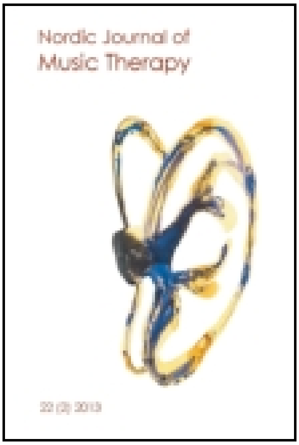

Nordic Journal of Music Therapy

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/rnjm20

Controlled trial of live versus recorded lullabies in preterm infants

Rasa Garunkstiene[ab], Jurate Buinauskiene[a], Ingrida Uloziene[c] & Egle Markuniene[a]

[a] Department of Neonatology, Medical Academy, Lithuanian University of Health Sciences, Eiveniu st. 2, LT-50009 Kaunas, Lithuania

[b] Centre of Neonatology, Children's Hospital, Affiliate of Vilnius University Hospital Santariskiu Klinikos, Santariskiu st. 7, LT-08406 Vilnius, Lithuania

[c] Department of Otolaryngology, Medical Academy, Lithuanian University of Health Sciences, Eiveniu st. 2, LT-50009 Kaunas, Lithuania

Published online: 05 Sep 2013.

To cite this article: Rasa Garunkstiene, Jurate Buinauskiene, Ingrida Uloziene & Egle Markuniene (2014) Controlled trial of live versus recorded lullabies in preterm infants, Nordic Journal of Music Therapy, 23:1, 71-88, DOI: 10.1080/08098131.2013.809783

To link to this article: http://dx.doi.org/10.1080/08098131.2013.809783

Nordic Journal of Music Therapy, 2014
Vol. 23, No. 1, 71–88, http://dx.doi.org/10.1080/08098131.2013.809783

Controlled trial of live versus recorded lullabies in preterm infants

Rasa Garunkstiene[a,b]*, Jurate Buinauskiene[a], Ingrida Uloziene[c] and Egle Markuniene[a]

[a]*Department of Neonatology, Medical Academy, Lithuanian University of Health Sciences, Eiveniu st. 2, LT-50009 Kaunas, Lithuania;* [b]*Centre of Neonatology, Children's Hospital, Affiliate of Vilnius University Hospital Santariskiu Klinikos, Santariskiu st. 7, LT-08406 Vilnius, Lithuania;* [c]*Department of Otolaryngology, Medical Academy, Lithuanian University of Health Sciences, Eiveniu st. 2, LT-50009 Kaunas, Lithuania*

(*Received 22 July 2011; final version received 24 March 2013*)

The aim of this study was to compare the effects of live and recorded lullabies on physiological and behavioural state outcomes of stable preterm infants. We conducted a prospective, repeated measures crossover study, involving 35 stable infants of less than 32 weeks postmenstrual age. Each infant received a different intervention for three consecutive days (live lullabies, recorded lullabies, and no-music sessions). The infant was observed every 5 min for 30 min before, 20 min during, and 30 min after the intervention. The results revealed that the infants' heart rate (HR) decreased significantly for the live and recorded lullabies conditions but not for the control condition (p = .02). The findings also suggest that the live lullabies condition resulted in a deeper sleep than the recorded lullabies condition (p = .02) and the control condition (p = .006). No changes were observed in oxygen saturation level. The results of this study show that lullabies effectively reduce the HR of preterm infants less than 32 weeks postmenstrual age, and live lullabies have a greater beneficial impact on their sleep state than recorded lullabies.

Keywords: preterm infant; music therapy; lullabies

Introduction

Early interventions can improve the adaptation and neurobehavioural development of preterm infants (Spittle et al., 2010; Symington & Pinelli, 2006; Vanderveen, Bassler, Robertson, & Kirpalani, 2009). This is important as preterm infants neonatal intensive care units (NICUs) are exposed to a significant amount of environmental stress that has been shown to cause changes in infants' physiological parameters. Further, exposure to continuous noise from incubators and medical equipment changes infants' behaviour, increases tiredness and

*Corresponding author. Email: rasa.garunkstiene@gmail.com

disturbs the sleep–wake cycle. In the population of very low birth weight infants, sleep takes most of the time. A foetus (29–32 weeks' gestation) spends 80% of the time in utero in rapid eye movement (REM) (active) sleep (Merenstein & Gardner, 2006). Active sleep is associated with information processing and storing. Quiet sleep is restorative and anabolic, with lowered oxygen consumption and growth hormone release. These sleep states enable energy conservation and physiologic homoeostasis maintenance, and they are necessary for maturity and weight gain, which is very important for preterm infants in the NICU. A quiet alert state is more appropriate for older infants. During awake states, term infants are most attentive to their environment, focusing their attention on any stimuli that are present. As infants grow and mature, their sleep and awake patterns change. The development of sleep and awake states during infancy reflects central nervous system maturation and is important for growth, development, and learning (Merenstein & Gardner, 2006). To protect premature infants from the onslaught of stressful stimuli, they are often administered sedatives. Music therapy may be cost-effective, risk-free alternative to pharmacological sedation, and help the infants achieve a deeper sleep (Loewy, Hallan, Psych, Friedman, & Martinez, 2005).

Music therapy interventions can provide a safe and appropriately stimulating environment, resulting in beneficial outcomes for preterm infants (Standley, 2002). A series of studies has shown that music improves physiological responses and behaviour in infants, and reduces their stress during painful procedures (Bo & Callaghan, 2000; Keith, Russell, & Weaver, 2009; Lai et al., 2006; Teckenberg-Jansson, Huotilainen, Pölkki, Lipsanen, & Järvenpää, 2011; Whipple, 2000, 2008). By decreasing agitation of the infant, music therapy saves energy for maturation (Kemper & Hamilton, 2008; Lubetzky et al., 2010). It has also been found that the maternal voice increases the preterm infant's tolerance for milk, stimulates maturation of the sensory systems, and helps shape normal development (Krueger, Parker, Chiu, & Theriaque, 2010; Nöcker-Ribaupierre, 1999, 2004). Furthermore, the bond between the mother and the infant is strengthened when the preterm infants in the NICU listen to the mother's recorded singing (Cevasco, 2008). Also, research has suggested that the parent's singing with multimodal stimulation in the NICU reduces the preterm infant's stress behaviours and improves the parent's actions and responses (Whipple, 2000). Generally, music interventions promote positive parent–child interactions and enhance children's behavioural, communicative, and social development (Nicholson, Berthelsen, Abad, Williams, & Bradley, 2008). Therefore, music therapy is important for both the neurobehavioural and the physiological development of a preterm infant.

