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Physiological and emotional effects of pentatonic live music played for preterm neonates and their mothers in the Newborn Intensive Care Unit: A randomized controlled trial

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ABSTRACT

Objective: Despite attempts to increase calmness in the Newborn Intensive Care Unit (NICU), preterm neonates still experience stress. The question arises how to further promote the infants' wellbeing. Therefore, the immediate effects of pentatonic live music on preterm infants and their mothers were examined.
Design and methods: In a two-centre randomized controlled trial with crossover design preterm infants were exposed sequentially to two conditions: live pentatonic harp music (LPHM) used in Anthroposophic Medicine or standard care. The order of the conditions was randomized within each subject. The primary outcome was change of the number of oxygen desaturations < 90%/h, whereas secondary outcomes were: heart rate, respiratory rate, oxygen saturation, heart rate variability (HRV), the perfusion index, pulse-transit-time and maternal anxiety and others not reported on in this article.
Results: 21 preterm infants were randomized (14 girls), mean gestational age at measurement 35 + 0 weeks (SD 1 week). The primary outcome parameter showed no significant changes. Regarding the secondary outcomes the comparison of the pre-post-differences between the conditions showed significant effects for the HRV parameters pNN_{50} ($\Delta pNN_{50} = 1.46\%$, $z = -2.47$, $p = .001$) and SDNN ($\Delta SDNN = -0.06$ ms, $z = -2.25$, $p = .002$). The music intervention significantly increased the values of pNN_{50} (Mdn 1.2% vs. 2.6%, $p = 0.04$) and marginally those of SDNN (Mdn 31.7 ms vs. 36.4 ms, $p = 0.05$). No changes were found in the other parameters.
Conclusions: While the use of music in the NICU had no effect on the number of oxygen desaturations, it increased two HRV parameters indicative of infants' parasympathetic tone.

1. Introduction

Preterm infants survive at ever earlier gestational ages (GA), when cared for in modern newborn intensive care units (NICU). Intensive care carries with it a variety of stressors, ranging from interruptions of sleep, noxious background sounds, and often bright lights as well as multiple painful treatments and separation from their parents.[1] There is evidence that stress exposure in the NICU is associated with poorer brain development and neurobehavioral outcomes in preterm neonates.[1,2] To reduce stressors, several approaches have been implemented into NICU care, e.g. kangaroo care, individualized developmental care [3,4] and use of sound meters. Another approach to stress reduction and creation of a soothing environment is the use of music.[5]

Although results vary,[6–9] beneficial music effects have been reported in several studies, e.g. regarding heart rate (HR), respiration rate (RR), oxygen saturation (SpO_2), desaturation rate, salivary cortisol, and heart rate variability (HRV).[10–14] Intermittent hypoxemic episodes are a common problem in preterm neonates and are associated with poorer neurodevelopmental outcomes.[15] In one study it was shown that the

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number of desaturation decreased statistically significant after a pentanonic music intervention.[13] However, no control condition was realized in this study. Therefore, we decided to further study the impact of pentatonic music on the number of desaturation rates. The HRV in the newborn is considered an indicator of autonomous nervous system (ANS) maturity.[16] Other potentially useful physiological parameters, not yet studied, in this context might include the perfusion index (PI) indicative of relative vasoconstriction [17] [18] and pulse transit time (PTT-W1),[19] closely associated with cardiovascular stiffness.[20]

Aside from neonates, parents also benefit from music intervention as demonstrated in lower anxiety and self-reported stress reduction.[14,21,22] Pregnancy and childbirth per se can be described as critical life events, and thus trigger mental disorders in persons with existing vulnerability.[23] The authors of a metaanalysis conclude that preterm parents experience only little more stress than parents of term born neonates an therefore, perceive preterm birth as only one potential complication related to childbirth.[24] However, in other studies parents of preterm neonates are facing additional trouble, such as a higher risk of developing a depression [25] and a higher number of posttraumatic stress disorder symptoms [26]; the latter correlating with and adverse eating and sleeping behavior of the infant.

