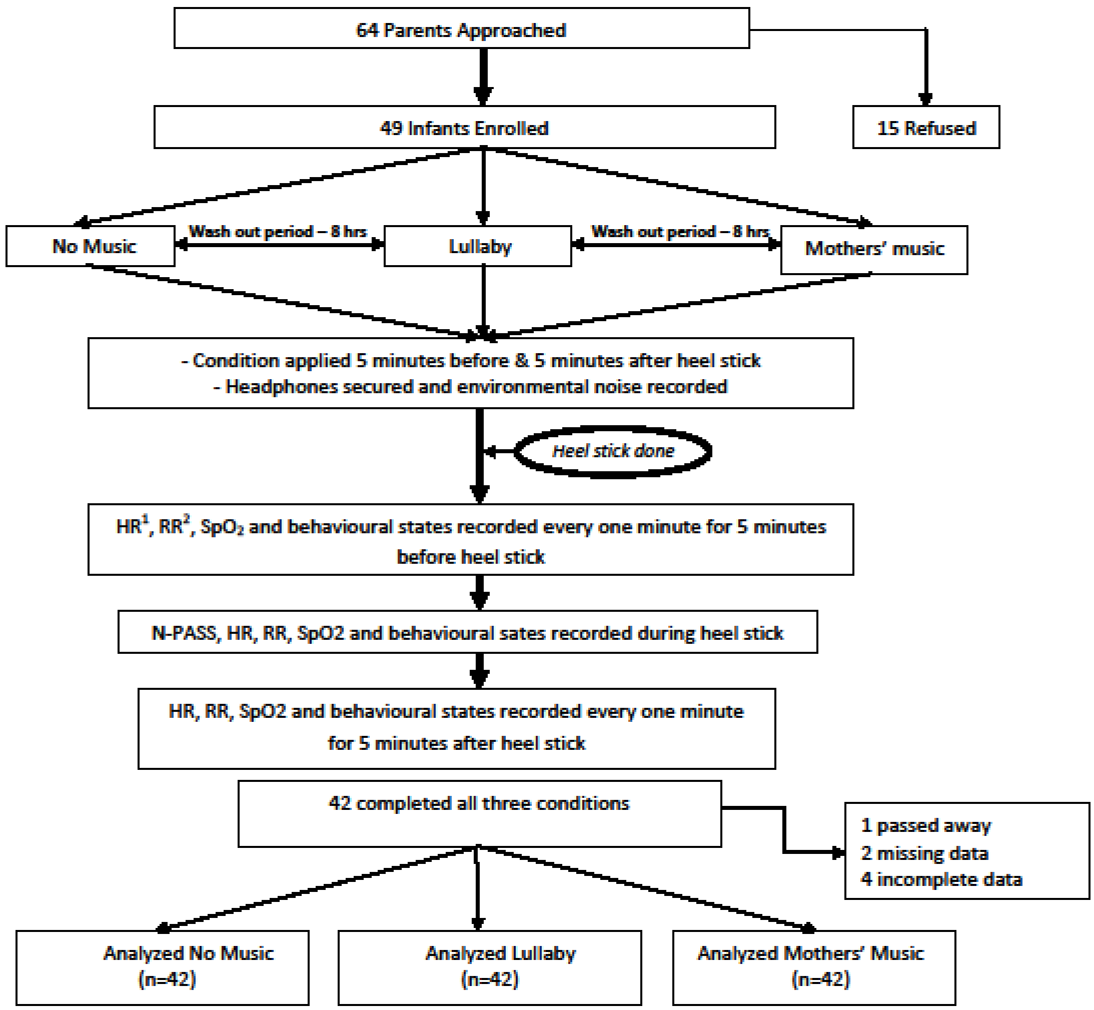
* $p < 0.05$ comparing pre and post values per condition.