The aforementioned studies varied mainly in the usage of live music and recorded music with the majority of the studies using recorded music. However, live music is more flexible and can readily adapt to the infant's responses, mirror and support emotions, and synchronize with the respiratory rate or HR. In using live music, the music therapist is a part of the environment, playing soothing music that relates to the patient, caregiver, and staff needs, thereby attending to, and adjusting to the instant input and response of the immediate situation. Live music can also be shifted in the moment or entrained to match the child's physiological responses (Loewy et al., 2005; Shoemark, 2006). Research examining acoustic parameters of infant-directed versus infant-absent (the same song in the absence of the infant) singing found that the tempo was slower and the pitch and jitter (variation in the fundamental frequency at the smallest time period) factor higher in the infant-directed than the infant-absent versions. Pitch variability was higher in the infant-directed versions of playsongs but not lullabies (Trainor, Clark, Huntley, & Adams, 1997). Many of these acoustic modifications likely attract infants' attention, and playsongs and lullabies likely communicate different emotional messages. If the aim of the music therapy intervention is to sedate the preterm infant, lullaby-type music is most appropriate (Schwartz, 2004) as it has a calming effect because of the slow tempo, flowing melodies, repetitive phrases, and soft tone colour.

Study by Arnon et al. (2006) is the only study that has compared the influence of live versus recorded music on the physiological state and behaviour of infants older than 32 weeks postmenstrual age. The study found that live music decreased the HR and improved the infant's behaviour 30 min after the intervention.

The effect of live versus recorded music on infants of younger gestational age is yet to be evaluated. It is important that the effect of music on very low birth weight infants is carefully examined as these infants can be easily overstimulated and irritated because of a low tolerance for environmental stimuli. Therefore, studies are needed that systematically examine the use of live music with preterm infants less than 32 weeks of postmenstrual age.

The purpose of this study is to examine the impact of live lullabies on physiological and behavioural responses in preterm infants less than 32 weeks of postmenstrual age. We hypothesized that live lullabies would reduce the HR, improve the oxygen saturation, and help the infants achieve a deeper sleep state significantly more than recorded lullabies.

Materials and methods

Participants and setting

The study was performed at two tertiary care medical centres: the Department of Neonatology at the Medical Academy of Lithuanian University of Health Sciences and the Centre of Neonatology, Children‘s Hospital, Affiliate of Vilnius University Hospital Santariskiu Klinikos (Lithuania) from 2008 to 2009. The Lithuanian Bioethics Committee (14 July 2008 Nr. 42) and the Kaunas Regional Biomedical Research Ethics Committee (5 March 2008 Nr. BE-1-36) granted permission for this study. The parents of the infants were informed of the content of the study, and written consent for participation and publication was obtained. Inclusion criteria for the study were as follows: preterm infants, 28–32 weeks postmenstrual age, in stable condition, without oxygen therapy with parents' agreement. The exclusion criteria were as follows: congenital anomalies that can influence neurological development, grade III intraventricular and/or intraparenchimal haemorrhage, periventricular leucomalacia, or suspected hearing loss after hearing screening with transient evoked otoacoustic emissions.

The investigation took place in the post-intensive care units of the preterm infants, where they received usual care. Thirty-five stable infants were investigated. Infants were placed on their backs or sides, as preterm infants sleep with more central apneas in the prone position (Bhat et al., 2006). During the investigation they did not receive sedative medicine or pain relief medicine. Lullabies were heard through the open porthole at the side of the head from a distance of about 30 cm. The thermal environment in the incubators (Ameda, Illinois, USA) was managed with air servocontrol. This helped to maintain the infants' temperature while isolette portals were open. Tested infants were video recorded during all sessions, as stated in the agreement signed by the parents. Incubators were partly covered to protect infants' eyes from direct light. The time chosen for the intervention was afternoon to reduce any interference by environmental noise.

Design

The study used a prospective repeated measures crossover design. Each infant was exposed to each of the three treatment conditions namely live lullabies, recorded lullabies, and no intervention-control. One intervention was offered per day for three consecutive days. The treatment conditions were offered in random order (Figure 1). From here on, these conditions will be referred to as *live lullabies session, recorded lullabies session*, and *no intervention session*, respectively. During each session the infant was observed every 5 min for 30 min before, 20 min during, and 30 min after the intervention (*before intervention, during intervention,* and *after intervention periods*). The session was started 30 min after feeding to calm down the infants and put them to sleep. The infants were gavage fed every 3 hours. The feeding protocol was consistent throughout the 3 days of the study.

Intervention

A music therapist (J.Z.-T.) selected the lullabies, which included Lithuanian and traditional Western lullabies as well as lullabies from other countries. A complete list of lullabies and their characteristics is included in the Appendix. All lullabies were sung in Lithuanian and were in simple, duple meter, except for two which used a simple triple meter. The tempo of the recorded lullabies was slow (60–80 bpm). The singing manner was slightly

