Live Music Is Beneficial to Preterm Infants in the Neonatal Intensive Care Unit Environment

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ABSTRACT: Background: *Music stimulation has been shown to provide significant benefits to preterm infants. We hypothesized that live music therapy was more beneficial than recorded music and might improve physiological and behavioral parameters of stable preterm infants in the neonatal intensive care unit.* **Methods:** *Thirty-one stable infants randomly received live music, recorded music, and no music therapy over 3 consecutive days. A control of the environment noise level was imposed. Each therapy was delivered for 30 minutes. Inclusion criteria were postconceptional age ≥ 32 weeks, weight ≥ 1,500 g, hearing confirmed by distortion product otoacoustic emissions (DPOAEs), and no active illness or documentation of hyperresponsiveness to the music. Heart rate, respiratory rate, oxygen saturation, and a behavioral assessment were recorded, every 5 minutes, before, during, and after therapy, allowing 30 minutes for each interval. The infant's state was given a numerical score as follows: 1, deep sleep; 2, light sleep; 3, drowsy; 4, quiet awake or alert; 5, actively awake and aroused; 6, highly aroused, upset, or crying; and 7, prolonged respiratory pause > 8 seconds. The volume range of both music therapies was from 55 to 70 dB. Parents and medical personnel completed a brief questionnaire indicating the effect of the three therapies.* **Results:** *Live music therapy had no significant effect on physiological and behavioral parameters during the 30-minute therapy; however, at the 30-minute interval after the therapy ended, it significantly reduced heart rate (150 ± 3.3 beats/min before therapy vs 127 ± 6.5 beats/min after therapy) and improved the behavioral score (3.1 ± 0.8 before therapy vs 1.3 ± 0.6 after therapy,* $p < 0.001$*). Recorded music and no music therapies had no significant effect on any of the tested parameters during all intervals. Both medical personnel and parents preferred live music therapy to recorded music and no music therapies; however, parents considered live music therapy significantly more effective than the other therapies.* **Conclusions:** *Compared with recorded music or no music therapy, live music therapy is associated with a reduced heart rate and a deeper sleep at 30 minutes after therapy in stable preterm infants. Both recorded and no music therapies had no significant effect on the tested physiological and behavioral parameters. (BIRTH 33:2 June 2006)*

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The prognosis of infants with very low birthweight has significantly improved during the last decade, without concomitant improvement in neurodevelopmental outcome (1). The importance given to stress reduction techniques, to allow optimal neurobehavioral function, led to the development of a range of therapies such as the Neonatal Individualized Developmental Care and Assessment Program (NIDCAP) (2); control of external stimuli (vestibular, auditory, visual, tactile); clustering of nursery care activities; and positioning or swaddling of preterm infants to provide a sense of containment similar to the intrauterine experience (3).

Music was also suggested as a tool for alleviating stress, providing a cost-effective and enjoyable strategy to improve empathy and compassion without interfering with routine work in the hospital and neonatal intensive care unit setting (4,5). A meta-analysis of 10 clinical trials showed that music therapy has a significant clinical benefit for preterm infants in the neonatal intensive care unit (6). A positive effect on long-term variables such as length of hospitalization, weight gain, and nonnutritive sucking rate, and short-term variables such as oxygenation, heart rate, and behavioral score was reported (7).

Most studies used recorded music delivered by free field or earphones, and compared the yield of lullabies with routine auditory stimulation (8–10). ("Free field" delivery means that the sound is transferred to the ear via sound waves and not via artificial conductor, that is, earphone.) However, the effect of pop, jazz, and other Western types of music versus lullaby and classical music, as well as the effect of live versus recorded music delivery systems, were not systematically assessed. The purpose of our study was to compare the effect of live music therapy, recorded music therapy, and no music therapy on short-term physiological and behavioral parameters of stable preterm infants during their stay in the neonatal intensive care unit.

Methods

Participants

The study was carried out in the neonatal intensive care unit of Meir Medical Center, Kfar-Saba, Israel, during a 6-month period that ended in March 2005. Preterm infants were assigned to receive live music therapy, the same recorded music therapy, or no music therapy. All therapies were performed in a random order over 3 consecutive days for 30 minutes, to 3 infants at a time, starting an hour after completion of feeding.

Inclusion criteria were postconceptional age ≥ 32 weeks, weight ≥ 1,500 g, hearing confirmed by distortion product otoacoustic emissions (DPOAEs), and no acute illness or documentation of hyperresponsiveness to the music. Infants were excluded if they had anomalies associated with neurological problems (i.e., intraventricular hemorrhage grade 3–4, periventricular leukomalacia) or received medications such as phenobarbital or oxygen that might interfere with the reaction to music stimuli. The study protocol was approved by the Institutional Review Board, and a written informed consent was obtained from all parents.