In Anthroposophic Medicine, an integrative medical system based on the work of Rudolf Steiner,[27] music therapy plays a major role as complementary treatment approach in the NICU. Especially, pentatonic music, which is based on a five tone scale, is considered soothing for infants.[28] In the pentatonic scale only whole tones exist. This lends the sound a harmonic, calming and elevating quality.[29] Evidence to the use of pentatonic music at the time is largely anecdotal and empirical tests of it as intervention are scarce, however. Therefore, the current study aimed to examine the effects of pentatonic live music played on a children's harp, on the cardiac and respiratory physiology of preterm neonates and on the level of anxiety of their mothers. Aside from previously often reported parameters such as desaturation rate, HR and RR, the impact on less well (HRV parameters), and not yet investigated measures (PI and PTT-W1) was studied. This led to two hypotheses:

Primary Hypothesis: Live pentatonic harp music (LPHM) in the NICU will decrease the number of oxygen desaturations < 90%/h for one hour after play end.

Secondary Hypotheses: LPHM will decrease HR and RR for 15 min after the intervention. LPHM will increase HRV, SpO_2, PI and PTT-W1 for 15 min after play end. The maternal anxiety assessed with the state trait anxiety inventory (STAI-X1) will decrease and the mothers will perceive their neonates as more relaxed after the LPHM.

2. Patients and methods

Design: This was a prospective two-center, randomized crossover study with subjects acting as their own controls. A two-period crossover design was used to minimize differences in the neonates' clinical state between the conditions.

Participants: The study was performed in the NICU (Level 2) of the Children's Hospital of the University of Tübingen, Germany, and in the NICU (Level 2) of the Filderklinik, Filderstadt, Germany. Data collection took place from July to October 2013.

Inclusion criteria were GA of 26 + 0–34 + 6 weeks and days at birth in room air and in an open crib at time of study. Exclusion criteria were heart defect or cardiac arrhythmia; significant disease (e.g. neonatal infection), genetic or congenital anomalies or documented or suspected hearing problems. Concerning the neonates' mothers no additional exclusion criteria were defined.

2.1. Intervention

On one day every neonate participated sequentially under two conditions, each lasting 2 h 15 min, starting with an one hour pre phase and ending with an one hour post phase. During the middle 15 min (intervention phase) either live music was played on a children's harp (music condition, MC) or no intervention took place (control condition, CC). Measurements started after feeding the neonates and changing their nappies. During the session the neonates were lying in their beds. The music intervention was performed by the first author, a psychologist, who had studied hand harp music play in the NICU and who was supervised by a trained anthroposophic music therapist experienced in working with preterm neonates. The children's harp used in the study (Choroi Vertriebs GmbH, Filderstadt, Germany) is tuned pentatonically. The pentatonic scale consists of five tones, e.g. d'-e'-g'-b'-a'. Music was played in a semi-standardized way, starting with a two-minute fade-in of arpeggios and ending with a two-minute fade-out of arpeggios. In between freely varied melodies were played in an adagio triple meter. Immediately before and after the intervention phase the mothers, if present, answered the study questionnaires.

2.2. Outcomes

During the MC and CC respectively, neonates' desaturations, HR and RR as well as bradycardia events were measured via ECG and pulse oximetry using the portable monitoring system VitaGuard® VG 3100 (Getemed Medizin- und Informationstechnik AG, Teltow, Germany). Inter-beat-intervals measured with the VitaGuard were imported into the software HRV-Scanner (BioSign GmbH, Ottenhofen, Germany) with which HRV parameters were calculated. A desaturation (primary outcome parameter) was defined as a reduction of oxygen saturation to values < 90%, if the device's signal quality (SigIQ) was > 0.3. the PI was > 0.02% and the reduction was < 8% absolute from one measuring point to the next. A bradycardia event was defined as a reduction of HR < 80 beats per minute (bpm) for more than one beat, if the ECG signal was undistorted immediately before the event's onset. Additional parameters calculated by the VitaGuard® VG 3100 included the PI and the PTT-W1 and parameters of the HRV such as a RMSSD (root mean square of successive differences), SDNN (standard deviation of normal-t- normal) and pNN_{50} (proportion of the number of interval differences of successive normal-to-normal intervals > 50 ms divided by the total number of normal-to-normal intervals).