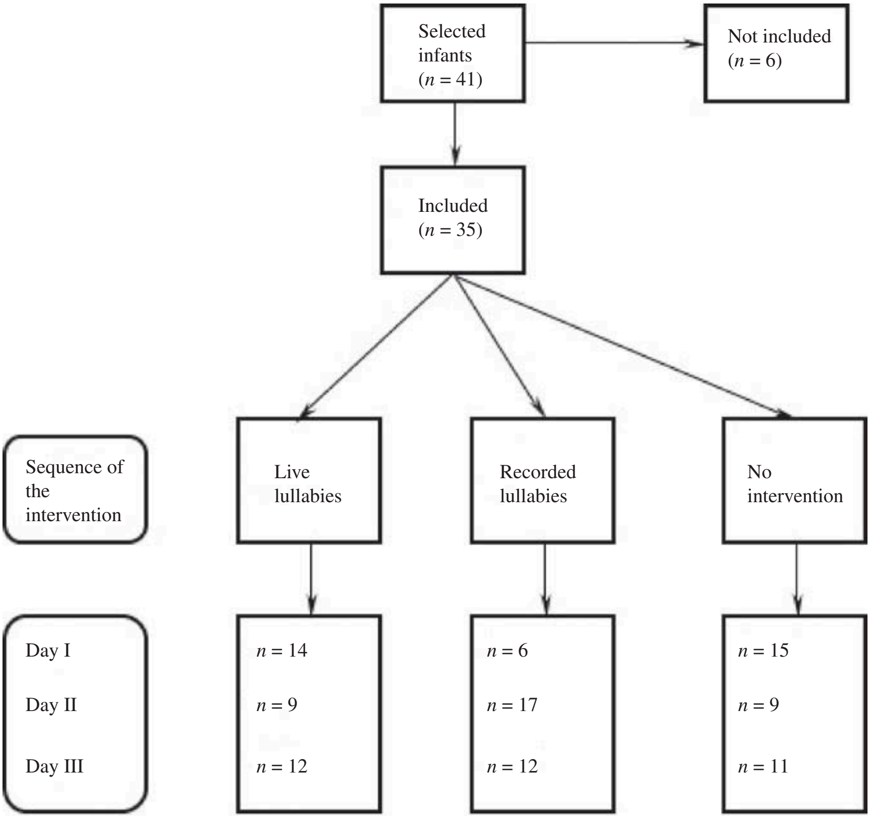

Figure 1. Performance scheme of the investigation.

adjusted to the infant state. The music therapist followed the infant and, for instance, if the infant was anxious, his or her breath rate increased, the therapist slowed down the tempo a little, started singing in a low or gradually lower voice, mellowing the vocal timbre at the same time. The music therapist observed the infant behaviour and intuitively adapted the music. The same female music therapist (J.Z.-T.) sang the lullabies with words live and as well as in the recorded version. For consistency purposes, the recorded session and the live lullabies session consisted of the same lullabies and did not use any accompanying instruments. Therefore, all infants listened to the same lullabies during all sessions. This was to ensure that the voice qualities were the same for the recorded and the live conditions for the infants. The female vocal was chosen considering the literature on the beneficial impact of the mother's voice on the premature infant's well-being (Cevasco, 2008; Krueger et al., 2010; Nöcker-Ribaupierre, 1999, 2004). Ilari and Sundara (2009) furthermore found that infants listen to unaccompanied singing longer, even if the language is unfamiliar to them. These capacities are evident for term infants, but possibly they are also present in preterm infants. Vocal singing transfers language; moreover, interaction through language improves vocalizations in very preterm infants (Caskey, Stephens, Tucker, & Vohr, 2011). It is also important to note that in unaccompanied direct singing, there are more emotions attracting attention. The positive emotion conveyed by the mother's tone of voice is highly salient to infants (Trainor, 1996).

Equipment

For the recorded music session, lullabies were recorded on an MP3 player, Creative Zen Stone Plus (Creative, Singapore) in a studio. The lullabies were presented in the same order for the recorded and the live music conditions. As stated above, the same music therapist sang the live and the recorded lullabies. The recordings were played using Creative Giga Works HD50 (Creative, Singapore) speakers, placed outside the open porthole at the side of the head about 30 cm. During live lullaby sessions, the music therapist also sang from the open porthole at the same distance. The acoustic level was measured with the sound meter geo-Fennel FSM 130+ (Geo-Fennel, Germany) (A scale) before and during the intervention. The acoustic environment at the infant's ear was 47.8 ± 6.6 dB; during both the recorded and live intervention it was 50.5 ± 6 dB. The background sound level was 44.3 ± 6.7 dB. All infants were on a pulse oximeter Massimo Radical (Siemens, Germany) that measured the transcutaneous oxygen saturation and heart frequency with a sensor placed on foot or hand.

Measurement

As per Arnon's protocol (2006), the following outcome data were collected before, during, and after the intervention (live, recorded lullabies, and control data) in 5 min interval.

Physiological Responses. An investigator (R.G.) collected equipment-monitored physiological function levels (oxygen saturation and HR).

Behavioural State. One nurse (D.M.) received special training to assess the infants' behavioural state. She was blinded to the study intervention (live, recorded, none), and observed and scored the soundless video recordings for infant behavioural state. The music therapist was not visible in the video recordings to assure outcome assessor blinding. Behavioural state was evaluated using the Als scale (Als, 1984). The selection of this behavioural scale was based on the Arnon's study protocol (2006). In this scale, the infant's behavioural state is given a numerical score as follows: 1, deep sleep (eyes closed, regular breathing, no movements of extremities); 2, light sleep (eyes closed, twitches or startles of extremities, REM, irregular breathing); 3, drowsy (eyes open (but roving or not focused) or closed, irregular breathing, some body movements); 4, quiet awake or alert (eyes open, focused, very few or no body movements); 5, actively awake and aroused (eyes open, active extremity movements); 6, highly aroused, upset or crying (upset, fussing, highly aroused, crying); and 7, prolonged respiratory pause > 8 sec.

Procedures

This study's protocol was based on the study protocol of Arnon's 2006 study with premature infants (Arnon et al., 2006). As outlined in the study procedures below, our study protocol deviates from Arnon's in regards to postmenstrual age, individual music administration, distance between music source and infant, use of instrumental accompaniment.

In the Arnon study, the postmenstrual age was >32 weeks, weight >1500 g; all therapies were applied to three infants at a time, started an hour after feeding and continued for 30 min; live music was performed at a distance of 1–2 metres from the infant's bed unit; the tape recorder with two speakers was placed 1 metre from the infant's bed unit; the music was 'a lullaby style, soothing, rhythmic, repetitive, wordless blend of Eastern and Western musical elements, sung by a female voice with a frame drum and an accompanying instrument (the harp)' (Arnon et al., 2006, p. 132); throughout the study period, the same two nurses collected the data.

In contrast, in the present study, the preterm infants were younger than 32 weeks of postmenstrual age and placed in the incubator; the investigation was started 30 min after feeding; lullabies were heard through the open porthole at the side of the head at the distance of about 30 cm; the duration of the intervention was 20 min; lullabies, without accompaniment, were sung by a music therapist; the recorded lullabies were played using speakers, placed outside incubator; equipment-monitored physiological function levels were collected by the principal investigator; infants were video recorded during all sessions; one nurse observed and scored the soundless DVD for infant state after the study.