Table 3: Predictors of the Neonatal Pain Assessment Scores (N-PASS) during heel stick procedure

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	-2.93	3.71		-.792	.43
Type of music (Quran =1, Fayrouz = 2, other =3)	.16	.21	.09	.53	.54
Music Condition (mothers' music =1, lullaby =2, no music =3)	-.50	.18	-.22	-2.13	**.04**
Gender (male = 1, female = 2)	-.21	.09	-.29	1.22	.09
Gestational age of infant (28 - 31 weeks = 1, 31.1 to 36 weeks =2)	.69	.15	.71	3.28	**.00**
Gestational age at study (30 to 34 weeks = 1, 34.1 to 37 weeks =2)	.04	.08	0.92	1.09	.08
Birth Weight in grams (≤ 1500 = 1, >1500 =2)	-.01	.01	-.52	-2.23	**.04**
APGAR score at 5 minutes (≤ 8 =1, > 8 =2)	-.26	.38	-.18	-1.75	.07
Was intubated on Respirator (No = 0, Yes =1)	.01	.09	.03	.09	1.01

R^2= 0.20

Figure 1: Study Protocol and Flow Diagram



[1]HR: Heart rate, [2]RR: respiratory rate

Figure 2: The iFrogz Audio Coda headphones used in the study

Figure 3: Average percent time infants spent in active alert state per condition before and after heel stick

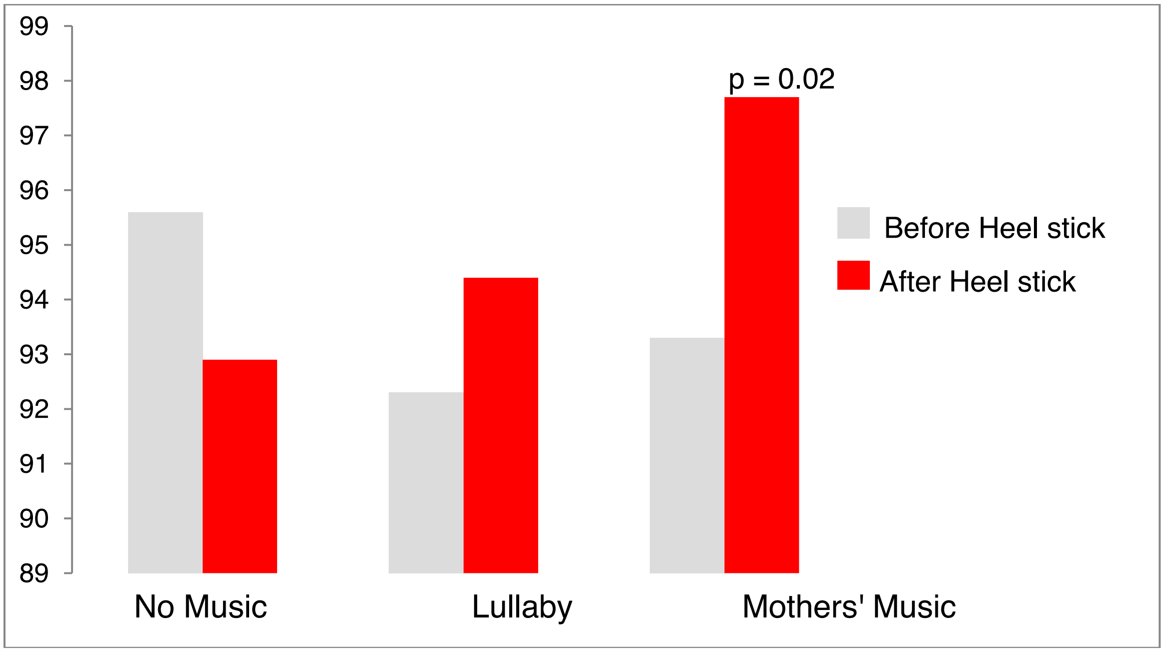


Figure 4: Average percent time infants spent in quiet alert state per condition before and after heel sticks