The study mothers answered the German version STAI-X1,[30] a 20-item questionnaire that refers to anxiety as a current state (Cronbach`s alpha: 0.91), before and after the intervention phase. Sum scores range from 20 to 80 points with higher values indicating more anxiety experienced. Furthermore, mothers were asked to rate the perceived emotional state of their child before and after the intervention phase, for which an in-house-created 7-item questionnaire with total values ranging from 7 to 28 points was utilized. It included statements such as "My child is tense" or "My child is relaxed". Again, higher scores indicated greater perceived tension.

2.3. Sample size calculation

The optimal sample size was estimated using the software G*Power Version 3.1.3.[31] The estimation was based on a meta-analysis that identified an overall large effect size (Cohen's $d = 0.83$) of music on physiological parameters of preterm neonates.[8] A sample size of $n = 15$ was considered sufficient to detect large effects on a significance level of $\alpha = 0.05$. To detect possibly smaller effects, we decided to include $n = 21$ neonates.

2.4. Randomization

For the randomization 20 lots were prepared by the first author AR. Every lot declared the order of the conditions; ten with the order 1. MC – 2. CC and ten with the order 1. CC – 2. MC. For the 21st child two extra lots were prepared one indiciatin the first possible order and the second one vice versa. The lots were placed in sealed envelopes. Shortly before starting the first measurement an neonate's mother or a nurse drew one of the envelopes for randomization.

2.5. Blinding

No blinding was realized.

2.6. Statistical analysis

For data analysis SPSS Statistics Version 21 and 22 (IBM Deutschland GmbH, Ehningen, Germany) was used. All tests were carried out two-tailed. Data first were preprocessed using VitaWin Version 3.3 (Getemed, Teltow, Germany) and Microsoft Office Excel 2007. For comparison of phases of equal length, only the last 15 min of the pre-phase and the first 15 min of the post-phase were included in the analysis of the continuously measured parameters such as SpO_2 and HR. The 15-minute intervention phase was included fully. For the comparison of the phases all measuring points of the 15 min of each phase were averaged. Concerning the cardiac events, the entire 1-hour pre and post phase was analyzed by comparing the number of events. On the basis of the Kolomogorov-Smirnov-test for most variables a normal distribution could not be assumed. Therefore, nonparametric statistics were employed. The inferential statistical analyses for cross-over designs were conducted as recommended in the medical literature.[32] Therefore, the pre-post-differences for each condition were compared by use of the unpaired Mann-Whitney-U-test. This assured the intra-individual sums of the pre-post-differences of each condition were compared, in order to assure exclusion of carry-over effects. Because for this step the null hypothesis should be accepted, a *p*-value < 0.20 was considered statistically significant to follow a more conservative approach. In a second step the treatment effects were analyzed by comparing the intra-individual differences of the pre-post-differences of each condition using the unpaired Mann-Whitney-U-test. Here, a *p*-value < 0.05 was considered statistically significant. If carryover effects could not be excluded the second step consisted of a Mann-Whitney-U-test which was carried out using only the data of the first condition of each subject ($p < 0.05$). Thirdly, a pre-post-comparison within the conditions was conducted using the Wilcoxon-Signed-Rank-test ($p < 0.05$). To describe the pre-post-changes within one condition, the effect size *r* was calculated using the following formula: $= \frac{Z}{\sqrt{N}}$ [33]. Effect sizes were interpreted as being small (> 0.10), medium (> 0.30) or large (> 0.50). Furthermore, several control variables were recorded and analyzed using *t*-tests und χ^2-tests (as an acceptance of the null hypothesis was aimed for the control variables like presence of parents and child´s state a *p* value < 0.20 was considered as statistically significant). In case of the sound level, the same procedure as explained for the outcome parameters was used.

2.7. Ethical approval

The investigation was approved by the ethical review committee for research with human subjects of Eberhard Karls University of Tübingen, Germany (Nr. 228/2013BO1) the oversight institution for the Children's Hospital of the University of Tübingen, where the study was carried out. It was registered at www.ClinicalTrials.gov of the U.S. National Institutes of Health (identification number NCT01908244). Prior to enrolment parents were informed about the study procedure by the first author (AR) and their written informed consent was obtained.