Statistical analysis

The statistical analyses were performed using the SAS statistical package (SAS Institute Inc., Cary, NC, USA). Descriptive statistics of the infants' data were calculated. Inferential statistical analyses were performed in the following two ways: the data were compared within each intervention session (before intervention, during intervention, and after intervention) and between different sessions. A repeated measures analysis of variance was not used, since the outcome data were not normally distributed. Instead, the nonparametric Friedman test was employed to compare data of the three different sessions (*live lullabies session, recorded lullabies session*, and *no intervention session*), and data between groups was compared using the Wilcoxon signed ranks test for dependent samples. This test also was used to compare the data within each intervention session (*before intervention, during intervention,* and *after intervention periods*). Bonferroni correction for multiple comparisons was applied. The data were examined for normality of distribution by the Shapiro–Wilk test of normality. The randomness of the sequence of the interventions was tested by chi-square test, and the relationship between morbidity and heart activity was tested using linear regression analysis. The difference of relationship was significant when $p < .05$. The required minimal sample size (30 infants) for the study was calculated assuming a HR mean difference of five beats per minute, a level of significance of .05, and power 80%. Sample size calculations were performed with the statistical analysis SAS program power calculation procedure Proc Power.

Results

Forty-one infants were considered for study participation. Six infants were excluded for the following reasons: three of them did not pass hearing screening with transient evoked otoacoustic emissions, and three mothers did not want their infants to undergo any intervention. Therefore, 35 infants were included in the study. The infants' demographical and medical characteristics are summarized in Table 1. Each infant served as his/her own control. A linear regression method showed that congenital infections, respiratory distress syndrome, and birth asphyxia did not influence HR during the interventions (recorded lullabies $F = 1.54$, $df = 3$, $p = .22$; live lullabies $F = 1.95$, $df = 3$, $p = .14$; control condition $F = 1.01$, $df = 3$, $p = .4$). The sequence of the interventions was random (recorded lullabies $\chi^2 = 1.0857$, $df = 2$, $p = .58$; live lullabies $\chi^2 = 5.20$, $df = 2$, $p = .07$; control condition $\chi^2 = 1.60$, $df = 2$, $p = .44$).

The empirical means of HR, behavioural state, and oxygen saturation at different moments before, during, and after the intervention are graphically presented in Figures 2–4. The visual presentation of the results suggests the following:

Table 1. Study sample characteristics ($n = 35$).

Characteristics	Mean ± SD (range)	Number
Gestational age (weeks)	28.6 ± 1.1 (26–30)	
Postmenstrual age (weeks)	30.7 ± .9 (28–32.4)	
Chronological age (days)	15 ± 6.3 (7–32)	
Birth weight (g)	1257.5 ± 263.3 (760–1854)	
Current weight (g)	1299.7 ± 208 (936–1815)	
Apgar score (1 min, points)	6.5 ± 1.2 (3–8)	
Apgar score (5 min, points)	7.7 ± .9 (5–9)	
Gender (male/female)		19/16
Nationality (Lithuanian/other)		28/7
Intrauterine infection		20
Respiratory distress syndrome		16
Birth asphyxia		19
Intracranial haemorrhage (grade I-II)		8

Note: SD – standard deviation.

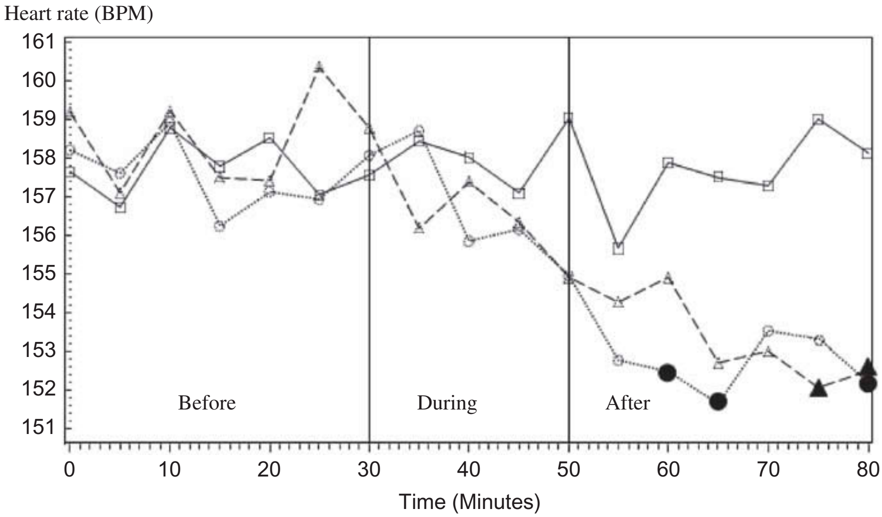

Figure 2. Comparison of heart rate (beats per minute) between different sessions. Note: ….○…. live lullabies, ….●…. $p < .05$, with Bonferroni correction, as compared to the control condition; ---Δ--- recorded lullabies, ---▲--- $p < .05$, with Bonferroni correction, as compared to the control condition; __□__ control condition.

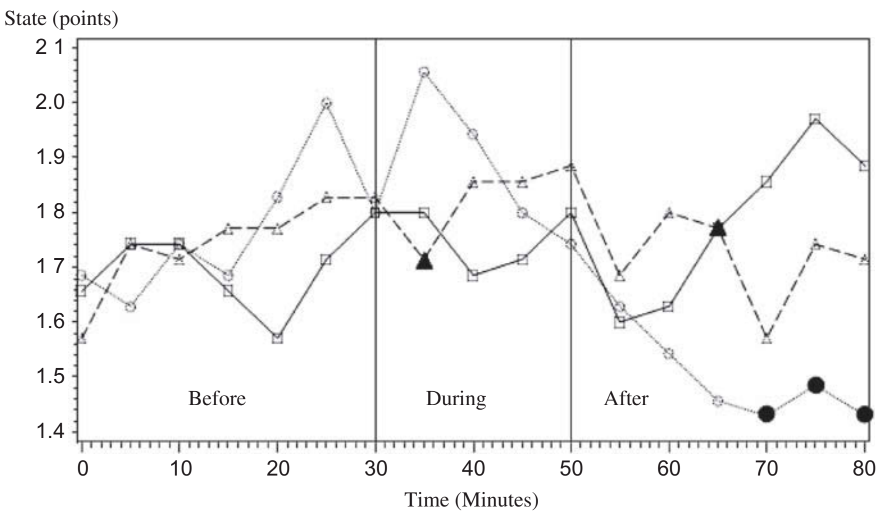

Figure 3. Comparison of behavioural state (points) between different sessions. Note: ….○…. live lullabies, ….●…. $p < .05$, with Bonferroni correction, as compared to the control condition; ---Δ--- recorded lullabies, ---▲--- $p < .05$, with Bonferroni correction, as compared to the live lullabies; __□__ control condition.