Measures

Heart rate (beats per minute), respiratory rate, oxygen saturation, and the infant's behavioral state as defined by Als (11) were recorded, every 5 minutes, in 3 intervals; before, during, and after the 3 therapies, allowing 30 minutes for each interval. The infant's state was given a numerical score as follows: 1, deep sleep; 2, light sleep; 3, drowsy; 4, quiet awake or alert; 5, actively awake and aroused; 6, highly aroused, upset, or crying; and 7, prolonged respiratory pause > 8 seconds.

In all study phases the objective measurements of music or background sound levels were performed with the 407790 Octave Band Sound Analyzer, a type 2 integrating sound level meter using the decibel-A scale filter (Extech Instruments, Melrose, Massachusetts, USA). Before each recording, the sound level meter that simulated typical reception of sound in the human ear was adjusted with the 407744 sound level calibrator (Extech Instruments, Melrose, Massachusetts, USA), according to the manufacturer's instructions and specifications at a range of 30 to 130 dB and a frequency of 25 to 10,000 Hz.

After each therapy interval, both medical personnel and parents were asked to complete a brief questionnaire indicating the effect of the therapy. Each interval was graded on a scale of 1 to 10; a grade of 4 or less indicated a harmful effect, 5 indicated no effect, and 6 and more indicated a beneficial effect.

Procedure

The infant was lying in a supine position, and music was played at a volume between 55 and 70 dB. Live music was performed at a distance of 1 to 2 meters from the infant's bed unit and comprised a lullaby style, soothing, rhythmic, repetitive, wordless blend of Eastern and Western musical elements sung by female voice with frame drum (E.G.) and an

accompanying instrument (harp, S.S.). The same music was played by means of a free field system, while a tape recorder with two speakers was placed 1 meter from the infant's bed unit.

For all 3 therapies, a control of the environment noise level was imposed to maintain constancy and to minimize possible effects on emotions and behavior of the infants. The monitor alarms were silent and the ward's door was closed to minimize interference from the outside. As recommended by the American Academy of Pediatrics (12), background noise measured near the infant's ear did not exceed 45 dB. All therapies were carried out an hour after the completion of feeding, while infants were on a 3-hour feeding schedule. Throughout the study period, the same nurses (A.S., and L.F), who received special training to define the infants' behavioral state, collected the data.

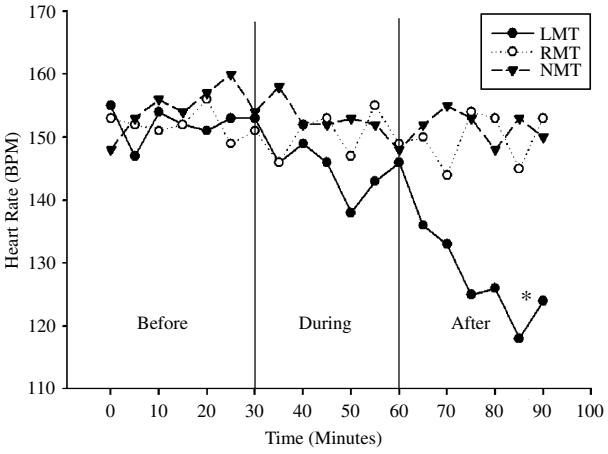

Fig. 1. Effect of each therapy on the infant's heart rate (p < 0.001, between the after-live music therapy [LMT] interval and all other intervals pertaining to live music interval, recorded music therapy, and no music therapy).

Data Analysis

A within-subjects, counterbalancing, repeated-measures analysis was designed. The medical staff performed data analysis in a blinded fashion, each individual being unaware which infant received each therapy. Statistical analysis was performed using the GBStat v 6.5 PC software (Dynamic Microsystems Inc, Silver Spring, Maryland, USA). The multiple *t* test comparisons with Bonferroni adjustment and the Kruskal-Wallis ANOVA test were used to compare the medians of the 3 therapy groups. Unless otherwise indicated, data were expressed as mean ± standard deviation. Probability values of less than 0.05 were considered significant.

Results

Of the 37 preterm infants who were eligible for entering the study, 31 were enrolled. Three were excluded because of incomplete data and 3 others because parents refused participation in all 3 therapies. No infants had signs of hyperresponsiveness to the music. Characteristics of the study sample are shown in Table 1.

The mean sound level of the 2 music therapies was not significantly different; both played at a higher volume than the background noise and not exceeding 70 dB (Table 2).