3. Results

The parents of 38 preterm neonates were informed about the study (see Fig. 1). The parents of 21 neonates (14 girls, 7 boys; mean gestational age at measurement 35 + 0 weeks (SD 1 week) gave informed consent. Reasons for withholding consent were amongst others feared stress for the neonate or oncoming discharge. Characteristics of the study population are shown in Table 1. Tables 2–4 show the median values, the interquartile ranges and the effect size *r* (pre-post-comparison within one condition) of the outcome parameters. For the primary outcome (No of desaturations < 90%/h) no carry-over effect was identified. No significant effect was found for the comparison of the pre-post-differences (ΔNo of desaturations < 90%/h = -1.5, $z = -0.09$, $p = 0.97$).

For the secondary outcomes carry over effects could not be ruled out for SDNN and pNN_{50}. Therefore, only the data of the first condition of each subject was included for pNN_{50} and SDNN. In pNN_{50} the pre-post-differences between the conditions differed significantly from each other (ΔpNN_{50} = 1.46% $z = -2.47$, $p = 0.01$). Within the MC, pNN_{50} was significantly higher after music exposure than before (ΔpNN_{50} = 1.40%, $z = -2.03$, $p = 0.04$). In the CC no change of pNN_{50} was observed (ΔpNN_{50} = 0.10%, $z = -0.02$, $p = 0.99$., see Fig. 3). Within SDNN the pre-post-differences also differed significantly between the conditions (ΔSDNN = -0.06 ms, z = -2.25, $p = 0.02$). The SDNN showed a trend to be higher after music exposure than before (ΔSDNN = 4.7 ms, $z = -1.93$, $p = 0.05$).

For the other parameters carryover was not assumed as the test on carryover effects was not significant. The PI showed no significant difference for the pre-post-test between the conditions (ΔPI = 0.4%, $z = -.99$, p = 0.35). However, the PI significantly rose over time in the MC (ΔPI = 0.26%, $z = -2.52$, $p = 0.01$) whereas no change was seen in the CC (ΔPI = −0.14%, $z = -1.23$, $p = 0.22$; see Fig. 2). The largest within-effect was shown on the STAI-X1. Mothers reported less anxiety after listening to the music intervention than beforehand (ΔSTAI-X1 = -4, $z = -2.53$, $p = 0.01$). Because the STAI-X1 was administered only twice in the CC, no comparison of the pre-post-difference between the conditions could be conducted. The mother-reported neonate emotional state did not change over time.

Additional control variables showed unexpectedly significant differences: During the MC mothers were significantly more often present during the intervention phase ($\chi^2_{(2)} = 7.33$, $p = 0.03$) than in the intervention phase of the CC. The child's state (awake vs. doze vs. asleep) at the beginning of the intervention phase also differed significantly between the two conditions ($\chi^2_{(2)} = 4.78$, $p = 0.10$). In the MC 42% of the neonates were dozing at the beginning of the intervention phase, whereas in the CC that was only the case for 26% while the other neonates were asleep at this time. There was also a significant difference in the registered sound levels in the pre phases. In the MC the sound level was significantly higher than in the CC (*Δsound level* = 0.1 dB(C), $z = 1.68$, $p = 0.11$). For the other control variables (duration of measurement, feeding mode before measurement, neonate's position and overall presence of mothers) no difference between the conditions was found.

4. Discussion

This study tested the effects of a single LPHM intervention on physiological parameters of preterm neonates and on the anxiety of their mothers as well as on the mothers' perception of their child's state. Several of the measured parameters showed significant results, yet the primary variable failed to do so. This might have been due to the overall low number of desaturations during the study. The largest within-effect was found in the reduction of maternal anxiety.

The finding of a reduction of anxiety after a receptive music intervention is consistent with other studies on the effects of music on parents in the NICU [21,22] and was confirmed in a recently published meta-analysis.[7]

As mentioned above, in a number of studies, positive effects of music interventions on the commonly used vital signs of preterm neonates - that is SpO_2, HR and RR - have been shown.[10,12,22] However, the clinical relevance of the observed changes should be discussed critically. For example Loewy et al.[22] reported a statistically significant decrease of HR from pre-to post-phase of 0.6 bpm and a reduction of the