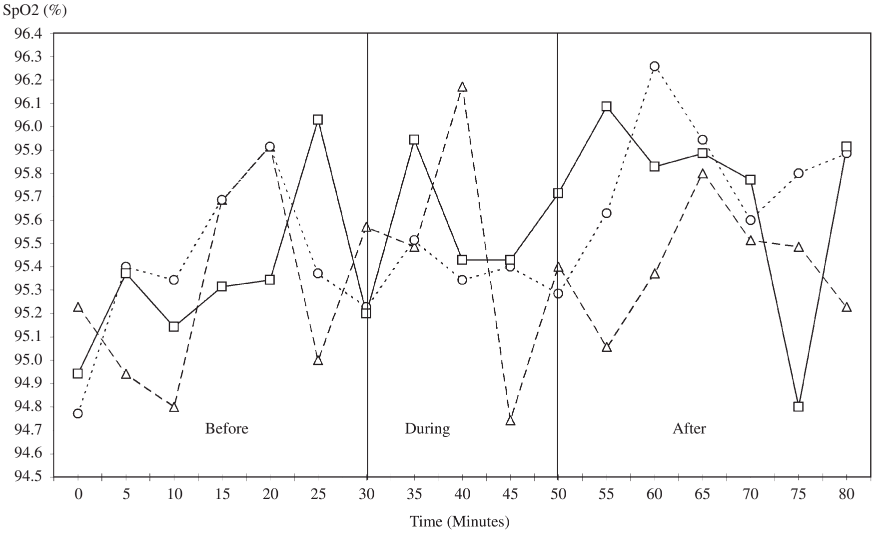

Figure 4. Comparison of oxygen saturation (percentage) between different sessions. Note: ....○.... live lullabies, ---Δ--- recorded lullabies, __□__ control condition.

(1) HR decreased significantly during and after the live and recorded lullabies interventions. This downward trend in HR began at the middle of the lullaby session and continued after the intervention. For the control group, the HR was stable during all periods (Figure 2).
(2) The behavioural state changed significantly immediately following the live lullabies (i.e. the infants demonstrated deeper sleep). None of the other conditions resulted in behavioural changes (Figure 3).
(3) The graphs do not suggest any significant changes in oxygen saturation level (Figure 4).

To confirm these observations, statistical tests were applied. Because the assumption of normality of the data was not met, the nonparametric Friedman's test was used for comparing three cumulative distributions from the dependent samples and the Wilcoxon signed ranks test for comparing two cumulative distribution functions from two dependent samples.

Initially, the hypotheses of equality of the cumulative distribution functions of the arithmetic means of measurements of any of three considered outcomes (HR, behavioural state, and oxygen saturation) after intervention for live, recorded, and no lullabies sessions were tested. We applied the Friedman's test and obtained p-values of .02, .04 and .18 and Friedman's statistic values of 7.87, 6.30, 3.49 for HR, behavioural state, and oxygen saturation, respectively. As a result, the null hypothesis could not be rejected for oxygen saturation. The distribution of HR and that of behavioural state had different distributions (the null hypothesis could be rejected) minimum for two of the three sessions (*live lullabies session, recorded lullabies session*, or *no intervention session*).

The Wilcoxon signed ranks test was applied for pairwise comparisons. Comparing live and the control condition (no lullabies), there was a statistically significant difference between the two conditions for HR [$W = -157.5$, $p = .007$] (from 10th min after the intervention) and behavioural state [$W = -121.5$, $p = .006$] (from 20th min after the intervention) with live music resulting in greater reductions. As for the comparison between recorded lullabies and the control condition, a statistically significant difference was only observed for HR [$W = 130.5$, $p = .02$] (from 25th min after the intervention). Finally, there was a statistically significant difference between recorded music and live lullabies for behavioural state [$W = -121$, $p = .02$] (at 15 min after the intervention) with live music resulting in greater improvement in behaviour but not for any of the other outcomes. Even after applying the Bonferroni method for multiple comparisons, the differences remained statistically significant. While there was no significant difference in HR between the live and recorded music condition, the infants' HR was significantly lower during music conditions than during the control condition. The infants' behavioural state significantly changed only when live lullabies were used, namely their sleep was markedly deeper.

Pairwise comparison of the cumulative distribution functions of the arithmetic means of measurements was performed with all three considered outcomes (HR, behavioural state, and oxygen saturation) before, during, and after intervention. Means ± standard deviations of these three outcomes before, during, and after the interventions are provided in Table 2. This pairwise comparison involved the Wilcoxon signed ranks test.

For infants receiving a live lullaby session, the HR before and during the intervention hardly changed, but decreased significantly more after the intervention than during [$W = 6.0939$, $p < .001$] and before [$W = 234$, $p < .001$] the intervention. This difference remained significant even after applying a Bonferroni correction. For infants receiving the recorded lullaby session, the HR before and during the intervention was nearly the same, but HR the post-intervention was notably lower than during [$W = 2.876$, $p = .007$] and before the intervention [$W = 4.824$, $p < .001$], even after applying the Bonferroni method. As for behavioural state, meaningful differences were only found for the live music session, namely the post-intervention behavioural score was significantly better than during [$W = 234.5$, $p < .001$] and before [$W = 164$, $p = .003$] the intervention, again with the Bonferroni method applied. Oxygen saturation was not significantly influenced by any of the interventions.

Table 2. Comparison of heart rate, behavioural state, and oxygen saturation (means ± standard deviation) before, during, and after the interventions.