The heart rate, oxygen saturation, respiratory rate, and behavioral assessment score of the infants in all 3 therapies were not statistically different 30 minutes before therapy. During the 30-minute therapy, live music therapy was associated with a decrease of the heart rate that was the lowest after 20 minutes; however, this decrease was statistically insignificant. At the 30-minute interval after therapy, live music therapy was associated with a significantly reduced heart rate, with the lowest rate after 24 minutes ($p < 0.01$) (Table 3; Fig. 1). The behavioral assessment score

Table 1. Study Sample Characteristics ($n = 31$)

Characteristic	*Median (Range)*	*Number*	*Frequency*
Male/female		14/17	
Jews/Arabs		18/13	
Gestational age (wk)	29 (25–34)		
Birthweight (g)	1175 (650–1737)		
Apgar score (1 min)	4 (0–9)		
Apgar score (5 min)	7 (4–10)		
Postconceptional age (wk)	34 (32–40)		
Weight at testing (g)	1738 (1584–2524)		
Chronic lung disease			4/31
Intraventricular hemorrhage grade 1–2			6/31

showed a gradual decline while the infant was receiving live music therapy, but it reached statistical significance only after therapy with the lowest score at 25 minutes ($p < 0.001$) (Fig. 2). No infant experienced prolonged respiratory pause greater than 8 seconds. Lower respiratory rate and increase oxygen saturation were also documented in the after-therapy interval compared with the two other intervals; however these differences did not reach statistical significance (Table 3). No physiological or behavioral effects were recorded in recorded music therapy and no music therapy during all 3 intervals.

Both medical personnel ($n = 23$) and parents ($n = 26$) preferred live music therapy to recorded music and no music therapies ($p = 0.07$ and $p = 0.04$, respectively); however, only among the parents was live music therapy significantly more effective than recorded and no music therapies. None of the 3 therapies was considered ineffective or harmful (Table 4).

Discussion and Conclusions

Preterm infants are vulnerable to a range of diseases associated with immaturity of the organ systems and to stress stimuli during their stay in the neonatal intensive care unit. A favorable environment may help to reduce some of these morbidities. The effect of music was shown to have a positive effect on caregiver attitudes, mood, and behavior and, concomitantly, on the infants' physiological and behavioral state (13). Our study design elements mimic sounds that the infant may have been exposed to in the uterus and the mother's heart beat by using a wordless, rhythmic, constant, repetitive, soothing lullaby sung by a female voice with Eastern frame drum and an accompanying instrument. Being a multicultural society, our infants mainly belong to Jewish and Arab families with different cultural and musical backgrounds; therefore, a blend of Eastern and Western wordless melody that can apply to all was chosen.

The musical duet adjusted well to the neonatal intensive care unit space without interfering with technical aspects of care or routine work, and provided a valuable tool for alleviating stress. Our data showed that live music played in the neonatal intensive care unit to stable preterm infants at 32 weeks postconceptional age and older for 30 minutes resulted in an improvement of physiological and behavioral short-term stress parameters. Live music therapy was associated with a significant decrease in heart rate and a calmer deeper sleep, occurring only 30 minutes after therapy ended. Respiratory rate and oxygen saturation also improved after live music therapy, but these parameters did not reach statistical significance.

In contrast to live music therapy, both recorded music therapy and no music therapy had no bearing on the tested parameters. Standley found that the combined effect of live singing (Brahms' lullaby) and multimodal stimulation was associated with increased weight gain per day and an earlier discharge of female infants compared with the group who received no stimulation (7). In another study, infants whose parents received training in music and multimodal stimulation had improved parent-infant bonding, shorter length of hospitalization, and daily greater average of weight gain (13). Neither study compared live with recorded music or evaluated the short-term effect of music. Considering that weight gain and time to discharge may be influenced by factors other than music therapy, the net effect of music can be judged more precisely while analyzing physiological and behavioral short-term parameters. Furthermore, in our within-subjects, repeated-measures design conducted for 3 consecutive days,

Table 2. Comparison Between the Mean Music and No Music Sound Levels During the 3 Study Therapies

Therapy	*Mean Sound Level (dB)**	*Range of Mean Sound Level (dB)*
LMT	60.35 ± 4.85	55.53–64.79
RMT	63.72 ± 5.12	54.66–69.21
NMT	40.61 ± 3.63	38.27–44.72

**Mean ± SD.*
LMT = live music therapy; RMT = recorded music therapy; NMT = no music therapy.

Table 3. Effect of Live Music Therapy on Physiological and Behavioral Parameters in Preterm Infants During Study Therapies ($n = 31$)*