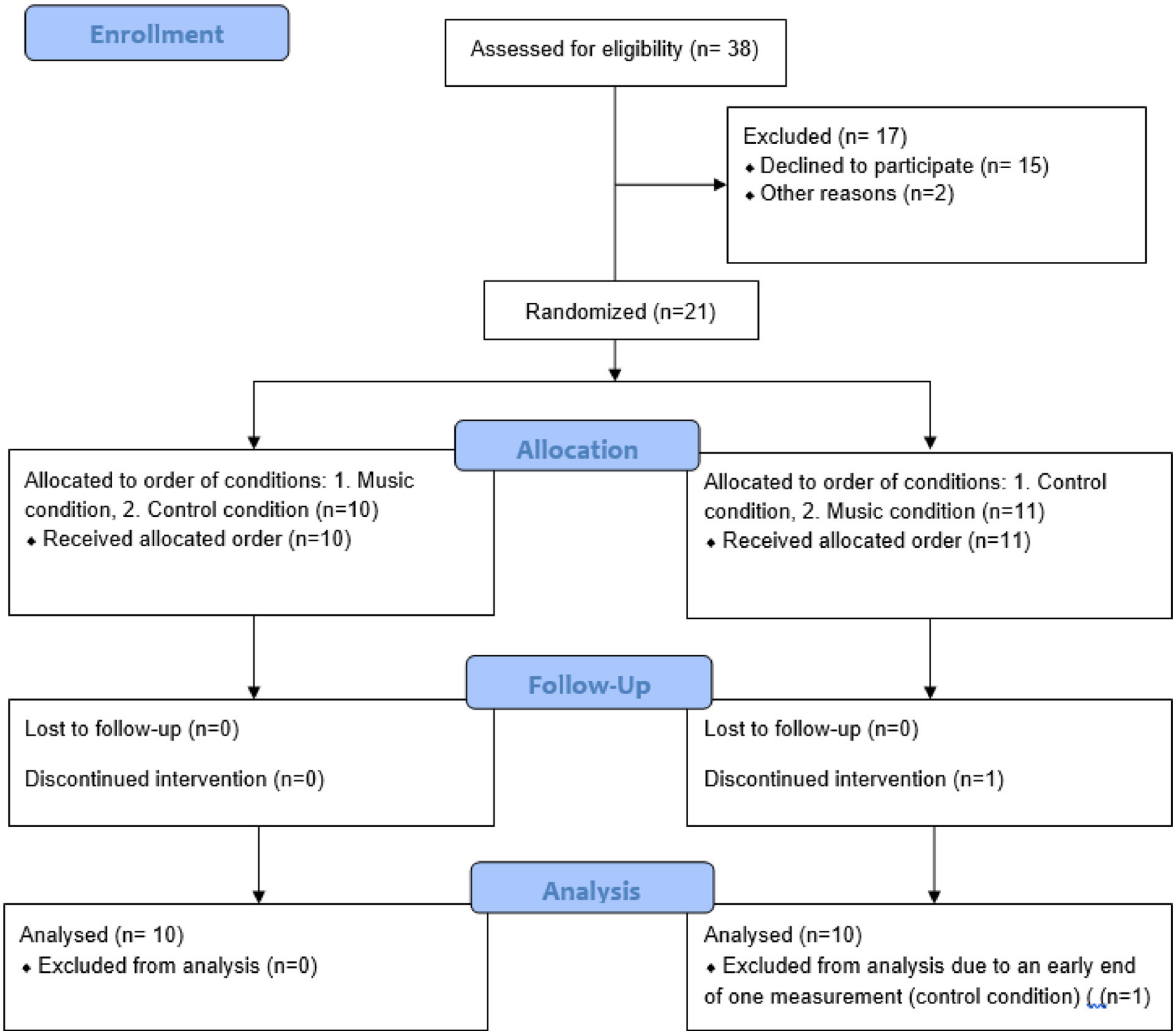

Fig. 1. CONSORT Flow Diagram.

Table 1
Characteristics of the study population.