	Before intervention/During intervention		
Intervention	HR (bpm)	State (points)	SpO_2 (%)
Live lullabies	157.7 ± 13.9/156.5 ± 14.3 (p = .19)	1.8 ± .7/1.9 ± .7 (p = .21)	95.4 ± 3.5/95.3 ± 3.4 (p = .8)
Recorded lullabies	158.6 ± 11.4/156.3 ± 12 (p = .02)	1.7 ± .7/1.8 ± .7 (p = .34)	95.3 ± 3.2/95.4 ± 2.7 (p = .71)
	During intervention/After intervention		
Intervention	HR (bpm)	State (points)	SpO_2 (%)
Live lullabies	156.5 ± 14.3/152.8 ± 13.9 (p < .001*)	1.9 ± .7/1.5 ± .6 (p < .001*)	95.3 ± 3.4/95.8 ± 3.2 (p = .08)
Recorded lullabies	156.3 ± 12/153.3 ± 12.1 (p = .007*)	1.8 ± .7/1.7 ± .7 (p = .18)	95.4 ± 2.7/95.4 ± 2.8 (p = .87)
	Before intervention/After intervention		
Intervention	HR (bpm)	State (points)	SpO_2 (%)
Live lullabies	157.7 ± 13.9/152.8 ± 13.9 (p < .001*)	1.8 ± .7/1.5 ± .6 (p = .003*)	95.4 ± 3.5/95.8 ± 3.2 (p = .26)
Recorded lullabies	158.6 ± 11.4/153.3 ± 12.1 (p < .001*)	1.7 ± .7/1.7 ± .7 (p = .93)	95.3 ± 3.2/95.4 ± 2.8 (p = .81)

Notes: *$p < .05$, with Bonferroni correction. SpO_2 (%) – saturation of peripheral oxygen, percentage; HR, bpm – heart rate, beats per minute.

Discussion

The results of the current study show that music therapy positively affects the HR and behavioural state of preterm infants of 28–32 weeks postmenstrual age. The infants' HR significantly decreased with live as well as recorded lullabies sessions. These results differed significantly from the control condition during *after the intervention period*. Although the HR between live and recorded lullabies was not significantly different, the results clearly indicate an earlier beneficial impact of live lullabies on HR than recorded lullabies. The results also indicate that live lullabies resulted in a deeper sleep in the infants. As was discussed in the introduction section, sleep is necessary for maturity and weight gain, two important health concerns for preterm infants in the NICU. In a recent pilot study (Olischar, Shoemark, Holton, Weninger, & Hunt, 2011), the sleep of 20 neurologically healthy infants (33–42 weeks GA) in NICU was measured with amplitude-integrated electroencephalography (aEEG). Ten infants were exposed to recorded music. A trend of more mature sleep–wake cycles were reported compared to no-music controls, suggesting that there might be a small effect of music on quiet sleep in infants. The data of this study indicate that music may reduce disturbance in the state regulations for the infants.

Our study did not confirm the findings of other studies regarding the positive influence of music listening on oxygen saturation levels in preterm infants. Possibly because, contrary to other studies, our patients were not administered oxygen therapy, so, the fluctuation of the oxygen saturation was more stable (Bo & Callaghan, 2000; Cassidy & Standley, 1995; Desquiotz-Sunnen, 2008; Farhat, Amiri, Karbandi, Esmaily, & Mohammadzadeh, 2010; Keith et al., 2009). Cassidy and Standley's study (1995), for example, found that music improved oxygen saturation, heart and respiratory rate without increasing apneas and bradycardias in infants aged 24–30 weeks gestational age. Another study found that music therapy in NICU for infants of 23–36 weeks of gestation increases their oxygen saturation, improves their behaviour, and reduces HR and apneas (Desquiotz-Sunnen, 2008).

Positive experiences are essential for healthy neurological development. Appropriate infant stimulation, paired with physiological stabilization, enhances physiological and neurobehavioural development (Hodgson, Nakamura, & Walker, 2007; Merenstein & Gardner, 2006) and alters brain function and structure (Als et al., 2004). However, tolerance for stimulation at the time of contact must be carefully assessed (Neal & Lindeke, 2008; Shoemark, 2006). Some studies have shown that music therapy is safe for very low birth weight infants (Cassidy & Standley, 1995; Desquiotz-Sunnen, 2008; Haus & Hennecke, 2003). In the scope of our study, agitation was not observed.

In the current study, we compared live versus recorded lullabies for preterm infants and assessed their impact on the infants. However, we did not evaluate the preference of the parents or medical staff for live versus recorded music.

Results of other studies have suggested that staff and particularly parents preferred live music to recorded music (Arnon et al., 2006).

To the best of our knowledge, live and recorded music for preterm infants have only been compared in one study (Arnon et al., 2006) with infants of about 34 weeks postmenstrual age. In our study, the mean postmenstrual age was 30.7 weeks. Despite the younger postmenstrual age, our study found a greater effect of music therapy than recorded in previous study. This can be explained by several factors: in our study, statistical tests for dependent samples were used, which makes them more accurate than statistical tests for independent samples used in the earlier study. Moreover, another difference is that the lullabies were sung without any instrumental accompaniment. As discussed in the previous sections, a human voice, both spoken and sung, attracts the attention of infants, and they listen to the unaccompanied singing longer as compared with the voice and instrumental accompaniment (Ilari & Sundara, 2009). However, the evidence suggests that infant-directed singing attracts their attention, and mothers use the emotional qualities of singing to regulate their infant's state (Trainor, 1996).

In this study, we used the voice of a female music therapist. However, future researches should compare the differential impact of the mother's voice and songs performed by others. It is already known that neonates discriminate between parents' and others' voices (Ockleford, Vinceb, Laytonb, & Readerb, 1988). In a recent study (Caskey et al., 2011), data highlight the early interaction through language is occurring with preterm infants and their parents. In addition, very preterm infants vocalize significantly more when a mother or father is visiting. Therefore, future studies should also explore the role of the father's voice and male voices. Also, the cultural aspects of music should be investigated, since research has shown that infants' musical preferences appear to be driven by culture-specific experience and a culture-general preference for simplicity (Soley & Hannon, 2010).