Test Parameter	*Before Therapy*	*During Therapy*	*After Therapy*
Heart rate (BPM)	150 ± 3.3	144 ± 3.7	127 ± 6.5†
Respiratory rate (per min)	49 ± 7.3	52 ± 8.3	41 ± 7.9
O_2 saturation	91 ± 6.8	89 ± 10.1	94 ± 4.5
Behavioral score	3.1 ± 0.8	2.5 ± 0.3	1.3 ± 0.6†

**Mean ± SD*; † $p < 0.05$, *between after and before therapy and after and during therapy. BPM = beats per minute.*

variations among participants, such as difference of postconceptional age, history of illness, or change in environmental variables within the study period, which may be presented in a longer period, were eliminated.

Our results showed that live music was considered by parents to be significantly more beneficial than recorded music and no music therapies. As for medical personnel, all 3 therapies were considered beneficial for the preterm infant, with a tendency for live music therapy. Other investigators showed that medical personnel in the neonatal intensive care unit preferred recorded music to live music by more than twofold (14); however, no specification was given as to the type of music that was played and for how long, or any other explanation for this preference. We hypothesized that the crooning quality of the human voice compared with recorded music was reassuring and calming to both babies and adults, bringing about a change in the neonatal intensive care unit environment. Nurses were more relaxed and positive, and their interactions with infants and parents were improved. Live music may also have some intrinsic sound properties that are absent in recorded music (5).

Habituation that is defined as a decreasing response to a repeated stimulus is a fundamental type of learning that may influence behavioral responses (15,16). Our type of music was introduced to the infants for the first time in their life and in a random order. In addition, since the same music was played only twice, no habituation effect could confound the study results.

It was shown that exposure to live harp music was beneficial to preterm infants and lowered cortisol levels and respiratory rates (17). Nevertheless, measuring cortisol levels in preterm infants required manipulation or even venipuncture and may not be an accurate sign of stress reduction in the neonatal intensive care unit environment. Even months after hospitalization, preterm infants with extremely low gestational age may exhibit high basal and sustained levels of cortisol because of chronic stress (18).

Given that the data were recorded for 30 minutes before, during, and after therapy, no conclusion can be drawn as to the actual length of the effect of music. Extending the length of follow-up to an hour or more to see if the effect was sustained could validate the findings, yet a longer follow-up would interfere with the feeding schedule of the infants.

In conclusion, it was shown that, compared with recorded music or no music therapies, live music therapy is associated with a reduced heart rate and a deeper sleep in stable preterm infants at 30 minutes after therapy. Both recorded and no music therapies had no significant effect on the tested physiological and behavioral parameters. Further research is needed to assess the feasibility and reproducibility of our results and their long-term effect on the development of preterm infants.

Table 4. Attitudes of Medical Personnel and Parents Toward Live Music, Recorded Music, and No Music Therapies

Therapy	*Medical Personnel (n = 23)*	*Parents (n = 26)*
LMT	8.3 ± 2.1	9.2 ± 1.4†
RMT	7.8 ± 1.8	8.5 ± 2.2
NMT	8.0 ± 2.3	7.9 ± 2.6

**Mean ± SD; † p < 0.05, between live music therapy and the two other (recorded music and no music therapies).*
LMT = live music therapy; RMT = recorded music therapy; NMT = no music therapy.

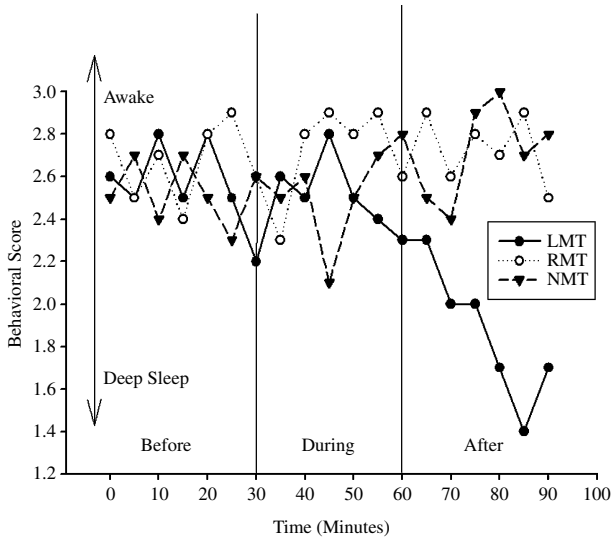

Fig. 2. Effect of each therapy on the infant's behavioral state (p < 0.001, between the after-live music interval [LMT] interval and all other intervals pertaining to live music therapy, recorded music therapy, and no music therapy).

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