Variable	*n (%)*	*M (SD)*	*Minimum*	*Maximum*
Infants	21 (100)			
GA birth (weeks + days)	–	32 + 1 (1 + 6)	27 + 6	34 + 3
GA measurement (weeks + days)	–	35 + 0 (1 + 3)	32 + 1	38 + 5
Postnatal age (weeks + days)	–	2 + 6 (1 + 4)	1 + 1	7 + 0
Birthweight (g)	–	1586 (325)	980	2350
Weight at measurement (g)	–	1983 (419)	1421	3282
Delivery mode				
Vaginal birth	5 (23.8)	–	–	–
Caesarean section	16 (76.2)	–	–	–
Apgar-Score				
1 minute	–	7.2 (1.5)	4	9
5 minutes	–	8.6 (1.0)	7	10
10 minutes	–	9.2 (0.6)	8	10
Mothers	15 (100)			
Age	15 (100)	32.9 (4.9)	24	40
Primiparae	12 (80)	–	–	–

Note: GA = gestational age, Apgar-Score = score to evaluate the vital functions of a newborn.

RR of 0.8 breaths per minute, when neonates listened to a lullaby. In the recently published meta-analysis mentioned above [7] the authors concluded that only the effects of music interventions on the RR of preterm neonates, but not on other physiological parameters, could be confirmed.[7] As described earlier the current study did not find changes in the desaturation rate, HR and RR, perhaps due to the relatively calm state of the neonates at the beginning of the MC. However, the current study identified several changes in subtler physiological parameters such as HRV. Similar results were reported in a recent study of the effects of kangaroo care with or without maternal singing.[14] The authors concluded that kangaroo care alone might decrease or mask the effects of other interventions such as music on the neonates' vital signs, yet that nevertheless music had an impact on autonomic stability. Concerning the child's emotional state, the mothers' evaluations did not change over time. Already in the pre-phase the neonates were rated as relaxed and calm. Therefore, further reduction of stress seemed hardly possible (floor effect).

4.1. Limitations

Since blinding of the parents concerning the intervention was not feasible in the current study mothers might have given socially desirable answers. It also must be taken into account that parents in general have high expectations about the effects of music on their neonates. In a survey with parents in the NICU, Pölkki and colleagues [34] found out,

Table 2
Summary of the physiological parameters in both conditions – Part 1.

Variable	Music condition		Control condition	
	Mdn (IQR)	*r*	*Mdn (IQR)*	*r*
Heart rate in bpm				
Pre phase	153.8 (146.7; 159.6)	–	150.9 (144.2; 156.5)	–
Intervention	152.5 (147.7; 157.0)	–	150.3 (146.1; 155.0)	–
Post phase	152.4 (146.5; 159.2)	.0	151.3 (147.4; 157.8)	−.1
Respiration rate per minute				
Pre phase	45.0 (40.5; 50.0)	–	43.0 (38.5; 48.5)	–
Intervention	45.0 (38.0; 51.5)	–	41.0 (38.0; 46.5)	–
Post phase	45.0 (38.0; 49.5)	−.1	40.0 (37.5; 45.5)	−.2
Pulse transit time in ms				
Pre-phase	173.8 (165.2; 178.7)	–	171.7 (164.8; 182.6)	–
Intervention	175.6 (166.3; 181.5)	–	172.0 (164.3; 184.1)	–
Post-phase	170.3 (161.6; 180.9)	−.1	173.1 (162.8; 181.8)	−.2
Perfusion index in %				
Pre phase	1.28 (1.19; 1.68)	–	1.47 (1.03; 1.70)	–
Intervention	1.46 (1.18; 1.90)	–	1.33 (1.09; 1.79)	–
Post phase	1.54 (1.25; 1.97)	.40	1.33 (1.10; 1.85)	.20

Table 3
Summary of the physiological parameters in both conditions – Part 2.

Variable	Music condition		Control condition	
	Mdn (IQR)	*r*	*Mdn (IQR)*	*r*
RMSSD in ms				
Pre phase	37.0 (28.3; 44.3)	–	37.1 (29.5; 51.0)	–
Intervention	37.8 (31.1; 49.5)	–	38.7 (31.6; 43.9)	–
Post phase	38.4 (31.6; 59.1)	−.3	36.2 (31.5; 44.8)	−.1
SDNN in ms				
Pre phase	31.7 (29.4; 38.6)	–	32.8 (25.6; 43.2)	–
Intervention	37.7 (26.5; 41.6)	–	35.4 (30.2; 46.6)	–
Post phase	36.4 (31.6; 48.7)	-:3	37.6 (30.3; 42.8)	−.1
pNN_{50} in %				
Pre phase	1.2 (.7; 4.2)	–	1.6 (.7; 4.2)	–
Intervention	2.2 (1.0; 4.3)	–	2.0 (1.0; 3.3)	–
Post phase	2.6 (1.2; 5.2)	−.3	1.7 (1.3; 2.4)	.0
Number of desaturations				
Pre phase	2.0 (.0; 5.0)	–	1.0 (.0; 8.0)	–
Intervention	.0 (.0; 1.8)	–	.0 (.0; 3.0)	–
Post phase	2.5 (.0; 8.5)	−.1	3.0 (.0; 6.0)	.0
Number of bradycardias				
Pre phase	.0 (.0; .0)	–	.0 (.0; .0)	–
Intervention	.0 (.0; .0)	–	.0 (.0; .0)	–
Post phase	.0 (.0; .0)	−.2	.0 (.0; .0)	.2