Singing to an infant appears to be culturally universal (Unyk, Trehub, Trainor, & Schellenberg, 1992). Very preterm infants are extremely fragile; therefore, carefully applied live singing could help them maintain homoeostasis in this complicated period of life.

Conclusion

The results of the present study suggest a beneficial impact of lullaby singing on HR and the behavioural state of preterm infants of less than 32 weeks of postmenstrual age. Additionally, the data indicate that live lullabies are more effective than recorded lullabies. Therefore, it is recommended that live music rather than recorded is used when working with preterm infants.

The use of music therapy in neonatal care is in its infancy in Lithuania. It is hoped that the positive results of this study will result in more widespread applications of music therapy services with preterm infants in Lithuania and beyond.

Acknowledgements

The authors acknowledge Zebrauskaite-Talockiene Jurgita, a music therapist, for her active participation; Mauricaite Dangute, a neonatal nurse, for the behaviour assessment; Gudziunas Gytis and Prof. Bagdonavicius Vilijandas (Department of Mathematical Statistics of Vilnius University Faculty of Mathematics and Informatics) for their statistical analysis; and the mothers and infants, who participated in the study, and the medical staff for their support.

Notes on contributors

Rasa Garunkstiene, Doctor of Medical Sciences, is a neonatologist at the neonatal intensive care unit of Children's Hospital, Affiliate of Vilnius University Hospital Santariškiu Clinic. His academic interests include neonatal intensive care and music therapy.

Jurate Buinauskiene, Doctor of Medical Sciences, is Associate Professor at Neonatology Clinic, Lithuanian University of Health Sciences. His academic interests include prematurity, perinatal CNS pathology, and effect of diabetes on newborns.

Ingrida Uloziene, Doctor of Medical Sciences, is Associate Professor at the Department of Otorhinolaryngology, Lithuanian University of Health Sciences. His academic interests include objective evaluation of hearing in children, brainstem auditory-evoked potentials, otoacoustic emission, and otoneurology.

Egle Markuniene, Doctor of Medical Sciences, is Associate Professor at Neonatology Clinic, Lithuanian University of Health Sciences. His academic interests include influence of infant breastfeeding on their health and relationship development between mother and child.

References

Als, H. (1984). *Manual for the naturalistic observation of newborn behavior (preterm and fullterm infants)*. Boston, MA: The Children's Hospital.

Als, H., Duffy, F.H., McAnulty, G.B., Rivkin, M.J., Vajapeyam, S., Mulkern, R.V., … Eichenwald, E.C. (2004). Early experience alters brain function and structure. *Pediatrics*, *113*, 846–857.

Arnon, S., Shapsa, A., Forman, L., Regev, R., Bauer, S., Litmanovitz, I., & Dolfin, T. (2006). Live music is beneficial to preterm infants in the neonatal intensive care unit environment. *Birth*, *33*(2), 131–136.

Bhat, R.Y., Hannam, S., Pressler, R., Rafferty, G.F., Peacock, J.L., & Greenough, A. (2006). Effect of prone and supine position on sleep, apneas, and arousal in preterm infants. *Pediatrics*, *118*, 101. doi: 10.1542/peds.2005-1873

Bo, L.K., & Callaghan, P. (2000). Soothing pain-elicited distress in Chinese neonates. *Pediatrics*, *105*(4), e49.

Caskey, M., Stephens, B., Tucker, R., & Vohr, B. (2011). Importance of parent talk on the development of preterm infant vocalizations. *Pediatrics*, *128*, 910.

Cassidy, J.W., & Standley, J.M. (1995). The effect of music listening on physiological responses of premature infants in the NICU. *Journal of Music Therapy*, *32*(4), 206–227.

Cevasco, A.M. (2008). The effects of mothers' singing on full-term and preterm infants and maternal emotional responses. *Journal of Music Therapy*, *45*(3), 273–306.

Desquiotz-Sunnen, N. (2008). Chant et prématurité projet de musicothérapie en néonatologie [Singing for preterm born infants music therapy in neonatology]. *Bulletin de la Societe des Sciences Medicales du Grand-Duche de Luxembourg*, *1*, 131–143.

Farhat, A., Amiri, R., Karbandi, S., Esmaily, H., & Mohammadzadeh, A. (2010). The effect of listening to lullaby music on physiologic response and weight gain of premature infants. *Journal of Neonatal-Perinatal Medicine*, *3*(2), 103–107.

Haus, R., & Hennecke, K.-H. (2003). Musiktherapie bei Frühgeborenen: Praktische Durchführung und mögliche Auswirkungen anhand eines Fallbeispiels [Music therapy for prematures: Further overtension or necessary stimulation?]. *Zeitschrift für Geburtshilfe und Neonatologie*, *207*, 225–227.

Hodgson, D.M., Nakamura, T., & Walker, A.K. (2007). Prophylactic role for complementary and alternative medicine in perinatal programming of adult health. *Forschende Komplementärmedizin*, *14*, 92–101.

Ilari, B., & Sundara, M. (2009). Music listening preferences in early life infants' responses to accompanied versus unaccompanied singing. *Journal of Research in Music Education*, *56*(4), 357–369.

Keith, D.R., Russell, K., & Weaver, B.S. (2009). The effects of music listening on inconsolable crying in premature infants. *Journal of Music Therapy*, *46*(3), 191–203.

Kemper, K.J., & Hamilton, C. (2008). Live harp music reduces activity and increases weight gain in stable premature infants [letter]. *Journal of Alternative and Complementary Medicine*, *14*(10), 1185–1186.

Krueger, C., Parker, L., Chiu, S.-H., & Theriaque, D. (2010). Maternal voice and short-term outcomes in preterm infants. *Developmental Psychobiology*, *52*, 205–212.

Lai, H.-L., Chen, C.-J., Peng, T.-C., Chang, F.-M., Hsieh, M.-L., Huang, H.-Y., & Chang, S.-C. (2006). Randomized controlled trial of music during kangaroo care on maternal state anxiety and preterm infants' responses. *International Journal of Nursing Studies*, *43*, 139–146.

Loewy, J., Hallan, C., Psych, L., Friedman, E., & Martinez, C. (2005). Sleep/sedation in children undergoing EEG testing: A comparison of chloral hydrate and music therapy. *Journal of PeriAnesthesia Nursing*, *20*(5), 323–332.