Note: Mdn = median, IQR = interquartile range (25^{th} percentile; 75^{th} percentile), *r* refers to the pre-post-comparison within one condition.

Table 4
Summary of the questionnaires.

Variable	Music condition			Control condition		
	n	*Mdn (IQR)*	*r*	*n*	*Mdn (IQR)*	*r*
STAI-X1						
Pre phase	9	29.0 (24.5; 43.0)	–	2	34.5 (32.0; '-)	–
Post phase	9	25.0 (21.0; 36.5)	−.4	2	33.0 (33.0; 33.0)	−.1
State of the child						
Pre phase	9	8.0 (7.0; 10.5)	–	2	10.0 (10.0; 10.0)	–
Post phase	9	7.0 (7.0; 10.5)	.0	2	11.5 (10.0; '-)	−.2

Note: Mdn = median, IQR = interquartile range (25^{th} percentile; 75^{th} percentile), *r* refers to the pre-post-comparison within one condition.

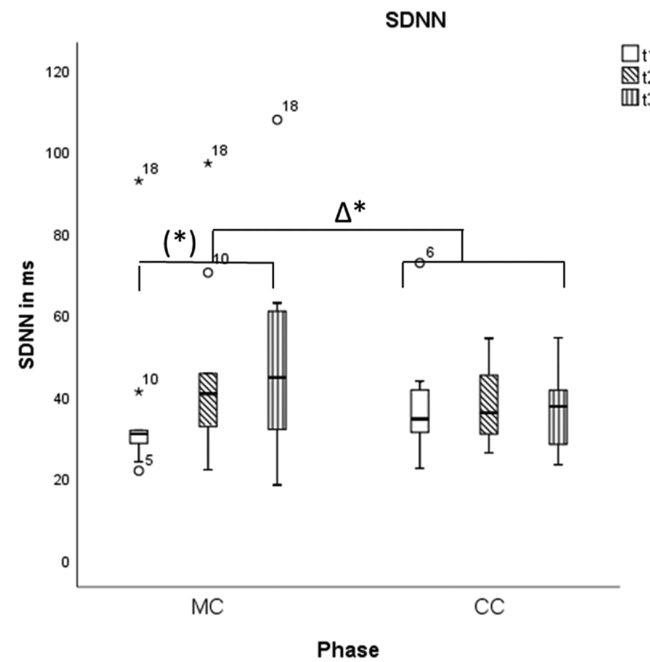

Fig. 2. Changes of the HRV parameter: SDNN.
Note: MC = music condition, CC = control condition, t1 = pre phase, t2 = intervention phase, t3 = post phase. Because carryover effects could not be ruled out, only data of the first measurement of each subject was analyzed. SDNN: Standard Deviation of Normal to Normal (higher values indicate a higher heart rate variability).

that more than 90% of parents believed, that music would increase their neonates' feeling of security and decrease the neonates' experienced stress. Still more than 80% considered that music would improve their neonates' sleep as well as console a crying neonate.

A second limitation of the current study is inherent in its design: In the CC the STAI-X1 was answered only twice, namely before and after the intervention phase; thus, the results must be interpreted with caution. Mothers were asked to refrain from interacting with their child during the measurement. Therefore many mothers decided to leave the NICU during the actual measurements. Only the mothers, who were interested in the music intervention itself decided to stay in the NICU. Thirdly, given that the sample size was estimated on the basis of a meta-analysis, that identified large overall music intervention effects [8] the small sample size of the current study did not allow identification of smaller effects. Moreover, it must be noted that correction of the multiple test *p*-values was not performed. Due to the effectiveness approach of the study design it can be assumed, that the results found are generalizable to other NICU setting.

4.2. Implications

All study measurements took place in the course of one day, which typically started in the afternoon due to organizational reasons. That meant that the second study condition in some cases lasted well into the evening. Given the mothers' already complex situation with an neonate in the NICU, requiring them to be physically present during the study itself was not deemed appropriate. However, in future studies this

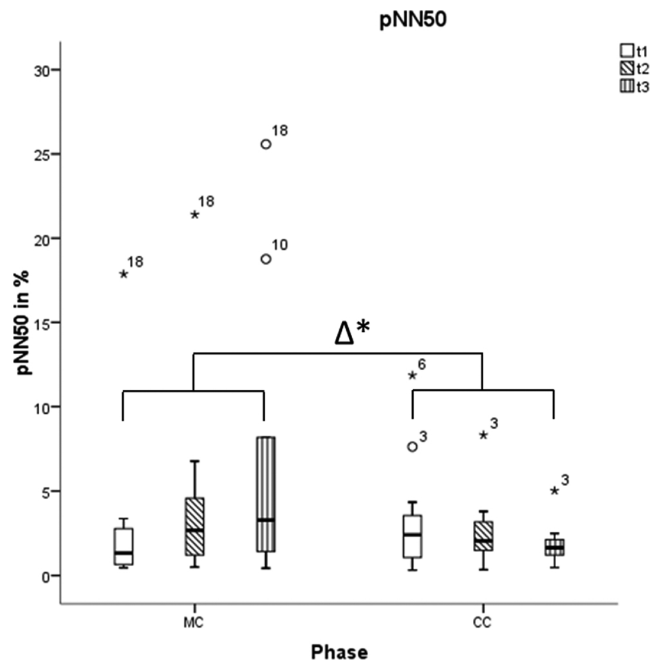

Fig. 3. Changes of the HRV parameter: pNN_{50}.
Note: MC = music condition, CC = control condition, t1 = pre phase, t2 = intervention phase, t3 = post phase. Because carryover effects could not be ruled out, only data of the first measurement of each subject was analyzed. pNN_{50}: proportion of the number of interval differences of successive normal-to-normal intervals > 50 ms divided by the total number of normal-to-normal intervals (higher values indicate a higher heart rate variability).

should be taken into account.

There is some evidence that the effects of live music might be greater as compared to those of recorded music.[35] In a meta-analysis Standley [9] concluded, that live music without physical contact was more effective than recorded music without physical contact. If the music application was combined with physical touch however, recorded music tended to be more beneficial. Since the use of live music is common in anthroposophic music therapy, in the current study the music intervention was presented live. It was presented, as mentioned, by a psychologist, supervised throughout by an experienced music therapist. Positive effects of pentatonic live music played by a medical scientist had been reported in another study.[13] Nevertheless, an experienced NICU music therapist might have played the music intervention with additional expertise and sensitivity to each neonate's response thresholds and conceivably achieved stronger beneficial results.

Given this and other studies' beneficial results and that music for neonates, especially the singing of lullabies, seems to be something inherently human, NICU professionals likely should encourage parents to sing or play music for their neonates. As the children's harp is easy to play it might help overcome parents' inhibition and shyness to sing or play music in the NICU for their neonate, and help bring parents be close to their neonates. In summary, the current study examined the short-term effects of pentatonic live harp music on preterm neonates and their mothers in the NICU. The study as such was quite feasible. Only in one case the second measurement (music condition) did not take place on the same day as the control condition and therefore both conditions were rescheduled for the next day. The study nevertheless includes multiple implications for future research. In a first step we investigated the effects on pentatonic music vs. standard care. A consequently following second step could involve the comparison of pentatonic to simply harmonic music to test if there's a benefit caused by the characteristics of the pentatonic scale.

4.3. Conclusion

Given, that preterm-born children still show impaired autonomic nervous system activity and reactivity at the age of 9–10 years corrected age, [36] it seems to be particularly important to support ANS development from early on. Despite no changes were found in the primary outcome parameter, with the reported heart rate variability changes in mind, the use of music might, nevertheless, play an important role in the NICU.

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