Lubetzky, R., Mimouni, F.B., Dollberg, S., Reifen, R., Ashbel, G., & Mandel, D. (2010). Effect of music by Mozart on energy expenditure in growing preterm infants. *Pediatrics*, *125*, e24–e28.

Merenstein, G.B., & Gardner, S.L. (2006). *Handbook of neonatal intensive care* (6th ed.). Mosby: St. Louis.

Neal, D.O., & Lindeke, L.L. (2008). Music as a nursing intervention for preterm infants in the NICU. *Neonatal Network*, *27*(5), 319–327.

Nicholson, J.M., Berthelsen, D., Abad, V., Williams, K., & Bradley, J. (2008). Impact of music therapy to promote positive parenting and child development. *Journal of Health Psychology*, *13*(2), 226–238.

Nöcker-Ribaupierre, M. (1999). Premature birth and music therapy. In T. Wigram & J. De Backer (Eds.), *Clinical applications of music therapy in developmental disability, paediatrics and neurology*. Philadelphia, PA: Jessica Kingsley Publishers.

Nöcker-Ribaupierre, M. (2004). The mother's voice – a bridge between two worlds. In M. Nöcker-Ribaupierre (Eds.), *Music therapy for premature and newborn infants*. Gilsum NH: Barselona Publishers.

Ockleford, E.M., Vinceb, M.A., Laytonb, C., & Readerb, M.R. (1988). Responses of neonates to parents' and others' voices. *Early Human Development*, *18*, 21–36.

Olischar, M., Shoemark, H., Holton, T., Weninger, M., & Hunt, R.W. (2011). The influence of music on aEEG-activity in neurologically healthy newborns > 32 weeks' gestational age. *Acta Paediatrica*. doi: 10.1111/j.1651-2227.2011.02171.x.

Schwartz, F.J. (2004). Medical music therapy for the premature baby – research review. In M. Nöcker-Ribaupierre (Ed.), *Music Therapy for Premature and Newborn Infants*.
Shoemark, H. (2006). Infant-directed singing as a vehicle for regulation rehearsal in the medically fragile full-term infant. *Australian Journal of Music Therapy*, *17*, 54–63.
Symington, A.J., & Pinelli, J. (2006). Developmental care for promoting development and preventing morbidity in preterm infants. *Cochrane Database of Systematic Reviews*, 2, CD001814.
Soley, G., & Hannon, E.E. (2010). Infants prefer the musical meter of their own culture: A cross-cultural comparison. *Dev Psychol*, *46*(1), 286–292.
Spittle, A.J., Anderson, P.J., Lee, K.J., Ferretti, C., Eeles, A., Orton, J., … Doyle, L.W. (2010). Preventive care at home for very preterm infants improves infant and caregiver outcomes at 2 years. *Pediatrics*, *126*(1), e171–e178.
Standley, J.M. (2002). A meta-analysis of the efficacy of music therapy for premature infants. *Journal of Pediatric Nursing*, *17*(2), 107–113.
Teckenberg-Jansson, P., Huotilainen, M., Pölkki, T., Lipsanen, J., & Järvenpää, A.-L. (2011). Rapid effects of neonatal music therapy combined with kangaroo care on prematurely-born infants. *Nordic Journal of Music Therapy*, *20*(1), 22–42.
Trainor, L.J. (1996). Infant preferences for infant-directed versus noninfant-directed playsongs and lullabies. *Infant Behavior & Development*, *19*, 83–92.
Trainor, L.J., Clark, E.D., Huntley, A., & Adams, B.A. (1997). The acoustic basis of preferences for infant-directed singing. *Infant Behavior & Development*, *20*(3), 383–396.
Unyk, A.M., Trehub, S.E., Trainor, L.J., & Schellenberg, E.G. (1992). Lullabies and simplicity: A cross-cultural perspective. *Psychology of Music*, *20*, 15–28.
Vanderveen, J.A., Bassler, D., Robertson, C.M.T., & Kirpalani, H. (2009). Early interventions involving parents to improve neurodevelopmental outcomes of premature infants: A meta-analysis. *Journal of Perinatology*, *29*, 343–351.
Whipple, J. (2008). The effect of music-reinforced nonnutritive sucking on state of preterm, low birthweight infants experiencing heelstick. *Journal of Music Therapy*, *45*(3), 227–272.
Whipple, J.J. (2000). The effect of parent training in music and multimodal stimulation on parent-neonate interactions in the neonatal intensive care unit. *Journal of Music Therapy*, *37*(4), 250–268.

Appendix 1

The list of lullabies

(1) A-a pupa (*Rock-a-bye… Little Bean*); Lithuanian folk lullaby; Trichord C-Es-F, Range C4–F4.
(2) Katinėlis guli (*Here Lies the Kitten*); Lithuanian folk lullaby; Trichord D-F-G, Range D4–G4.
(3) Tykus vakars atėjo (*Calm Night Approached*); Lithuanian folk music, words Navickienė L.; B-dur, Range B3–Fis4.
(4) AaAa liūli, šarkos varnos nuliūdo (*Rock-a-bye… How Sad is Every Crow and Every Magpie*); Byelorussian folk lullaby, Lithuanian translation; A-dur, Range A3–Fis4.
(5) Vaike, miegok (*Sleep, My Child, Sleep*); Music Reichart J.F., words German's folk, Lithuanian translation; D-dur, Range A3–A4.

(6) Zuikis vaiką lingavo (*Hare Dandled a Chlild*); Lithuanian folk lullaby; Trichord C-Es-F, Range C4–F4.
(7) Pamojuokime saulelei (*Let Us Wave to the Sun*); Unknown Lithuanian author; Bb-dur, Range F3–G4.
(8) Čiūčia liūlia, užmik vaikeli *(Hush little Baby)*; American lullaby, Lithuanian translation; D-dur, Range G3–G4.
(9) Aa Aa pupa, kur lopšely supa (*Rock-a-bye… Little Bean Rocking the Cradle)*; Lithuanian folk music, words Navickienė L.; Es-dur, Range Bb3–Es4.
(10) Miki, vaikuti brangus *(Schlaf, Kindchen)*; Music Mozart W.A., Lithuanian translation; Bb-dur, Range Bb3–Bb4.